WSEO-P--95-054

Energy Life Cycle Cost Analysis

Guidelines for Public Agencies

March 1995

MASTER

WSEO

Washington State Energy Office

Foreword

Public agencies are responsible to ensure that energy conservation practices and renewable energy systems are employed in the design of major facilities as described in RCW 35.35. Public agencies are directed to include life cycle cost analysis in the design phase of any major facility. The Washington State Energy Office is identified in RCW 35.35.050 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.

WSEO Contacts

Any of the life cycle cost analysis spreadsheet tools can be downloaded from the Electric Ideas Clearinghouse Bulletin Board system. ?Go Files, Select Other Library, Download ELCCA (Q, E, or L). Zip for Quattro, Excel, or Lotus format. File contains LCCA and maintenance cost spreadsheets.

1-800-762-3319 (WA, OR, ID, MT) or (360) 586-6854
For questions on these guidelines or assistance in preparing ELCCA's contact:
Washington State Energy Office
ELCCA lead reviewer
925 Plum Street SE
P.O. Box 43165
Olympia, WA 98504-3165
(360) 956-2056

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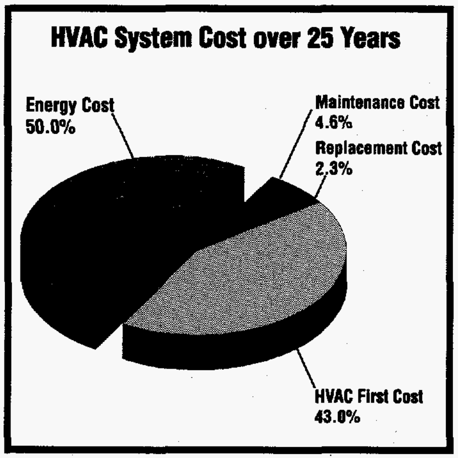
Introduction



The State of Washington encourages energy-efficient building designs for public agencies. The Washington State Energy Office (WSEO) supports this goal by identifying advances in building technology and sharing this information with the design community and public administrators responsible for major construction projects. Many proven technologies can reduce operating costs—and save energy—to an extent that justifies some increases in construction costs.

WSEO prepared these Energy Life Cycle Cost Analysis (ELCCA) guidelines for the individuals who are responsible for preparing ELCCA submittals for public buildings. Key terms and abbreviations are provided in Appendix A.

Chapters 1 and 2 serve as an overview—providing background, defining energy life cycle cost analysis, explaining which agencies and projects are affected by the ELCCA requirements, and identifying changes to the guidelines that have been made since 1990. They explain "what needs to happen" and "why it needs to happen." Chapters 3 to7 provide the "how to," the instructions and forms needed to prepare ELCCA submittals.

Why Do Life Cycle Cost Analysis?

The 1994 Non-Residential Energy Code (NREC) provides basic requirements for building an energy-efficient facility. There are still many optional systems (mechanical, controls, envelope, etc.) and configurations (e.g. daylighting) that can meet all the code requirements. Options can usually be found that result in additional life cycle cost benefits to the owner. These options may have significant differences in first cost, energy cost, and maintenance cost. The life cycle cost analysis provides a method to evaluate these various options so that the owner can select the best system for the building.

Background

In 1975, the Washington State Legislature enacted into law "Energy Conservation in Design of Public Facilities." The intent of this law is to ensure that energy conservation practices are incorporated into the design of major public facilities—both new construction and extensive renovations. The law requires preparation of a life cycle cost analysis that covers the design of energy systems. The law applies to state agencies, including colleges and universities, and political subdivisions of the state, such as cities, counties, school districts, and other special taxing districts.

In 1978, the State Superintendent of Public Instruction (SPI) authorized WSEO to review public schools' energy life cycle cost analyses, commonly referred to as Energy Conservation Reports (ECRs). WSEO developed ECR guidelines for school projects in 1980 and revised them in 1990.

In 1991, new legislation strengthened the mandate to perform ELCCAs for public agencies. That legislation also authorized WSEO to recover the costs of reviewing ELCCA submittals.

The guidelines presented here adapt the earlier versions of the guidelines *so they can be used by all public agencies.* The terms "energy life cycle cost analysis" and "ELCCA" are used throughout this publication; however, documents provided by the Superintendent of Public Instruction continue to use the terms "Energy Conservation Report" and "ECR."

Requirements pertaining to energy life cycle cost analyses are based on the Revised Code of Washington (RCW) 39.35 and the Washington Administrative Code (WAC) 180-27-075. Relevant sections of the RCW and WAC are provided in Appendix B.

What Is an Energy Life Cycle Cost Analysis?

Life cycle cost analysis is a decision-making tool for building design. The analysis accounts for initial costs associated with constructing or renovating a facility as well as the cost of owning and operating a facility over its useful life. *Energy* life cycle cost analysis specifically considers these costs for energy systems (heating, cooling, lighting, building envelope, and domestic hot water). It takes into account the initial cost of each alternate energy system as well as other predictable costs over the expected system life: operation and maintenance, energy, system or component replacement, and the cost of money.

The completed ELCCA report recommends alternatives that make the most economic sense while providing for the comfort, health, and productivity of the building occupants.

What Is the Purpose of the ELCCA Guidelines?

The purpose of the guidelines is to define a procedure and method for performing life cycle cost analysis, promote the selection of low life cycle cost alternatives, and provide a standard reporting format. The guidelines are presented in the form of practical instructions that help ELCCA analysts prepare their submittals.

Some of the specific objectives of the guidelines include:

- Explain the ELCCA submittal requirements and format.
- Identify the phases of the design process when the ELCCA needs to be prepared, reviewed, and approved or disapproved.
- Provide the economic assumptions that need to be used for fuel escalation rates, inflation rates, equipment service lives, building lives, and maintenance costs.
- Encourage ELCCA analysts to incorporate renewable resources into their designs when it is cost-effective and feasible to do so.

Which Public Agencies Must Prepare ELCCAs?

State agencies (including colleges and universities, and political subdivisions of the state, such as cities, counties, school districts, and other special taxing districts) are required by law to prepare ELCCAs for major projects.

When Must an ELCCA Report Be Prepared?

Major Facilities

An ELCCA report must be prepared when a project will result in a major facility that is publicly owned or leased and has 25,000 square feet or more of usable floor space.

Renovations

An ELCCA is required when additions, alterations, or repairs of a major facility within any 12-month period exceed 50 percent of the value of the original facility *and* affect energy-using system(s).

Who Reviews and Approves ELCCAs?

WSEO developed these guidelines to explain submittal requirements. However, the responsibility for ensuring that lifecycle cost analyses are prepared by a qualified analyst and reviewed rests with each public agency. *Actual final approval of the work is the responsibility of the public agency commissioning the work.* The life cycle cost analysis should provide information to help ensure that energy conservation practices and renewable energy systems are incorporated into design of public facilities. Further, it is WSEO's belief that maximum value from the ELCCA process can only be achieved through earnest analysis and independent review.

WSEO will provide for review of all ELCCAs produced to satisfy RCW 39.35. WSEO will accomplish this through its own technical staff or through designated reviewers from other public entities identified as having sufficient technical training and experience to conduct an adequate and independent review. For public school projects, WSEO will continue to act as the designated reviewer of ECRs as specified in WAC 180-27-075.

Appendix C shows the Review Process Checklist WSEO uses to check for format and technical accuracy in ELCCA submittals.

Who Is a Qualified ELCCA Analyst?

The ELCCA submitted should be developed by a qualified analyst. The analyst must be a registered architect or professional engineer and have experience with an approved computer energy simulation model. The analyst should have public building design experience and be familiar with energy system options and energy modeling techniques.

How Much Have These Guidelines Changed?

The 1990 version of these guidelines only applied to K-12 school districts that used SPI's D-Form Process. This publication can be used by any public agency to prepare ELCCA submittals. Changes in the submittal requirements include:

- **Three methods of compliance were developed.** They are prescriptive, prototypical, and detailed analysis.
- **Name change.** "Energy Conservation Report (ECR)" is a term reserved for energy life cycle cost analysis reports prepared for K-12 school projects that receive state construction dollars through SPI. This publication uses the term ELCCA; however, SPI documents continue to use the term "ECR".

- **Utility role.** These revised guidelines articulate a role for utilities in the ELCCA process beginning with the development of the work plan.
- **Renewable resources worksheet.** As part of the work plan, ELCCA analysts are asked to complete a worksheet that identifies renewable energy resources that are available to the project.
- **Maintenance cost information.** These guidelines include information on how to calculate maintenance costs and account for operator skills in the life cycle cost process.
- **Verification checklist.** In addition to the work plan, energy use simulation, economic analysis, and addendum, the ELCCA process now includes the verification checklist. Its purpose is to track whether any of the energy systems recommended in the ELCCA report have been designed, constructed, and installed in the building. This information will be provided to designers to help them with future projects.

Chapter 2

Overview of the ELCCA Process

Chapter 2 covers four major areas: (1) identifying projects that require an energy life cycle cost analysis, (2) describing the ELCCA submittal process, (3) introducing the methods of compliance, and (4) explaining how the preparation of the ELCCA integrates with the phases of building design.

Projects Requiring an ELCCA

Public agencies are required by RCW 39.35 to have an ELCCA prepared when public funds are used to build and/or *operate* the following:

1. New major facilities, buildings, or additions that have 25,000 square feet or more of usable floor space.
2. Building renovations or modernizations that have 25,000 square feet or more of usable floor space, *when* the project cost divided by the building value is greater than 0.5 and the project affects the energy-using system(s).
3. Combinations (or multiples) of 1 and 2 above that will be built on the same site during any 12-month period are considered a single project. If the sum of the affected areas is equal to or greater than 25,000 square feet, an ELCCA is required.

Examples:

1: An agency plans to remodel a 25,000-square-foot building at a cost of $45 per square foot. The building value is $80 per square foot. The project cost (25,000 × $45 = $1,125,000) divided by the building value (25,000 × $80 = $2,000,000) is equal to 0.5625, which is greater than 0.5. Therefore, the project requires an ELCCA.

2: 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 bid the following May. This project will require an ELCCA because the affected area is greater than 25,000 square feet (15,000 + 20,000) and the phases are planned to take place within a 12-month period (October to May).

It is a public agency's responsibility to require an ELCCA when planning a project that meets any of the preceding criteria. An agency should determine whether an ELCCA is required *before* contracting with a design firm. Otherwise, an agency may incur the cost of preparing a report when one is not required. Once the report is prepared and submitted, WSEO must complete the review and charge for its services.

Contact WSEO if you still need help deciding whether your project requires an ELCCA. WSEO engineers can provide consultation; however, the final decision remains with the agency.

Projects Not Requiring an ELCCA

When an ELCCA is not required, the project engineer still needs to prepare and submit for review a Public Facility Energy Characteristics (PFEC) form for projects greater than 5,000 sf. This form provides information on the buildings' energy characteristics that the state requires. (This form is located at the end of Chapter 5.) The PFEC form should be sent to:

Lead ELCCA Reviewer
Washington State Energy Office
P.O. Box 43165
Olympia, WA 98504-3165

ELCCA Process

The three major steps in the ELCCA process are (1) analysis by a qualified analyst (see Chapter 4 for details), (2) review of the report by a qualified reviewer (see Appendix C, the "review process checklist" WSEO uses to check for format and technical accuracy in ELCCA submittals), and (3) approval of the report by the responsible agency.

The ELCCA process contains four separate submittals: (1) work plan, (2) energy use simulation and economic analysis (the ELCCA report), (3) addendum, and (4) verification checklist. Each submittal is prepared at a different phase of the building design process. Instructions on how to prepare each submittal are provided in Chapters 3 to 7. The submittal requirements vary with the method of compliance selected.

Participants and Responsibilities

All four submittals must be prepared by an architect or engineer licensed in the State of Washington. The analyses must be considered in the design of all major publicly owned or leased facilities. The architect or engineer who prepares the submittals is referred to in these guidelines as the "ELCCA analyst."

The ELCCA analyst is responsible for ensuring that the ELCCA submittal is technically accurate and completed in a timely manner. The quality of the work should support solid decision-making regarding the energy systems designed into and ultimately installed in a facility.

The utility representatives are asked to provide information on utility programs and make recommendations on measures that can be incorporated into the work plan.

An ELCCA reviewer is assigned by WSEO to each ELCCA submittal. This individual is responsible for reviewing and approving the work plan, the energy use simulation and economic analysis, the addendum, and the verification checklist. In addition, the ELCCA reviewer serves as a resource to help the ELCCA analyst and utility representative(s) develop a list of viable system options. (Electric and natural gas utilities should be invited to participate in the ELCCA process; they may offer financial and/or technical assistance to the project.)

The agency should direct the project architect to include the ELCCA analyst and the utility representatives in discussions during the schematic design. Recommendations for energy conservation measures that may be incorporated into the work plan and design should be solicited from all participants. Coordinating the ELCCA process with utilities may provide opportunities for additional conservation measures. Representatives from electric and gas utilities are listed in Appendix D.

The building owner should review the proposed options for energy-saving design with the design team. The owner needs to provide information on the capabilities of the facility's operations staff as well.

Methods of Compliance

All projects require that a work plan be prepared when the design team is preparing the schematic design. The work plan describes the basic elements of the building, including envelope components, lighting system, and preferred heating fuel choice.

Public agencies may choose from three methods to demonstrate compliance. These choices allow flexibility and eliminate most of the analysis for smaller, less complex projects. They are described in detail in Chapter 3. Figure 2.2 identifies the submittals that are required for each method.

- **Prescriptive Path.** This path may be applied to smaller facilities (under 100,000 square feet) where all components (envelope, lighting, control, and mechanical systems) of the design meet the prescriptive standards that will provide low life cycle cost operation.
- **Prototypical Design.** This method has been developed for public agencies that wish to reuse a previous facility design. The new facility must be based on a previously approved design that has a detailed energy and life cycle cost analysis completed within the past two years. The analyst must show that the proposed design is substantially similar to the original facility.
- **Detailed Energy and Life Cycle Cost Analysis.** This method is the full analysis that has always been part of the ELCCA guidelines. A computer simulation and life cycle cost analysis of system options is required. These results are compiled in a written report recommending the final configuration for the building.

