GUIDEBOOK

GUIDE TO PREPARING FEASIBILITY STUDIES for ENERGY EFFICIENCY PROJECTS

EFFICIENCY · ENERGY FOR THE FUTURE ·

Gray Davis, *Governor*

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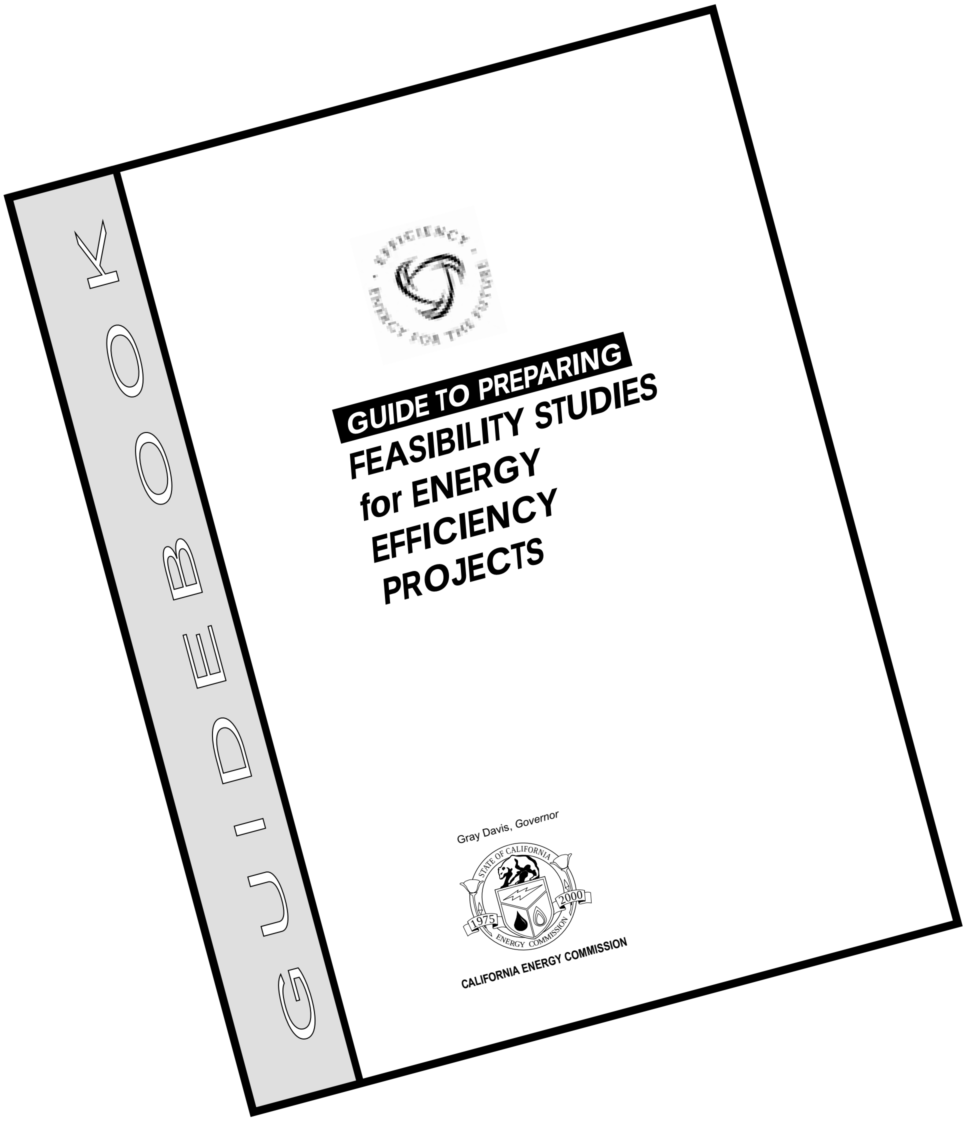

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This document is one of a series of publications contained in the Energy Commission's *Energy Efficiency Project Management Handbook* series. These handbooks are designed to help local governments, schools and other public entities successfully implement energy efficiency projects in their facilities.

For information on how to obtain copies of other documents, contact the Nonresidential Buildings Office at (916) 654-4008. All documents can be downloaded from the Energy Commission's Web Site at: <www.energy.ca.gov/reports>.

INTRODUCTION

This document serves as a technical guide for those preparing a feasibility study or energy audit to evaluate energy efficiency measures. This Guide provides information on the minimum technical and economic analysis and assumptions needed for various technologies.

The Guide is divided into the following parts:

Part 1 **Overview**—defines a feasibility study and identifies the minimum analytical requirements for different types of energy efficiency measures.

Part 2 **Feasibility Study Content and Format**—discusses the pertinent information for the feasibility study, including study format, the required technical analysis and assumptions and building simulation modeling needed.

Part 3 **Feasibility Study Project Hierarchy**—discusses the order for evaluating energy efficiency measures to avoid double counting the energy savings.

Part 4 **Typical Energy Efficiency Measures**—contains a partial listing of typical projects.

Part 5 **Example Equipment Loads and Efficiencies**—contains examples of equipment loads and efficiencies for both baseline and proposed conditions.

Part 6 **Additional Information**—lists resources to help the energy auditor.

Part 7 **Life Cycle Cost**—discusses life cycle cost, equipment life and maintenance needs.

The Guide was originally developed to help energy auditors prepare feasibility studies that could justify Energy Commission funding of recommended energy projects. Since project funding was often based on energy savings, it was important that the methodology and assumptions used to determine savings and costs were technically sound and reasonable. Also, an Energy Commission study showed that a good quality study with accurate information on facility operations would result in organizations achieving the stated project savings and benefits. This correlation has also been documented by others who specialize in monitoring and verification of projects.

Since a good quality study is critical, many have used this Guide as a template for preparing studies not associated with an Energy Commission program. Organizations hiring engineering consultants, energy services companies and others have used this document to identify the minimum energy audit/feasibility study requirements. This version of the guide has been slightly modified to emphasize the technical requirements of a good feasibility study rather than the administrative requirements for Energy Commission funding.

1. OVERVIEW

This section defines a feasibility study, discusses the different types of studies, the qualifications of those who should prepare the studies, and defines the acronyms and terms that will be used throughout this Guide.

General Information about Feasibility Studies

A feasibility study is a technical and economic analysis of potential energy saving projects in a facility that:

- Provides information on current energy-using equipment operations such as lighting and heating, ventilating and air conditioning systems,
- Identifies technically and economically feasible energy efficiency improvements for existing equipment, and
- Provides reviewers with sufficient information to judge the technical and economic feasibility of the recommended projects.

Feasibility Study Preparer Requirements

The person preparing the feasibility study should have experience in evaluating energy project(s) for the client's type of facility. The preparer should not have conflicting financial interests with equipment vendors or manufacturers. The latter is important to ensure an objective analysis. In some cases, an engineer may be an appropriate choice for evaluating heating, ventilating, and air conditioning (HVAC) projects and HVAC controls and modifications.

The Energy Commission’s publication entitled *How to Hire an Energy Auditor to Identify Energy Efficiency Projects* provides information on how to select and hire someone to prepare the study. Information on how to request a copy is contained in Part 6.

Comprehensive or Targeted Feasibility Studies

The feasibility study can either evaluate **all** energy efficiency opportunities in a facility or focus on one or specific projects. In either case, the study must contain all justifying assumptions and calculations used to evaluate the projects and determine the energy savings, energy cost savings, and project costs.

A. **Comprehensive Study** - This study analyzes all major energy-using systems and contains recommendations for operation and maintenance (O&M) improvements and cost-effective energy projects. A comprehensive study is a good choice for those who have implemented few or no energy saving projects. This study serves as an energy management tool to assist in future facility planning decisionsWhen preparing the study, the analyst must ensure that savings are not double-counted from one project to another.

B. **Targeted Study** - This study analyzes only specific projects. A targeted study may be appropriate for those that have recently installed energy-saving projects and who want to focus on areas not yet analyzed.

When doing targeted studies, the analyst should consider the impacts that a recommended project would have on future project installations. For instance, if an energy generation project is installed, that project could adversely affect the economics of installing future energy saving measures. The reason for the impact is because the energy generation project may require a minimum electrical or thermal load to be economically feasible. Subsequent installation of load reducing projects could impact the economic viability of the energy generation project.

Study Options for Various Project Types

The study requirements for various project options are shown on Table 1-1. The following is a brief discussion of the options.

A. Lighting projects only - Includes all types of conversions or retrofits to high efficiency lighting and installation of controls (photocell, occupancy sensors). Refer to Table 1-2 for the information to be contained in the study.

B. Lighting and heating, ventilating and air conditioning (HVAC) projects or HVAC projects only-totaling less than $50,000 - Includes all HVAC projects, HVAC controls, domestic hot water, building envelope projects, and/or project combinations with or without lighting. Refer to Table 1-2 for the information to be contained in the study.

C. Lighting and heating, ventilating and air conditioning (HVAC) projects or HVAC projects only-totaling more than $50,000 - Includes all HVAC projects, HVAC controls, domestic hot water, building envelope projects, and/or project combinations with or without lighting. Refer to Table 1-3 for the information to be contained in the study. If lighting is more than 80 percent of the project cost use Tables 1-2 or 1-3.

D. Comprehensive studies - A comprehensive study evaluates all cost-effective energy efficiency opportunities, including lighting, HVAC, controls, domestic hot water, building envelope and maintenance/operation opportunities. Table 1-4 identifies the specific information to be contained in the study.

E. Energy generation projects - Includes projects which produce electricity or heat through cogeneration or use of renewables. Refer to Table 1-4 for the information to be contained in the study.

Definitions/Acronyms

The following are definitions and/or acronyms of common terms used in this Guide.

- **Analyst** - An individual responsible for analyzing energy efficiency opportunities in a facility and preparing the feasibility study.

- **Building** - The following are the building descriptions for various organizations:
  - **Local government** - individual, discrete structures (e.g., jail, city hall, library)
  - **K-12** - entire school campus, including all wings, relocateables, and individual buildings
  - **Colleges** - individual, discrete structures (e.g., library, administration, Gym)
  - **Hospitals** - individual, discrete structures including all wings connected to the main hospital

- **Energy Commission** - California Energy Commission

- **DHW** - Domestic hot water equipment (e.g., water heater)

- **ECM or EEM** - Energy conservation measure (ECM), also known as an energy efficiency project or energy efficiency measure (EEM). An ECM or EEM is a modification to a building or facility which results in reduced energy use and/or energy cost.

- **Energy Generation** - A project which generates electricity, heat and/or steam. Examples include, but are not limited to, cogeneration and use of solar, geothermal, biomass and wind.

- **Facility** - A building, group of buildings or other energy-using component analyzed in the feasibility study. Examples include civic center, school, college, hospital, water pumping, water delivery systems, and water and wastewater treatment.

- **HVAC** - Heating, Ventilating and Air Conditioning Equipment

- **O&M** - An operation and maintenance measure is a modification to existing equipment that reduces energy use and returns the equipment to its original efficiency level.

- **Organization** - An organization is the governing body that oversees the operation and budget of the facility, such as city council or school district.

Table 1-1
Study Requirements for Various Energy Project Options

Feasibility Study Sections:	(1) Lighting Only	(2) Lighting and HVAC Projects or HVAC Projects Exclusively totaling less than $50,000	(3) Lighting and HVAC Projects or HVAC Projects Exclusively totaling more than $50,000	(4) Comprehensive Feasibility Study	(5) Energy Generation Projects
Cover/Executive Summary	✓	✓	✓	✓	✓
Facility Background/Site Information	✓	✓	✓	✓	✓
Site Energy Use			✓	✓	✓
Energy Using Systems				✓	✓
Technical Project Summaries	✓	✓	✓	✓	✓
Appendix A - Baseline Energy Use	✓	✓	✓	✓	✓
Appendix B - Energy Balance			✓	✓	✓
Appendix C - EEM Calculations	✓	✓	✓	✓	✓
Appendix D -Weather Data			✓	✓	✓
Appendix E - Cut Sheets/Vendor Quotes	✓	✓	✓	✓	✓
Appendix F - Consultant Field Data Sheets	✓	✓	✓	✓	✓

- Lighting only projects, see Table 1-2, page 1-5.
- Lighting and HVAC or HVAC only projects totaling $50,000 or less, see Table 1-2, page 1-5.
- Lighting and HVAC or HVAC only projects totaling more than $50,000 see Table 1-3, page 1-6. If lighting is 80% or more of the total project cost, use either Tables 1-2 or 1-3.
- Project analysis from a comprehensive study, see Table 1-4, page 1-7.
- Energy generation projects (cogeneration, renewables), see Table 1-4, page 1-7.

Table 1-2
Feasibility Study Requirements for All Lighting Projects or Projects Totaling $50,000 or Less

Feasibility Study Sections	Example Lighting Projects* • Fluorescent retrofits • Incandescent conversions • Metal halide/high pressure sodium retrofits • Controls	Example Projects Totaling £ $50,000 • Heating, ventilating and air conditioning projects (HVAC) • DHW or building envelope projects • Equipment controls • Above projects with lighting
Cover/Executive Summary	Pages 2-1 to 2-6	Pages 2-1 to 2-6
Facility Background/Site Information	Pages 2-7 to 2-8	Pages 2-7 to 2-8
Technical Project Summaries	Pages 2-22 to 2-23	Pages 2-21 to 2-26 complete the appropriate sections
Appendix A - Baseline Energy Use	Pages 2-A-1 to 2-A-11	Pages 2-A-1 to 2-A-11
Appendix C - Energy Efficiency Measure Calculations	Pages 2-C-5 to 2-C-9 and 2-C-30 to 2-C-35	Pages 2-C-1 to 2-C-20 (complete the appropriate sections) and pages 2-C-30 to 2-C-35
Appendix E - Cut Sheets and Vendor Cost Quotes	Page 2-E-1	Page 2-E-1
Appendix F - Field Data Sheets	Page 2-F-1	Page 2-F-1

*Refer to project hierarchy, pages 3-1 to 3-6, for a recommended order of evaluating multiple projects

Table 1-3
Feasibility Study Requirements for
Projects Totaling More than $50,000

Feasibility Study Sections	Example Projects: • HVAC projects • DHW or building envelope projects • Equipment controls • Above with lighting (if lighting costs are more than 80 percent of the total project cost, use Table 1-2 or 1-3)
Cover/Executive Summary	Page 2-1
Facility Background/Site Information	Pages 2-7 to 2-8
Site Energy Use	Pages 2-9 to 2-17
Technical Project Summaries	Pages 2-21 to 2-26 (complete the appropriate sections)
Appendix A - Baseline Energy Use	Pages 2-A-1 to 2-A-11
Appendix B - Energy Balance	**For projects that affect only electrical use, complete the following**: • Lights: Table B-2a or B-2b, pages 2-B-11 and 2-B-12, respectively • HVAC: Tables B-3, B-4 and B-5, pages 2-B-13 to 2-B-15 • Miscellaneous equipment: Table B-6, page 2-B-16 • Domestic hot water: Table B-7, page 2-B-17 • **For projects that affect only natural gas use, complete the following:** • HVAC: Tables B-8, B-9 and B-10, pages 2-B-18 to 2-B-20 • Domestic hot water: Table B-7, page 2-B-17 • Domestic hot water (pool boiler): Table B-11, page 2-B-21 • Miscellaneous equipment: Table B-12, page 2-B-22 • **For projects that affect both electricity and natural gas use, complete all the tables in Appendix B, pages 2-B-1 to 2-B-22.** • **If using DOE 2.1, HAP or Trace, refer to pages 2-B-1 to 2-B-5**
Appendix C - EEM Calculations	Pages 2-C-1 to 2-C-20 (complete the appropriate sections) <u>and</u> pages 2-C-30 to 2-C-35
Appendix D -Weather Data	Pages 2-D-1 to 2-D-2
Appendix E - Cut Sheets/Vendor Quotes	Page 2-E-1
Appendix F - Field Data Sheets	Page 2-F-1

* Refer to project hierarchy, pages 3-1 to 3-6 for the order of project evaluation.

Table 1-4
Feasibility Study Requirements for
Projects from a Comprehensive Feasibility Study or for Energy Generation Projects

Feasibility Study Report Sections	**Comprehensive Feasibility Studies*** • O & M projects • Lighting • Building envelope, HVAC, DHW projects • Equipment controls **Energy Generation Feasibility Studies*** • Cogeneration • Renewables
Cover/Executive Summary	Page 2-1
Facility Background/Site Information	Pages 2-7 to 2-8
Site Energy Use	Pages 2-9 to 2-17
Energy Using Systems	Pages 2-18 to 2-20
Technical Project Summaries	Pages 2-21 to 2-27
Appendix A - Baseline Energy Use	Pages 2-A-1 to 2-A-11
Appendix B - Energy Balance	Pages 2-B-1 to 2-B-22
Appendix C - EEM Calculations	Pages 2-C-1 to 2-C-35
Appendix D -Weather Data	Pages 2-D-1 to 2-D-2
Appendix E - Cut Sheets/ Vendor Quotes	Page 2-E-1
Appendix F - Field Data Sheets	Page 2-F-1

* Refer to project hierarchy, pages 3-1 to 3-6, for the order of evaluating multiple projects.

2 FEASIBILITY STUDY CONTENT AND FORMAT

This section specifies the content and format for the feasibility study based on Table 1-1. Each element of the study is described including the minimum information, tables and graphic requirements. Other formats can be used provided similar information described in this section are included in the study.

1. Cover Page, Table of Contents and Preface (required of all studies):

A. **Cover page** - Indicate the name of the facility and governing organization (e.g., school and school district, respectively) receiving the feasibility study; name, address, and telephone number of the company completing the study; and report date.

B. **Table of contents** - Number the pages consecutively (e.g., 1, 2, 3) or consecutively within each report section (e.g., 1-1, 1-2). The table of contents will identify the major sections and the specific page numbers.

C. **Preface** - Indicate the facility staff who assisted in the preparation of the study, and the name(s) of the analysts responsible for collecting data, analyzing energy projects and/or preparing the study, in whole or in part.

2. Executive Summary (required of all studies) - This section will be prepared in narrative format and discuss the following:

A. **Annual energy cost and savings** - Indicate total annual energy costs and how much cost can be reduced by installing the recommended projects.

B. **Energy Sources** - For **comprehensive studies only**, indicate the major sources of energy used by the facility (e.g., natural gas, electricity) and their primary end use (e.g., lighting, HVAC). If the EEMs affect one type of energy, discuss only that source of energy.

C. **Project Summary Tables**- Prepare both individual data tables for each building and a combined table summarizing all recommended projects which include the information shown on Table 2-1.

D. **Total project cost, energy savings and energy cost savings** - Indicate the total project cost and estimated annual energy and cost savings.