Fit with Building Design Phases

The ELCCA process must be complete, accurate, and timely for it to benefit the design team and the facility's decision makers. This section explains how the process should integrate with the phases of building design. Figure 2.1 shows this integration.

The ELCCA process from start to finish requires varying amounts of time, from several months to over a year for verification, and involves many people. The process can be broken down into the following tasks with the goals and responsibilities identified below.

1. Contractual Agreement Awarded for Schematic Design

The ELCCA analyst may already be a member of the design team. If not, the facility owner is encouraged to select an ELCCA analyst before the design team begins its work. The ELCCA analyst must work closely with and be part of the design team, should be experienced in LCCA, and may need to meet utility program qualifications.

2. Work Plan Developed

The ELCCA analyst prepares a work plan of potential energy saving options to be analyzed with input from the design team, ELCCA reviewer, owner, and electric and natural gas utilities. It is crucial during the work plan development to see that all viable options are considered. The ELCCA analyst prepares the work plan and submits it to the ELCCA reviewer who then reviews it with the analyst. The reviewer, at this point, may suggest additional options to be analyzed. Once the scope of work is agreed on, the ELCCA analyst begins the study.

3. Energy Use Simulation and Economic Analysis Conducted

It is important to complete this part of the ELCCA submittal prior to the design development stage so that any recommended changes can be easily incorporated into the design. At this point, the ELCCA reviewer may have questions about the energy use simulation or economic analysis and may comment on the report. The reviewer's comments should be addressed in a timely manner before proceeding to the next phase of design. Once these comments are addressed satisfactorily, the report should be presented by the ELCCA analyst to the Value Engineering (VE) team, if a VE study is part of the project.

4. Addendum Submitted

The ELCCA analyst must submit an ELCCA Addendum a *minimum of eight weeks before* construction documents are released for bid. The addendum will identify any changes suggested by the VE team or identified during the design process and accepted by the owner. The addendum must contain a revised ELCCA report, if there have been changes in the design that affect energy systems; a verification checklist; and a completed PFEC form.

5. Addendum Approved

The ELCCA reviewer will examine the addendum and any revised materials on energy use simulation and economic analysis that are submitted. The reviewer will send a copy of the PFEC form to WSEO when the ELCCA is recommended for approval.

Because the lack of compliance with guidelines may entail redesign and costly delays, it is important to obtain approval *before* preparation of working drawings. *The owner should not authorize the announcement of a bid date until the ELCCA report has been approved.*

6. Verification Submitted

The verification checklist should be completed as part of the punch list inspection prior to acceptance by the owner. A copy of the signed verification checklist needs to be submitted to WSEO.

F2.1 ELCCA Integration with Building Design Phases

Fit with Building Project Phases

Responsibility	A/E Selection	Schematic Design 0% - 14% ‡			Design Development 14% - 35% ‡			VE Review 35% ‡		Construction Documents 35% - 74% ‡				Bid Phase 74%‡	Construction Administration 74% - 99%‡	Closeout 99%-100%
Owner	Selects A/E team and VE team	Determines whether ELCCA is required; selects analyst	Participates in work plan development*			Reviews ELCCA report			Selects ELCCA and VE team recommendations			Approves ELCCA addendum	Returns written response to utility offer	Points out in preconstruction meeting the clause giving contractor responsibility for correct installation of ecms †	Observes implementation of ELCCA and VE team measures	Verifies implementation of ELCCA measures; accepts project and sends completed verification checklist to WSEO
A/E Team		Determines whether ELCCA is required; prepares schematic design	Participates in work plan development*		Prepares design development documents			Presents design to VE team		Verifies to owner that ELCCA decisions will be incorporated in design Incorporates owner's decisions, itemizes ecms, & incorporates clause that states contractor is responsible for correct installation of ecms in construction documents †						Recommends acceptance of project to owner
ELCCA Analyst			Prepares ELCCA work plan*		Prepares ELCCA report*	Submits ELCCA report to owner and reviewer	Responds to reviewer comments	Presents ELCCA report to VE team		Prepares addendum reflecting owner's decisions*		Prepares verification checklist				
ELCCA Reviewer			Participates in work plan development*	Approves ELCCA work plan*		Reviews energy use simulation and economic analysis*					Review addendum*	Recommends approval of addendum to owner				
VE Team								Reviews design and ELCCA report; makes recommendations to owner								
Utilities			Participates in work plan development* and gives direction based on utility program*									Funding offer when utility requirements completed				Verifies implementation and pays for conservation measures, if applicable

* These steps are iterative and interdependent.

† Liquidated damages should include lost operating cost savings and lost utility incentive in addition to installation cost.

‡ Percentages of building project phases refer to cumulative percentage of A/E fee.

F2.2 ELCCA Submittal Requirements

	Situation	PFEC	Work plan	Energy Use Simulation	Life Cycle Cost Analysis	Report	Abbreviated Report	Addendum	Verification Checklist	Verification Completion
Select Method of Compliance *	Prescriptive	●	●				●	●	●	●
	Prototypical Design (initial submittal)	●	●	●	●	●		●	●	●
	Prototypical Design (based on an approved design)	●	●				●	●	●	●
	Detailed Analysis	●	●	●	●	●		●	●	●

* Minor projects (Projects over 5,000 sf but less than 25,000 sf) should submit a PFEC to WSEO.

Chapter 3

Work Plan

This chapter explains the first ELCCA submittal—the work plan—and what it should contain.

Overview

The work plan is most useful when it is developed early in the design, schematic, or conceptual phase of a project. The work plan functions as a scope of work. It begins with a brief project description, then identifies the energy systems to be analyzed during the energy use simulation and economic analysis.

The work plan is developed with input from the design team, building owner, and electric and natural gas utilities that will serve the new or renovated facility. The analyst then submits the work plan to the ELCCA reviewer who then discusses the various components of the work plan with the analyst and may suggest additional measures to consider. Once the analyst and reviewer reach agreement, work on the ELCCA report can begin. The work plan requires the ELCCA analyst to contact the utilities to identify potential measures to be studied. (A list of suggested energy-efficiency measures is provided in Appendix E.)

Methods of Compliance

Before beginning the work plan, the ELCCA analyst needs to determine which of the following methods of compliance applies to the project.

Prescriptive Path

For the prescriptive path method, there is no requirement for computer modeling or life cycle cost analysis of the proposed building. Certain buildings under 100,000 square feet that meet the prescriptive requirements for envelope, lighting, domestic hot water, and HVAC systems set forth in Tables 3.1, 3.2, and 3.3 are eligible for this path. These prescriptives for certain building types have been demonstrated to have low life cycle costs. After the work plan is completed, if the analyst, owner, and reviewer agree the selected path remains the most appropriate, the analyst prepares an abbreviated report. (See Chapter 5, page 5-6for a description)

Prototypical Design

Sometimes a set of building plans and specifications are used to build more than one building.

If the subsequent buildings remain true to the original, the design can be considered "prototypical" and a detailed analysis may not be required. The original prototypical design must undergo a detailed analysis before it can be used as the basis for prototypical designs under these guidelines. When an original design has been approved, it can be used as the basis for other designs for a period of two years (from the date it was approved).

If a design is to be duplicated, the analyst needs to identify it as a prototypical design in the work plan. The ELCCA reviewer decides whether the subsequent buildings are similar enough to the original design to qualify as a prototypical design. If after reviewing the work plan, the owner and ELCCA reviewer agree that the prototypical design alternative is warranted, the analyst prepares an abbreviated report. (See Chapter 5, page 5-7 for a description.)

When evaluating the potential of the prototypical design alternative, consider the following criteria, which guide the ELCCA reviewer's decision:

- Prototypical designs must be built using the same basic plans and specifications. Minor differences in floor plan may be allowed: deletions or additions affecting less than 15 percent of the original floor area, or inverting the design to construct the mirror image.
- Energy systems such as a building envelope, glazing, lighting, mechanical and domestic hot water should all be essentially identical to the original plans. However, it may be possible to change the systems within the context of an abbreviated report.
- The proposed site should have similar climate and energy rates.
- Although two building made to a prototypical design appear similar, they are likely to experience differing energy use and first costs for a number of reasons:
    - differences in as-built conditions
    - differences in use or operator awareness
    - degree of preventive maintenance
    - orientation of building relative to compass points
    - changes in altitude, microclimate, or the degree of shading

In reaching a decision, the ELCCA reviewer may weigh these factors and the benefits against the costs of preparing a new analysis.

Detailed Analysis

For all other facilities, a complete energy use simulation, an economic analysis, and a full report needs to be completed. (See Chapters 4 and 5.) Prescriptive envelope, lighting, and water heating systems may still be incorporated into the design, if desired, to limit the number of systems that need to be analyzed. HVAC system options will always need to be analyzed if this compliance path is chosen.

Work Plan Preparation

The work plan form is located at the end of this chapter. Please photocopy and use the form.

Project Description and Building Envelope Worksheet

Provide the requested information about the project and the details of the envelope components.

The prescriptive envelope requirements shown in Table 3.1 must be met for every building. If the components selected meet or exceed these standards, no further life cycle cost analysis for envelope systems is required.

If the ELCCA analyst recommends analyzing envelope options, at least one option must meet the prescriptive requirements.

T3.1 Envelope Components: Prescriptive for New Construction

ELCCA Envelope Prescriptive Options For Both Zone 1 and 2					
		Option 1	Option 2	Option 3	Option 4
Roof	Zone 1	R-38 batt. R-21* rigid	R-38 batt. R-30 rigid	R-38 batt. R-30 rigid	R-38 batt. R-30 rigid
	Zone 2	R-38 batt. R-30* rigid	R-38 batt. R-30 rigid	R-38 batt. R-30 rigid	R-38 batt. R-30 rigid
Wall		R-19 wood framing	R-19 steel framing	8" conc. block with R-10 exterior or interior insulation	12" conc. block with integral insulation U=0.11
Windows* **(wall area)**		U = 0.60 (20% max)	U = 0.60 (20% max)	U = 0.60 (20% max)	U = 0.60 (20% max)
Skylight (include in window area)		U = 1.20	U = 1.20	U = 1.20	U = 1.20
Door		U = 0.50	U = 0.50	U = 0.50	U = 0.50
Floor	Zone 1	R-19*	R-19*	R-19*	R-19*
	Zone 2	R-30	R-30	R-30	R-30
Slab		R-10	R-10	R-10	R-10

* May not meet code if electric resistance heating is used. All U-values must be tested values.

** Zones 1 and 2 as defined in the Washington State Energy Code.

Lighting Systems Worksheet

The prescriptive lighting requirements in Table 3.2 must be met for each building. The prescriptive lighting system must use three lamp fixtures with T-8 type lamps and electronic ballast. Multiple switching shall be provided to all occupied areas. Metal halide fixtures may be used where appropriate (e.g., gymnasiums) provided they also meet the power lighting density levels in Table 3.2. Two lamp fixtures with T-8 type lamps and electronic ballast may be used in accessory areas (corridors, lobbies, storage, and toilet areas). If a lighting system other than those provided for in the prescriptive requirement is recommended, the analyst will have to compare the lighting system to the prescriptive lighting system to show that the selected system has a lower life cycle cost.

Complete the worksheet describing the baseline lighting system and any proposed alternatives. (See Figure 5.4 on page 5-9.)

T3.2 Building Lighting Power Densities

Facility	Base Levels* (watts per square foot average)
K-12 Schools	1.35
Office Buildings	1.20
Warehouse	0.50
Assembly	1.10
All Other Occupancies	1.50

* These are the base levels unless governing code requirements are stricter.

Mechanical/Controls Systems Worksheet

The prescriptive HVAC system in Table 3.3 may be used for buildings under the prescribed size, or for each building, three distinctly different

HVAC systems must be selected for analysis. These systems should evaluate at least two fuel options. When feasible, a renewable energy resource should be evaluated.

Describe in detail each of the mechanical systems, including the controls and distribution systems, to be analyzed.

T3.3 Prescriptive HVAC Paths

Building Type	Electric Rates*		
	< 0.03/kwh	0.03 to 0.05/kwh	> 0.05/kwh
Middle School (> 50,000 < 100,000 sf)	AAHP VAV/E	VAV/G/E AAHP	VAV/G/E AAHP
Office Two Story (< 50,000 sf)	VAV/E Gas/Dx	VAV/E Gas/Dx	VAV/E Gas/Dx
Office Four Story (> 40,000 < 100,000 sf)	WSHP/G/O/P 4PFC/G	4PFC/G WSHP/G/O/P	4PFC/G WSHP/G/O/P
Health/Institutional (> 40,000 < 100,000 sf)	WSHP/G/O/P VAV/G	VAV/G/E 4PFC/G	VAV/G/E 4PFC/G
Elementary School (< 50,000 sf)			
Seattle (All of Western WA)	Gas Furnaces AAHP	Gas Furnaces AAHP	Gas Furnaces AAHP
Yakima (Zone 1 Eastern Counties)	Gas Furnaces AAHP	Gas Furnaces AAHP	Gas Furnaces WSHP/G/O/P
Spokane (All Climate Zone 2)	Gas Furnaces AAHP	Gas Furnaces WSHP/G/O/P	Gas Furnaces WSHP/G/O/P

*Average rate including demand charges.

System Descriptions
General Requirements for All Systems—All buildings shall be provided with direct digital controls (DDC) and computerized energy management control system (EMCS). All HVAC equipment shall meet or exceed the minimum efficiency requirements in the current Non-Residential Energy Code and shall include economizers.
AAHP—Air-to-air packaged heat pumps with electric resistance as secondary heating source.
Gas Furnaces—Unitary gas furnaces without cooling.
VAV/E—Factory-assembled VAV with perimeter fan-powered boxes (with electric duct heat), forward-curved centrifugal fan and variable speed drive, air-cooled direct expansion cooling.
VAV/G—Factory-assembled VAV with central gas boiler and perimeter fan-powered boxes, forward-curved centrifugal fan and varriable speed drive, air-cooled direct expansion cooling.
Gas/Dx—Unitary gas furnaces with direct expansion cooling.
WSHP/G/O/P—Closed-loop water source heat pumps with gas, oil, or propane boiler and water heat storage tank (50-100 gal/ton).
WSHP/ELEC—Closed-loop water source heat pumps with electric boiler and water heat storage tank (50-100 gal/ton)
4PFC/G—Four pipe fan-coil unit with central boiler and reciprocating chiller/cooling tower.

G=Gas E = Electric O = Oil P = Propane

Domestic Hot Water Worksheet

A worksheet must be completed for each building describing the domestic hot water systems.

Renewable Resources Worksheet

The ELCCA process encourages public administrators and their design teams to consider energy systems that use renewable resources (e.g., solar, wind, geothermal, biomass, and heat recovery). Anticipated increases in energy costs over the next 20 years may make renewable systems more attractive and cost-effective than they have been in the past.

If renewable resources are identified, then their potential cost-effectiveness should be analyzed. The renewable resources to be analyzed should be indicated in the work plan.

Submittal

Fax or mail the completed work plan to the ELCCA reviewer, building owner, project architect, and utility representatives.

Review and Approval

The ELCCA reviewer studies the work plan for completeness and appropriateness. The ELCCA analyst, design team, owner, reviewer, and utilities may negotiate which alternatives should be included in the work plan. After the ELCCA reviewer approves the work plan, the ELCCA analyst can begin the energy use simulation and economic analysis of the selected energy systems.

WSEO Washington State Energy Office

ELCCA Work Plan

1a Project Description

Title: | Date:

Project Owner:

Building Area: ☐ New: sf | ☐ Remodel: sf

Total Area at Completion: sf

Building Life: (25 years default)*

Location: | Functional Uses:

Electric Utility: | Phone: | Gas Utility: | Phone:

Contact: | Contact:

Fundable Measures:

Current Design Phase: | Estimated ELCCA Report Date: | VE Date: | Estimated Bid Date:

ELCCA Analyst: | Phone:

Firm Name: | Fax:

Compliance Method: ☐ Prescriptive Path ☐ Detailed Analysis ☐ Prototypical Design *(If not initial design, identify initial design)*

* If the ELCCA analyst recommends using a different building life, a written justification must be submitted to and approved by the ELCCA reviewer.

1b Building Envelope

(Provide separate form for new and remodeled areas.)

	Framing Type	Insulation Material	Thickness/R-Value	Approximate Areas (sf)
Roof/Ceiling				
Prescriptive:				
Proposed:				
Wall				
Prescriptive:				
Proposed:				
Glazing		% of Gross Wall	U-Value	
Prescriptive:				
Proposed:				
Doors				
Prescriptive:				
Proposed:				
Floor				
Prescriptive:				
Proposed:				
Slab Perimeter				
Prescriptive:				
Proposed:				

2 Lighting Systems

Baseline System	Space 1	Space 2	Space 3	Space 4
Area Function				
Space Name				
Fixture Type				
Lamp Type				
Ballast Type				
Fixture Lumens				
Lighting Power Density (w/sf)				

Proposed	Space 1	Space 2	Space 3	Space 4
Space Name				
Fixture Type				
Lamp Type				
Ballast Type				
Fixture Lumens				
Lighting Power Density (w/sf)				

Lighting Design by: **Phone:**

Company:

3 Mechanical Systems

Describe terminal units, areas served, central fans, distribution system, heating AFUE, cooling COP, fuel sources, heat recovery type, estimated cfm and area served by the system, HVAC controls, and energy management system.

Prescriptive: *Title*

Alternative 1: *Title*

Alternative 2: *Title*

Alternative 3: *Title*

Alternative 4 (if required): *Title*

Renewable Energy Resources:

Energy Simulation Model: **Weather Station:**

4 Domestic Hot Water (DHW)

Number of Units	Space 1	Space 2	Space 3
Capacity:			
Fuel Type:			
Recovery Rates:			
Storage Tank Sizes:			
Length of Recirculation Lines:			
Booster Heaters:			
Energy Efficiency Considerations			
Thermostat setting (°F):			
Bottom insulation board (electric?):			
Recirculation pump used?			
Return aquastat setpoint (°F):			
Time clock or energy management system control:			
Heater elements or burner			
Circulation pumps			
Intermittent ignition (gas only):			
Flue damper (gas only):			
Type (indiv., point of use, central):			

5 Renewable Resources (Alternative Energy Systems)

Describe the renewable resources that you think may have the best potential for this facility.

____

____

____

____

____

____

The following is a list of potential renewable resources to consider:

Solar
Geothermal
Heat Recovery
Photovoltaics

Is there a source of waste heat near the facility? ☐ Yes ☐ No

Chapter 4

Energy Use Simulation and Economic Analysis

This chapter provides the information needed to perform the energy use simulation and economic analysis required for the "detailed analysis" method of compliance.

The energy use simulation and economic analysis constitute the bulk of work for ELCCA submittal. Here, the energy systems selected in the work plan are analyzed and compared. With careful analysis, the ELCCA analyst can identify the configuration of individual energy systems having the lowest life cycle costs and recommend that the systems be designed into the building.

The ELCCA analyst is responsible for running energy use simulations and economic analyses for the energy systems identified in the work plan and for documenting the results. For the maximum benefit to the project, the simulation and analysis are run early in the design development phase of overall building design. When the basic systems are identified, the ELCCA analyst should select feasible system enhancements. Table 4.1 provides a few possible options.

T4.1 Suggested System Controls/Enhancements

Select two additional options. At least one option should deal with HVAC enhancements or HVAC controls. For assistance in this selection, contact the ELCCA reviewer.

Lighting Controls	HVAC Controls
Occupancy sensors	Hydronic loop temperature optimization
Daylighting controls	Demand limiting
Lumen maintenance controls	Optimum start/stop
Building sweeps	Enhanced scheduling of ventilation air
Dimmable or dual-level HIDs	Reset air temperature
	Reset chiller temperature
	Reset boiler temperature
HVAC Enhancements	**DHW System**
Hydronic loop VSD	Control water heaters for occupancy
Thermal storage	More efficient water heater
Ground coupled heat pumps	Point-of-use systems
Occupancy sensors vent. air	Heat-pump water heaters
100% O.A. integrated economizer	
Improved pumping efficiency	
ASD fans	
Heat recovery ventilation air	
High efficiency equipment	
Evaporative cooled condenser	
Reclaim condenser heat	
Evaporative (pre)cooling	
Water/ice storage	
Dual-speed assembly area fan	

Energy Use Simulation

Energy use simulation means computer modeling the energy behavior of a building. The computer models simulate the time-based phenomena that affect a building's energy use, e.g., occupancy schedules, thermal mass response, and HVAC control sequences. This section provides the analysis requirements and tools needed to perform the energy use simulation.

Developing the Baseline

The Washington State Energy Code (WSEC) and other applicable codes must be met when developing life cycle costs analyses. However, the State wants to do more than meet minimum code requirements. The following information specifies the required prescriptive levels for thermal performance and lighting power densities for publicly owned or leased facilities. Alternatives will need to be analyzed if *any* component does not meet the prescriptive requirements.

Building Envelope Performance

If each component in the envelope meets or exceeds the prescriptive baseline requirements in Table 3.1 (see Chapter 3, page 3-3), a complete analysis of three different envelope systems is not required.

Lighting Systems

Typical layouts and lighting density calculations are required for each functional area. The design must meet the prescriptive lighting power densities shown in Table 3.2 (see page 3-3) unless the governing energy code requirements are stricter. If the proposed lighting design meets these levels, further analysis is not required. Project design teams are encouraged to improve the efficiencies of their designs beyond the prescriptive standards by evaluating new technologies.

Building Mechanical Systems

The ELCCA guidelines require that three *distinctly* different HVAC systems be analyzed. The baseline mechanical and HVAC control systems should be a prescriptive system from Table 3.3 (see page 3-4).

Domestic Hot Water

The baseline domestic hot water system should be the lowest first cost system that is acceptable to the building owner.

Approved Simulation Models

If the prescriptive path is not used, a computer energy simulation is required for the ELCCA report; it is the best available tool to properly assess the energy impacts of design alternatives. Approved computer software programs are shown in Table 4.2. These programs have been extensively tested and widely used. Other programs or other versions of the listed program may be used with prior approval from the ELCCA reviewer; however, only commercially available software specifically created for building simulations will be considered.

T4.2 Approved Energy Simulation Software

DOE 2.1	Micro-DOE
Micro-AXCESS	Trace 600
Carrier HAP	VCACS, EP 3.3, CEAC
ADM-DOE or ADM-2	Blast 3.0
ESAS	ESP-II
Trace 500	

It is the responsibility of the ELCCA analyst to select the best computer program for the facility being modeled. A model that does not properly address features or characteristics of a particular facility should not be used if a more appropriate program is available. The program selected must be one in which the analyst has sufficient experience to produce accurate results. The "hourly model" is the preferred tool for larger or more complex facilities. If modeling assumptions are accurate, a skilled analyst can make good comparative estimates of the various design alternatives.

Certain complex and innovative measures cannot be accurately modeled with any existing software. In these cases, the ELCCA analyst needs to describe in detail the technique that will be used to estimate the results of installing a complex or innovative measure. Before completing the analysis, the analyst and the ELCCA reviewer should agree on the method that is likely to work best.

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 or high-efficiency electronic ballasts may be at least partially offset by downsized chillers, cooling coils, chilled water piping, pumps, ductwork, and fans. First cost interactions must be considered in the analysis.

Computing Interactive Alternatives

Changes in one energy-using system (envelope, lighting, HVAC) often interact and affect the energy usage of other systems. For all interactive alternatives, a computer energy simulation must be used to calculate energy usage.

The iterative, or rolling baseline, method is the preferred way to account for interactions among various energy-efficiency measures. The steps involved in this method are:

1. Incorporate into the reference baseline model any envelope measures that have a lower life cycle cost than the reference baseline.
2. Next, add any lighting measures that have lower life cycle cost than the reference baseline.
3. Finally, with the proposed envelope and lighting measure incorporated, analyze HVAC 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. Include only the recommended systems in the executive summary.

Input Assumptions

Envelope U-values. Care must be exercised in calculating effective U-values for all envelope components to ensure that they comply with the *ASHRAE Handbook of Fundamentals*. The effects of window frames, stud walls, insulation voids, thermal bridging, sloped roofs, and other losses should be accounted for in the calculations.

Infiltration. Infiltration losses can be significant depending on how the facility is used. WSEO recommends that 0.038 cfm/sf be used as a beginning assumption. The ELCCA analyst may use a different value if the reason for an adjustment is stated and justified by the characteristics of the facility.

Glazing and shading coefficients. The manufacturer's tested window unit U-value and shading coefficients should be used if available. If the ELCCA analyst does not know the specific window to be installed, he or she should use the Washington State Non-Residential Energy Code (WSEC) default U-value for the type of window being considered.

Internal gains. Internal gains due to latent and sensible heat given off by occupants should be adjusted to reflect activity and actual occupancy levels for each zone (e.g., elementary school occupants are children and internal gains will be less than ASHRAE figures for adults).

Lighting. Table 3.2 (see Chapter 3, page 3-3) provides typical power densities for various building types. Input the correct lighting power density for each HVAC zone of the model. Some zones, such as corridors, may have less density, while others, such as drafting rooms, may have more. Do not select a global building code default value for lighting power densities. Include off-hour activities and custodial work in the hours of operation.

System and occupancy schedules. The analyst should use the actual building schedules or the default schedules provided by WSEC reference standard (RS-29).

Miscellaneous equipment loads. The ELCCA analyst should only 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. Instead, input reasonable values for each zone. The usage for unoccupied hours should be set at no less than 30 percent of the peak equipment load. See Table 4.3 below for typical receptacle power densities for various building types.

T4.3 Typical Occupancy Densities, Receptacle Power Densities, and Hot Water Usage

The following values should only be used if specific design information is not available.

Building Type	Occupancy (sf/person)	Receptacle (watts/sf)	DHW (Btu/person-hour)
Assembly	**50**	0.2-0.4	215
Health/Institutional	**200**	1.0-1.5	135
Office	**275**	1.0-1.5	175
School	**75**	0.5-1.0	215
Warehouse	**15,000**	0.1-0.3	225

Values are adapted from ASHRAE Standard 90.1-1989.

Critical HVAC parameters. Every input should be as realistic as possible using manufacturer's data if available. Equipment capacities; diversities; percentage of outside air; economizer cooling setpoint; and efficiencies for motors, fans, pumps, and heating and cooling equipment are all important parameters that should be carefully checked. Part-load efficiencies should be used when available. Equipment capacity should match design intent to the extent known unless output indicates the equipment does not meet loads.

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 way the building will actually be operated.

Economic Analysis

Economic analysis employs life cycle cost analysis to compare the costs of owning and operating a building's energy systems throughout the building's economic life. In addition to initial construction and installation costs, life cycle cost analysis accounts for annual maintenance and energy costs, escalation and inflation of fuel prices, time value of money, and equipment replacement costs and salvage values. This section provides the analysis requirements and tools needed to perform the life cycle cost and economic analysis.

WSEO's LCCA Spreadsheet

For the economic analysis portion of the ELCCA report, analysts must use the post processing spreadsheet—available in Excel, Lotus 1-2-3, and Quattro—provided by WSEO. To obtain a free copy of the spreadsheet on an IBM-formatted 360 Kb 5-1/4" floppy disk, see the contacts listed inside the front cover. An example of the spreadsheet is shown in Figure 4.3 on page 4-11.

After obtaining an electronic copy of the spreadsheet and retrieving the file, input the following:

- Title (project name, description, and project number, if applicable)
- Construction Costs and Periodic Equipment Replacement Costs
- First-Year Maintenance Costs
- First-Year Energy Costs (each fuel type)
- Fuel Price Escalation (over and above general inflation)
- Real Discount Rate

The spreadsheet calculates the following for each year of the facility's economic life:

- Total Annual Costs
- Present Worth Factor, 1/(1+i)^n, where n = year, i = discount rate
- Present Worth of Annual Costs
- Present Worth of Cumulative Costs (25-year life cycle cost)

The present worth of cumulative cost is the summation of the present worth of annual costs over the study period. It is also called "net present value" or "25-year life cycle cost" by some analysts. It predicts life cycle costs of the alternatives.