TABLE 2-1
RECOMMENDED ENERGY EFFICIENCY MEASURES
ALL BUILDINGS COMBINED

ECM Description	**Peak Demand Savings (KW)**	**Annual Electric Savings (KWh)**	**Annual Natural Gas Savings (therms)**	**Annual Cost Savings**	**Installation Cost**	**Simple Payback (years)**
Lighting Projects						
Replace incandescent with compact fluorescent	3	14,556	0	$1,333	$1,458	1.1
Install T-8 lamps and electronic ballasts	48	266,405	0	$24,113	$100,790	4.2
Install occupancy sensors	0	1,114	0	$100	$358	3.6
HVAC Projects						
Use DX cooling at night in pharmacy	0	8,399	953	$923	$0	Immediate
Shut off exhaust fans at night	0	30,516	0	$1,501	$2,568	1.7
Insulate bare pipes	0	0	3,583	$1,964	$3,507	1.8
Clean filters and coils	11	63,128	0	$5,560	$19,276	3.5
Install premium efficiency motors	16	86,352	0	$7,847	$31,617	4.0
Other Projects						
Reduce DHW tank temperature	0	0	593	$325	$0	Immediate
Use instant heaters for DHW	0	0	5,236	$2,857	$2,276	0.8
Total	78	470,470	10,365	$46,523	$191,850	3.5

TABLE 2-1 (continued)
RECOMMENDED ENERGY EFFICIENCY MEASURES
ADMINISTRATION BUILDING

ECM #*	ECM Description	Peak Demand Savings (KW)	Annual Electric Savings (kWh)	Annual Natural Gas Savings (Therms)	Annual Cost Savings	Installation Cost	Simple Payback (years)
3.5.1	Insulate bare pipes	0	0	1,124	$616	$1,582	2.6
3.5.2	Clean filters and coils	4	10,426	0	$1,400	$7,711	5.5
3.5.3	Install premium efficiency motors	3	10,944	0	$1,284	$8,256	6.4
	Subtotal	7	21,370	1,124	$3,300	$17,549	5.3

* The ECM # refers to the section in the feasibility study where the project is discussed.

TABLE 2-1 (continued)
RECOMMENDED ENERGY EFFICIENCY MEASURES
SOCIAL SERVICES BUILDING

ECM #*	ECM Description	Peak Demand Savings (KW)	Annual Electric Savings (kWh)	Annual Natural Gas Savings (Therms)	Annual Cost Savings	Installation Cost	Simple Payback (years)
Lighting Projects							
4.4.1	Replace incand with compact fluor	3	14,556	0	$1,333	$1,458	1.1
4.4.2	Install occupancy sensors	0	891	0	$80	$179	2.2
4.4.3	Install T-8 lamps and electronic ballasts	11	36,169	0	$4.356	$25,115	5.8
HVAC Projects							
4.5.2	Install premium efficiency motors	3	15,752	0	$1,337	$4,658	3.5
4.5.4	Clean filters and coils	1	3,386	0	$448	$2,891	6.5
	Subtotal	18	70,754	1,124	$7,554	$34,301	4.5

* The ECM # refers to the section in the feasibility study where the project is discussed.

TABLE 2-1 (continued)
RECOMMENDED ENERGY EFFICIENCY MEASURES
HEALTH CARE SERVICES BUILDING

ECM #*	**ECM Description**	**Peak Demand Savings (KW)**	**Annual Electric Savings (kWh)**	**Annual Natural Gas Savings (Therms)**	**Annual Cost Savings**	**Installation Cost**	**Simple Payback (years)**
Lighting Projects							
5.4.1	Install T-8 lamps and electronic ballasts	13	44,177	0	$5,048	$27,819	5.5
5.4.2	Replace incand with compact fluor	0	3,311	0	$249	$1,967	7.9
5.4.3	Install occupancy sensors	0	223	0	$20	$179	9.0
HVAC Projects							
5.5.1	Use DX cooling at night in pharmacy	0	8,399	953	$923	$0	Immed
5.5.2	Insulate bare pipes	0	0	2,459	$1,348	$1,925	1.4
5.5.3	Shut off exhaust fans at night	0	30,516	0	$1,501	$2,568	1.7
5.5.4	Install premium efficiency motors	6	22,779	0	$2,294	$9,972	4.3
	Subtotal	18	107,405	3,412	$11,383	$44,430	3.9

* The ECM # refers to the section in the feasibility study where the project is discussed.

TABLE 2-1 (continued)
RECOMMENDED ENERGY EFFICIENCY MEASURES
JAIL

ECM #*	ECM Description	Peak Demand Savings (KW)	Annual Electric Savings (kWh)	Annual Natural Gas Savings (Therms)	Annual Cost Savings	Installation Cost	Simple Payback (years)
Lighting Projects							
4.4.3	Install T-8 lamps and electronic ballasts	24	186,059	0	$14,709	$47,856	3.3
HVAC Projects							
4.5.2	Clean filters and coils	6	49,316	0	$3,712	$8,674	2.3
4.5.4	Install premium efficiency motors	5	38,877	0	$2,932	$8,731	3.0
Other Projects							
6.6.1	Reduce DHW tank temp	0	0	593	$325	$0	Immed
6.6.2	Use instant heaters for DHW	0	0	5,236	$2,857	$2,276	0.8
	Subtotal	35	274,252	5,829	$24,535	$67,537	2.8

* The ECM # refers to the section in the feasibility study where the project is discussed.

3. Facility Background and Site Information

(required of all studies)

A. Facility Description - discuss the following:

1. **Facility operations** -Discuss the current facility operations by building or facility function and include a table containing the information shown on Table 2-2. Show location and discuss any on-site generation facilities.

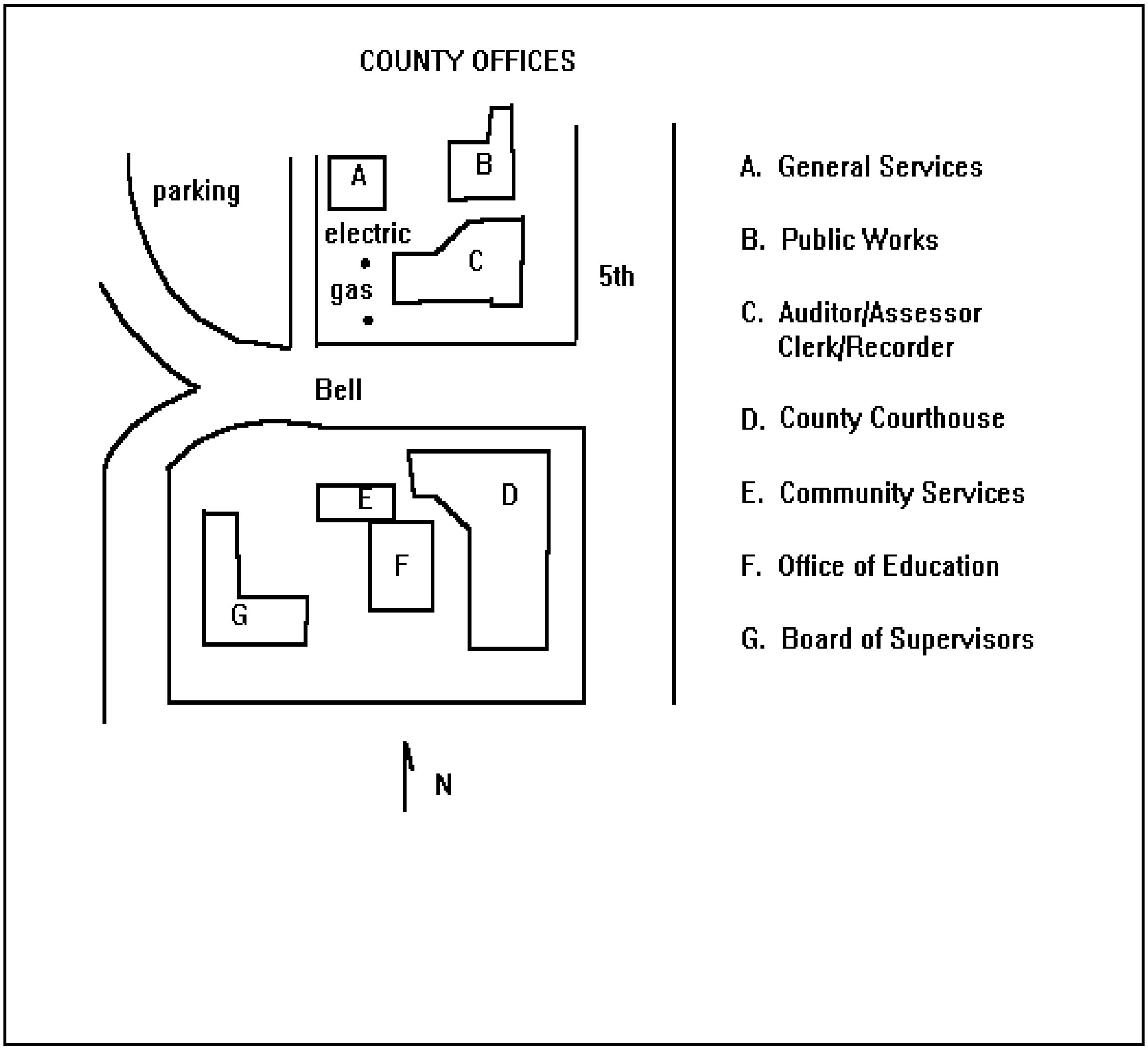
Table 2-2
Building Information and Summary

Facility Function: _________________________(e.g., courthouse, county offices, detention facility, city offices, school, hospital, administration, college, etc.)

Building Name Address	Area (gross square feet)	Building Occupancy Schedule (primary staff schedule) Hours/day	Days/year
Example: General Services 1000 Bell Street	6,000	7 a.m. - 7 p.m.	350 days/yr
Public Works 800 5th Street	10,000	8 a.m. - 5 p.m.	350 days/yr
Auditor/Assessor 1100 Bell Street	18,000	8 a.m. - 5 p.m.	350 days/yr
Courthouse 1201 Bell Street	80,000	8 a.m. - 5 p.m.	350 days/yr
Community Services 1005 Bell Street	9,000	8 a.m. - 5 p.m.	350 days/yr
Office of Education 1003 Bell Street	15,000	8 a.m. - 5 p.m.	350 days/yr
Board of Supervisors 801 Bell Street	22,000	8 a.m. - 5 p.m.	350 days/yr
Total	160,000		

2. **Site plan** - provide a site plan showing the names and locations of buildings (see Figure 2-1).

Figure 2-1
Sample Site Plan



4. Site Energy Use (required of some studies, see Tables 1-3 and 1-4)

A. Baseline Energy Consumption

1. Discuss the current energy use by each energy type and comment on any abnormal usage (e.g. electricity usage is high in the summer when the facility is shut down). If the facility is currently generating its own energy (e.g. cogeneration), there must be a discussion of the amount of purchased and generated electricity and the amount of fuel used for generation and heat displaced.

2. Provide graphs showing month by month usage for each type of energy used by the facility (Figures 2-2 and 2-3). Use the most representative utility billing history covering a 12 month period. If there were any anomalies in energy equipment operations, then the analyst must explain how the 12-month utility billing history used in the feasibility study accounted for this anomaly and is representative of the facility's typical energy use. The information presented in these graphs should be consistent with the energy baseline determined in Appendix A, pages 2-A-1 to 2-A-12.

B. Energy Balance

1. The energy balance is used to compare the surveyed energy use with the actual metered use from the utility bills. It is a tool that allows the analyst to estimate the annual operating hours of energy using equipment. Using the method described in Appendix B, pages 2-B-1 to 2-B-22, discuss how each major type of energy is used in the facility, by percent of total use. As an example, the feasibility study will discuss the percentage of electricity used for lighting, HVAC operations, other major loads and miscellaneous uses.

2. Provide pie charts for each major type of energy used showing the major end uses within the facility (Figures 2-4 and 2-5).

C. Energy Concerns Expressed by the Facility Staff

Discuss any energy concerns, interests and/or specific EEMs for which the facility staff has requested an evaluation. Though these projects may not be cost-effective, they should be discussed and evaluated in the study.

Figure 2-2
Sample Facility
Baseline Electricity Usage

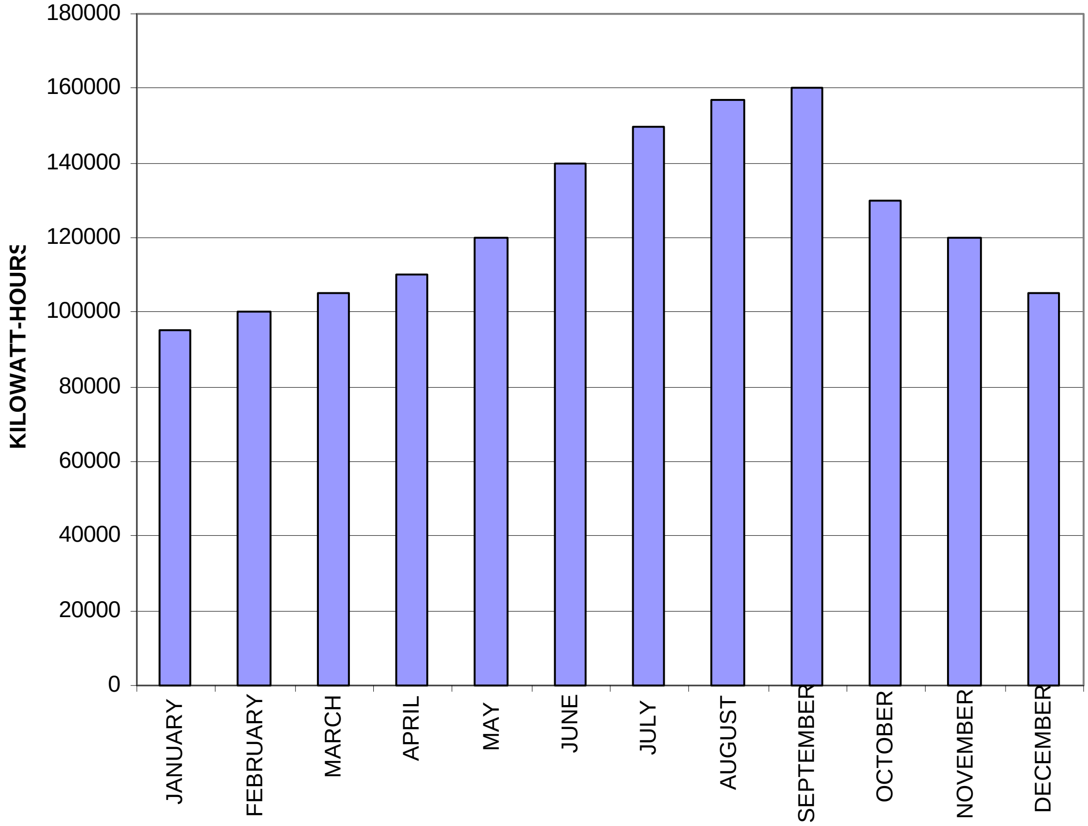


Figure 2-3
Sample Facility
Baseline Natural Gas Usage

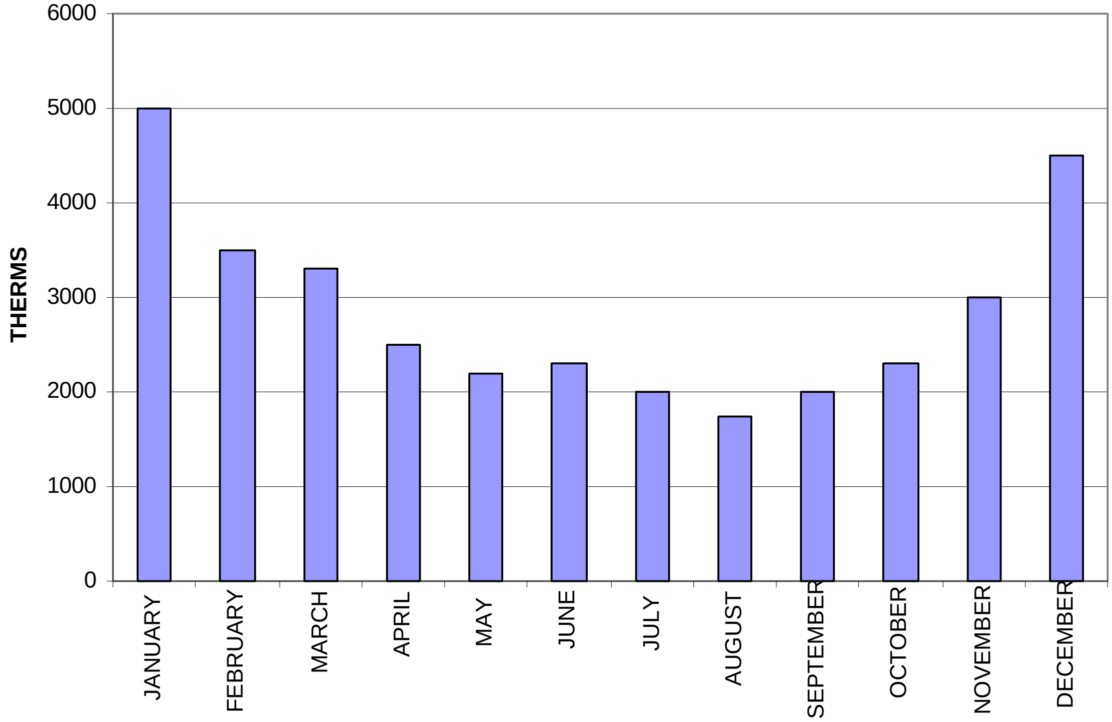


Figure 2-4
Sample Facility
Baseline Electrical Energy Balance

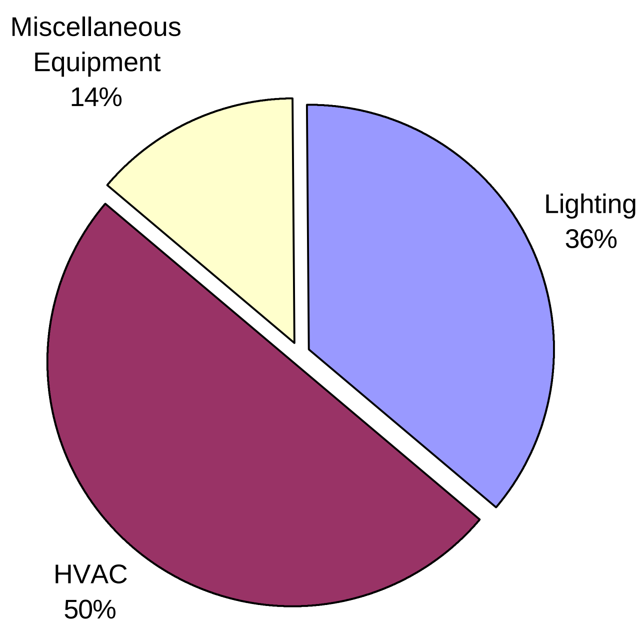
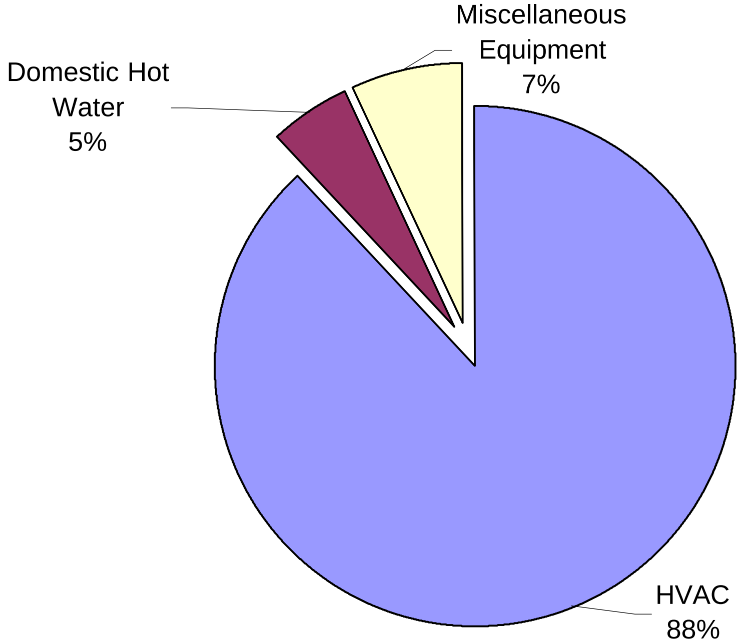


Figure 2-5
Sample Facility
Baseline Natural Gas Energy Balance



D. Determining Energy Use in Individual Buildings on the Same Meter with Other Buildings

This section pertains **only** to analysts preparing studies for individual buildings in a multi-building complex served by one electric and/or gas meter. In this situation, the analyst will need to determine the energy use of the audited buildings. This section provides information on some of the methods that can be used to estimated building energy use.