Fuel Price Escalation Rates

ELCCA analysts should use the escalation rates presented in Table 4.4. There may be reasons to deviate from these regional average escalation projections in certain utility service areas, where unusual economic or demographic conditions exist. In such special cases, the ELCCA analyst may elect to perform an "escalation sensitivity analysis." To do this, calculate life cycle costs first using the escalation rates given in Table 4.4 and again using assumed local escalation rates. Document the local rates and their source, and explain why they were chosen.

T4.4 Forecast of Fuel Price Escalation Rates

Real rates over and above the general inflation rate.

Fuel Type	1995-2000	2001-2010	2011-2020
#2 Fuel Oil	1.0%	1.3%	1.7%
Natural Gas	0.8%	1.0%	0.9%
Electricity			
Investor Owned	0.1%	0.7%	0.7%
Public Utility	0.1%	0.3%	0.3%

- Forecast figures for natural gas are for medium growth rates from the draft 1996 Northwest Power Plan.
- Forecast figures for #2 Oil are based upon medium low growth rates.
- Forecast figures for public utilities are for high growth rates for the 1995-2000 period and medium high for 2001-2010.

Inflation and Discount Rates

The rates presented in Table 4.5 are to be used for the economic analysis. WSEO plans to update Tables 4.4 and 4.5 every two years.

T4.5 Forecast of Inflation, Discount, and Maintenance Escalation Rates

Figures in percent per year.

	Nominal	Real
General Inflation	3.0%	0.0%
Discount	6.0%	2.9%
Maintenance Escalation	3.5%	0.5%

Note: The general inflation rate does not enter into a "real rate" analysis. General inflation is input when a "nominal rate" analysis is performed. Either method will produce the same conclusions.

There are two methods to calculate price escalation and discounting: real price escalation and nominal price escalation. Either method can be used. However, if one is selected, then all calculations for economic forecasts and escalation rates must be consistent with the selected evaluation approach (real or nominal). The linkage between real and nominal escalation is the general inflation rate.

Example

% Nominal = [Real + Inflation + (Real x Inflation)] x 100, where real escalation and inflation are given in decimal equivalents.

For example, if the long-range real price escalation of #2 distillate oil was 5.3 percent per year and general inflation was 4.8 percent per year, then the corresponding nominal price escalation would be 10.35 percent per year.

% Nominal = [0.053 + 0.048 + (0.053 x 0.048)] x 100 = 10.35%

Economic Building Life/Equipment Service Life

A default of 25 years has been set as the building economic life. A longer or shorter building life may be used if it is justified and approved in the work plan.

ELCCA analysts should use the information on equipment lives presented in Table 4.6 (pages 4-12 and 4-13). This table is based on *1987 ASHRAE HVAC Systems and Applications Manual and Service Life of Energy Conservation Measures* produced by the Bonneville Power Administration. ELCCA analysts may deviate from the given values with prior approval. For equipment not found in this table, use the best available published data.

Construction and Equipment Replacement Costs

Provide itemized system cost estimate for each alternative analyzed by component. Cost should include materials, labor, overhead and profit, and taxes. Proposed or expected utility incentives or rebates are not to be included in the analysis.

Replacement cost for equipment should be included based on the estimated cost of replacing the equipment at the end of its expected life. The life expectancy for various equipment can be found in Table 4.6 or as determined from another source if the equipment is not specified in the table.

Maintenance Cost Estimating Procedure

The ELCCA guidelines require a breakdown of maintenance costs for each mechanical system analyzed. The following procedure explains how to estimate annual total HVAC maintenance costs for heating and cooling equipment and distribution systems for a building. This procedure compares maintenance costs for various systems to a common baseline, which allows the cost of one system to be compared to the cost of another. *The procedure should not be used to prepare operation and maintenance budgets.*

ELCCA analysts may use the procedure explained below, or they may calculate annual maintenance costs using their own standard practice. 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 costs of labor, materials, and consumable products for the following categories:

- replacement/servicing (filters, belts, etc.)
- lubrication
- general housekeeping
- rebalancing
- control calibration
- troubleshooting
- service contracting (if any)
- small equipment replacement (an allowance for periodic replacement within the service life of the measure)

Maintenance Cost Spreadsheet

Total annual estimated maintenance can be calculated automatically for each building using the Maintenance Costs spreadsheet available from the Washington State Energy Office. To obtain a free copy of the spreadsheet on an IBM-formatted 360 Kb 5-1/4" floppy disk, see the contacts listed inside the front cover.

Step 1. The ELCCA Maintenance Cost Estimating form shows shaded areas where the ELCCA analyst needs to input specific data for the proposed project. (See Figure 4.1, page 4-10 for an example.) These data are:

- Project Name
- Alternative System's Number (Alt. No.)
- Building Sq. Ft.
- System Cost
- Primary System Type
- Terminal System Type
- Fuel Type Code
- Control System Type

The analyst should use information from existing records to fill in the first four shaded squares (project name, alt. no., building sf, and system cost).

Step 2. Complete the next four shaded squares by selecting the appropriate numerical code for the primary system, fuel type, and control system. Select the appropriate alpha code for the terminal system type. (See Figure 4.2 on page 4.10, which shows the numerical and alpha codes.)

Once these codes are entered, the spreadsheet will automatically calculate the annual maintenance cost per square foot. The analyst may change the cost by documenting the reasons why a different cost is appropriate.

The spreadsheet also automatically estimates annual maintenance expenditures by *maintenance item* (annual maintenance cost multiplied by building area and prorated by maintenance items, which are adjusted by control system type and fuel type).

Step 3. The analyst then inputs the adjustment factors for difficulty, geographic location, and owner's experience; otherwise, the standard default values of 1.0 will be used. These adjustment factors are based upon the analyst's knowledge of the following conditions:

Difficulty factor: Based on proposed equipment configuration and space layout and ease of access and serviceability. The spreadsheet assumes a factor of 1.0 as an average design condition. Recommendation: Use input factors between 0.8 and 1.0 for much better than average conditions and 1.5 for much worse than average conditions.

Location factor: Accounts for cost variations based on proximity to available sources of repair and replacement parts and/or service. The spreadsheet assumes a factor of 1.0 as an average condition (e.g., within one hour travel time from a large population area). Recommendation: Input factors between 0.75 and 1.0 for much better than average conditions and 1.5 for much worse than average conditions.

Experience factor: Used to reflect the owner's familiarity with a particular type of equipment or system. For example, the owner may already operate several facilities with the proposed types of system and has excellent repair parts and service capabilities in-house. The spreadsheet assumes a factor of 1.0 as an average condition. Recommendation: Input factors between 0.75 and 1.0 for much more than average experience and 1.5 for much less than average experience.

Once the ELCCA analyst inputs the difficulty, location, and experience factors, the spreadsheet automatically provides the annual cost estimate for each maintenance item and calculates an estimate of total annual maintenance costs.

F4.1 ELCCA Maintenance Cost Estimating Example

Shaded portions indicate required inputs.

Project Name:	Bldg. XYZ	**Alt No.**	Baseline
Building Sq.Ft.	25,000		
System Cost	$175,000		
Primary System Type	3		
Terminal System Type	C		
Fuel Type Code	2		
Control System Type	1		
Annual Maint. Cost per sf	.25		

Maintenance Item	Annual Dollars	Difficulty Factor	Location Factor	Experience Factor	Annual Estimate
Replacement/Servicing filters, belts, etc	1,562.5	1	1	1	1,562.5
Lubrication	312.5	1	1	1	312.5
General Housekeeping	1,562.5	1	1	1	1,562.5
Rebalancing	625.0	1	1	1	625.0
Controls Calibration	625.0	1	1	1	625.0
Troubleshooting	312.5	1	1	1	312.5
Service Contracting (if any)					0
Small Equipment Replacement	3,500.0	1	1	1	3,500.0
TOTAL ANNUAL ESTIMATED MAINTENANCE	(Adjusted)				8,500.0

F4.2 Maintenance Cost Spreadsheet Codes

Primary System Descriptions	Code
Boiler	1
Boiler plus Chiller Cooling	2
Boiler plus DX Cooling	3
Double-Bundle Chillers	4
Central Water Source Heat Pump	5
Forced-Air Furnace	6
Forced-Air Furnace with DX Cooling	7
Direct Energy (electric resistance)	8
Unitary Rooftop	9
Unitary Rooftop plus DX Cooling	10
Water-Loop Heat Pump	11
Unitary Heat Pumps	12

Terminal System Type	Code
Dual Duct (with or without VAV)	A
Multizone or Modified Multizone	B
Single Zone (with or without reheat)	C
Variable Volume (without reheat)	D
Variable Volume (with reheat)	E
Ceiling Induction	F
Two-Pipe Fan Coil	G
Two-Pipe Unit Ventilator	H
Four-Pipe Fan Coil	I
Four-Pipe Unit Ventilator	J
Unitary Heating/Cooling	K
Unitary Heat Pump	L
Nonair Heating	M

Fuel Type	Code
Electric	1
Natural Gas	2
Propane	3
Oil	4

Control System	Type
Direct Digital	1
Combination	1.5
Pneumatic	2

F4.3 Life Cycle Cost Spreadsheet

Available from WSEO. Shaded portions indicate required inputs.

ENERGY LIFE CYCLE COST ANALYSIS SPREADSHEET "ELCCA3.XLS" 27-Feb-95
08:36

------------ PROJECT DATA------------

PROJECT: Facility Name (Firm Name)
ALT. No.: Description (Analyst's Name)

----------- DISCOUNT & ESCALATION Real Rates per WSEO Jan 1995-----------

Q & A:	1 = Yes		Years:	Rate:
	0 = No	Real Discount Rate (i)	1,993 - 2,020	2.9%
		Electricity...............	1,993 - 2,000	0.1%
IOU Electric	1	(Investor Owned Utility)	2,001 - 2,020	0.7%
POU Electric(PUD)**	0	Natural Gas	1,993 - 2,000	0.8%
Natural Gas Fuel?	1		2,001 - 2,010	1.0%
Propane Fuel?	0		2,011 - 2,020 ...	0.9%
Oil Fuel?	0	Maintenance	1,993 - 2,020	0.5%
Coal Fuel?	0	Replacement	1,993 - 2,020	0.0%
Wood/Renewable	0	Inflation	1,993 - 2,020	3.0%

$1,110,857 =25-year LCC

--------- ANNUAL REAL CASH FLOWS---------

(Begin) Year	First & Replace. Costs	Annual Maint. Costs	Annual Nat.Gas Costs	Annual Electric Costs	Total Annual Costs	Present Worth Factor	Present Worth of Annual Costs	Present Worth of Cumulative Costs
1995	$491,000	$1,200	$16,523	$13,477	$31,200	(1+i)^-n		
1,995	$491,000	--	--	--	$491,000	1.00	$491,000	$491,000
1,996	0	1,206	16,655	13,490	31,352	0.97	30,468	521,468
1,997	0	1,212	16,788	13,504	31,504	0.94	29,754	551,222
1,998	0	1,218	16,923	13,517	31,658	0.92	29,056	580,278
1,999	0	1,224	17,058	13,531	31,813	0.89	28,376	608,654
2,000	2,100	1,230	17,195	13,545	34,069	0.87	29,532	638,186
2,001	0	1,236	17,367	13,639	32,242	0.84	27,160	665,346
2,002	0	1,243	17,540	13,735	32,518	0.82	26,620	691,966
2,003	0	1,249	17,716	13,831	32,795	0.80	26,091	718,057
2,004	0	1,255	17,893	13,928	33,076	0.77	25,572	743,629
2,005	0	1,261	18,072	14,025	33,358	0.75	25,064	768,693
2,006	2,100	1,268	18,252	14,123	35,744	0.73	26,099	794,792
2,007	0	1,274	18,435	14,222	33,931	0.71	24,078	818,870
2,008	0	1,280	18,619	14,322	34,222	0.69	23,599	842,469
2,009	26,000	1,287	18,805	14,422	60,514	0.67	40,555	883,024
2,010	0	1,293	18,994	14,523	34,810	0.65	22,671	905,695
2,011	0	1,300	19,164	14,625	35,089	0.63	22,209	927,904
2,012	2,100	1,306	19,337	14,727	37,470	0.62	23,048	950,952
2,013	0	1,313	19,511	14,830	35,654	0.60	21,312	972,264
2,014	0	1,319	19,687	14,934	35,940	0.58	20,878	993,142
2,015	0	1,326	19,864	15,039	36,228	0.56	20,452	1,013,594
2,016	0	1,333	20,043	15,144	36,519	0.55	20,035	1,033,629
2,017	0	1,339	20,223	15,250	36,812	0.53	19,627	1,053,256
2,018	2,100	1,346	20,405	15,357	39,207	0.52	20,315	1,073,571
2,019	0	1,353	20,589	15,464	37,405	0.50	18,835	1,092,406
2,020	0	1,359	20,774	15,572	37,706	0.49	18,451	1,110,857
Totals:	$525,400	$32,030	$465,907	$359,299	$1,382,636		$1,110,857	=25-year LCC
	1st+Repl	Maint	Fuel	Elec				

Energy Conservation Measure/Equipment

Median Service Life (years)

Building Envelope

Air curtain	10
Blanket insulation	24
Molded insulation	20
Solar shade film	7
Tinted and reflective coating	14

Domestic Hot Water

Heat-pump water heater	10
Point-of-use water heater	12
Solar water heater	15

Electric Transformers — 30

HVAC

Air Conditioners

Commercial through-the-wall	15
Computer room	15
Residential single or split package	15
Roof-top multizone	15
Roof-top single-zone	15
Water-cooled package	15
Window unit	10

Air Terminals

Diffusers, grilles, and registers	27
Induction and fan-coil units	20
Low-leakage damper	9
VAV and double-duct boxes	20

Air Volume System	**11**
Variable inlet vane dampers	20
Duct work	30
Air side economizer	10

Air Washers	**17**

Boilers, Hot Water (Steam)

Cast iron	30
Electric	15
Steel fire-tube	25
Steel water-tube	30
Burners for boilers	21
Steam traps	7