1. **Area of the buildings not audited is less than or equal to 20 percent of the total square footage covered by the utility meter** - The analyst can prorate the energy use of the audited buildings based on square footage.

2. **Area of the buildings not audited is more than 20 percent of the total square footage on the utility meter** - The analysts can do one of the following:

   a. ***Submeter the Audited Buildings***: Submeter the electric use, chilled water and/or hot water flow rate, as appropriate, for the building(s) analyzed over a period of at least 2 weeks. This information will be used in building simulation models to extrapolate the usage over an annual period. A detailed discussion of the submetering procedure is contained in the next section (pages 2-15 to 2-17).

      If the energy projects analyzed in the feasibility study will only affect the electrical use of the building, then only submetering the electrical use and chill water flow rate (if electrical chiller) will be needed. In this case, submetering of the gas use and hot water flow rate (if gas boiler) is not necessary.

      If the energy projects analyzed affect both electric and natural gas use, then submetering of the electric use, chill water and hot water flow rate will be necessary.

   b. ***Building Simulation Modeling***: Use building simulation models (e.g., DOE-2) to simulate building usage of the omitted buildings and provide detailed simulation of the buildings to be studied using actual data. Actual building envelope and HVAC system configuration and schedule data will need to be inputed into the model for the omitted buildings. The analyst can use estimated power densities for lighting, domestic hot water, and miscellaneous equipment for the omitted buildings.

E. Submetering Individual Buildings

One method of determining the baseline energy consumption of individual buildings on the same utility meter as other buildings is to submeter the buildings.

1. General

The submetering period must be representative of the “normal” schedule for each of the buildings and may or may not be simultaneous. The submetering dates for each building must be identified on each set of data. The analyst will perform HVAC simulation modeling on the collected data to determine the annual equipment energy balance for each building. In some cases, the local utility may be able to assist in the submetering.

2. Electrical Submetering

a. ***Buildings With Existing Submeters that Measure Electrical Demand (KW) and Electricity Consumption (kWh***)

The facility staff or analyst will: (1) obtain 12 continuous months of electrical demand and electricity consumption data and (2) correlate the hourly readings with the electrical demand data, **or** collect electrical consumption and demand information for this building and record the hourly demand readings for at least two weeks.

b. ***Buildings with No Electrical Submeters***

The analyst or facility staff will: (1) install a temporary submeter for at least two weeks in the building and (2) collect electrical consumption and demand information for this building and record the hourly demand readings during the sampling period.

c. Swimming Pool Complex

If the complex is not submetered, then the analyst or facility staff will: (1) take one time measurements (e.g. measuring amperage and voltage or power consumption) for all equipment that operates 24 hours per day (e.g. pool pump) (2) indicate whether the measurements are based on line or phase current, and (3) identify the equipment and record the capacity (name plate) and the annual operating hours for equipment not operating 24 hours per day.

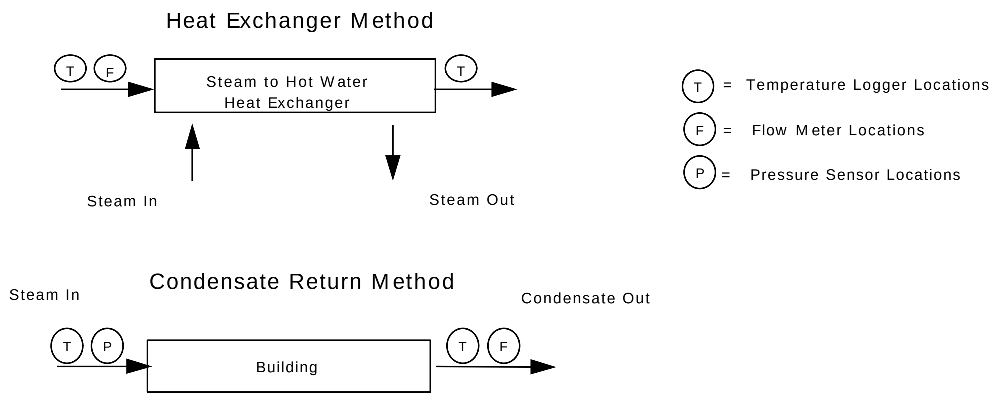
3. Hot Water Submetering

If a central boiler provides steam or hot water for space heating to several buildings, but there are no submeters to meter steam or hot water to each building, then the analyst or facility staff will do the following:

a. Steam or Hot Water Fed to Heat Exchangers in the Buildings

If the steam goes through a heat exchanger and heats up the hot water in the hot water loop of each building, install either: 1) flow or Btu meters on the hot water side of each heat exchanger, or 2) flow or Btu meters on the condensate return line to determine the Btu consumption. The data collected will be used by the analyst to perform an hourly heating simulation for the buildings, relative to the outside air temperature. Figure 2-6 shows a schematic of the flow meter, temperature logger and pressure sensor locations for the heat exchanger and condensate return methods.

Figure 2-6 Steam or Hot Water Submetering



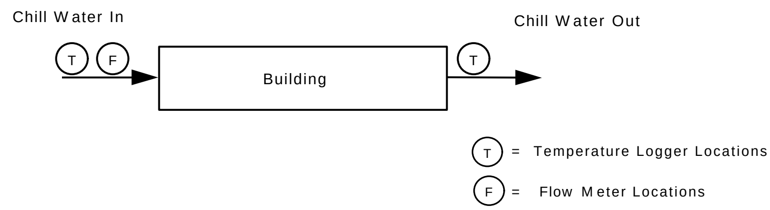
b. Swimming Pool Metering

If a boiler provides heat for a swimming pool and space heat for buildings through heat exchangers, the analyst or facility staff will install a flow meter on the swimming pool heat exchanger similar to that previously described for buildings. The collected data will be used by the analyst to perform a heating simulation model of the pool. The flow data will need to be collected for at least two weeks.

4. Chilled Water Submetering

The chilled water energy baseline can be determined similar to the hot water submetering discussed on page 2-16. The analyst will install a flow meter on the chilled water branch leading to the building for at least two weeks. Figure 2-7 shows a schematic of the location of the flow meter and the temperature logger.

Figure 2-7
Chill Water Submetering



5. Outside Air Temperature Measurements

A temperature logger must be installed in one of the buildings to record hourly temperature during the submetering period. The location should be in a shady area, free of solar and wind interference.

6. Current Utility Bills

The analyst will correlate the submetered information to the facility's total annual electrical and gas consumption (Appendix A).

a. Occupancy Hours and Load

For the buildings submetered, the analyst will indicate the typical occupancy period (e.g., 6am to 10pm, weekdays, 8am to 5pm weekends) and occupancy load (e.g., 200 staff).

b. Building Simulation Modeling

The analyst must use one of the following computer programs to develop an annual energy use profile using the submetered data:

- DOE 2.1-based models (e.g., Visual DOE, Power DOE)
- HAP (Hourly Assessment Program), Carrier Corporation
- TRACE 600, Trane Company
- Modified Temperature Bin Models per ASHRAE
- RSPEC (Reduced Swimming Pool Energy Cost) for swimming pools only, U.S. Department of Energy

5. Energy Using Systems (required of comprehensive and energy generation project studies)

A. Lighting Systems

1. Discuss the current type of lighting and the operating characteristics (e.g., 4-tube energy saver (34W) lamps with energy saving ballasts) on a building-by-building basis. Identical lighting systems can be aggregated (e.g., Buildings A and C are lighted with 75W incandescent lamps).

2. Indicate the current light levels based on net footcandle measurements for various areas within the facility. Net footcandles are measured light levels which exclude day-lighting. During the day, net footcandle measurements are determined by comparing the difference in light levels when the lights are turned on and off. At night, the net footcandles can be determined with the lights on. Discuss whether these light levels are within Illuminating Engineering Society (IES) specifications. Table 2-3 lists some IES recommended light levels for some areas. For other areas, refer to the the latest edition of the IES Lighting Handbook.

3. Discuss how the recommended EEMs will solve the facility's lighting problems.

B. Heating, Ventilating and Air Conditioning Systems (HVAC)

1. For each building, discuss the type of HVAC systems, the operating characteristics and controls for each HVAC system.

2. Discuss the problems with the current HVAC systems, if any, and whether the study recommendations would correct these problems. Include any measurements (e.g., boiler stack gas temperature) and efficiency calculations to substantiate the need for corrective action.

C. Other Energy Using Systems

1. Discuss the type of domestic hot water (DHW) system, the operating characteristics, the buildings served by each system and how the units are controlled. Discuss whether any recommended measure would solve any existing DHW system problem.

2. If the facility has sterilizers, laundry, kitchen, swimming pools, or other energy using systems that are a major portion of the energy use (e.g., 5 percent or more), then indicate the electrical and/or thermal load requirements and type of equipment and the frequency of operation.

Table 2-3
IES Recommended Average Light Levels for Selected Areas[1]

Type of Location	*Illuminance Category*[2]	*Range of Footcandles*
SCHOOL		
Classrooms/Lecture Rooms	D	30-50
Library	E	50-100
Science Lab	E	50-100
Drafting	E	50-100
Shops	E	50-100
Gym	D	20-30
Office	D	30-50
Corridors	C	10-20
Kitchen	E	50-100
Cafeteria (Dining)	B/C	5-20
Restrooms	C	10-20
HOSPITAL		
Exam Rooms	E	50-100
Nurses' station	D	30-50
Laboratories	E	50-100
Office	D	30-50
Stairways	C	10-20
Corridors	C	10-20
Medical Records	E	50-100
Lobby	C	10-20
Patient Rooms	B	5-10
Pharmacy	E	50-100
Surgical Suite	F	100-200
CITY/COUNTY		
Court Rooms	C	10-20
Jail Cells	D	30-50
Elevators	C	10-20
Libraries	E	50-100
Offices	D	30-50
Auditoriums/Exhibition Halls	C	10-20
Conference Rooms	D	30-50
Fire Stations	D	30-50
Lobbies/Reception Area	C	10-20
Electronic Data Processing (keyboard reading)	D	30-50

Notes:
[1.] Extracted from *Lighting Handbook*, Illuminating Engineering Society of North America1993 Application Volume
[2.] Reference Work-Plane
A, B, C -- General lighting throughout spaces
D, E, F -- Illuminance on task

6. On-Site Electricity and Energy Generation

Describe the electricity and/or energy generation system, if one exists, and how it operates to reduce energy use/cost. Provide information in the following areas:

- Capacity
- Heat rate or power/energy generation efficiency
- Amount of energy recovered
- Fuel type used
- Actual annual operating hours
- Annual operating costs, including fuel and maintenance costs
- Amount of displaced energy (e.g., kWh and therms) and energy cost avoided by the facility
- If the electricity or heat is sold, indicate the amount sold, the sale price and the type of utility contract, if applicable.

7. Technical Project Summaries (required of all studies)

This section discusses the study requirements for different categories of EEMs. Part 3 of this Guide, pages 3-1 to 3-6, provides information on the order for evaluating various energy efficiency measures. Analyst can follow this project evaluation order or use another based on the equipment replacement needs of the facility. The main point is to evaluate projects in a logical order based on implementing the least costly items first, such as operation and maintenance improvements rather than equipment replacement.

This section determines project economics using simple payback. The simple payback calculation only considers the project cost and the first year annual energy cost savings. The cost savings do not include any non-energy savings, such as maintenance or environmental benefits. A more accurate method of calculating project economics is to use life cycle cost. This methodology considers annual operation and maintenance cost over the life of the equipment. The analyst should refer to Part 7, pages 7-1 to 7-16, for information on life cycle costs, maintenance cost and equipment life for various types of EEMs.

A. **Building Envelope EEMs** (see Part 4, pages 4-1 to 4-4, for a listing of typical projects) - the minimum information requirements include:

1. Discussion of the existing conditions and the rooms and/or buildings to be affected by the EEM.

2. Discussion of the proposed modification and the energy savings and benefits. Discuss any non-energy benefits, physical constraints and/or other considerations.

3. A reference to the specific appendix where the reader can find detailed information on assumptions, calculations and detailed project savings and costs. For specific calculation requirements, refer to Appendix C (pages 2-C-1 to 2-C-5 and 2-C-30 to 2-C-35).

4. Provide a summary table containing the following:

   a. Annual electric savings (kWh/year), if applicable, rounded to the nearest whole number
   b. Peak demand reduction (kW/month), if applicable, rounded to the nearest whole number
   c. Annual natural gas or fuel savings (therms/year), if applicable, rounded to the nearest whole number
   d. Annual energy cost savings ($/year) rounded to the nearest whole dollar
   e. Installed project cost rounded to the nearest whole dollar
   f. Simple payback (years) rounded to the nearest one decimal place

5. Indicate any expected increases or decreases in maintenance cost or time associated with the project.

6. Discuss the expected life of recommended new equipment.

B. Lighting EEMs for Buildings (see Part 4, pages 4-1 to 4-4 for a listing of typical projects) - minimum information requirements include:

1. Discussion of the existing conditions and the rooms and buildings affected by the EEM. Identify the current type of fixtures, the net footcandle measurements (page 2-18) and the observed or reported hours of operation. The analyst must comment on whether the light levels meet the IES recommended standard (Table 2-3, page 2-19) for the task. Explain any problems with the existing equipment.

2. Discussion of the proposed modification and the energy savings and benefits resulting from the proposed modification. Include a discussion of:

   a. The new anticipated light levels (if lamps and fixtures changed) and the percent reduction in operating hours (if occupancy sensors are installed); and
   b. Any non-energy benefits, physical constraints and/or considerations.

   If the proposed EEM is not recommended, then specify the reasons.

3. A reference to the specific appendix where the reader can obtain detailed information on assumptions, calculations and detailed project savings and cost. For specific calculation/analytical requirements, refer to Appendix C, pages 2-C-5 to 2-C-9 and 2-C-30 to 2-C-35 .

4. A table summarizing the following:

   a. Annual electric savings (kWh/year) rounded to the nearest whole number
   b. Peak demand reduction (kW/month) rounded to the nearest whole number
   c. Annual energy cost savings ($/year) rounded to the nearest whole dollar
   d. Installed project cost rounded to whole dollars
   e. Simple payback (years) rounded to the nearest one decimal place

5. An estimate of the useful life of each EEM.

6. Indicate any expected increases or decreases in maintenance cost or time associated with the project.

7. Other Considerations - If air conditioning savings are claimed for any lighting projects, then the calculations must be included in Appendix C of the feasibility study. The calculations must identify the reduction in seasonal cooling load due to reduced internal heat gain and the corresponding heating energy penalties. Refer to Part 5 for information on lighting and air conditioning loads.

   By implementing the lighting EEMs, the electrical load for the facility will be reduced. This "new" facility electrical load will be the baseline for considering the initial HVAC energy efficiency projects. For additional information, refer to Part 3, pages 3-1 to 3-6.

C. **Lighting EEMs associated with traffic signals and streetlights** - minimum information requirements include:

1. Discussion of the existing condition and the number of street lights or traffic signals affected by the EEMs. Identify the current lamp type and wattages, and the observed or reported operating hours.

2. Discussion of the proposed modification including the energy savings and project benefits, physical constraints and/or other considerations.

3. A reference to the specific appendix where the reader can review the assumptions and calculations of project savings and cost. For specific calculations, refer to Appendix C, pages 2-C-5 to 2-C-9 and 2-C-30 to 2-C-35.

4. A table summarizing the following:

   a. Annual electric savings (kWh/year) rounded to the nearest whole number
   b. Peak demand reduction (kW/month) rounded to the nearest whole number
   c. Annual energy cost savings ($/year) rounded to the nearest whole dollar
   d. Installed project cost rounded to whole dollars
   e. Simple payback (years) rounded to the nearest one decimal place

5. An estimate of the useful life of each EEM.

6. Indicate any expected increases or decreases in maintenance cost or time associated with the project.

D. **Domestic Hot Water EEMs** (see Part 4, pages 4-1 to 4-4, for typical projects) - minimum information requirements include:

1. Discussion of the existing conditions, and the rooms and buildings affected by the EEM. The analyst must comment on what energy problem, if any, is caused by the current conditions and the condition of the existing equipment.

2. Discussion of the proposed modification, the energy savings and benefits, physical constraints and/or other considerations. If the proposed EEM is not recommended, then the reason(s) must be specified.

3. A reference to the specific appendix where the reader can find detailed information on assumptions, calculations and detailed project savings and cost. Refer to Appendix C, pages 2-C-10 to 2-C-13 and 2-C-30 to 2-C-35, for the specific analytical/calculation requirements.

4. A summary table of the following project findings:

   a. Annual electric savings (kWh/year), if applicable, rounded to nearest whole number
   b. Peak demand reduction (kW/month), if applicable, rounded to the nearest whole number
   c. Annual natural gas or fuel savings (therms/year), if applicable, rounded to the nearest whole number
   d. Annual energy cost savings ($/year) rounded to the nearest whole dollar
   e. Installed project cost rounded to the nearest whole dollar
   f. Simple payback (years) rounded to the nearest one decimal place

5. An estimate of the useful life of each analyzed EEM.

6. A statement indicating whether implementation of the recommended EEM would increase, decrease or have no effect on annual maintenance and operating costs compared to the existing installation.

7. If no DHW EEMs are feasible, then state the reasons and include substantiating site data, calculations or conditions, that the DHW system is operating at the most energy efficient levels. All DHW EEMs considered but not analyzed should be indicated in this section.

E. **HVAC EEMs** (see Part 4, pages 4-1 to 4-4, for a listing of typical projects) - minimum information requirements include:

1. Discussion of the existing conditions and the rooms and buildings to be affected by the EEM. Identify the current HVAC system, and the measured or estimated efficiencies. Indicate the observed or reported hours of operation and what energy problem, if any, is caused by the

current conditions. For built-up systems (HVAC systems that are purchased as components and constructed on-site), comment on whether the outside air flows and temperatures meet Title 24 or other standards. Indicate the condition of the existing equipment.

2. Discussion of the proposed modification and the energy savings and benefits resulting from the proposed modification. The analyst must comment on how the proposed modification would affect the temperature and ventilation flows of the affected HVAC systems. Include a discussion of the anticipated ventilation flow rates, the reduction in operating hours, and any physical constraints or considerations. Justify that the air flow meets the minimum requirements specified by the American Society of Heating , Refrigerating and Air-Conditioning Engineers, Incorporated (ASHRAE). Outside air flow rates must be determined by actual measurements or from data in the mechanical drawings.

3. A reference to the specific appendix where the reader can obtain information on assumptions, calculations and detailed project cost. Refer to Appendix C, pages 2-C-13 to 2-C-20 and 2-C-30 to 2-C-35, for the specific analytical/calculation requirements.

4. A table summarizing the following:

   a. Annual electric savings (kWh/year), if applicable, rounded to the nearest whole number
   b. Peak demand reduction (kW/month), if applicable, rounded to the nearest whole number
   c. Annual natural gas or fuel savings (therms/year), if applicable, rounded to the nearest whole number
   d. Annual energy cost savings ($/year) rounded to the nearest whole dollar
   e. Installed project cost rounded to the nearest whole dollar
   f. Simple payback (years) rounded to the nearest one decimal place

5. An estimate of the useful life in years of each EEM.

6. A statement indicating whether implementation of the recommended EEM(s) would increase, decrease or have no effect on annual maintenance and operating costs compared to the existing installation. The annual maintenance and operating costs must be quantified if additional and/or specialized maintenance will be needed.

7. If no HVAC EEMs are feasible, then state the reasons and include substantiating data, calculations, or other justification that the existing system is operating at the most energy efficient levels. All

EEMs considered but not evaluated should be identified in this section along with the justification.

F. **On-Site Electricity and Energy Generation** (see Part 4, pages 4-1 to 4-4, for a listing of projects) - minimum information requirements include:

1. Discussion of the existing conditions and buildings affected by the project. Identify the current HVAC and DHW systems to be affected, and any specific energy-related problems with these systems.

2. Discussion of the proposed modification, the energy savings and benefits resulting from the proposed modification. Identify any physical constraints or regulatory permitting considerations that may prevent successful implementation. If the proposed project is not recommended, then specify the reasons.

3. A reference to the specific appendix containing assumptions and detailed project calculations of savings and cost. Refer to Appendix C, pages 2-C-21 to 2-C-35 for the specific requirements.

4. A table summarizing the following:

    a. Annual electricity savings (kWh/year) rounded to the nearest whole number
    b. Annual electricity generation for resale (kWh/year) rounded to the nearest whole number
    c. Peak demand reduction (kW/month) rounded to the nearest whole number
    d. Annual natural gas or fuel savings (therms/year) rounded to the nearest whole number
    e. Annual energy generation fuel use (therms/year) rounded to the nearest whole number
    f. Annual energy cost savings ($/year) rounded to the nearest whole dollar
    g. Installed project cost rounded to the nearest whole dollars
    h. Simple payback (years) rounded to the nearest one decimal place

5. An estimate of the useful life of the recommended project in years.

6. A statement indicating whether implementation of the energy generation project would increase, decrease or have no effect on annual maintenance and operating costs compared to the existing installation. Provide an estimate of the annual maintenance and operating costs for the recommended energy generation project.

APPENDIX A - BASELINE ENERGY USE

Appendix A consists of two parts: Part A involves determining the baseline energy use and energy cost. Part B involves calculating the weighted utility rates for for various EEMs.

A. Determining Baseline Energy Use and Cost

Each feasibility study shall contain the following:

1. A table showing the most representative, consecutive, available 12 months of energy use by energy type. The period will end with the most recent utility bill at the time of the site survey. Three sample tables (Tables A-1 to A-3) have been provided to illustrate the information needed for different energy types and rate schedules. Table A-1 is for natural gas baseline energy use. Tables A-2 and A-3 are for different electric rate schedules. Use either these tables or develop new tables with the same information.

2. Facilities using propane or oil can use the natural gas table (Table A-1), but identify the months fuel was delivered and the energy charge, excluding any customer charges. Omit minimal propane or oil use, such as less than 1 percent of total annual use (natural gas plus propane fuel).

3. Copies of all energy utility rate schedules applicable at the time of the site survey.

4. A copy of the most recent month's utility bill for each account/meter.

5. For feasibility studies covering only a few buildings, complete one table for the entire facility (all buildings on the same meter) and one table for the specific buildings covered in the feasibility study.

Table A-1
SAMPLE FORMAT
BASELINE ENERGY USE

NATURAL GAS[1]

Facility:___________ AFFECTED BUILDINGS:______________________
UTILITY: San Diego Gas and Electric (SDG&E)

Gas Account No.					Rate Schedule: GN-1			
Month	Year	Season[2]	Energy Use[3] Tier 1, Therms	Energy Use[3] Tier 2 Therms	Total Energy Use, Therms	Procurement Charges [4] ($)	Transportation Charges [4] ($)	Historical Energy Cost[5] ($)
Feb.	1999							
Mar.								
Apr.								
May								
Jun.								
Jul.								
Aug.								
Sept.								
Oct.								
Nov.								
Dec.								
Jan.	2000	W	3000	3456	6456			3620
Total								

FOOTNOTES:

1. One table must be completed for each natural gas utility account. If the facilities use other fuel, such as propane or oil, the amount of delivered fuel volume for the most recent 12 months must be indicated in the Total Energy Use column. If a few buildings are studied but there are other buildings on the same meter, complete one table for the entire facility which is on the same meter and one table for the buildings included in the study. Indicate in a footnote how the energy use was calculated for these buildings (see pages 2-14 to 2-17).

2. Seasons vary from utility to utility, indicate summer (S) or winter (W) rates.

3. Indicate the amount of natural gas used in each tier. If the facility is not on a tiered rate schedule, then provide total electricity consumption in the column labeled Total Energy Use.

4. Procurement and Transportation charges are applicable only if natural gas is purchased from a third party gas supplier (e.g., Spurr or Remac). Procurement charges are paid to the third party supplier for natural gas. Transportation charges are generally paid to the local gas utility for transporting the gas through their pipelines. If natural gas is purchased from your local gas utility, leave these two columns blank.

5. Identify the amount paid for natural gas including procurement and transportation costs from the actual utility bills for the period covered by the 12-month period indicated in the month and year columns. Indicate these actual billings in the column labeled Historical Energy Costs. Attach a copy of one of the utility bills, and a copy of the rate schedule applicable at the time of the audit.

Table A-2
SAMPLE FORMAT
BASELINE ENERGY USE

ELECTRICITY FOR NON-TIME-OF-USE RATE SCHEDULES[1]

Facility:________________ AFFECTED BUILDINGS:___________________
UTILITY: Southern California Edison (SCE)

Electric Account No.:				Rate Schedule: GS-2				
Month	Year	Season[2]	Maximum Demand[3] (kW)	Non- Time Demand[3] (kW)	Energy Use[4] Tier 1 (kWh)	Energy Use[4] Tier 2 (kWh)	Total Energy Use (kWh)	Historical Electric Costs[5] ($)
Feb.	1999							
Mar.								
Apr.								
May								
Jun.								
Jul.								
Aug.								
Sept.	1999	S	250	250	75000	5040	80040	10526
Oct.								
Nov.								
Dec.								
Jan.	2000							
Total								

FOOTNOTES:
1. One table must be completed for each account number. This form only applies to meters billed on non-time-of-use rate schedules. If a few buildings are studied but there are other buildings on the same meter, complete one table for the entire facility which is on the same meter and one table for the buildings included in the study. Indicate in a footnote the method of calculating the electricity use in these buildings (see pages 2-14 to 2-17).

2. Seasons vary from utility to utility, indicate summer (s) and winter (w) rates.

3. Identify the time related and non-time related maximum demands for each month as provided in the utility bill.

4. Indicate the amount of electricity used in each tier. If the facility is not on a tiered rate schedule, then provide total electricity consumption in the column labeled Total Energy Use.

5. Identify the amount paid for electricity from the actual utility bills for the period covered by the 12-month period indicated in the month and year columns. Indicate these actual billings in the column labeled Historical Electric Cost. Attach a copy of one of the utility bills, and a copy of the rate schedule applicable at the time of the site survey.

Table A-3
SAMPLE FORMAT
BASELINE ENERGY USE

ELECTRICITY - TIME-OF-USE RATE SCHEDULES[1]

Facility:__________________ AFFECTED BUILDINGS:__________________

UTILITY: Southern California Edison (SCE)

Electric Account No.:				Rate Schedule: TOU-8						
Mon	Year	Season[2]	Maximum Demand[3] (kW)	On-Peak Demand[4] (kW)	Mid-Peak Demand[4] (kW)	On-Peak Energy Use[5] (kWh)	Mid-Peak Energy Use[5] (kWh)	Off-Peak Energy Use[5] (kWh)	Total Energy Use[6] (kWh)	Historical Electric Costs[7] ($)
Feb	1999									
Mar										
Apr										
May										
Jun										
Jul										
Aug										
Sep										
Oct										
Nov										
Dec										
Jan.	2000	W	735			None	75200	95000	170200	13,689
Tot										

FOOTNOTES:

1. One table must be completed for each account number. This form only applies to meters billed on time-of-use rate schedules. If a few buildings are studied but there are other buildings on the same meter, complete one table for the entire facility which is on the same meter and one table for the buildings included in the study. Indicate in a footnote the method of calculating the electricity use in these buildings (see pages 2-14 to 2-17).

2. Seasons vary from utility, indicate summer (s) and winter (w) rates.

3. Identify the maximum demand for each month as indicated on the utility bill.

4. Identify the on- and mid-peak demand (if applicable) as indicated on the utility bill. If this information is not available on the utility bill or from the utility company, then indicate how the on- and mid-peak demands were calculated as a footnote to the table.

5. Indicate the total kWh used in the on, mid and off-peak periods as indicated on the electric bill.

6. Calculate the total energy use for each month. The total is the sum of the on-peak, mid-peak and off-peak energy use.

7. Identify the amount paid for electricity from the actual utility bills for the period covered by the 12-month period in the month and year columns. Indicate these actual billings in the column labeled Historical Electric Cost. Attach a copy of one of the utility bills, and a copy of the rate schedule applicable at the time of the site survey.

B. Calculating the Weighted Average Utility Rates

Utility rates vary with time and season. These variances need to be reflected in the energy rates used to calculate cost savings for EEMs. For example, when replacing exterior lights, the savings calculations should include only a combination of off- and mid-peak rates. It is inaccurate to use average annual rates because the average rate includes on-peak and demand cost. These costs are not offset by improvements to exterior lights used during off-peak periods.

1. Electricity Rate Schedules

a. Demand Savings

Utilities generally charge demand rates for maximum kW demand or peak demand occurring during different rate periods of the billing month. If an EEM can reduce kW demand during the facility's peak operating hours, then demand charges can be saved. Table A-4a identifies the typical EEMs with demand charge savings, and provides an example for calculating the weighted average demand cost.

b. Energy Savings

(1) For facilities on time-of-use rate schedules, the analyst must calculate the weighted average utility rates to be used to calculate the energy cost savings for the EEMs in the feasibility study. The use of average rates is ***not acceptable***. Table A-4a provides some sample formulas of how the weighted average utility rates can be calculated for several typical EEMs. These formulas may need to be adjusted or modified to account for differences in equipment operating hours or actual energy use by the facility.

(2) For facilities on flat rate or tiered rate schedules, the following average rate formula can be used: [(total electric cost - total fixed charges - total demand charge)/total electricity use in kWh]. In some cases, the use of average rates for facilities on a tiered rate schedule may be inappropriate. In these instances the feasibility study must justify the rates to be used to calculate the energy cost savings for EEMs.

(3) If simulation models are used to derive the average electricity (electricity and demand) charges, use Table A-4b.

(4) The feasibility study must contain a table similar to Tables A-4a or A-4b which indicates the utility rates to be used for each EEM. The basis for the rates used must be referenced as a footnote.

2. Natural Gas Rate Schedules

a. For facilities on a tiered rate schedule, the analyst must calculate the weighted average utility rate used to calculate the EEM cost savings identified in the feasibility study. The use of average rates is unacceptable and if used by the analyst could result in rejection of the entire feasibility study. Table A-5a provides some sample formulas showing how the weighted average utility rates can be calculated for several typical EEMs. These formulas may need to be adjusted or modified to account for differences in equipment operating hours or actual energy use by the facility.

b. For facilities on a flat rate schedule, the analyst can use the following average rate formula: [(total calculated fuel costs - fixed charges) / total natural gas use in therms].

c. If simulation models are used to derive the average energy charges, use Table A-5b.

d. The feasibility study must contain a table similar to Tables A-5a or A-5b which indicates the utility rates to be used for each EEM. The basis for the rates used must be referenced as a footnote.

Table A-4a
SAMPLE FORMULAS FOR CALCULATING THE WEIGHTED AVERAGE ELECTRIC RATE FOR SELECTED EEMs

		Electricity Utility Energy Rate to Use in EEM Calculations ($/kWh)			Demand Rate Use Calculations ($/kW-month)
Energy Conservation Measure	Demand Savings (Y/N)	Time of Use Rate Schedule[1] Energy Rates	Tiered Rate[2] Schedule	Flat Rate Schedule	Time of Use Rate Schedule[1] Demand Rates
Exterior lights	No	[(Mid Peak Op. Hr./Total Op. Hr.) x Avg. MID Rate]+ [(Off Peak Op. Hr/Total Op. Hr.) x Avg. OFF Rate]	Average Tiered Rate	Average Flat Rate	No
Interior lights	Yes	[(On Peak Op. Hr./Total Op.Hr.)x ON Peak Rate] +[(Mid Peak Op. Hr./Total Op.Hr.)x Avg. MID Rate] +[(Off Peak Op. Hr./Total Op.Hr.)x Avg. OFF Rate]	Average Tiered Rate	Average Flat Rate	[(summer hours/total hours) x (summer peak rate + summer part peak rate + summer max demand rate)] + [(winter hours/total hours) x (winter part peak rate + max. demand rate)]
Motion sensors/ photocells	No	[(Reduced On Peak Hr./Total Red. Hr.) x ON Peak Rate] +[(Reduced Mid Peak Hr/Total Red. Hr.) x Avg.MID Rate] +[(Reduced Off Peak hr./Total Red. Hr.) x Avg. OFF Rate]	Average Tiered Rate	Average Flat Rate	No

NOTE:

1 Please use these tables, or other equivalent . Use the estimated hours of operation and actual rate schedules to calculate the average energy and demand charges. Indicate all the formulas as a footnote.
- ~ Op. Hr.= Daily or annual operating hours whichever applies
- ~ Red. Hr.= Reduced daily or annual operating hours whichever applies
- ~ ON = On-Peak or Peak Period rate in $/kWh
- ~ Avg. MID = Annual average Summer and Winter MID-Peak or Partial Peak rate in $/kWh
- ~ Avg. OFF = Annual average Summer and Winter OFF-Peak or OFF-Peak rate in $/kWh
- ~ max demand rate = Maximum Demand

2 If average tiered rates are inappropriate, the feasibility study must explain and justify the reason for using other rates.

Table A-4a - (Cont'd)
SAMPLE FORMULAS FOR CALCULATING THE WEIGHTED AVERAGE ELECTRIC RATE FOR SELECTED EEMs

		Electricity Utility Rate to Use in EEM Calculations ($/kWh)			Demand Rate Use Calculations ($/kW-month)
Energy Conservation Measure	Demand Savings (Y/N)	Time of Use Rate Schedule[1] Energy Rates	Tiered Rate[2] Schedule	Flat Rate Schedule	Time of Use Rate Schedule[1] Demand Rates
Energy management systems/time clocks	If yes, justify	[(Reduced On Peak Hr./Total Hr.) x ON Peak Rate] + [(Reduced Mid Peak Hr/Total Hr.) x Avg.MID Rate] + [(Reduced Off Peak hr./Total Hr.) x Avg.OFF Rate]	Average Tiered Rate	Average Flat Rate	No
Variable speed motors	No	[(Reduced On Peak Hr./Total Hr.) x ON Peak Rate] + [(Reduced Mid Peak Hr/Total Hr.) x Avg.MID Rate] + [(Reduced Off Peak hr./Total Hr.) x Avg.OFF Rate]	Average Tiered Rate	Average Flat Rate	No
Energy efficient motors	Yes	[(On Peak Op. Hr./Total Op. Hr.) x ON Peak Rate] + [(MID Peak Op. Hr./Total Op. Hr.) x Avg. Mid Rate] + [(OFF Peak Op. Hr./Total Op. Hr.) x Avg. Off Rate]	Average Tiered Rate	Average Flat Rate	[(summer hours/total hours) x (summer peak rate + summer part peak rate + summer max demand rate)] + [(winter hours/total hours) x (winter part peak rate + max. demand rate)]

NOTE:

[1] Op. Hr.= Daily or annual operating hours whichever applies
Red. Hr.= Reduced daily or annual operating hours whichever applies
ON = On-Peak or Peak Period rate in $/kWh
Avg. MID = Annual average Summer and Winter MID-Peak or Partial Peak rate in $/kWh
Avg. OFF = Annual average Summer and Winter OFF-Peak or OFF-Peak rate in $/kWh
max. demand rate = Maximum Demand

[2] If average tiered rates are inappropriate, then the feasibility study should specify and provide justification for the tiered rate used.

Table A-4b[1]
FORMAT FOR CALCULATING THE AVERAGE ELECTRIC RATE USING SIMULATION MODELS

Energy Conservation Measure	Rate Schedule[2]	Simulation Model[3]	Average Energy[4] Rates ($/kWh)	Reference Page for EEM Cost Savings[5]	Reference Page for EEM Electricity (kWh) Savings[6]
Interior Lights	TOU-8	DOE 2.1E	0.13	A-25	A-26
Exterior Lights					
Motion Sensors/Photocells					
Energy Management Systems/Time Clocks					
Variable Speed Motors					
Energy Efficient Motors					

Notes:

1. Use this table if simulation models are used to derive the average energy and demand rates. Use simulated EEM operating hours and actual rate schedules.
2. Specify the applicable rate schedule(s).
3. Specify the simulation model used to derive the average rates.
4. Average Energy Rate is the average cost of energy, including energy and demand charges, used by the simulation model to derive the EEM's energy cost savings.
5. Specify the page number of the report where the EEM cost savings, calculated by simulation model, can be found.
6. Specify the page number of the report where the EEM kWh savings, calculated by simulation model, can be found.

Table A-5a

SAMPLE FORMULAS FOR CALCULATING THE WEIGHTED AVERAGE FUEL RATE FOR SELECTED EEMs

	Gas Rate to Use in EEM Calculations ($/therm)	
Energy Conservation Measure	Tiered Rate Schedule[1]	Flat Rate Schedule
Energy management systems/time clocks	$(T_1/\text{Total}) \times ((S_1 + W_1)/2) +$ $(T_2/\text{Total}) \times ((S_2 + W_2)/2)$	Average Rate
Boiler replacement	$(T_1/\text{Total}) \times ((S_1 + W_1)/2) +$ $(T_2/\text{Total}) \times ((S_2 + W_2)/2)$	Average Rate

NOTE:

[1] T1 = Total Reduced Annual Tier 1 natural gas usage
T2 = Total Reduced Annual Tier 2 natural gas usage
Total = Total Reduced Annual natural gas usage
S1 = Summer Tier 1 rate in $/therm
W1 = Winter Tier 1 rate in $/therm
S2 = Summer Tier 2 rate in $/therm
W2 = Winter Tier 2 rate in $/therm

Table A-5b[1]
FORMAT FOR CALCULATING THE AVERAGE NATURAL GAS RATE USING SIMULATION MODELS

Energy Conservation Measure	Rate Schedule[2]	Simulation Model[3]	Average Energy[4] Rates ($/Therm)	Reference Page Number for Energy Cost Savings[5]	Reference Page Number for Natural Gas (therm) Savings[6]
Energy management system	G-NR1-Gas	DOE 2.1E	0.57	A-27	A-28
Boiler Replacement					

Notes:

1. Use this table if simulation models are used to derive the average natural gas rates. Use simulated EEM operating hours and actual rate schedules.
2. Specify the applicable rate schedule(s).
3. Specify the simulation model used to derive the average rates.
4. Average Energy Rate is the average cost of natural gas, used by the simulation model to derive the EEM's energy cost savings.
5. Specify the page number of the report where the EEM cost savings, calculated by simulation model, can be found.
6. Specify the page number of the report where the EEM therm savings, calculated by simulation model, can be found.