Coils

DX, water, or steam	20
Electric	15

Condensers

Aircooled	20
Evaporative	20

Controls

Computer-logic EMS	13
Deadband thermostat	13
Electric controls	16
Electronic controls	15
Pneumatic controls	20
Time clocks	10

Cooling Towers

Ceramic or FRP	34
Galvanized metal	20
Variable-pitch fan for cooling tower	13
Wood	20
Chiller strainer cycle economizer	15
Water side economizer	11

Fans

Axial	20
Centrifugal	25
High-inlet/low-discharge-type air destratification	15
Paddle-type air destratification	10
Propeller	15
Ventilating roof-mounted	20

Furnaces (gas- or oil-fired) — 18

Heat Exchangers (shell and tube) — 24

Heat Pumps

Commercial air-to-air	15
Commercial water-to-air	19
Residential air-to-air	15

Energy Conservation Measure/Equipment

Median Service Life (years)

Heat Recovery

Heat recovery from refrigeration condensers	11
Plate-type/heat-pipe recovery system	14
Rotary-type heat recovery system	11
Makeup air unit for exhaust hood	10

Package Chillers

Absorption	23
Centrifugal	23
Reciprocating	20
Scroll or screw	20

Pumps

Base mounted	20
Condensate	15
Pipe mounted	10
Sump and well	10

Radiant Heaters

Electric or gas	10
Hot water or steam	25

Reciprocating Compressors 20

Thermal Energy Storage Systems

Ice	19
Water	20

Unit Heaters

Electric or gas	13
Hot water or steam	20

Valve Actuators

Hydraulic	15
Pneumatic	20
Self contained	10

Lighting

Compact fluorescent *(detachable ballast)*	12
Dimming systems	20
Ballast *(all types)*	12
Lighting fixture *(fluorescent, HID, etc.)*	20
Motion sensor	10
On-off switching	7

(Note: For lamps, use tested lamp life)

Motors and Drives

High-efficiency electric motor	17
Motor starters	17
Standard electric motor	15
Variable-speed DC motor	18
Variable-speed drive—belt type	10
Variable-speed drive—solid state	15

Reciprocating Engines 20

Refrigeration

Automatic cleaning system for condenser tubes	15
Condenser floating head pressure control	10
Hot gas bypass defrost	10
Polyethylene strip curtain	3
Refrigeration case cover	11
Unequal parallel refrigeration	14

Steam Turbines 30

References

- "Service Life of Energy Conservation Measures," Bonneville Power Administration (July 14, 1987); prepared by Xenergy, Inc., and Ecotope, Inc.
- Table 5, "Equipment Service Life," Chapter 49, *1987 ASHRAE HVAC System and Applications Handbook.* Obtained from a nationwide survey conducted in 1977 by ASHRAE TC 1.8 (RP 186).
- "Building Maintenance, Repair, & Replacement Database (BMDB) for Life-Cycle Cost Analysis," American Society for Testing of Materials (ASTM) E917.

Chapter 5

Preparing the Report

The information gathered from the energy use simulation and economic analysis should be prepared as a report on 8.5 × 11 paper. The binding should allow the report to lie flat when opened. Each section needs a labeled tab to allow quick and easy access, and labeling should be consistent throughout the report. Each alternative system should be assigned a label that is used in the computer model and in the report. In addition, each page needs to have its own unique page number—hand numbering the pages is acceptable—and page numbers need to be included in the table of contents. The report should be printed on both sides of the page.

Report Contents and Instructions

Title Page

Date

Project name (and project identification number, if known)

Building owner (also list public agency, if different than owner)

Table of Contents

List of Participants

Contact name, firm name, address, and telephone and fax numbers for the following:

Building owner (also provide name of governmental agency and its chief executive officer if different than building owner)

Project architect

Project manager

ELCCA analyst

ELCCA reviewer

Natural gas and electric utility representatives

Mechanical engineer

Electrical engineer (lighting designer)

Value engineering team

Statement of Compliance

Provide a written declaration that the ELCCA report complies with RCW 39.35 and the ELCCA guidelines. This statement needs to be signed and stamped by the ELCCA analyst. The architect signs that he or she has reviewed the report.

I. Executive Summary

Begin the summary by identifying the energy systems (envelope, lighting, HVAC, controls, and domestic hot water) that have the lowest life cycle cost and are recommended for inclusion in the building design.

II. Public Facility Energy Characteristics (PFEC) Form

A. Complete the form with information about each of the recommended energy systems. If the project includes both new construction and renovation, provide a separate form for each portion of the building. (The PFEC form is located at the end of this chapter.)

B. For the recommended systems, estimate the building's annual energy costs and maintenance costs. 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 building's energy usage by end use and by annual expenditure of energy dollars. Devote individual slices of the pie to lighting, heating, mechanical cooling, HVAC fans, domestic hot water, and miscellaneous.

D. Create a table summarizing the cost of each recommended energy system. Identify the system and its initial construction/installation cost, annual fuel cost, annual maintenance cost, total life cycle cost, and Energy Usage Index (EUI).

E. Project timeline. Provide an updated timeline.

III. Project Description

1. New Construction and Addition Projects

Provide the following information:

- description of the site
- facility size, number of stories
- occupancy schedule for the facility, both daily and annually
- how the facility is to be used
- special facility considerations, e.g., noise control, aesthetics, environmental concerns
- anything out of the ordinary that might affect the facility's energy use
- description of any existing mechanical systems

2. Renovation Projects

Provide the infomation requested for new projects, and describe the existing facility and its existing energy systems.

Summary of Utility Assistance

Briefly describe any technical or financial aid to improve the project's energy efficiency that may be available from natural gas and electric utilities.

IV. Baseline Building Description and Economic Assumptions

The baseline building component values shall be the prescriptive baseline. Begin by documenting these component values. When component values are not provided by the prescriptive, the baseline values will come from the system with the lowest first cost acceptable to the owner.

Energy Simulation (Model) Assumptions

Describe the modeling program to be used and any input assumptions. Provide the building occupancy schedule, lighting, and HVAC schedules, heating/cooling setpoints, and control strategies such as "optimal start/stop."

Economic Assumptions

Include a copy of the current utility rate schedules. Indicate if there are any qualifications that must be met before the project can be served under this rate schedule.

Provide the following rates: fuel price escalation, maintenance, replacement inflation, and general inflation.

If assumptions (such as staff maintenance experience and equipment preferences) are dictated by the building owner, indicate what they are. Include the baseline annual energy consumption and EUI.

V. Building Envelope

Begin by describing the prescriptive envelope, followed by the other alternatives analyzed.

Describe the envelope components (roof, wall, floor), indicating materials and insulation values. Show typical sections and U-value calculation for all construction types. If the baseline does not meet or exceed prescriptive standards, provide this information also for each alternative analyzed. Figures 5.1 and 5.2 on pages 5-4 and 5-5, respectively, provides sample formats.

If envelope alternatives are analyzed, for each alternative indicate the initial construction cost, projected annual maintenance costs, and estimated energy cost. Include life cycle cost spreadsheets, energy simulation model with input changes highlighted, and output pages indicating estimated energy use.

VI. Lighting Systems

The lighting designer should describe the baseline system for each functional area of the building (e.g., library, gymnasium, corridor, offices, classrooms). Include the following information for each functional area: in a drawing, show room size, fixture layout, and ceiling height. Also, complete and include the Typical Space Lighting Comparison form for each functional area. (See Figure 5.4, page 5-9.) Include the life cycle cost spreadsheet for each alternative analyzed.

Provide this information for the other alternatives analyzed.

VII. HVAC Systems

Begin by describing the baseline system. Include the following: single-line diagram system advantages, input assumptions, energy simulation output, annual energy and maintenance costs, and construction costs. Include the life cost spreadsheet. Next, describe the other alternatives.

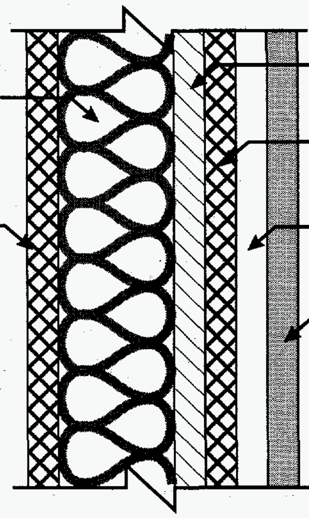
VIII. Controls Systems

Include a Controls Checklist (located at the end of this chapter) for the recommended control system described in this part of the report.

IX. Domestic Hot Water

Describe the baseline domestic hot water (dhw) system. If alternatives are analyzed, provide insulation levels, AFUE, controls, energy simulation output and costs (annual energy cost, maintenance cost, material & labor cost).

Wall Section



Note: For metal studs, see *Factsheet Metal Elements in the Building Envelope: A Practitioner's Guide, October 1993*

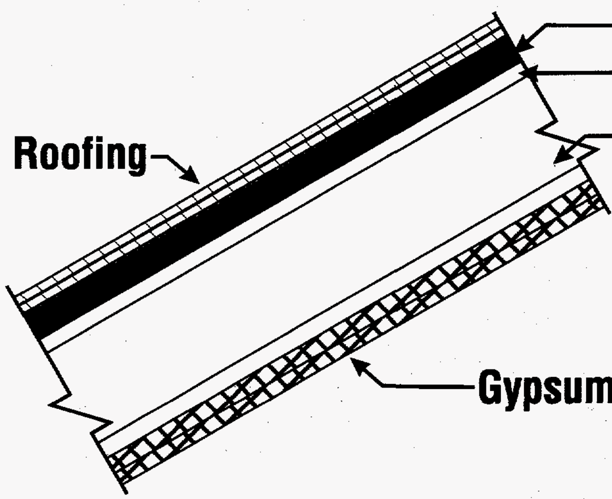
Between Framing		At Framing	
Element	**R-Value**	**Element**	**R-Value**
Inside Air Film	0.68	Inside Air Film	0.68
5/8" GWB	0.45	5/8" GWB	0.56
1/2" Plywood Sheathing	0.62	1/2" Plywood Sheathing	1.04
R-19 Insulation	19.00	2X6 Stud @ 16" O.C.	5.61
1/2" Plywood Sheathing	0.62	1/2" Plywood Sheathing	0.62
1/2" Air	0.91	1/2" Air	0.91
7/8" Stucco	0.13	7/8" Stucco	0.21
Outside Air Film	0.17	Outside Air Film	0.17
Total R Value	22.58	Total R-Value	9.08
Framing Percentage			18%

$$U\text{ - ave} = \frac{\text{Insulated Fraction*}}{\text{Insulated R-Value}} + \frac{\text{Framed Fraction*}}{\text{Framed R-Value}}$$

$$U\text{ - ave} = \frac{0.82}{22.74} + \frac{0.18}{9.35} = 0.055$$

** Use cavity ratio in WSEC (Sec.#2005.2)*

Roof Section



Between Framing		At Framing	
Element	**R-Value**	**Element**	**R-Value**
Inside Air Film	0.61	Inside Air Film	0.61
2 layers 1/2" GWB	0.90	2 layers 1/2" GWB	0.90
12" Air Space	0.91	2 X 12" @ 24" O.C.	12.00
5/8" Plywood Sheathing	0.77	5/8" Plywood Sheathing	0.77
Rigid Insulation	21.50	Rigid Insulation	21.50
Composite Shingle Roof	0.44	Composite Shingle Roof	0.44
Outside Air Film	0.17	Outside Air Film	0.17
Total R-Value	25.30	Total R-Value	36.39
Framing Percentage			13%

$$U\text{-roof} = \frac{\text{Insulated Fraction}}{\text{Insulated R-Value}} + \frac{\text{Framed Fraction}}{\text{Framed R-Value}}$$

$$U\text{-roof} = \frac{0.87}{25.30} + \frac{0.13}{36.39} = 0.038$$

X. Appendices

Include the following:

A. Approved work plan

B. Computer input and output data for the baseline building

C. For alternatives, provide input data with changes highlighted and provide output data

D. Scaled floor plan showing the HVAC zones as modeled

E. Site plan including orientation

Abbreviated Report for Prescriptive Path

An abbreviated report for prescriptive path must follow the same format as a full report and contain the following information:

Title Page

Table of Contents

List of Participants

Statement of Compliance

Executive Summary with a complete description of the energy systems recommended and a Public Facilities Energy Characterictics (PFEC) form.

Work-plan Timeline if there are any changes since the work plan was completed.

Project Description

Summary of Utility Assistance

Building Envelope Section—Provide sections and U-value calculations for all roof, wall, floor, and slab edge areas of the building. The sections should be taken from architectural drawings. Minor variances for existing construction where bringing the envelope up to the prescriptive requirements are not economically feasible may be allowed if approved by the reviewer. If any of the envelope components do not meet or exceed the prescriptive requirements, then each envelope component that does not meet the prescriptive standard needs to be analyzed using the method shown in Figure 5.3 on page 5-8 or an alternative method approved by the reviewer. The energy use calculated by this method, along with the incremental cost difference, will then be used in life cycle cost comparisons.

Lighting System Section—Provide a description of the proposed fixtures. If any of the lighting components do not meet or exceeds the prescriptive requirements, then each lighting component that does not meet the prescriptive standard needs to be analyzed using the method shown in Figure 5.4 on page 5-9 or an alternative method approved by the reviewer. The energy use calculated by this method, along with the incremental cost difference, will then be used in life cycle cost comparisons.

HVAC System Section—Provide a statement that describes which of the prescriptive systems was selected and why. Then provide a schematic drawing showing the proposed system and a narrative describing the components and efficiencies of the equipment. If the HVAC system is other than the prescriptives, then the prescriptive path method cannot be used.

Control System Section—Provide the controls checklist (See form located at the end of this chapter.).

Domestic Hot Water Section—Describe the domestic hot water system.

Appendices—should include the calculations used (if any).

Abbreviated Report for Prototypical Design

An abbreviated report may be used if preapproved at the work plan stage. A copy of the original report for the prototypical design should be included with the workplan. An abbreviated report for a prototypical design must have 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 and complete a Public Facilities Energy Characteristics (PFEC) form.

Work plan Timeline if there were any changes made since the work plan was completed.

Project Description

Summary of Utility Assistance

Sections describing any energy system (envelope, lighting, HVAC, controls, or domestic hot water) revised from the prototypical design. A new energy use simulation and life cycle cost analysis may be required as determined at the work plan stage.

Appendices

Report Review

Once the report on the energy use simulation and economic analysis has been prepared, provide copies to the ELCCA reviewer, building owner, project architect, and participating utilities.

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 want to see that the report has been submitted prior to the project's scheduled value engineering (VE) date (if applicable) and that the report complies with these guidelines. At this stage, the reviewer will send a letter to the analyst listing any questions or concerns about the report. The analyst will then have up to 30 days to respond to those questions or concerns. This process may then be repeated until all of the reviewers' concerns have been addressed (See Appendix C for Review Process Checklist).

ENVELOPE ENERGY USAGE COMPARISON FORM (Degree-Day Method)

Prescriptive Envelope Options			Option 1 R-19 insulation with wood framing		Option 2 R-19 insulation with steel framing		Option 3 8" conc. block and R-10 insulation		Option 4 12" conc. block with intergral insul.	
				U-Factor **		U-Factor **		U-Factor **		U-Factor **
Roof	Zone 1	batt	R-38	0.031	R-38	0.031	R-38	0.031	R-38	0.031
		rigid	R-21	0.045 *	R-30	0.032	R-30	0.032	R-30	0.032
	Zone 2	batt	R-38	0.031	R-38	0.031	R-38	0.031	R-38	0.031
		rigid	R-30	0.032 *	R-30	0.032 *	R-30	0.032 *	R-30	0.032 *
Wall			R-19	0.062	R-19	0.110	R-10	0.090		0.110
Window *				0.600		0.600		0.600		0.600
Skylight				1.200		1.200		1.200		1.200
Door				0.500		0.500		0.500		0.500
Floor	Zone 1		R-19	0.056 *	R-19	0.056 *	R-19	0.056 *	R-19	0.056 *
	Zone 2		R-30	0.033	R-30	0.033	R-30	0.033	R-30	0.033
Slab			R-10	0.540	R-10	0.540	R-10	0.540	R-10	0.540

* May not meet code if electric resistance heating is used.

** The units for U-Factor are Btu/hr-sqft-F

INPUT ASSUMPTIONS

1) Heating Degee Days for the site (HDD) ________ Reference ***
2) Estimated Component Area (CA) ________ square feet
3) Overall Estimated Heating System Efficiency (EFF) ________ % ****
4) Average Energy Cost ________ $/unit

*** "Recommended Outdoor Design Temperatures Washington State" By the Puget Sound Chapter/ASHRAE April 1986

**** The overall estimated heating system efficiency should be adjusted to account for all distrution losses.

PRESCRIPTIVE ENVELOPE SYSTEMS

Instructions

a) This form needs to be completed for each envelope option that does not meet prescriptives.
(Note: the proposed design needs to meet the energy code)
b) Provide input assumptions and select U-Factor from prescriptive options above.
c) Complete the calculations for the prescriptive UA and the estimated energy usage.
d) Provide section and U-Factor calculations for the proposed component.
e) Complete the calculations for the proposed UA (PUA) and the estimated energy usage.
f) Multiply the heating fuel used per year by the average energy cost to determine the annual cost.
g) Input the annual cost into the life cycle cost spreadsheets.
h) Provide a detailed cost estimated for each proposed and corresponding prescriptive option considered.
These costs should include the interactive effects of the HVAC system where possible.
These costs will be input into the life cycle cost spreadsheets.

Prescriptive UA

[________ (Prescriptive Component U-Factor) x ________ (Component Area) = ________ (UA)]

Est. Energy Usage ________ ***** = (________ (UA) x ________ (HDD) x 24 hours/day) / ________ (EFF)

***** Note the units for the estimated energy usage are in Btu's/yr

Proposed UA

[________ (Propsed Component U-Factor) x ________ (Component Area) = ________ (PUA)]

Est. Energy Usage ________ ***** = (________ (PUA) x ________ (HDD) x 24 hours/day) / ________ (EFF)

***** Note the units for the estimated energy usage are in Btu's/yr

TYPICAL SPACE LIGHTING ESTIMATION FORM

Lamp type	Fixture Type	Ballast type	Fixture Wattage	Lumens/lamp	Lumens/fixture
40 watt T-12	2 lamp	Magnetic	82 / fixture	3,050	6,100
40 watt T-12	3 lamp	Magnetic	124 / fixture	3,050	9,150
40 watt T-12	4 lamp	Magnetic	165 / fixture	3,050	12,200
40 watt T-12	2 lamp	Electronic	69 / fixture	3,050	6,100
40 watt T-12	3 lamp	Electronic	102 / fixture	3,050	9,150
40 watt T-12	4 lamp	Electronic	137 / fixture	3,050	12,200
34 watt T-12	2 lamp	Magnetic	70 / fixture	2,700	5,400
34 watt T-12	3 lamp	Magnetic	108 / fixture	2,700	8,100
34 watt T-12	4 lamp	Magnetic	141 / fixture	2,700	10,800
34 watt T-12	2 lamp	Electronic	62 / fixture	2,700	5,400
34 watt T-12	3 lamp	Electronic	89 / fixture	2,700	8,100
34 watt T-12	4 lamp	Electronic	123 / fixture	2,700	10,800
32 watt T-8	2 lamp	Electronic	59 / fixture	2,900	5,800
32 watt T-8	3 lamp	Electronic	88 / fixture	2,900	8,700
32 watt T-8	4 lamp	Electronic	117 / fixture	2,900	11,600

Building type	Watts/sq.ft
K-12 Schools	1.35
Offices	1.2
Warehouses	0.5
Assembly	1.1
All Other Areas	1.5

INPUT ASSUMPTIONS

1) Annual operating hours ____ hours/year
2) Number of fixtures ____ each area
3) Typical area ____ Sq.Ft.
4) Functional Use ____
5) Average Energy Cost ____ $/kWh

INSTRUCTIONS

1) This form needs to be completed for each functional area where the lighting does not meet prescriptives.
   (Note: The proposed lighting design needs to meet the energy code)
2) Provide input assumptions and select fixture data from chart above.
3) Complete the calculations for prescriptive and proposed systems.
4) Multiply the yearly energy use times the average energy cost to determine the annual cost.
5) Input the annual cost into the life cycle cost spreadsheet.
6) Provide a detailed cost estimate for each proposed and corresponding prescriptive option considered.
   These costs will be input into the life cycle cost spreadsheet. Maintenance cost also need to be included in the life cycle cost spreadsheet.

PRESCRIPTIVE LIGHTING SYSTEM- Three lamp fixtures with 32 watt T-8 lamps & electronic ballast

Energy Usage.

____ hrs/yr. x ____ fixtures x 88 watts/fixture)/1000 W/KW = ____ kWh/yr

Lumens.

____ fixtures x 8,700 total lumens) = ____ total area lumens*

Watts per square foot.

____ fixtures x 88 watts/fixture) / ____ area = ____ watts/sq.ft.

PROPOSED LIGHTING SYSTEM

Energy Usage.

____ hrs/yr. x ____ fixtures x ____ watts/fixture)/1000 W/KW = ____ kWh/yr

Lumens.

____ fixtures x ____ total lumens) = ____ total area lumens*

Watts per square foot.

____ fixtures x ____ watts/fixture) / ____ area = ____ watts/sq.ft.

* Note: The total area lumens for either lighting system should be approximately equal.

Public Facilities Energy Characteristics Form

WSEO use only	Reviewer	Approval ❑ Yes ❑ No
Comment		Date Received

Owner	City	Reporting Date
Project Name/Occupancy Type	Project Number	No. of Occupants
Building Name	Gross sf	Net Usable sf

Envelope Component* Description	U	x A	= UA	% of UA Total
Roof Type 1				
Roof Type 2				
Wall Type 1				
Wall Type 2				
Door Type 1				
Door Type 2				
Window Type 1 Frame Type				
Window Type 2 Frame Type				
Floor Type 1				
Floor Type 2				
Perimeter Insulation Thickness, Type / R-Value	F-Value	Length		

Gross Wall Factor	UA Max Allowed by Code	(UA Max - UA Total)/UA Max x 100%	UA Total	100%

Mechanical

Heating Fuel AFUE	Cooling Plant COP	CFM of Heat Recovery	Type	Area Served
HVAC System Type(s)			Minimum OA (cfm)	EUI (Btu/sf-yr)

Lighting

Building	Total Wattage Outdoor ________kW	Total Wattage Indoor ________ kW	Lighting Power Density ________W/sf	Submitted by: (Affix professional stamp and sign)
Area 1	Fixture, Lamp, Ballast type:		Lighting Power Density ________W/sf	
Area 2	Fixture, Lamp, Ballast type:		Lighting Power Density ________W/sf	
Firm Name/ELCCA Analyst				

* Use back of form to list additional information.

Controls Checklist

Proposed Control Systems (describe): ____________________

____

____

Lighting Control

Type: ☐ Switched ☐ Energy Management Control System (EMCS) ☐ Time Clocks

☐ Other (describe): ____________________

____

____

Domestic Hot Water

Type: ☐ Time Clock ☐ EMCS ☐ No Control

Circulation Pump: ☐ Yes ☐ No Control Type: ☐ Time Clock ☐ EMCS ☐ No Control

HVAC

Operating Schedules

	Typical Weekday	Typical Weekend
Start Times:		
Stop times:		

Proposed Mechanical Alternatives:	1	2	3	4

Individual Room or Zone Control (describe): ____________________

Control System: ☐ Time Clock ☐ EMCS

Control Type: ☐ DDC ☐ Pneumatic ☐ Power Line Carrier

Thermostat Type: ☐ Night Setback Capabilities ☐ Override Capabilities ☐ On/Off ☐ Proportional

Thermostat Setpoints: Heating ______ °F Cooling ______ °F Night Setback ______ °F

Ventilation Air Controls: ☐ Fixed Damper ☐ CO_2 Sensor ☐ Morning Warm-up Cycle

Economizer Controls: ☐ Dry Bulb Temperature Control ☐ Enthalpy Controls ☐ None

☐ Integrated ☐ Nonintegrated

Monitoring Capabil.: ☐ Building ☐ Other Describe: ____________________

Central Systems

Supply Air Temperature Heating/Cooling

Heating Reset Capabilities: ☐ Yes ☐ No ☐ Describe ____________________

Cooling Reset Capabilities: ☐ Yes ☐ No ☐ Describe ____________________

Water-Loop Temperatures

Heating Reset Capabilities: ☐ Yes ☐ No ☐ Describe ____________________

Cooling Reset Capabilities: ☐ Yes ☐ No ☐ Describe ____________________

Fan Control

Inlet Vane: ☐ Yes ☐ No

Variable-Speed Controller: ☐ Yes ☐ No

Chapter 6

ELCCA Addendum

The next step in the approval process is to submit the addendum. This chapter describes the ELCCA addendum and the process for developing it.

The ELCCA analyst should prepare the addendum at the end of the design development phase or very early in the construction document phase. At this point, value engineering has taken place and the ELCCA reviewer has evaluated the energy simulation and life cycle cost analysis component of the ELCCA.

The addendum responds to and analyzes additional systems suggested by the VE team. It is prepared in letter form. (See example in Figure 6.1.)

If no changes are recommended, the ELCCA analyst sends a letter that informs the ELCCA reviewer that no changes to the ELCCA report were suggested and submits the initial Verification Checklist with recommended systems listed. (See Chapter 7.)

When owner has approved recommended changes, the ELCCA analyst sends a letter that informs the ELCCA reviewer of the suggested changes. The following attachments accompany the letter when changes have been recommended:

- *Revised* Public Facility Energy Characteristics form (prepared by the ELCCA analyst);
- Initial Verification Checklist (with recommended systems completed by the ELCCA analyst);
- An outline of the final design strategy, new energy simulation outputs, and new LCCA showing the impact of the design changes on the project. (An example of WSEO's ELCCA spreadsheet is shown in Figure 4.3.)

As shown in Figure 6.1, the addendum should be addressed to the ELCCA reviewer. (Note: The address shown in the example should be used when the WSEO serves as the ELCCA reviewer.) Copies of the letter need to be sent to the building owner, project architect, and utility representative.

Review and Approval

While reviewing the addendum, the reviewer may call or write to the analyst and ask for additional clarification on the suggested changes.

After any questions are resolved, the ELCCA reviewer approves the addendum and prepares a letter of recommendation to the owner. The letter verifies that the ELCCA report has been reviewed and recommends that the ELCCA be approved. The reviewer also sends copies of the letter to the analyst and project architect.

F 6.1 ELCCA Addendum Cover Letter

Washington State Energy Office
925 Plum Street S.E.
P.O. Box 43165
Attention: ELCCA Reviewer
Olympia, WA 98504-3165

Re: ______________________ Project
________________________ Owner

Project No.: ____________________
____

Dear ELCCA Reviewer:

The Value Engineering (VE) review for this project has recently been completed. As a result of the VE review, the following changes to the project design strategies have been proposed:

Check the appropriate space:

☐ No changes have been proposed. No further analysis of the energy consumption or life cycle cost for the facility is necessary.

☐ The following changes to the facility design have been proposed as a result of the VE review. The attached PFEC revised form outlines the new final design strategies. The accompanying computer model run and life cycle cost calculation show the impact of these design changes on the facility.

1. ____
2. ____
3. ____

The owner has approved these changes as representing the final building design.

Sincerely,

____

ELCCA Analyst

Enclosures:
1. PFEC Form (if update is required)
2. Computer Model Data (if update is required)
3. Life Cycle Cost Calculations (if update is required)

Chapter 7

Verification Checklist

This chapter explains the verification checklist, which constitutes the final part of the ELCCA submittal. One purpose of the verification checklist is to help the owner verify that the recommended systems were incorporated into the design and were installed. The information in the checklist also provides a database to evaluate how well energy-efficient measures are being integrated into public buildings. WSEO maintains this database using information from the completed checklist, and requests that a signed copy of the completed checklist be forwarded for this purpose.