APPENDIX B - ENERGY BALANCE

The purpose of the energy balance is to compare the surveyed facility energy use to the metered facility energy use. This comparison helps the analyst in determining the reasonableness of the baseline energy use assumptions. The accuracy of the baseline assumptions is critical in correctly evaluating and estimating the energy savings for the recommended EEMs. **This Appendix includes 12 energy balance summary tables which must be completed for comprehensive and energy generation project studies. For all other projects, please refer to Table 1-1, Page 1-4, to determine which tables must be completed in this Appendix.**

A. General Instructions

All calculations used to estimate the amount of energy used for operating HVAC and lighting equipment must be justified by one or more of the following methods: 1) actual measurements (such as flue gas analysis, temperature, footcandle readings), 2) installation of run hour meters, or 3) load profiles based on site data, or on-site observations. The specific method used must be substantiated with the equipment duty factor, equipment efficiency, hours of operation and other data, as appropriate, in the feasibility study.

Various building simulation models can be used to analyze current energy consumption and potential projects. Part 6 contains information on how to obtain copies of the following main building simulation models:

- DOE 2.1-based models (e.g., Visual DOE, Power DOE), U.S. Department of Energy
- HAP (Hourly Assessment Program), Carrier Corporation
- Trace 600, The Trane Company
- Modified Temperature Bin Models per ASHRAE
- RSPEC (Reduce Swimming Pool Energy Cost, for swimming pools only), U.S. Department Of Energy

B. Report Requirements for DOE 2.1

1. Summary of Proposed Energy Use

For each building, provide a summary table delineating the current base energy and the proposed energy use after implementation of the proposed EEM (lights, VAV, EMS, etc.). The following is a sample summary table:

Building Name:		
Base Energy Usage Before EEM Implementation (Appendix A): 1,100,000 kWh		
Proposed EEM*	**New Baseline Energy Use (kWh)***	**Energy Saved (kWh)**
New Lighting	900,000	200,000
VAV System	750,000	150,000
EMS	600,000	150,000

* The order of the EEMs should follow Part 3, pages 3-1 to 3-6. The above table assumes that all EEMs are implemented in the order shown. For example, the lighting project saves 200,000 kWh resulting in a new electricity baseline of 900,000 kWh (1,100,000 - 200,000).

2. Summary of Specific Input and Output Reports

Provide a summary of the specific input and output reports generated for each building and project type (new lighting, VAV, EMS, etc.).

3. Required Reports

The following reports must be organized by building and included in Appendix B (input of the baseline parameters) and Appendix C (simulated output reports to justify EEM savings and cost) of the feasibility study:

- BDL, Building Description Language
- LS-B, Loads Simulation, Port B
- SV-A, Systems verification, Port A
- PV-A, Plant verification, Port A
- PS-C, Equipment Part Load Operation
- PS-G, Electrical Load Scatter plot

C. Report Requirements for HAP

1. Summary of Proposed Energy Use

For each building, provide a summary table delineating the current base energy and the proposed energy use after implementation of the proposed EEM (lights, VAV, EMS, etc.). The following is a sample summary table:

Building Name:		
Base Energy Usage Before EEM Implementation (Appendix A): 1,100,000 kWh		
Proposed EEM*	**New Baseline Energy Use (kWh)***	**Energy Saved (kWh)**
New Lighting	900,000	200,000
VAV System	750,000	150,000
EMS	600,000	150,000

* The order of the EEMs should follow Part 3, pages 3-1 to 3-6. The above table assumes that all EEMs are implemented in the order shown. For example, the lighting project saves 200,000 kWh resulting in a new electricity baseline of 900,000 kWh (1,100,000 - 200,000).

2. Summary of Specific Input and Output Reports

Provide a summary of the specific input and output reports by building.

3. Required Reports

The following reports must be organized by building and included in Appendix B (input reports of the baseline parameters) and Appendix C (simulated output reports to justify EEM savings and cost) of the study:

a. Air System Simulations
- Monthly Data
- Sizing Equipment

b. Plant Simulations
- Monthly Data

c. Building Simulations
- Annual Component Costs
- Annual Energy Costs
- Monthly Energy Costs
- Monthly Energy Use by Energy Type

d. Verification Reports
- Design Weather Parameters (input) (one page summary)
- Simulation Weather Data (input) (one page summary)
- Schedules (input and output) (people, lights, and equipment)
- Construction Material (input)
- Utility Rates (input)
- Space (input)
- Air System (input and output)
- Plant (input and output)

4. **Organization of HAP Reports** - Organize the reports by building as follows:

   a. ***Common Data*** - If each building is the same, include the data in a common data file; if each building is different, include the information with the input data for each building:
      - Wall Construction
      - Roof
      - Window
      - Electric
      - Gas

   b. ***Input Data***
      - Weather Data and Schedules
      - Building Data
      - Space Data
      - Air System Data
      - Plant Data

   c. ***Output Data***
      - Existing Building Output Data
      - Re-run building data with each new EEM (e.g, lighting, VAV, EMS)

C. Report Requirements for Trace 600

1. Summary of Proposed Energy Use

For each building, include a summary table delineating the current base energy and the proposed energy usage after implementation of the proposed EEM (lights, VAV, EMS, etc.). The following is a sample summary table:

Building Name:		
Base Energy Usage Before EEM Implementation (Appendix A): 1,100,000 kWh		
Proposed EEM*	**New Baseline Energy Use (kWh)***	**Energy Saved (kWh)**
New Lighting	900,000	200,000
VAV System	750,000	150,000
EMS	600,000	150,000

* The order of the EEMs should follow Part 3, pages 3-1 to 3-6. The above table assumes that all EEMs are implemented in the order shown. For example, the lighting project saves 200,000 kWh resulting in a new electricity baseline of 900,000 kWh (1,100,000 - 200,000).

2. Summary of Specific Input and Output Reports

Provide a summary of the specific input and output reports generated for each building and EEM.

3. Required Reports

The following reports must be organized by building and included in Appendix B (input reports of the baseline parameters) and Appendix C (simulated output reports to justify EEM savings and cost) of the study:

a. Model Input

- climate information
- building parameters
- time of day operating schedule
- people/lighting/appliance/miscellaneous loads and schedule
- air handling/cooling/heating equipment description
- assignment and operating schedule
- part load and full load energy consumption
- building energy management system controls

b. Simulation Output (Baseline)

- monthly utility costs
- energy use summary
- monthly energy consumption
- system summary
- equipment energy consumption
- associated energy saving spreadsheets for pre- and post-EEM installation

D. Energy Balance Calculations

A complete energy balance must be performed for comprehensive feasibility studies and energy generation project studies. The balance includes all major energy using equipment within a facility. Refer to Table 1-1, Page 1-4 to determine which energy balance tables must be completed.

1. Lighting

If a lighting energy balance is required per Table 1-1, then either Table B-2a or B-2b must be completed. The following minimum information must be indicated in Table B-2a, on page 2-B-11, for current operating conditions:

a. Fixture type
b. Number of fixtures
c. Watts/lamp
d. Ballast type

e. Watts/fixture

f. Annual operating hours - identify the annual operating hours for each usage pattern separately

In lieu of Table B-2a, the analyst can complete Table B-2b if no lighting EEMs are recommended. The analyst can use the watts/square foot (W/sf) constant from the *ASHRAE Handbook of Fundamentals* to estimate the lighting power density.

2. HVAC

If an energy balance for the HVAC equipment must be completed per Table 1-1, page 1-4, this section will discuss the minimum requirements for determining baseline energy use. Some typical efficiency and load information for various types of equipment is contained in Part 5 (pages 5-1 to 5-7). The analyst can use this information if substantiation is provided to confirm that the actual conditions are consistent with the factor(s) in Part 5.

a. All HVAC Systems Except Single Zone Units

(1) Simulation models must be used for each central chiller/boiler, variable air volume, dual duct and/or multizone unit. Acceptable simulation models are listed on page 2-B-1.

(2) The following must be provided for each model used:

(a) The name of the program used

(b) The input baseline data including all equipment operating assumptions and constants for each building and for each HVAC system. For DOE 2.1, HAP or Trace 600, refer to the specific requirements on pages 2-B-1 to 2-B-5.

(c) The weather data including the source

(d) Default values

b. Requirements for Single Zone Units

(1) Simulation models are not required for single zone packaged units (gas/electric, heat pumps) or split systems serving only one zone (e.g., classroom, office)

(2) Energy use must be determined based on field data, equipment size, hours of operation and assumed duty cycle. Substantiate how the energy use was calculated.

3. EEMs Recommending HVAC Replacements or Switching Fuels

Simulation models are required if the feasibility study analyzes projects involving packaged unit/split system replacements, or switching the type of HVAC fuel currently used (e.g., electric resistance heating to gas furnace). The new project baseline hours must correspond to the energy balance calculations in this Appendix.

4. Domestic Hot Water/Miscellaneous Equipment

It is unnecessary to identify and account for all DHW and miscellaneous equipment, unless there is an EEM affecting the operations of this equipment, or if the facility operates a large commercial laundry and/or kitchen.

Calculations of the miscellaneous energy use can be based on standard constants found in the latest editions of the *ASHRAE Handbook of Fundamentals* or the *Means Electrical Cost Data*.

RSPEC swimming pool simulation model available from the U.S. Department Of Energy may be used to model and evaluate swimming pool EEMs.

E. Annual Equipment Operating Hours

The annual hours of operation for all equipment (HVAC, lighting, and others) must be justified in the feasibility study. The method of justification must be discussed and substantiated with copies of annual schedules, equipment operating logs or other sources of verification.

F. Energy Balance Tables

Please refer to Table 1-1, Page 1-4, to determine which energy balance tables must be completed from pages 2-B-10 to 2-B-22.

1. Balance Summary

Table B-1 compares the annual audited use with the actual use from the utility bills tabulated in Appendix A. The ratio between audited and the actual should be close to 95 percent. However, this ratio cannot exceed 100 percent.

2. Electricity Balance

a. The electricity balance identifies the electricity used for lighting, HVAC and other equipment. The analyst can either use the electricity balance spreadsheets on Tables B-2 to B-7, pages 2-B-11 to 2-B-17, or use their own spreadsheets if they contain the same information. These or similar tables must be completed even if building simulation programs (i.e., DOE 2.1E, etc.) are used.

b. Tables B-2a/B-2b to B-7 are intended to summarize the specific calculations/simulations of existing lighting, HVAC and other systems.

   (1) Provide copies of the simulation models showing the inputs and outputs, assumptions and calculations used to substantiate the data in Tables B-2a/B-2b to B-7.

   (2) Indicate the requested justification or calculation as a footnote on the table.

c. The information from Tables B-3, B-4 and B-5 can be placed on one table provided that the information is identified and grouped separately and also subtotaled by category (i.e. Packaged Units, Other than Packaged Units and Chillers).

3. Natural Gas Balance

a. This balance identifies the major equipment using natural gas, such as HVAC and DHW systems. Either the natural gas balance spreadsheets on Tables B-7 to B-12, pages 2-B-17 to 2-B-22, can be used in the feasibility study, or analysts can develop their own spreadsheets provided that they contain the same information. Tables B-7 to B-12, or equivalent, must be completed even if building simulation programs (i.e., DOE 2.1E, etc.) are used.

b. Tables B-7 to B-12 are intended to summarize the specific calculations/simulations of existing HVAC and other systems.

   (1) Provide copies of the HVAC simulation models, assumptions and calculations, and inputs and outputs used to substantiate the data (e.g., efficiency) in Tables B-7 to B-12.

   (2) Indicate the requested justification or calculation as a footnote on the table.

c. The information from Tables B-8, B-9 and B-10 can be placed on one table provided that the information is identified and grouped separately and also subtotaled by category (i.e. Packaged Units, Boilers and Natural Gas Chillers).

4. Other Fuels (Propane, Oil)

a. Facilities using propane or oil should provide the same type of information indicated on the natural gas spreadsheets, Tables B-7 to B-12. The tables must specify the specific fuel used. Tables B-7 to B-12, or equivalent must be completed even if building simulation programs (i.e., DOE 2.1E, etc) are used.

   Please refer to Table 1-1, Page 1-4, to determine which energy balance tables must be completed.

b. The information in the tables is intended to summarize the specific calculations/simulations of existing HVAC and other systems.

   (1) Provide copies of the HVAC simulation models and calculations to substantiate the data in the tables (e.g., efficiency).

   (2) Indicate the requested justification or calculation as a footnote on the table.

Table B-1

Comparison of Metered Versus Audited Energy Use

	kWh
Annual Audited Electrical Use (Total from Tables B-2 to B-7)	
Annual Metered Electrical (Appendix A)	
Ratio of Audited to Metered Electrical Use	

	Therms
Annual Audited Natural Gas Use (Total from Tables B-7 to B-12)	
Annual Metered Natural Gas Use (Appendix A)	
Ratio of Audited to Metered Natural Gas Use	

	Btu
Annual Audited Fuel Use (Total from Tables B-7 to B-12)	
Annual Purchased Fuel Use (Appendix A)	
Ratio of Audited to Purchased Fuel Use	

Table B-2a
LIGHTING ELECTRICITY BALANCE

Facility:										
Building and Location	Fixture[1] Type	Number of Fixtures	Watts[2] per Lamp	Watts[3] per Fixture	Hours/ day	Days/ year	Use[4] Factor	Hours/ year	Total Kilowatts	Lighting kWh/ Year
Example: Science/Lab	Fluorescent (2X4X4F40)	455	40	186	9	180	0.78	1620	66	106,938
Total										

Notes:

[1] Identify all abbreviations used for fixtures and specify the lamp and ballast type: 2x4x4F40 troffer = 2 foot by 4 foot 4-40 watt lamps with two standard ballast

[2] Watts per lamp does not include ballast

[3] Watts per fixture includes ballast

[4] Use factor is the percentage of time the equipment is actually on versus its operating schedule. For instance, a light fixture is observed to be on about 7 hours/day even though the operating schedule is 8 am to 5 pm. Therefore, the use factor will be 0.78. The average use factor for a one year period will be used. The use factor should consider burned out bulbs; therefore, the factor should be less than one. **Please provide justification for the factor used by including the inputs and outputs from simulation models <u>or</u> other substantiation for the use factor.** Reference the feasibility study page which substantiate this factor.

Table B-2b
LIGHTING ELECTRICITY BALANCE
FOR STUDIES WITH NO LIGHTING PROJECTS RECOMMENDED

Facility:								
Building	Square Footage[1] (s.f.)	W/s.f.[2]	Total kW[3]	Use Factor[4]	hr/dy[5]	dy/yr[6]	hr/yr[7]	kWh/yr[8]
Administration	20,000	2.0	40	0.9	9	180	1620	58,320
Hospital								
Police Department								
Total								

Notes:

1 Total area of the each building studied.
2 W/s.f. = watts/square foot. **Please state the source for the W/s.f., i.e. ASHRAE, Means Electrical, or equivalent.**
3 Total kW = total kilowatts
4 Use factor is the percentage of time the lights are actually on versus its operating schedule. For instance, the lights are used for 4.5 hours/day even though the operating schedule is 8 am to 5 pm. Therefore, the use factor will be 0.5. The average use factor for a one year period will be used. The use factor should include burned out lights in the building; therefore, the factor should be less than one. **Please provide justification for the factor used by including the inputs and outputs from simulation models <u>or</u> other substantiation for the use factor**. Reference the specific feasibility study pages which substantiate this factor.
5 hr/dy = hours/day
6 dy/yr = days/yr
7 hr/yr = hours/year
8 kWh/yr = kilowatt hours per year

Table B-3
ELECTRICITY BALANCE
HVAC EQUIPMENT- PACKAGED UNITS

Facility:

Equipment: Packaged Units, Compressors, Fans, Pumps, Motors, etc..

Building/ Equipment Name	Equipment Type	Qty[1]	hp[2]	Efficiency [2]	Volts	Amps	P.F[3]	Phase	Load Factor[4]	Total kW[5]	Use Factor[6]	hr/dy[7]	dy/yr[7]	hr/yr[7]	kWh/yr[8]
Math/ A/C unit-1	Fan Motor	1			220	10	0.8	1	0.67	1.18	0.75	9	90	810	716
PE/ A/C unit-2	Resistance Elements	2			220	23	1	1	1	10.12	0.35	9	90	810	2,869
	Compressor														
	Pump														
Total															

Notes:

1 Qty = Quantity

2 hp = rated (nameplate) horsepower of fan and pump motors. When converting fan/pump motor hp to kW, indicate set efficiency (e.g. 80%, etc).

3 P.F. = Power Factor

4 Load Factor is the percentage of power consumption at full load. Please substantiate the value used for the load factor and identify all assumptions. Indicate whether the load factor was estimated or measured.

5 Total kW, show equation and assumptions used to calculate the total kW, and indicate whether the values were based on measurements, or nameplate data.

6 Use factor is the percentage of time the equipment is actually on versus its operating schedule. For instance, a fan is observed to be on about 6 hours/day even though the operating schedule is 8 am to 4 pm. The average use factor for a one year period will be used. Therefore, the use factor will be 0.75. **Please justify the value used for the use factor and include the inputs and outputs from simulation models <u>or</u> other substantiation for the use factor.** Reference the specific feasibility study pages which substantiate this factor.

7 hr/dy = hours/day; dy/yr = number of cooling days/year; hr/yr = number of cooling hours/year.

8 kWh/yr = kilowatt hours/year.

Table B-4
ELECTRICITY BALANCE
HVAC EQUIPMENT - OTHER THAN PACKAGED UNITS

Facility:

Equipment: Other than Packaged Units, Fans, Pumps, Motors, etc.

Building/ Equipment Name	Equipment Type	Qty[1]	hp[2]	Efficiency	Volts	Amps	P.F[3]	Phase	Load Factor[4]	Total kW[5]	Use Factor[6]	hr/dy[7]	dy/yr[7]	hr/yr[7]	kWh/yr[8]
Science/ CHWP-2	Chill Water Pump #2	1			220	40	0.85	1	0.71	5.31	0.67	9	90	810	2,882
	Supply Fan														
	Cooling Tower Fan														
	Circulation Pump														
Total															

Notes:

1 Qty = Quantity
2 hp = rated (nameplate) horsepower of fan and pump motors. When converting fan/pump motor hp to kW, indicate set efficiency (e.g. 80%, etc).
3 P.F. = Power Factor
4 Load Factor is the percentage of power consumption at full load. **Simulation models must be used to justify this factor. Please include inputs and outputs from simulation models used to justify this number.** Reference the specific feasibility study pages which substantiate this factor.
5 Total kW, show equation and assumptions used to calculate the total kW, and indicate whether the values were on measurements, or nameplate data.
6 Use factor is the percentage of time the equipment is actually on versus its operating schedule. For instance, a fan is observed to be on about 6 hours/day even though the operating schedule is 8 am to 5 pm. The average use factor for a one year period will be used. Therefore, the use factor will be 0.67. Simulation models must be used to justify this number. **Please substantiate the value used for the use factor as a footnote and include the inputs and outputs from simulation models.** Reference the specific feasibility study pages which substantiate this factor.
7 hr/dy = hours/day; dy/yr = number of cooling days/year; hr/yr = number of cooling hours/year. If the simulation model does not produce a use factor, please indicate Equivalent Annual Full Load Hours (EAFLH) instead of hr/yr, and explain how EAFLH is calculated and derived. EAFLH is the equivalent amount of time the unit is operating at full load. Specify all assumptions and weather data used.
8 kWh/yr = kilowatt hours/year. **The inputs and outputs from the simulation models must be used to justify this number.**

Table B-5
ELECTRICITY BALANCE
HVAC - CHILLERS OTHER THAN PACKAGED UNITS[1]

Facility:

Bldg/Location	Category/Item	Tons	kW/ton[2]	Load Factor[3]	Use Factor[4]	Cooling hr/yr[5]	kWh/yr[1,6]
Science/Roof	chiller	80	0.85	0.67	0.75	1050	35,879
Total							

Notes:

1 **All HVAC cooling equipment (except single zone packaged units) must include the inputs and outputs from the simulation programs to substantiate the electricity balance. For chiller replacements and TES projects, hourly simulation by month must be used.**

2 kW/ton (kilowatts/ton of refrigeration) - Please provide justification e.g., manufacturer data sheets.