Contents

The checklist identifies the components analyzed in the approved ELCCA report. It should cover the envelope insulation levels, window and door type, lighting, HVAC, domestic hot water and control systems, and expected commissioning activities as appropriate. The checklist should be clear and concise enough to be understood by a layperson and should be thorough enough to demonstrate the installation of each energy-efficiency measure.

The completed checklist verifies that the components were installed in the completed facility. Completing the checklist may be as simple as comparing the checklist to as-built records. If as-built records are not available yet, a walk-through with the project architect or contractor should provide the necessary information.

Responsibilities

Completing the checklist is not expected to require additional research. The ELCCA analyst creates the initial checklist by listing components of the approved energy-efficiency measures that should be verified as installed. (The ELCCA verification checklist is located at the end of this chapter.)

The initial checklist is submitted with the addendum. The ELCCA reviewer compares the checklist to the ELCCA report and addendum for agreement and sends a copy to the building owner and the project architect. The checklist is best completed by the owner's representative and signed during project closeout but prior to making the final payment. The completed checklist should be submitted to the building owner with a copy sent to WSEO. Completing the checklist during punch list preparation should minimize the effort involved.

ELCCA Verification Checklist

Date:	Project Number:
Project Title:	School District or Agency:
ELCCA Analyst:	
Firm Name:	Phone Number:

Envelope Description

	Recommended	Describe If Other than Recommended
Roof System*		☐Y ☐N
Wall System*		☐Y ☐N
Glazing and Frame		☐Y ☐N
Doors		☐Y ☐N
Floor Insulation		☐Y ☐N
Slab Perimeter Insulation		☐Y ☐N

*Describe type and level of insulation, framing material, and exterior finish.

Lighting Description (Describe number, lamps/fixture, and lamp and ballast type)

	Recommended	Describe If Other than Recommended
Space 1 Name		☐Y ☐N
Space 2 Name		☐Y ☐N
Space 3 Name		☐Y ☐N
Space 4 Name		☐Y ☐N
Space 5 Name		☐Y ☐N
Space 6 Name		☐Y ☐N
Space 7 Name		☐Y ☐N
Space 8 Name		☐Y ☐N

Mechanical Systems Decription (Describe heating and cooling plants, efficiency, and distribution system)

	Recommended:	Describe If Other than Recommended:
System1		
System 2		
System 3		

Domestic Hot Water (DHW) System Description (Describe fuel type and distribution, i.e., centralized, decentralized)

	Recommended:	Describe If Other than Recommended:
DHW System		

HVAC, Lighting and Other Control Systems Description

	Recommended:	Describe If Other than Recommended:
HVAC		
Lighting		
Other		

Building Commissioning

HVAC Balance* Performed	☐ Y ☐ N	Type Performed	
Controls Training Performed	☐ Y ☐ N	If Yes, Describe Training	
		Hours of Training	Number Participating
HVAC Operations Training Performed	☐ Y ☐ N	If Yes, Describe Training	
		Hours of Training	Number Participating

*HVAC balance includes air balance to ensure air flows are occurring as designed and water balance to ensure proper equipment water flows are achieved.

Return Completed form to:
Lead ELCCA Reviewer
Washington State Energy Office
P.O. Box 43165
Olympia, WA 98504-3165

Appendix A

Glossary of Terms

Analyst: Unless otherwise indicated, refers to ELCCA analyst.

Annual Fuel Utilization Efficiency (AFUE): Obtained by deducting losses for exhausted latent and sensible heat, cyclic effects, infiltration, pilot burner effect, and the losses from a standing pilot during the nonheating season.

Base Year: Calendar year in which the analysis is performed.

Baseline Building: Building that serves as a starting point on which an iterative or "rolling baseline" energy analysis is based. For ELCCA purposes, the baseline building would meet the "prescriptive standards."

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

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

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

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

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, insurance, and routine maintenance.

Energy Systems: Includes heating, ventilating, cooling, lighting (interior and exterior), supply of DHW, envelope components (roof and wall insulation; glazing and frame types; door and frame types; floor insulation level; slab insulation level), and any other systems or components that account for 10% or more of the building energy consumption.

Energy Use Simulation: Evaluation of all energy systems and components by 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 at its location). The evaluation of an energy system should include a description and simulation of the control systems used to operate the energy system. Control systems should be selected to minimize equipment operation (lighting, DHW pumps, HVAC pumps, fans, coils, compressors, etc.) while maintaining necessary building operations. Such complex analysis is usually done with the aid of a computer model of the building energy systems.

F-Factor: Perimeter heat loss expressed in Btu/hr ft°F.

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

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 (professional design fees, permits, tax, etc.).

Maintenance Costs: Costs of maintaining HVAC, lighting, and DHW systems in good working order, repair of the building, annual maintenance contracts, and salaries of facility staff performing maintenance tasks. Annual maintenance costs vary with each facility depending on system types.

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) in Appendix B.

Nominal Price Escalation: Gross price change including the effect of general inflation.

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, and fire sprinklers. The aforementioned cost may be excluded from the stated project costs providing that the costs are not included in the building value.

Real Price Escalation: Net price change after adjusting for general inflation.

Renewable Resource: Nonconventional fuel such as active or passive space heating and cooling, solar domestic water heating, windmills, waste heat recovery (see RCW 39.35.030(11) in Appendix B), biomass, refuse derived fuels, photovoltaic devices, and geothermal energy.

Renovation: Within any 12-month period, any additions, alterations, or repairs that exceed 50 percent of the value of a major facility and that 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.

Salvage Value: Value of competing alternatives at the end of the life cycle period. (Salvage value is positive if it has residual economic value and negative if equipment requires demolition.)

Appendix B

Energy Conservation in Design of Public Facilities

RCW Chapter 39.35

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 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 lifecycle 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 should be considered in the design of all publicly owned or leased facilities.

[1982 c 159 1; 1975 1st ex.s. c 177 1.]

NOTES:

Applicability—1982 c 159: "This act does not apply to a major facility construction or renovation on which a lifecycle cost analysis is commenced under chapter 39.35 RCW before June 10, 1982." [1982 c 159 5.]

RCW 39.35.020 Legislative declaration.

The legislature declares that it is the public policy of this state to ensure 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.]

NOTES:

Applicability—1982 c 159: See notes following RCW 39.35.010.

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

(2) "Office" means the Washington State Energy Office.

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

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

(5) "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.

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

(7) "Lifecycle 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 state energy office. The office shall update these projections at least every two years.

(8) "Lifecycle 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.

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

(10) "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;

(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.

(11) "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, 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.

(12) "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.

[1991 c 201 14; 1982 c 159 3; 1975 1st ex.s. c 1773.]

NOTES:

Captions not law—Severability—1991 c 201: See RCW 39.35C.900 and 39.35C.901.

Applicability—1982 c 159: See notes following RCW 39.35.010.

RCW 39.35.040 Facility design to include lifecycle cost analysis.

On and after September 8, 1975, 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 lifecycle cost analysis 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 lifecycle 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 which utilize renewable energy systems.

[1982 c 159 4; 1975 1st ex.s. c 177 4.]

NOTES:

Applicability—1982 c 159: See notes following RCW 39.35.010.

RCW 39.35.050 Lifecycle cost analysis — Guidelines.

The office, 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 lifecycle cost analysis to promote the selection of low lifecycle 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 renewable energy systems and cogeneration applications prior to commencing the energy consumption analysis;

(3) Establish times during the design process for preparation, review, and approval or disapproval of the lifecycle cost analysis;

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

(5) Determine lifecycle cost analysis format and submittal requirements to meet the provisions of chapter 201, Laws of 1991;

(6) Provide for review and approval of lifecycle cost analysis.

[1991 c 201 15.]

NOTES:

Captions not law—Severability—1991 c 201: See RCW 39.35C.900 and 39.35C.901.

RCW 39.35.060 Lifecycle cost analysis — Review fees.

The energy office may impose fees upon affected public agencies for the review of lifecycle cost analysis. The fees shall be deposited in the energy efficiency services account established in RCW 39.35C.110. The purpose of the fees is to recover the costs by the office for review of the analysis. The office 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 office shall provide detailed calculation ensuring that the energy savings resulting from its review of lifecycle cost analysis justify the costs of performing that review.

[1991 c 201 16.]

NOTES:

Captions not law—Severability—1991 c 201: See RCW 39.35C.900 and 39.35C.901.

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.]

WAC 180-27-075—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, which will be reviewed by the Washington State Energy Office. 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 assistance for which a district is eligible for the preparation of the energy conservation report shall be the state matching percentage multiplied by ten thousand dollars. The amount of state assistance for which a district is eligible for the report review fee charged by the Washington State Energy Office shall be the state matching percentage multiplied by the fee charged.

[Statutory Authority: RCW 28A.525.020 and chapters 39.35 and 60.28 RCW. 92-24-027, 180-27-075, filed 11/24/92, effective 12/25/92. Statutory Authority: RCW 28A.47.830.83-21-066 (Order 11-83), 180-27-075, filed 10/17/83.]

Appendix C

Review Process Checklist

This outline checklist should be used by reviewers as a guide to help verify that the analysis is properly documented and that the owner has the information to make viable decisions.

Project Title/Building Name: ______________________

Agency/Project Owner: ______________________

Reviewer: ______________ **Date:** ______________

Work Plan

Yes No

☐ ☐ Is work plan complete?
Envelope, Lighting, Mechanical, Water Heating & Renewables Checklist

☐ ☐ Are alternatives feasible and valid comparisons of system types?

☐ ☐ Were other alternatives suggested?

☐ ☐ Was a list of potential measures developed for utility rebates?

☐ ☐ Have renewables and fuel alternatives been investigated?

☐ ☐ Was a copy of the approved work plan with recommendations noted sent to analyst (c.c. owner, utility rep)?

ELCCA Report

Yes No

☐ ☐ Does the report contain all necessary items?
Note: Incomplete or poorly formatted reports may be returned to the analyst by the reviewer.

☐ Compare approved work plan to report.

☐ Check Component U-value calculations.

☐ Envelope U-values–spreadsheet comparison to code and prescriptives.

☐ Lighting layouts and calculations.

☐ Compare proposed service water heating to work plan checklist.

☐ Compare proposed energy management control system to work plan checklist.

Review Energy Analysis

Verify Modeling Inputs:

☐ Building orientation

☐ Zone definitions and occupancies

☐ U-values (compare model inputs to PFEC)

- ☐ Lighting and equipment power densities
- ☐ Operating schedules and setpoints
- ☐ HVAC parameters (cfm, fan kw, input power, zones served, capacities, outside air)
- ☐ Plant equipment (system type, efficiencies, part load efficiencies)

Modeling Output Checks:

- ☐ Loads not met (should be maximum of 5% to 7% out of range)
- ☐ Ventilation air/economizer operation
- ☐ Simultaneous heating and cooling (how much?)
- ☐ HVAC system COPs or EERs. Calculate output/input for given time period.
- ☐ Check estimated energy usage (EUI check with similar building).
- ☐ Check output to see whether hourly and monthly profiles are reasonable.

Review Economic Analysis

Yes	No	
☐	☐	First cost should be zero for the baseline system.
		For each alternative:
☐	☐	System cost information reasonable?
☐	☐	Maintenance cost data reasonable?
☐	☐	Replacement cost data reasonable?
☐	☐	LCCA-escalation factors correct?
☐	☐	Energy cost matches model results?
☐	☐	Action: send comment letter requesting clarification if needed.
☐	☐	Review response to comment letter.

Addendum

Letter Documenting VE Recommendations and Other Changes:

Yes	No	
☐	☐	Does the change affect the analysis? If yes, check revised economic analysis.
☐	☐	Check final Public Facilities Energy Characteristics Form.
☐	☐	Includes work plan timeline—all dates recorded
☐	☐	Action: send approval letter and project summary to owner (c.c. WSEO for database input).

Verification

- ☐ WSEO verifies final description of project and then records information in database.

Appendix D

Energy Smart Design Utilities

Lower Columbia Area

- **Clark Public Utilities**
  P.O. Box 8900
  Vancouver, WA 98668
  Dan Krebs
  (206) 699-3000, (503) 285-9141

- **Cowlitz County PUD**
  960 Commerce Avenue
  P.O. Box 3007
  Longview, WA 98632-0307
  James Wellcome
  (206) 577-7505

- **Skamania County PUD***
  P.O. Box 500
  Carson, WA 98610
  Mark Hughey
  (509) 427-5126

- **Wahkiakum County PUD**
  P.O. Box 248
  45 River Street
  Cathlamet, WA 98612
  Kim Smith
  (206) 795-3266

Puget Sound Area

- **City of Blaine**
  P.O. Box 490
  1200 Yew Street
  Blaine, WA 98230-0490
  Shelia McElhinney
  (206) 332-8820

- **City of Centralia**
  1100 North Tower Avenue
  Centralia, WA 98531-5044
  Gary Nordeen
  (206) 736-8085

- **Clallam County PUD***
  P.O. Box 1090
  Port Angeles, WA 98362-0207
  Dave Johnson
  (206) 452-9771, ext. 253

- **Town of Eatonville**
  P.O. Box 309
  210 Center Street West
  Eatonville, WA 98328-0309
  Seth Boettcher
  (206) 832-3361

- **Elmhurst Mutual Power & Light Co.**
  120 South 132nd Street
  Tacoma, WA 98444-4899
  Rich McClain
  (206) 531-7568

- **City of Fircrest**
  115 Ramsdell Street
  Fircrest, WA 98466-6912
  Jill Monley
  (206) 564-8900

- **Grays Harbor County PUD No. 1***
  P.O. Box 480
  2720 Sumner Avenue
  Aberdeen, WA 98520-0109
  Joanne Hansen
  (206) 532-4220

- **Lakeview Light & Power**
  P.O. Box 98979
  11509 Bridgeport Way S.W.
  Tacoma, WA 98498-0979
  Don Geiselman
  (206) 584-6060

- **Lewis County PUD No. 1**
  P.O. Box 330
  321 NW Pacific Avenue
  Chehalis, WA 98532
  Paul Foster/Jim Haselwood
  (206) 748-9261