3 Load factor is the percentage of power consumption at full load. **Please provide justification per simulation model.** Reference the specific feasibility study pages which substantiate this factor.

4 Use factor is the percentage of time the equipment is actually on versus its operating schedule. The average use factor for a one year period will be used. **Please provide justification per simulation model.**

5 Cooling hr/yr = cooling hours/year. If the simulation model does not produce a use factor, please indicate the Equivalent Annual Full Load Hours (EAFLH) instead of cooling hr/yr, and explain how EAFLH is calculated and derived. EAFLH is the equivalent amount of time the unit is operating at full load. Specify all assumptions and weather data used.

6 kWh/yr = kilowatt hours per year. **The inputs and outputs from the simulation models must be used to justify this number.** Reference the specific feasibility study pages which substantiates this factor.

Table B-6
ELECTRICITY BALANCE
MISCELLANEOUS EQUIPMENT

Facility:								
	Square Footage (s.f.)[1]	W/s.f.[2]	Total kW[3]	Use Factor[4]	hr/dy[5]	dy/yr[6]	hr/yr[7]	kWh/yr[8]
Office Equipment	20,000	1.5	35	0.5	9	180	1620	28,350
Shop Equipment								
Hospital Equipment								
Total								

Notes:

[1] Total area of the facility or buildings audited.

[2] W/s.f. = watts/square foot. **Please state the source for the W/s.f., i.e. ASHRAE, Means Electrical, or equivalent.**

[3] Total kW = total kilowatts

[4] Use factor is the percentage of time the equipment is actually on versus its operating schedule. For instance, the office equipment is used for 4.5 hours/day even though the operating schedule is 8 am to 5 pm. Therefore, the use factor will be 0.5. The average use factor for a one year period will be used. **Please provide justification for the factor used by including the inputs and outputs from simulation models <u>or</u> other substantiation for the use factor**. Reference the specific feasibility study pages which substantiate this factor.

[5] hr/dy = hours/day

[6] dy/yr = days/yr

[7] hr/yr = hours/year

[8] kWh/yr = kilowatt hours per year

Table B-7
NATURAL GAS/ELECTRIC BALANCE
DOMESTIC HOT WATER (DHW)

Facility:

Bldg/Location[1]	Equipment	Qty[2]	gal/dy[3]	dy/yr[4]	dT(F)[5]	Combustion Efficiency[6]	Standby losses[7]	th/yr[8]	kWh/yr[9]
Math/Basement (gas)	Water Heater	1	2,730	180	55	81%	8%	3,030	
Admin/Elect	Water Heater	1	2,500	180	60	100%	8%		1,030
Total									

Notes:
1 Bldg/location = Indicate building name and location for equipment
2 Qty = Quantity
3 gal/dy = gallons of hot water leaving the water heater daily. **Please state source for gal/day, i.e. ASHRAE or equivalent and provide the calculation (such as, gal/student x student/day)**
4 dy/yr = days/year
5 dT(F) = difference in temperature between incoming cold water and outgoing hot water, across the water heater, in degrees fahrenheit
6 Combustion Efficiency: state the source of the combustion efficiency factor such as nameplate data.
7 Standby losses: standby losses include skin, storage, tank and distribution losses. Please provide justification for the standby loss factor, including the assumptions for each type of loss and on-site measurements and observations. If the system has a large tank or long distribution lines, then the calculation will need to account for the mass difference at any one time.
8 th/yr = therms/year; use q = (m x cp x (Tout-Tin)) / (combustion efficiency x (1-standby losses)) Btu/yr where,
q = heat added to water in Btu/yr
m = mass flow rate of water in lb/yr, use 8.33 lb/gal
cp = specific heat of water, use 1 Btu/lb ^{o}F
Tout - Tin = dT(F)
9 kWh/yr = kilowatt hours per year; use q=(m x cp x (T out - Tin)) / ((1 - standby losses) x 3413). All units are the same as footnote 8.

Table B-8
NATURAL GAS BALANCE
SPACE HEATING- PACKAGED UNITS

Facility:									
Bldg/Location[1]	Equipment	Qty[2]	KBtu/hr (Input)[3]	Total KBtu/hr (Input)	Use Factor[4]	hr/dy[5]	dy/yr[6]	hr/yr[7]	th/yr[8]
PE/Roof	gas pack	2	400	800	0.45	9	90	810	2,916
Total									

Notes:
1 Bldg/location = Building name and location
2 Qty = Quantity
3 KBtu/hr = thousand Btu/hour input
4 Use factor is the percentage of time the equipment is actually on versus its operating schedule. For instance, a gas heater is observed to be on about 4 hours/day even though the operating schedule is 8 am to 5 pm. Therefore, the use factor will be 0.45. **Please justify the factor used by including the inputs and outputs from simulation models or other substantiation for the use factor.** Reference the specific feasibility study pages which substantiate this factor.
5 hr/dy = hours/day
6 dy/yr = number of heating days/year
7 hr/yr = number of heating hours/year
8 th/yr = therms/year

Table B-9
NATURAL GAS BALANCE
SPACE HEATING - BOILERS[1]

Facility:										
Bldg/Location (Main Meter)[2]	Equipment	Qty[3]	KBtu/hr (Input)[4]	Total KBtu/hr (Input)	Use Factor[5]	hr/dy[6]	dy/yr[6]	hr/yr[6]	th/yr[1,7]	Combined Efficiency[10]
Math/Basement	Boiler	2	1,260	2,520	.25	9	90	810	5,103	78%
Total										

Notes:

1 **Please include the inputs and outputs from the simulation programs used to substantiate natural gas balance.**

2 Bldg/location = Building/location of equipment

3 Qty = Quantity

4 KBtu/hr = Thousand Btu/hour

5 Use Factor is the percentage of time the equipment is actually on versus its operating schedule. The average use factor for a one year period will be used. **Simulation models must be used to justify this number. Please provide the inputs and outputs of the simulation models used to substantiate this number.** Reference the specific feasibility study pages which substantiate this factor.

6 hr/dy = hours/day; dy/yr = number of heating days/year; hr/yr = number of heating hours/year. If the simulation model does not produce a use factor, please indicate the Equivalent Annual Full Load Hours (EAFLH), and explain how EAFLH is calculated and derived. EAFLH is the equivalent amount of time the unit is operating at full load. Specify all assumptions and weather data used.

7 th/yr = therms/year. **The inputs and outputs from simulation models must be used to justify this number.**

8 Combined Efficiency: Includes combustion efficiency, standby losses (skin losses), and distribution losses. Please justify each of these components separately. Also provide nameplate data, a copy of flue gas test results, and other relevant data used to calculate the combined efficiency.

Table B-10
NATURAL GAS BALANCE
NATURAL GAS COOLING[1]

Facility:										
Bldg/Location (Main Meter)[2]	Equipment	Qty[3]	Tons[4]	Heat Input (kBtu/ton)[5]	Other Losses[6]	Load Factor[7]	Total KBtu/hr[8]	Use Factor[9]	hr/yr[10]	th/yr[11]
Math/Basement	Absorption Chiller (single effect)	2	200	20.0	11%	0.65	5,843	0.55	810	26,030
Physics/Basement	Steam Driven Turbine	1	300	13.5	12%	0.60	2,761	0.65	810	14,539
	Absorption Chiller (double effect)			12.0						
	Natural Gas Engine (without heat recovery)			8.0						
	Natural Gas Engine (with heat recovery)			6.3						
Total										

Notes:

1. **Please provide the inputs and outputs from the simulation programs used to substantiate natural gas balance.**
2. Bldg/location = Building/location of equipment
3. Qty = Quantity
4. Tons of refrigeration produced by the chiller. Please justify the numbers and include the source of the data (e.g., manufacturer data).
5. Chiller heat input (efficiency) in thousand Btu/ton. Please justify the numbers and include the source of the data (e.g., manufacturer data). The data values listed are examples only. Please convert all other input units (e.g., pounds of steam/ton) to kBtu/ton.
6. Other losses include boiler and distribution losses which were not accounted for in Table B-9. Please specify the kind of loss and justify this number. Avoid double counting the losses from Table B-9. Assume that standby loss is based on the steam used by the facility. If the distribution lines are long and this results in excessive loss, then explain how the losses were estimated. Reference the specific feasibility study pages which substantiate this factor.
7. Load Factor is the percentage of power consumption at full load. Simulation models must be used to justify this factor. Please provide inputs and outputs from simulation models to justify this number.
8. Total KBtu/hr (Input) = Thousand Btu/hour = (Qty x tons x heat input x load factor)/(1-losses).
9. Use Factor is the percentage of time the equipment is actually on versus its operating schedule. The average use factor for a one year period will be used. **Simulation models must be used to justify this number. Please provide the inputs and outputs of the simulation models used to substantiate this number.** Reference the specific feasibility study pages which substantiate this factor.
10. hr/yr = heating hours/year = (hours/day x heating days/year). Please justify this number. If the simulation model does not produce a use factor, please indicate the Equivalent Annual Full Load Hours (EAFLH), and explain how the EAFLH is calculated and derived. Include all assumptions and weather data used.
11. th/yr = therms/year. **The inputs and outputs from simulation models must be used to justify this number.**

Table B-11
NATURAL GAS BALANCE
DOMESTIC HOT WATER - POOL BOILER

Facility:

Pool Equipment	Quantity	Total kBtu/hr input[1]	Equivalent Annual Full load hours[2]	th/yr[3]	Combined Efficiency[4]
Boiler	1	550	875	4,813	75%
Total					

Notes:

[1] Total KBtu/hr = total thousand Btu/hour

[2] **Simulation models must be used to justify the annual full load operating hours to meet the heat loss from the pool based on local weather conditions. Please provide inputs and outputs from the simulation model used to substantiate this number.** Reference the specific feasibility study pages which substantiate this factor.

[3] th/yr = therms/year

[4] Combined Efficiency - Combined efficiency includes combustion efficiency, standby losses (skin losses), and distribution losses. Please justify each of these components separately. Also provide nameplate data, a copy of flue gas test results, and other relevant data used to calculate the combined efficiency.

Table B-12
NATURAL GAS BALANCE
MISCELLANEOUS EQUIPMENT

Facility:

Bldg/Location[1]	Equipment	Qty[2]	KBtu/hr (Input)[3]	Total Kbtu/hr (Input)	Use Factor[4]	hr/dy[5]	dy/yr[5]	hr/yr[5]	th/yr[6]
kitchen	oven	2	50	100	0.33	9	180	1620	535
Total									

Notes:
1. Bldg/location = name of building and location for miscellaneous equipment
2. Qty = Quantity
3. KBtu/hr = Thousand Btu/hour
4. Use factor is the percentage of time the equipment is actually on versus its operating schedule. For instance, the ovens are observed to be used 3 hours/day even though the kitchen is open 9 hours/day. Therefore, the use factor will be 0.33. The average use factor for a one year period will be used. **Please provide justification for the use factor used by attaching the inputs and outputs from the simulation models or other substantiation for the use factor**. Reference the specific feasibility study pages which substantiate this factor.
5. hr/dy = hours/day; dy/yr = days/year; hr/yr = hours/year
6. th/yr = therms/year

APPENDIX C -
ENERGY EFFICIENCY MEASURE CALCULATIONS

This Appendix specifies the information that must be contained in the feasibility study to justify the energy savings and energy cost savings for all EEMs. This Appendix is divided into the following parts:

- Building Envelope
- Lighting
- Domestic Hot Water (DHW)
- Heating, Ventilating and Air Conditioning (HVAC)
- On-Site Electricity and Energy Generation

For **comprehensive studies or studies analyzing energy generation projects**, the order of EEM analysis should follow Section 3, pages 3-1 to 3-6.

For **single purpose or targeted studies**, please refer to Table 1-1, page 1-4, to determine which tables in this Appendix must be completed**.**

All tables must show and specify the initial baseline condition (i.e., Appendix B) and the proposed condition.

A. Building Envelope

Analyze the existing condition and provide the inputs and outputs from building simulation models or other substantiation.

1. Methods for calculating building envelope project energy savings

a. Energy calculations on building envelope projects may be completed using one of the computerized building simulated hourly cooling or heating load models indicated in Appendix B, page 2-B-1.

b. Another method of calculating energy savings is to refer to the procedures in the Load and Energy Calculations Section of the latest edition of the *ASHRAE Handbook of Fundamentals.* The following are pertinent chapters from the 1997 Handbook:

(1) Thermal and Water Vapor Transmission Data
(2) Ventilation and Infiltration
(3) Climatic Design Information
(4) Nonresidential Cooling and Heating Load Calculations
(5) Fenestration
(5) Energy Estimating and Modeling Methods

2. Existing and Proposed Conditions

Provide a table containing information about the existing and proposed conditions. This table should be structured similar to Table C-1 and must show how the building heat loss or heat gain can be reduced by the proposed measure. A copy of the inputs and outputs from building simulation models or other substantiation must be included showing the existing and recommended conditions. At a minimum, the table must contain:

a. The specific report section number where the project was first discussed, such as, section 6.1.1.

b. The name of the facility and affected building(s).

c. Energy rate information including the account number, rate schedule and the weighted average electricity rate and demand rate, and natural gas/fuel rate used to calculate the energy cost savings as identified in Appendix A, pages 2-A-5 to 2-A-11.

d. A one or two sentence narrative describing the current situation and the proposed project.

e. Identification of the baseline building heat gain/loss. The current use should take into account the interaction of all other related EEMs as discussed in Part 3, pages 3-1 to 3-6. Simulation models showing the inputs and outputs to justify the baseline building heat gain/loss must be included with the table.

f. Identification of the recommended building heat gain/loss and energy use after installation of the recommended measure. This usage should be consistent with the calculated/simulated energy use contained in the simulation model spreadsheets used to justify the EEM. Include a copy of the inputs and outputs from simulation models, spreadsheets or others to justify the new energy use.

g. Convert the reduced building heat gain/loss to the reduced cooling or heating using the existing HVAC equipment efficiencies and their use factors. These efficiencies and use factors must be consistent with those previously identified in Appendix B. If another baseline is used for the HVAC equipment efficiencies, then identify the particular table and section in the feasibility study.

Report Section Number__________

Table C-1
BUILDING ENVELOPE PROJECT CALCULATIONS[1]

Facility: ________________________ Building:____

Electric Account Number:___________________________ **Fuel or Natural Gas Account Number:**_______________

Utility: Pacific Gas and Electric (PG&E)
Electric Rate Schedule: A-10
Demand Rate = $4.15/kW (Winter); $4.15/kW (Summer)
Energy Rate = $0.08802/kWh (Winter)
Energy Rate = $0.08802/kWh (Summer)
(weighted average rates calculated from Appendix A)

Utility: ____
Gas Rate Schedule:________
Natural Gas = $_______/therm (weighted average rate calculation from Appendix A)
Other Fuel = $_________/gallon (rate from Appendix A)

Current Condition: Leakage of conditioned air to the outside through the main lobby doors.

Recommended Condition: Install a vestibule to control amount of conditioned air escaping through the doors.

Energy Equipment Affected	Baseline Building Heat Gain/Loss[2]			Recommended Building Heat Gain/Loss			Energy Savings			Energy Cost Savings ($/yr)
	Electric Demand (kW/yr)	Electric Energy (kWh/yr)	Thermal (th or gal/yr)	Electric Demand[3] (kW/yr)	Electric Energy (kWh/yr)	Thermal (th or gal/yr)	Electric Demand (kW/yr)	Electric Energy (kWh/yr)	Thermal (th or gal/yr)	
Heat pumps	542	526710	0	454	351143	0	88	175567	0	15818
Total										

Note: 1. Include the inputs and outputs from building simulation models or other substantiation.
2. Indicate the basis for the baseline and refer to specific table from Appendix B or other table in the feasibility study.
3. Use cumulated annual demand reductions for demand savings.

3. Project Cost Estimate

Use the project cost estimate format from pages 2-C-30 to 2-C-35. The following are the procedures for estimating project cost:

a. Each project cost estimate must be substantiated and referenced with actual, recent (not more than six-months old) price quotes or use the standard cost estimating factors contained in the most recent edition of *Means Construction Cost Data* or other cost estimating references. **The basis for each cost must be footnoted on the table.**

b. The total equipment cost must include a detailed description of the equipment and material. The amount of contractor mark-up must be indicated for each type of equipment and material. If contractor mark-up is not applicable, a reason must be provided.

c. The total labor cost must identify the particular job classification (e.g., carpenter), the hours required for installation, and the cost per hour for installation including specification of the local city multiplier. All installation costs must use labor rates applicable to the facility (e.g., prevailing wage rates). If facility staff installs the projects, then combine wage labor and fringe benefit costs into a single hourly rate. Note the basis of the labor costs in a footnote.

d. The other installation cost items to be considered include demolition and disposal. These items must be included unless there is justification not to do so.

e. The engineering and design cost must be based on a percentage of the total cost for equipment, labor, and other installation cost items (items 3b, 3c and 3d, page 2-C-4). For building envelope projects, use **15 percent** for the engineering design fee, or state the reasons for a different fee in the footnotes.

f. Unless there is justification as to why it is unnecessary, consider the following project management costs:

   (1) Construction Management - Includes the cost of hiring someone to oversee project installation and final inspection Use 5 to 10 percent of the total cost for equipment, labor and other installation or state the reasons for another percentage.

   (2) System Commissioning - Includes verification that the equipment is operating according to the feasibility study parameters. Indicate the commissioning plan and cost.

   (2) Permits - Include permit fees for the following:

(a) Office of Statewide Health Planning and Development (hospitals)

(b) Office of the State Architect (K-12 schools and community colleges)

(c) Local planning agency or building permit

(3) Other costs not specified above - Identify any other cost including the reason(s) and basis for the costs.

g. Contingency - Ensure that recommended EEMs consider unforeseen costs. Include a 10 percent contingency. The 10 percent is based on the total installed project cost (all cost items on pages 2-C-4 and 2-C-5). If a different rate is used, Specify the reasons in a footnote.

B. Lighting Projects

1. Summary Table

Provide a summary table similar to Table C-2, page 2-C-7 with the following information about the existing fixtures and proposed modification:

a. The specific report section number where the project was first discussed, such as, section 6.2.1.

b. The name of the facility and affected building(s).

c. Energy rate information including account number, rate schedule and the weighted average electricity and demand rate used to calculate the energy cost savings, see Appendix A, pages 2-A-5 to 2-A-11.

d. A brief statement describing the current situation and the recommended project.

e. The building and room (or location) affected by the change (Bldg rm)

f. The current and recommended number of fixtures (# Fix)

g. The current and recommended number of lamps per fixture (lamps/fix)

h. The current and recommended watts per lamp (W/lamp). The current wattage should take into account any interactive effect among different EEMs (refer to Part 3, pages 3-1 to 3-6). For instance, if the EEM being analyzed is occupancy sensors, and there was a previous recommendation to convert the affected fixtures to T8 lamps and electronic ballast, then the baseline wattage should assume that the fixtures are now T8 lamps and electronic ballast.

i. The current and recommended watts per fixture (W/fix)

j. The current and recommended total watts for all fixtures (Total W)

k. For the current situation, indicate the annual operating schedule in terms of hours/day (hr/dy), and days/year (dy/yr).

l. The current and proposed use factor. The use factor is the percent of time the lights will be on. The proposed use factor is the percent of time the lights will be on due to installation of a recommended EEM (e.g., occupancy sensors). On the table, also, indicate the justification for the use factor.

m. The annual electricity usage (kWh/yr) for the existing and recommended fixtures

n. The annual electricity reduction (kWh/yr) due to implementing the recommended project

o. The annual demand reduction (kW/yr) due to implementing the recommended project

p. The annual electricity cost savings ($/yr) due to implementing the recommended project

Report Section Number__________

Table C-2
Lighting Project Calculations

Facility:____________________________ Building:_________________________

Electric Account Number/Rate Schedule:_______________ Rate:____ $/kWh (weighted average rate from Appendix A) ____ $/kW (from Appendix A)

Current Condition: 2 foot x 4 foot fixture using two 40 watt lamps and a standard ballast.

Recommended Condition: 2 foot x 4 foot fixture using two 32 watt (T-8) lamps and an electronic ballast.

CURRENT CONDITIONS[1]										RECOMMENDED CONDITIONS												
Bldg/ Rm	# Fix	lamp/ fix	W/ lamp	W/ fix	Total kW	Use[2] Factor	hr/dy	dy/yr	Total kWh/yr Used	# Fix	Lamps/ fix	W/ lamp	W/ fix	Total kW	Use[3] Factor	hr/dy	dy/yr	Total kWh/ yr used	kWh/ yr saved	kW/ yr saved	$/yr saved
Ex: Math 200	9	2	40	92	0.828	0.80	12	300	2,385	9	2	32	58	.522	0.90	12	300	1,691	694	.306	
Totals																					

Note:
1. Reference the source of the current conditions (e.g., Table B-2a or B-2b)
2. The Use Factor is the percent of time the lights will be on, as indicated in Table B-2a or B-2b.
3. Specify the new Use Factor and state the reason for the change.

2. Project Cost Estimate

Use the project cost estimate format from pages 2-C-30 to 2-C-35. The following are the procedures for estimating project cost:

a. Each project cost estimate must be substantiated and referenced with actual, recent (not more than six-months old) price quotes or use the standard cost estimating factors contained in the most recent edition of *Means Electrical Cost Data* or comparable cost estimating guides. **The basis for each cost must be footnoted on the table.**

b. The total equipment cost must include a detailed description of the equipment and all ancillary equipment, the number to be purchased and the cost per unit. The amount of contractor mark-up must be indicated for each type of equipment. If contractor mark-up is not applicable, a reason must be provided.

c. The total labor cost must identify a specific job classification (e.g., electrician), the hours needed for installation, the cost per hour and specification of the local city multiplier. Use labor rates applicable to the facility (e.g., prevailing rates). If a facility uses its own staff, then combine wage labor and fringe benefit costs into a single hourly rate and indicate the basis for the cost in a footnote.

d. Unless there is justification otherwise, the following installation cost items must be included:

   (1) *Demolition* - To be considered for **all** lighting projects involving total replacement of the entire fixture.

   (2) *Disposal* - To be considered for **all** lighting retrofits resulting in a replacement of the existing lamps and/or ballast. The following are typical disposal cost or provide justification and sources for other cost:

      (a) Fluorescent lamp disposal/recycle: $0.50/fluorescent lamp replaced

      (b) PCB containing ballast: $5.00/ballast

      (c) For other lamps (e.g., high intensity discharge) provide justification for the disposal cost to be used.

e. The engineering and design cost must be based on a percentage of the total cost for equipment, labor and other installation cost items (items 2b, 2c and 2d, page 2-C-8). For lighting projects, use an engineering design fee of **5 percent** or justify a different fee in a footnote.

f. Unless there is justification otherwise, the following project management cost items are to be considered:

(1) Construction Management - Include the cost of hiring someone to oversee the installation and final inspection. Use 5-10 percent of the total cost for equipment, labor and other installation, or justify a different percentage in the footnotes.

(2) System Commissioning - Includes verification that the equipment is operating according to the feasibility study parameters. Indicate the commissioning plan and cost.

(3) Permits - Include permit fees for the following:

(a) Office of Statewide Health Planning and Development (hospitals)

(b) Office of the State Architect (K-12 schools and community colleges)

(c) Local building permit office

(d) Other permits, please specify

(4) Other costs - Identify any other installation cost and include the reason(s) and basis for the costs.

g. Contingency - To ensure that recommended EEMs consider unforeseen costs, include a 10 percent contingency for all lighting projects. The 10 percent is based on the total installed project cost (all cost items on pages 2-C-8 to 2-C-9). A different percentage can be used if the reasons are indicated in a footnote.

C. Domestic Hot Water Projects

1. Summary Table

Provide a table containing information about the proposed project conditions. Table C-3 is a sample table showing all the required information. The following lists the minimum information to be contained in the table:

a. Identify the specific report section number where the project was discussed, such as, Section 6.3.1

b. Identify the name of the facility and the affected building(s)

c. Provide the energy rate information, including account number, rate schedule and the weighted average rate (refer to Appendix A, pages 2-A-5 to 2-A-11)

d. Describe the existing situation and the proposed project

e. Identify the name of the affected energy using system

f. Identify the type of modification to the system

g. Identify the affected components of each system to be modified

h. Indicate the current energy use of the system. The current energy use for the proposed EEM should either be based on the baseline conditions identified in Appendix B or a changed baseline due to the interaction of other feasible EEMs identified in the feasibility study (refer to Part 3, pages 3-1 to 3-6).

i. Indicate the energy usage of the recommended measure.

2. Energy calculation/simulation

a. Include the output reports, spreadsheets, equipment energy use calculations and/or computer simulations used to calculate the energy use of the recommended EEM. All output reports taking into account the interactive effects of implementing this and other recommended EEMs must be included in the feasibility study.

b. Documentation - Calculations of the estimated energy savings must include those items discussed in Appendix B, Tables B-7 or B-11 (pools).

Report Section Number ____

Table C-3
DOMESTIC HOT WATER
SAVINGS SUMMARY

Facility: Sample High School

Building Name:________________________________

Natural Gas/Fuel Account: ____________________
Utility: ____________________________
Natural Gas Rate Schedule, if applicable: ____________
Utility Rate: $___________/therm (weighted average or average rate calculated from Appendix A)

Current Condition: Uncovered Pool

Recommended Condition: Add pool cover

			Baseline Usage[1]		Recommended Measure Usage							
System	Modification	Component	Electrical (kWh/yr)	Thermal (th/yr)	Electrical (kWh/yr)	Savings (kWh/yr)	Rate ($/kWh)	Savings ($/yr)	Thermal (th/yr)	Savings (th/yr)	Rate ($/th)	Savings $
Pool Boiler	Pool Cover	Not applicable	140,160	28,858	140,160	0	0.0955	0	16,160	12,698	0.5558	7,058
Total												

Note: 1. Specify the reference baseline table from which this information was derived (e.g., Table B-11)

3. Project Cost Estimate

Use the project cost format indicated on pages 2-C-30 to 2-C-35. The following is a summary of the procedures:

a. Each project cost estimate must be substantiated and referenced with actual, recent (not more than six-months old) price quotes or the standard cost estimating factors contained in the recent edition of *Means Mechanical Costs Data and Means Electrical Cost Data* or other cost estimating references. **The basis for each cost must be footnoted on the table**.

b. The total equipment cost must include a detailed description of the equipment and all ancillary equipment, the number to be purchased, and the cost per unit. The amount of contractor mark-up must be indicated for each type of equipment. If contractor mark-up is not applicable, a reason must be provided.

c. The total labor cost must identify the specific job classification (e.g., electrician), the hours required for installation, the cost per hour for installation and the local city multiplier. Use labor rates applicable to the facility (e.g., prevailing wages). If facility staff installs the projects, combine the wage labor and fringe benefit costs into the hourly rate. Justify the labor costs in a footnote.

d. The other installation cost items to be considered include demolition and disposal. Specify cost of equipment removals or modifications.

e. The engineering design cost must be based on a percentage of the total cost for equipment, labor, and other installation cost items (items 3b, 3c and 3d from page 2-C-12). Use a ***15 percent*** fee or justify a different percent in a footnote.

f. Unless there is justification otherwise, the following project management cost items must be included:

   (1) Construction Management - Include the cost of hiring someone to oversee project installation and final inspection. Use 5 to 10 percent of the total cost for equipment, labor and other installation, or justify another percent in the footnotes.

   (2) System Commissioning - Includes verification that the installed equipment is operating according to the design documents. Indicate the commissioning plan and cost.

   (3) Permits - Include permit cost for the following:

(a) Office of Statewide Health Planning and Development (hospitals)

(b) Office of the State Architect (K-12 schools and community colleges)

(c) Local air pollution control districts

(d) Other permits, please specify

(3) Other costs not specified above - identify any other cost not specified above including the reason(s) and basis for the cost.

g. Contingency -To ensure that recommended EEMs consider unforeseen costs, all domestic hot water projects must include a 10 percent contingency. The 10 percent is based on the total installed project cost (all cost items on pages 2-C-12 and 2-C-13). A different percentage can be used if the reasons are indicated in a footnote.

D. Heating Ventilating and Air Conditioning EEMs

1. Summary Table

Provide a table similar to Table C-4 containing information about the existing conditions and equipment and the proposed modification. The following lists the minimum information to be contained in the table:

a. Identify the specific report section number where the project was discussed, such as section, 6.4.1.

b. Identify the name of the facility and affected building(s).

c. Provide energy rate information including the account number, rate schedule and the weighted average rate (refer to Appendix A, pages 2-A-5 to 2-A-11).

d. Describe the current situation and the proposed project.

e. Identify the name of the affected energy using system. Abbreviated nomenclature can be used (e.g., AHU#1, MZU#9, H.P. #10 or A.C. #2 or site designated No.), if a key to the abbreviations is provided. The abbreviations should be consistent with those previously used in Appendix B.

f. Identify the type of modification to the system (e.g., Time-of-Day Scheduling, Optimum Start/Stop, Lockout, Outside Air Temperature Reset)

g. Identify the affected components to be modified (e.g., supply fan, chilled water supply pump, hot water supply pump).

h. Indicate the current energy use of the system. The current baseline for the recommended EEM must consider the interaction of all other related EEMs as discussed in Part 3, pages 3-1 to 3-6. Indicate the table from which the baseline usage was determined (e.g., Table B-9). The baseline use for all central HVAC units (e.g. boilers, chillers, multizone, dual duct, etc.) must be substantiated with spreadsheets or simulation models as discussed in Appendix B.

i. Calculate the energy use of the recommended measure. This use should be consistent with the calculated/simulated energy usage in the simulation models or spreadsheets used to justify the EEM. Identify all conditions which have changed from the baseline and include a copy of the simulations.

2. Specialized Systems

The following requirements must also be incorporated into each simulation model for specialized mechanical projects:

a. Chiller Replacement and Thermal Energy Storage (TES) Projects

(1) Hourly simulations by month must be used to calculate both the baseline and the proposed EEM energy use. The analysis must include the daily cooling load profiles and the energy cost for both the before and after cases. For the after case, the performance curves are to be based upon the replacement equipment. The analysis must include part load efficiency profiles at a minimum of 10 percent increments. The following summarizes the information required:

(a) Load profiles: Load by hour (0000 to 2400) by month for a one year period

(b) Part Load: Part load efficiencies (percent load at a minimum of 10 percent increments, kW/ton)

(c) Specifications: Equipment specification sheets, with equipment performance curves

(d) Energy use and cost: Calculated energy use and cost for the before and the after case

(2) Chiller replacement projects will be limited to those using R-22, R-123 or R-134a. This restriction is not applicable to

absorption chillers. Refrigerants other than 22, 123 or 134a can be specified if the recommended chiller is convertible to these refrigerants in the future. However, both the cost of the conversion and the conversion methodology must be provided and substantiated with manufacturer data.

(3) Chiller replacement projects must consider the following since they can add to the cost of a chiller replacement project: a) provisions for proper recovery, handling and recycling (or sale) of the old refrigerant; b) installation of any required refrigerant containment devices; c) upgrade of the mechanical room ventilation system per ASHRAE standards for the new refrigerant used; and d) addition of safety devices, such as refrigerant monitors and respirators, per ASHRAE standards.

b. Energy Management System and Variable Frequency Drive Projects

(1) Provide an analysis of the loads using the simulation model previously used to determine the baseline in Appendix B.

(2) Complete Table C-5 by providing a list of control points for the energy management system, the equipment to be controlled and the control strategy.

3. Energy calculation/simulation

b. Include the output reports, spreadsheets, summaries of equipment energy usage calculations and/or simulations. All output reports taking into account the interactive effects of implementing this and other recommended EEMs should be included.

b. Documentation - The spreadsheet or simulation models used to calculate the estimated energy savings must include those items as discussed in Appendix B and the following:

(1) Hourly/bin simulations before and after project implementation. The bin or hourly analysis models used must be able to analyze at least three time blocks in a 24 hour period such as, 0000 to 0800, 0800 to 1600, and 1600 to 2400. The models should match information from Appendix B and must include:

(a) Tons of cooling for electric cooling applications

(b) Therms of input for heating application and absorption chillers

(c) Part load performance of the chiller(s)

(d) Performance of cooling tower(s)

(e) kW demand and kWh consumption

(2) Energy and demand costs and cost savings based on weighted average, or actual time of use costs, as determined in Appendix A.

Report Section Number __________

Table C-4
HVAC SAVINGS SUMMARY

Facility: Sample High School BUILDING NAME: _______________

Electric Account Number:
Utility: Pacific Gas and Electric (PG&E)
Electric Rate Schedule: A-10
Demand Rate = $4.15/kW (Winter); $4.15/kW (Summer)
Energy Rate = $0.08802/kWh (winter)
Energy Rate = $0.08802/kWh (summer)
(weighted average rate calculated from Appendix A)

Fuel or Natural Gas Account Number:______________
Utility: ____
Gas Rate Schedule:
Natural Gas = $_______/therm
(weighted average rate calculated from Appendix A)
Other Fuel = $_________/gallon

DESCRIPTION OF CURRENT CONDITION: 9 zone multi-zone unit controlled by a 7 day time clock without hot/cold deck resets.

RECOMMENDED CONDITION: Install EMS controls with optimal start, hot/cold deck reset. Includes cold deck reset based on zone demand and mixed air reset based on cold deck set point.

			Baseline Usage[1]		Recommended Measure Usage[2]					
System	Modification	Component	Electrical (kWh/yr)	Thermal (th/yr)	Electrical (kWh/yr)	Savings (kWh/yr)	Savings ($/yr)	Thermal (th/yr)	Savings (th/yr)	Total Savings $
MZU-1	Time-of-Day, Lockout & Reset	! Supply fan ! Cooling Coil ! Heating Coil	16,885 9,933 -	- - 5,515	11,490 3,556 -	5,395 6,377 -	515 609 -	- - 3,126	- - 2,389	- - $1,328
Totals										

Note: 1. Indicate source of Baseline Usage (e.g., Table B-4)
2. Identify changed conditions from the baseline usage.

Report Section No. ______________

Table C-5
Energy Management System - Control Points List

Facility: Sample High School

System	Zone(s)	Existing Control	Analog Input	Digital Input	Digital Output	Analog Output	Equipment/Operating Strategy
Ex: MZU-1	CLASSROOMS 100-108	None	8	0	16	10	Hot & Cold Deck; Return and Room Air Temperature, Supply Fan / Optimum Start/Stop
	TOTAL POINTS						

4. Project Cost Estimate

The format for estimating project cost is contained on pages 2-C-30 to 2-C-35. The following summarizes the procedures:

a. Each project cost estimate must be substantiated and referenced with actual, recent (not more than six-months) price quotes or the standard cost estimating factors contained in the most recent edition of *Means Mechanical Cost Data and Means Electrical Cost Data* or comparable cost estimating guides. **The basis for each cost must be footnoted on the table.**

b. The total equipment cost must include a detailed description of the equipment and all ancillary equipment, the number to be purchased, the cost per unit. The amount of contractor mark-up must be indicated for each equipment. If contractor mark-up is not applicable, a reason must be provided.

c. The total labor cost must identify the specific job classification (e.g., electrician), the hours required for installation, the cost per hour for installation and the local city multiplier. Use labor rates applicable to the facility (e.g., prevailing wages). If facility staff installs the projects, then combine the wage labor and fringe benefit costs into a single hourly rate and indicate the basis for the costs in a footnote.

d. Unless there is justification otherwise, include the following installation cost items:

    (1) Demolition and Disposal - Identify the cost associated with equipment removals or modifications.

    (2) Training - Identify cost associated with facility staff training on new equipment (e.g. Energy Management System, Thermal Energy Storage, etc.).

    (3) Set-Up - Identify cost for testing, balancing and calibrating equipment and systems.

    (4) Other Installation Costs - Identify other costs (e.g., equipment rental).

e. The engineering and design cost must be based on a percentage of the total cost for equipment, labor and installation (items 4b, 4c, and 4d, page 2-C-19). For all HVAC projects, use ***15 percent*** for the engineering fee or justify a different percentage.

f. Unless there is justification otherwise, include the following project management cost items:

(1) Construction Management - Includes the cost of hiring someone to oversee project installation and final inspection. Use 10 percent of the total cost for equipment, labor and other installation or justify a different percentage in the footnotes.

(2) System Commissioning - Includes the verification that the equipment is operating according to the parameters established in the design documents. Indicate the commissioning plan and cost.

(3) Permits - Include permit cost for the following:

(a) Office of Statewide Health Planning and Development (hospitals)

(b) Office of the State Architect (K-12 schools and community colleges)

(c) Local air pollution control districts

(d) Other permits, please specify

(4) Other costs - Identify and specify the reasons for other costs.

g. Contingency -To ensure that recommended EEMs consider unforeseen costs, include a 15 percent contingency. The 15 percent is based on the total installed project cost (all cost items on pages 2-C-19 and 2-C-20). If project circumstances dictate, use a different rate and indicate the reasons as a footnote.

E. On-Site Electricity and Energy Generation EEMs

1. General Instructions

a. Before considering any energy generation project, the feasibility study must first identify all opportunities to increase the energy efficiency of existing equipment. This is done by analyzing and identifying energy efficiency opportunities associated with the building envelope, lighting, HVAC and DHW systems (refer to Part 3, pages 3-1 to 3-6). By first reducing a facility's existing energy use in these areas, the analyst can correctly verify project feasibility and size the energy generation equipment based on the new thermal and electrical loads.

b. Energy generation projects generally would be analyzed when:

(1) A facility already operates relatively efficiently and has conditions which make it a candidate for an energy generation project and/or

(2) A facility has specifically requested an evaluation of an energy generation project

c. The analyst must use the new electric and thermal load profiles (current energy use minus the energy savings from all feasible EEMs in the feasibility study) as the energy use baseline for the energy generation project analysis.

d. The following minimum information is required when analyzing any energy generation project:

(1) Description of the technology and how the generated energy would be used by the facility

(2) Identification of equipment size. Provide product information in Appendix E (refer to page 2-E-1), such as:

(a) Capacity (kW, Btu/hour)

(b) Heat rate or power/energy generation efficiency (Btu/kWh or therms/hour)

(c) Parasitic loads (e.g., pumps, fans, motors)

(d) Utility interconnection limitations and cost

(3) Description of the proposed energy generation operations, including:

(a) How the system will be operated by the facility (e.g., continuous, load following, or on-peak operation)

(b) When the system will be operated (e.g., summer, winter or continuous)

(c) How the system will be controlled (e.g., timeclock operation, EMS)

(d) Who will operate and maintain the equipment

(e) What is the maintenance schedule and unscheduled downtime

(4) Provide the new electric and thermal load profiles, assuming implementation of all feasible EEMs with less than a 10 year simple payback. Provide the following profiles for each rate schedule season, at a minimum:

(a) The facility's 24-hour electric load profile for a typical weekday and weekend

(b) The facility's 24-hour thermal load profile for a typical weekday and weekend

(5) Discuss the annual operating and maintenance costs, and provide justification for the following:

(a) Operating fuel - specify the annual fuel cost and include utility rate schedule or quote from local supplier

(b) Maintenance - specify the maintenance cost (e.g., $/engine run hour or $/kWh) for scheduled and unscheduled down time. Include quote from maintenance firm or specify basis for cost.