- **Mason County PUD No. 1**
  North 21971 Highway 101
  Shelton, WA 98584-9763
  Pat McDonald
  (206) 877-5249

- **Mason County PUD No. 3**
  P.O. Box 2148
  Shelton, WA 98584-0490
  Jay Himlie
  (206) 426-8255

- **City of McCleary**
  City Hall, P.O. Box 360
  100 3rd Street
  McCleary, WA 98557
  Gary Dent
  (206) 495-3264

Puget Sound Area *(continued)*

- **Ohop Mutual Light Company**
  34014 Mountain Highway East
  Eatonville, WA 98328
  Jim Field
  (206) 847-4364

- **Orcas Power & Light Co.**
  P.O. Box 187
  Eastsound, WA 98245-0187
  Rita Davis
  (206) 376-3500

- **Pacific County PUD No. 2***
  P.O. Box 472
  405 Duryea Street
  Raymond, WA 98577
  Jim Dolan
  (206) 942-2411

- **Parkland Light & Water Co.**
  P.O. Box 44426
  12918 Park Avenue
  Tacoma, WA 98444-0426
  Rich McClain
  (206) 531-7568

- **Peninsula Light Company, Inc.**
  P.O. Box 78
  13315 Goodnough Drive N.W.
  Gig Harbor, WA 98335-0078
  Pat Maynard
  (206) 857-5950 ext. 313

- **Port Angeles City Light**
  P.O. Box 1150
  321 E. 5th
  Port Angeles, WA 98362-0217
  Don Madison/Mike Brown
  (206) 457-0411

- **Seattle City Light**
  1015 Third Avenue
  Seattle, WA 98104-1198
  Caroline Dethloff
  (206) 684-3534

- **Snohomish County PUD No. 1**
  P.O. Box 1107
  2320 California Street
  Everett, WA 98206-1107
  Dan Anderson
  (206) 304-1781

- **Town of Steilacoom**
  1030 Roe Street
  Steilacoom, WA 98388-1327
  Terry Huber
  (206) 581-1912

- **City of Sumas**
  P.O. Box 9
  433 Cherry Street
  Sumas, WA 98295-0009
  Sheila McElhinney
  (206) 988-5711

- **Tacoma Public Utilities/ Tacoma City Light**
  P.O. Box 11007
  Tacoma, WA 98411
  Francine Artis
  (206) 383-9652

- **Tanner Electric Cooperative**
  P.O. Box 1426
  45710 S.E. North Bend Way
  North Bend, WA 98045-1426
  Elmer Sams
  (206) 888-0623

Snake River Area

- **Benton County PUD***
  P.O. Box 6270
  524 South Auburn Street
  Kennewick, WA 99336
  Nancy Philipp
  (509) 582-2175

- **Benton Rural Electric Association**
  P.O. Box 1150
  402 Seventh Street
  Prosser, WA 99350
  Bruce Etzel
  (509) 786-2913

- **Columbia Rural Electric Assoc.**
  P.O. Box 46
  115 East Main Street
  Dayton, WA 99328
  Dave Reller
  (509) 337-6573

- **Franklin County PUD***
  P.O. Box 2407
  Pasco, WA 99302
  Darroll Clark
  (509) 547-5591

- **City of Richland Energy Resources Division**
  P.O. Box 190
  Richland, WA 99352
  Larry Dunbar, CEM
  (509) 943-7432

Upper Columbia Area

- **Big Bend Electric Coop., Inc.**
  P.O. Box 27
  Mesa, WA 99343
  Joe Pfeifer
  (509) 265-4221

- **Chelan County PUD No. 1**
  P.O. Box 1231
  Wenatchee, WA 98801
  Mike Green/Shaun Seaman
  (509) 663-8121

- **City of Cheney**
  609 Second Street
  Cheney, WA 99004
  Charlie Weber
  (509) 235-7235

- **City of Ellensburg**
  420 N. Pearl Street
  Ellensburg, WA 98926-3112
  Rich Wickwire/Gary Nystedt
  (509) 962-9863

- **Ferry County PUD No. 1**
  P.O. Box 324
  686 S. Clark
  Republic, WA 99166
  Ken Coyle/Brian Royer
  (509) 775-3325/5233

- **Grant County PUD**
  West 312 Third
  Moses Lake, WA 98837
  Jerald Tate/Rod Noteboom
  (509) 754-3541

- **Inland Power & Light Company**
  P.O. Box 4429
  East 320 Second Avenue
  Spokane, WA 99202
  Monty Schwahn
  (509) 747-7151

- **Kittitas County PUD No. 1**
  1400 East Vantage Highway
  Ellensburg, WA 98926-3112
  George Harmon
  (509) 925-3164

- **Lincoln Electric Cooperative, Inc.**
  P.O. Box 289
  Davenport, WA 99122
  Bob Morrison
  (509) 725-1141

- **Okanogan County Electric Cooperative, Inc.**
  P.O. Box 69
  265 Riverside
  Winthrop, WA 98862
  Ellen Lamiman
  (509) 996-2228

- **Pend Oreille County PUD No. 1**
  P.O. Box 190
  Newport, WA 99156
  Mark Cauchy
  (509) 447-3137

- **Vera Water & Power**
  P.O. Box 630
  North 601 Evergreen Road
  Veradale, WA 99037
  Michael DeVleming
  (509) 924-3800

Investor-Owned Utilities

- **Pacific Power & Light**
  920 S.W. Sixth Avenue, 440 PFFC
  Portland, OR 97204
  Ken Anderson
  (503) 464-5977

- **Portland General Electric**
  7881 S.W. Mohawk
  Tualatin, OR 97062
  Gary Heikkinen
  (503) 691-3984

Bonneville Power Administration Area/District Personnel

- **Bonneville Power Administration**
  P.O. Box 3621
  905 N.E. 11th Avenue
  Portland, OR 97208-3621
  Jim Dowty, RMCC
  (503) 230-5873

- **Lower Columbia Area**
  P.O. Box 3621
  1500 N.E. Irving Street, Rm. 578
  Portland, OR 97208
  Cathy Higgins/Claire Hobson, LRC/
  Gayle DeBruyne
  (503) 230-4212/5354/5437

- **Puget Sound Area**
  201 Queen Anne Avenue North,
  P.O. Box C-19030
  Suite 400
  Seattle, WA 98109-1030
  Kelly Erickson/Dorothy Preston/
  Brittany Andrus/Peggy Crossman
  (206) 553-5074/1149/2366/5083

- **Snake River Area**
  1520 Kelly Place
  Walla Walla, WA 99362
  Tom Osborn
  (509) 527-6262

- **Upper Columbia Area**
  707 West Main #500
  Spokane, WA 99201
  Andres Cicarelli, UBB
  (509) 353-2569

Support Services

- **Electric Ideas Clearinghouse**
  Toll-free hotline: 1-800-872-3568
  Fax: 1-800-872-3882
  925 Plum Street, Bldg. 4
  Olympia, WA 98504
  Electronic Bulletin Board
  1-800-762-3319

- **Lighting Design Lab**
  400 East Pine Street, Suite 100
  Seattle, WA 98122
  (206) 325-9711 or
  1-800-354-3864

* *CARES Utilities*

Appendix E

Energy-Efficiency Measures List

1.0 Envelope

1.1 Reduce Heat Losses—Ceiling/Roof

1.11 Additional Ceiling/Roof Insulation

1.12 Exhaust Attics

1.13 Use Light-Colored Roof Surfaces

1.14 Roof Sprinkling/Spray System

1.2 Reduce Heat Losses—Walls/Floors

1.21 Additional Wall Insulation

1.22 Additional Floor/Slab Insulation

1.23 Use Light Colored Exterior Surfaces

1.24 Thermal Mass/Passive Solar Heating

1.3 Reduce Heat Losses—Windows/Doors

1.31 Install Additional Glazing Layer

1.32 Install Movable Insulation

Multilayer reflective roller shade device

Operable insulating slats

Quilted insulating draperies

1.33 Use Special Coatings or Gases

Heat mirror

Low-e coatings

Argon gas window fill

1.4 Reduce Heat Gain—Windows/Doors

1.41 Install Exterior Shading

1.42 Install Interior Shading

1.43 Use Tinted or Reflective Coatings or Films

1.44 Optimize Window Sizing and Orientation

1.5 Reduce Infiltration

1.51 Caulk and Weatherstrip Doors and Windows

Dock shelters/seals

Install air curtains

1.52 Install Air-Lock Vestibule System or Revolving Doors

2.0 Lighting

2.1 Reduce Lighting Required

2.11 Utilize Task Lighting

2.12 Lighting Controls

- Selective switching
- Programmable timing control
- Occupancy sensors
- Energy management system

2.13 Use Light-Colored Interior Wall Finishes

2.2 Install More Energy-Efficient Lighting System

2.21 Use High-Efficiency Fixtures

- HID fixtures in selected locations
- Efficient exit signs
- Self-ballasted compact fluorescents

2.22 Use Efficient Exterior Fixtures

- High-pressure sodium HID fixtures
- Metal halide fixtures

2.23 Use High-Efficiency Ballast

- Electromagnetic/hybrid
- Electronic

2.3 Use Daylighting

2.31 Install Dimming Controls

2.32 Architectural Modifications

3.0 HVAC Systems

3.1 Air Distribution Systems

3.11 Reduce Energy Losses

- Increase duct insulation
- Install air-to-air heat recovery
- Runaround loop heat recovery

3.12 Reduce System Flow Rates

- Airflow and fan speed reduction
- VAV system to reduce fan energy use
- Variable speed drive motor for VAV

3.13 Reduce System Resistance

- High-efficiency filters
- Improve design and balance of duct system

3.14 Reduce Ventilation Loads

Reduce ventilation rate to minimum

Install local ventilation and makeup air hoods

3.15 Air Destratification

Enclosed high-velocity fan

Open propeller fans

Ductwork system with centrifugal or vane axial fans

3.2 Water/Steam Distribution

3.21 Reduce Energy Losses

Increase pipe insulation

Steam-trap monitoring system

3.22 Reduce System Flow Rates

Primary/secondary pumping with variable speed motors

Isolate off-line equipment in parallel piping circuits

Time control or interlocks on circulating pumps

3.23 Reduce System Resistance

Install booster pumps

3.3 Heating Plant

3.31 Improve Boiler or Furnace Efficiency

Match boiler size to load

Install multiple boilers

Condensing hydronic boiler

Increase heat transfer area

Preheat combustion air or fuel supply

Boiler water treatment

3.32 Install High-Efficiency Heat Pump

Air-to-air heat pump

Dual-fuel heat pump

Water-source heat pump

Ground-source heat pump

3.33 Install Radiant Heating System

3.4 Cooling Plant

3.41 Select More Efficient Cooling System

Use evaporative cooling

Use cooling tower instead of air-cooled system

Use heat recovery chiller

Direct cooling: well, pond, lake, or river

3.42 Improve Cooling Efficiency

Optimize chiller efficiency with temperature controls

Use multiple chillers and optimization controls

Increase chilled water design temperature

Optimize cooling tower flow controls

3.43 Increase Condensing Efficiency

Lower condenser water design temperature

Reset controls on water temperature

Tube-brush cleaning system

Chemical washing system

3.44 Improve Part-Load Performance

Select chillers based on Integrated Part Load Value (IPLV)

3.5 Control Systems

3.51 Demand Limiting EMCS/DDC

3.52 Optimize Start/Stop

3.53 Duty Cycling Control System (Reduce unoccupied ventilation)

3.54 Supply Temperature Setup/Setback Control System

Install programmable thermostats

Install controls and hardware to optimize hot-and-cold deck reset

3.55 Install Economizer Control System

3.56 Boiler Control Strategies

Draft control modifications

Barometric or flue shutoff dampers

Outside air temperature reset or heating lockout

Boiler optimization controls

Hi/low, modulating, or reduced excess air burner

Install flu gas analyzer—trim control

3.6 Thermal Storage Systems

3.61 Water Storage Tanks

3.62 Ice Storage Systems

3.63 Rock Bins

4.0 Water Heating

4.1 Reduce Water Heating Loads

4.11 Use Low Water Use Devices

4.12 Use Local Booster or Point-of-Use Heaters

4.13 Preheat Feedwater with Reclaimed Waste Heat

4.14 Timeclock Controls to Reduce Unoccupied Loads

4.2 Reduce System Losses

4.21 Increase Insulation on Hot Water Pipes

4.22 Increase Insulation on Water Storage Tanks

4.3 Install More Energy Efficient Water Heating System

4.31 Use Heat-Pump Water Heaters

4.32 Solar-Assisted Water Heater

5.0 Power Systems

5.1 Reduce Power System Losses

5.11 Correct Power Factors

5.12 Install Energy-Efficient Transformers

5.2 Install Energy-Efficient Motors

5.21 High-Efficiency Motors

5.22 Multispeed Motors

5.23 Variable-Speed Motors

5.24 Optimize Motor Sizing

5.3 Reduce Peak Power Demand

5.31 Demand Limit Controls (See 3.51)

6.0 Refrigeration

6.1 Improve Controls

6.11 Optimize Defrost Cycle Control

6.12 Optimize Condensing Unit Capacity Control

6.13 Install Floating-Head Pressure Control

6.2 Reduce Refrigeration System Losses

6.21 Install Refrigerated Space Doors or Curtains

6.22 Increase Insulation of Refrigerated Area

6.3 Improve Refrigeration System Efficiency

6.31 Multiple Compressors and Controls

6.32 Increase Condensing Unit Efficiency

6.33 Select High-Efficiency Compressor

Reciprocating compressor

Screw compressor

Rotary compressor

Parallel unequal reciprocating compressor

7.0 Miscellaneous

7.1 Heat Recovery

7.11 Install Double-Bundle Chillers

7.12 Reclaim Heat from Combustion System Flue

7.13 Reclaim Heat from Steam Condensate

7.14 Reclaim Heat from Waste Water

7.15 Laundry Process Heat Recovery

7.16 Reclaim Heat from Exhaust Air (See 3.11)

7.17 Pool Dehumidification Heat Recovery System

7.2 Install More Efficient Ancillary Equipment

7.21 Elevator/Escalator Optimization

7.22 Install Pool Cover