(c) Utility-stand-by and other charges

(d) Air pollution control and monitoring cost (if applicable)

(6) Discuss and identify all major required regulatory permits and other requirements for construction and operation, such as:

(a) Federal Energy Regulatory Commission (FERC) requirements and efficiency standards for qualifying facilities (QF)

(b) State and local rules and regulations including air pollution control district permits such as: New Source Review, Authority to Construct, and Permit to Operate

(c) Office of Statewide Health Planning and Development or Office of the State Architect requirements

(d) Utility-related issues, such as interconnections and electricity restructuring

(e) Environmental Impact Report (if applicable)

(7) Discuss the amount of reduced electric demand, energy use and/or fuel use. Include assumptions for the following:

(a) The amount of reduced electric demand (kW) and consumption (kWh). For facilities on time-of-use rates identify the kWh reduction for each rate period.

(b) The amount of reduced boiler use and the measured or estimated boiler efficiency (if applicable). Discuss how boiler efficiency was determined and whether the method is consistent with Appendix B.

(c) The amount of reduced chiller use and the measured or estimated chiller efficiency (if applicable). Discuss hiw chiller efficiency was determined nd whether the method is consistent with Appendix B.

(8) Discuss the project economics and how the energy cost savings were calculated, including:

(a) The reduced annual electric demand and energy cost

(b) The reduced annual boiler fuel cost

(c) The excess annual electricity sales in kWh and dollars (if applicable)

(d) The excess annual thermal energy sales (if applicable)

(e) Total project cost (see pages 2-C-30 to 2-C-35)

(f) The annual operating and maintenance (O&M) costs

(g) The simple payback with and without O&M costs.

2. Additional Requirements for Cogeneration Projects -For cogeneration projects include the following:

a. Electricity Savings Calculations

Cogeneration savings occur when the system is running. The use of average rates to calculate energy savings is unacceptable. The following discusses how utility rates should be calculated:

(1) Demand Savings

(a) Calculate the demand and savings based on the winter and summer demand rates.

(b) Prorate the demand savings based on the estimated engine run hours versus total annual hours, or substantiate savings based on proposed cogeneration operation schedule. This amount will be used to determine the amount of demand savings to be credited to the cogeneration project.

(2) Energy Savings

(a) Demand Rate - Use summer and winter energy charge for cogeneration electricity savings calculation. If the rate schedule has tiered rates, the analyst must first assume that electricity savings will first displace the tier two rate, then the tier one rate.

(b) Time-of-Use Rates - Calculate the value of the cogenerated electricity produced based on the engine run hours during each rate schedule time period. Separately identify the energy cost for demand and on-, mid-, and off-peak energy rates for the summer and winter periods.

(3) Avoided Cost Rate for Excess Power Sales

(a) Provide the new 24-hour electric and thermal profiles for the facility, assuming that all feasible energy efficiency measures identified in the feasibility study have been implemented and the savings realized. This profile must include a 24-hour electric load profile for the facility's weekday and weekend operation for each rate schedule season. This profile should be developed based on the load profiles from the utility or from the hourly readings of the electric meter.

(b) If the facility has excess power for sale during the low load time, the avoided cost rate should be used to calculate the electricity savings, not the actual electricity cost for that time period.

b. Natural Gas Savings Calculations

(1) Boiler Gas Savings

(a) Identify the gas rates for the winter and summer period from Appendix A.

(b) If the rate schedule has tiered rates, calculate the natural gas savings by assuming that the tier two rate gas use will be displaced first, then the tier one rate.

(2) Cogeneration Gas Cost

(a) Identify the customer charge if the cogeneration gas will be billed separately.

(b) Identify the utility incremental gas rate for the cogeneration gas allocation (in Btu/kWh).

(c) Identify the amount of gas to be charged at the cogeneration gas rate and the amount of gas to be charged at the regular boiler gas rate (Appendix A). Calculate the summer and winter gas use separately.

(d) Identify the amount of thermal energy credit only for the displaceable gas use. Cooking gas and unconnected thermal loads cannot be included as thermal credit. Excess cogenerated heat used in pools as a heat sink in the summer cannot be counted as thermal credit.

(3) Propane/Fuel Oil Displacement

(a) Provide one year of monthly propane bills (if available) or a spreadsheet summarizing annual propane use for the facility. The propane bills or the spreadsheet must identify the quantity used and the cost and be consistent with the use in Appendix A.

(b) Identify the amount of thermal credit for the displaceable gas use. Cooking gas and unconnected thermal loads cannot be included as thermal credit. Excess cogenerated heat used in pools as a heat sink in the summer cannot be counted as thermal credit.

(4) System Schematics and Displaced Equipment Efficiency

(a) System Schematics - provide schematics showing how the cogeneration system will be connected to the heating system.

(b) Boiler Efficiency - provide the name plate or measured boiler efficiency. This efficiency will be used in the thermal energy credit calculation and should be consistent with the boiler efficiency identified in Appendix B.

(5) Air Conditioning/Chiller

(a) If an absorption chiller or direct drive chiller is recommended in conjunction with the cogeneration system, provide performance information on the chiller, including a specification sheet, and schematics showing how the cogeneration and absorption chiller will be connected to the cooling system.

(b) Provide the name plate or measured efficiency to be used for calculating the cooling energy credit. The existing cooling equipment efficiency should be consistent with the information in Appendix B.

(6) Cogeneration Equipment Specifications - identify the following:

(a) Capacity (kW), fuel rate using the high heating value for natural gas (Btu/kWh or therms/hour), and the available waste heat (Btu/hour) from the cogeneration system.

(b) Parasitic loads (kW) associated with cogeneration system operations, including pumps and heat venting radiator fans.

(7) Cogeneration Operation Information

(a) Month by month operation data - explain how the cogeneration system will be controlled and operated. Provide proposed monthly operation data for the cogeneration system for 12 consecutive months including estimates for:

(i) Cogeneration output

(ii) Engine run hours

(iii) kWh generated during each rate period

(iv) Amount of useful thermal energy produced

(b) Annual PURPA Efficiency Standard Calculation - calculate and identify the FERC efficiency. This calculation is used to ensure that the cogeneration system complies with the FERC QF Efficiency Standards and qualifies for cogeneration gas rate and stand by service.

(c) Air emission data and permits-provide emission data and information on all necessary permits required for installing and operating the cogeneration system.

3. **Project Cost Calculations -** the project cost estimate format is contained on pages 2-C-30 to 2-C-35. The following is a summary of the procedures:

a. Each project cost estimate must be substantiated and referenced with actual, recent (not more than 6 months old) price quotes or the standard cost estimating factors contained in the most recent edition of *Means Mechanical Cost Data and Means Electrical Cost Data* or other cost estimating guides. ***The basis for each cost must be footnoted in the table.***

b. The total equipment cost must include a detailed description of the equipment and all ancillary equipment, the number to be purchased, the cost per unit, taxes and shipping cost. The amount of contractor mark-up must be indicated for each type of equipment. If contractor mark-up is not applicable, a reason must be provided.

c. The total labor cost must identify the specific job classification (e.g., electrician), the hours required for installation, the cost per hour for installation and the local city multiplier. Use labor rates applicable to the facility (e.g., prevailing wage rates). If facility staff installs the project, then combine wage labor and fringe benefit costs into a single hourly rate. Indicate the basis for all costs in a footnote.

d. Unless there is justification otherwise, the following installation cost items must be considered:

(1) Demolition and Disposal - Identify cost for equipment removals or modifications, such as boilers, piping, asbestos.

(2) Training - Indicate cost for training facility staff on equipment and system operations.

(3) Set-up - Indicate cost and plan for testing the system and related equipment

(4) Other installation - Identify other cost not specified (e.g., utility interconnection)

e. The engineering and design cost must be based on a percentage of the total cost for equipment, labor and installation (items 3b, 3c and 3d from page 2-C-28). Use ***15 percent*** for the engineering design fee or justify a different percentage.

f. Unless there is justification as to why it is unnecessary, the following project management cost items must be considered:

(1) Construction management - Includes the cost of hiring someone to oversee project installation and final inspection. Use 10 percent of the total cost for equipment, labor, and other installation or justify another percent in the footnote.

(2) System commissioning - Includes verification that the installed equipment is operating according to the parameters established in the design documents. Indicate the commissioning plan and cost.

(3) Permits - Include permit costs for the following:

(a) Office of Statewide Health Planning and Development (hospitals)

(b) Office of the State Architect (K-12 schools and community colleges)

(c) Local air pollution control districts

(d) Other permits, please specify

(4) Other costs - Identify and specify the reasons for other costs.

g. Contingency -To ensure that recommended EEMs consider unforeseen costs, use a 10 percent contingency. The 10 percent is based on the total installed project cost (all cost items on pages 2-C-27 to 2-C-29). A different percentage can be used if justification is provided in the study.

4. Calculation Methodologies for Other Energy Generation Projects

Many other alternative energy/power generation technologies are commercially available. The information for different technologies varies depending on circumstance and conditions. The previous discussion may not be applicable for some technologies. The analyst should consult with other organizations who have implemented the technology to determine the appropriate evaluation/calculation methodologies.

PROJECT COST ESTIMATE FORMAT

The following is the format for estimating project costs. One Project Cost Estimate (Table C-6 pages 2-C-31 to 2-C-35) to be prepared for each EEM.

Report Section Number: ________
EEM Code: _______

Table C-6

PROJECT COST ESTIMATE - FORMAT

A. Equipment						
Description	(a) Quantity	(b) $/unit	(c) Cost ($)	(d) Contractor mark-up ($)	(e) Total Cost ($)	Foot-note #
Subtotal						
Sales Tax (_____% of subtotal)						
A. Subtotal for equipment and supplies						

Notes:
(a) Quantity = The number of identical units or equipment to be purchased
(b) $/unit = The unit cost for each piece of equipment
(c) Cost = Quantity x ($/unit)
(d) Contractor Mark-up Cost = Contractor mark-up percent x Cost; specify the source of the contractor mark-up percent as a footnote to the table.
(e) Total Cost = Cost + Contractor mark-up cost

Table C-6 (Cont'd)

B. Labor				
Labor Classification	Hours	$/hour	Total Cost ($)	Foot-note #
B. Subtotal for labor				

C. Other Installation		
Description	Cost ($)	Footnote #
1. Demolition		
2. Disposal		
3. Training		
4. Start-Up		
5. Others (specify)		
C. Subtotal for Other Installation Costs		

Table C-6 (Cont'd)

D. Engineering and Design		
Total cost for equipment, supplies, labor and installation (A + B + C)	Percent of total cost for engineering and design (%)*	Total engineering and design cost (total cost multiplied by engineering and design %)

* Provide substantiation.

E. Project Management		
Description	Cost ($)	Footnote #
Construction management		
Permits		
Others (specify)		
E. Subtotal for other cost		

F. Contingency		
Total cost for equipment + labor + installation + engineering + project management costs (A + B + C + D + E)	Contingency percentage (%)*	Total contingency cost (total cost multiplied by contingency percentage)

* Provide justification.

Table C-6 (Cont'd)

Project Economics Summary	
Description	Cost
A. Equipment	
B. Labor	
C. Other Installation	
Subtotal (A + B + C)	
D. Engineering and Design	
Subtotal (A + B + C + D)	
E. Project Management	
F. Contingency	
Total Project Costs	

Project Simple Payback	
Total Project Costs ($)	
Annual Energy Savings ($)	
Simple Payback (years)	

Table C-6 (Cont'd)

Footnotes

(Note: Provide substantiation for all cost estimates. Include specific sections and page numbers from the most recent *Means Electrical Cost Data*, *Means Mechanical Cost Data*, copies of phone conversations and vendor quotes and catalogs, and all assumptions used to derive the specified cost)

1.

2.

APPENDIX D - WEATHER DATA

This appendix discusses when weather data must be included in the feasibility study, the format for presentation of data and sources of weather data.

A. Circumstances for Including Weather Data in the Study

The analyst must include a copy of the weather data used in completing all HVAC calculations and simulations in the feasibility study for:

- A comprehensive feasibility study,
- An energy generation project, or
- One or more projects totaling more than $50,000. Weather data are not needed if lighting constitutes more than 80 percent of the total project cost.

B. Weather Data Format

The weather data should be presented in one of the following formats:

- Hour by Hour Temperature Profiles
- Hourly Bin Temperature *(see sample on Table D-1)*

C. Some Sources of Weather Data

Facility Design and Planning Engineering Weather Data, Air Force, Army and Navy Manuals; AFM 88-29, TM 5-785 and NAVFAC P-89. Superintendent of Documents, Government Printing Office, Washington, D.C. 26402

BINMAKER, Gas Research Institute Fulfillment Center, 1510 Hubbard Drive, Batavia, Illinois 60510. <http:www.BinMaker.com>
This software program creates summaries of hourly weather data for 239 cities, including 10 in California. The program allows users to summarize weather data in different ways and was based on the Department of Defense's *Engineering Weather Data Manual*.

DOE 2.1-based models, Trace 600, HAP and other building simulation programs with weather data base modules.

Table D-1
WEATHER DATA (Bin Method)

Reference: Air Force Manual 88-29
Location: Sacramento, California/McClellan AFB

Temperature Range (NF)	Observation Hour Group			Total Observation
	00 to 08	08 to 16	16 to 24	
110/114		0	0	0
105/109		5	2	7
100/104		40	19	59
95/99		99	45	144
90/94	0	167	75	242
85/89	1	202	98	301
80/84	8	245	144	397
75/79	34	267	196	497
70/74	108	279	254	641
65/69	235	286	300	821
60/64	412	319	355	1086
55/59	522	353	415	1290
50/54	506	293	400	1199
45/49	418	193	313	924
40/44	343	116	201	660
35/39	218	41	74	333
30/34	84	11	21	116
25/29	26	1	1	28
20/24	2	0	0	2

APPENDIX E - CUT SHEETS AND VENDOR COST QUOTE REQUIREMENTS

All feasibility studies must include copies of product/vendor cut sheets. In addition, contractor proposals, pertinent pages from cost estimating source guides (e.g. Means, Dodge, Marshall and Swift, Grainger, Energy Depot) and all other related documentation used in calculating the energy project cost estimate must be included in this section.

APPENDIX F - CONSULTANT FIELD DATA SHEETS

All feasibility studies must include a copy of the field data sheets used to record site information. The following is a listing of information typically found in field data sheets:

- Initial or kick-off meeting notes - facility name, meeting participants (facility, consultant and utility staff) and facility operation data discussed
- Building data
- Occupancy schedules
- Lighting Survey - showing the types and locations (room and building) of fixtures, occupancy schedule and footcandle readings with lights on, off or at night.
- Heating, Ventilating and Air Conditioning Survey
    - Chiller - equipment identification, manufacturer, model, nameplate information, chiller type and electrical data, pump sizes and any pertinent diagrams, operating information, test results, buildings served, controls and schedule
    - Boiler - equipment identification, manufacturer, model, nameplate information, boiler type, pump sizes and any pertinent diagrams, operating information, test results, buildings served, controls and schedule, efficiency measurements, flue gas analysis results
    - Air Handler - building location, fan specifications, economizer operation, type, controls and schedule, and any pertinent diagrams
    - Packaged Units - equipment identification, manufacturer, model, nameplate information, buildings served, configuration, type of cooling and heating, pilot operation, outside air controls, on/off controls and schedule
- Other Major Energy Using Equipment - equipment identification, quantity, size or rating and operating schedule

3. EVALUATION OF ENERGY EFFICIENCY MEASURES

This section discusses the order in which energy efficiency measures (EEMs) should be evaluated in the feasibility study. The reasons for establishing an order or hierarchy for EEM evaluation are to: a) ensure that interactive effects among projects are considered so that savings are not double counted, and b) ensure that the basic EEMs are considered before starting complex HVAC and energy generation projects.

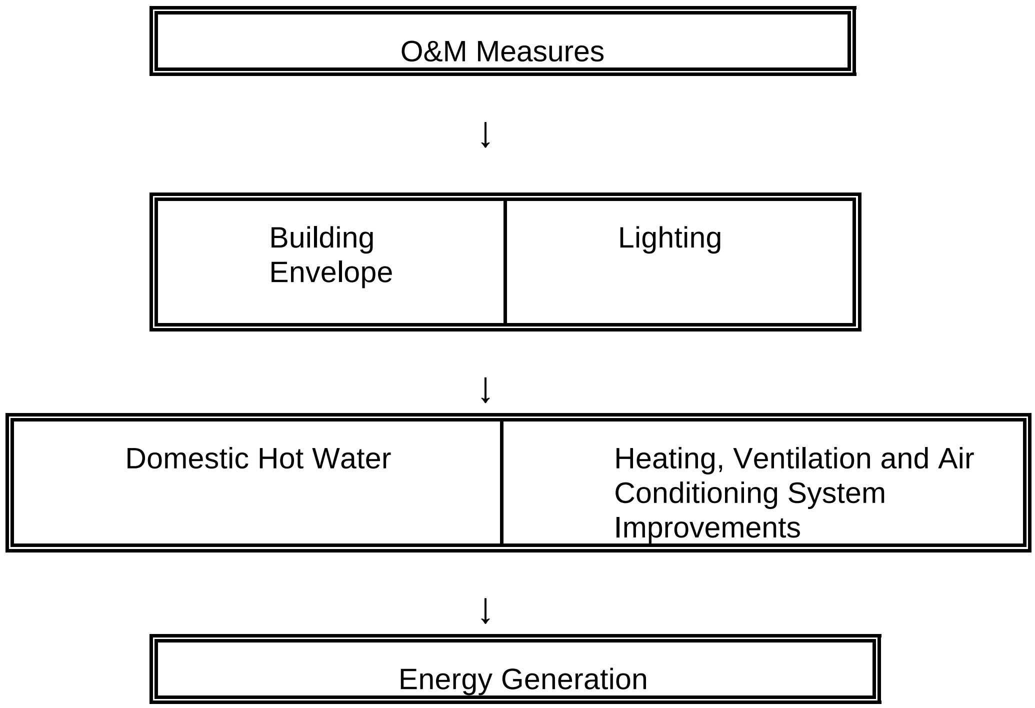
A. General Information

The interaction of all O&M measures and EEMs must be considered when calculating the project energy savings. If the implementation of one EEM has an impact on the energy savings of another EEM, then this interaction must be taken into account to prevent overstating the energy savings. Due to the interaction of related EEMs, the first EEM evaluated will affect the energy savings potential of subsequent EEMs. For instance, the feasibility study proposes two EEMs: one is a modification to the building envelope and the other is an HVAC modification. The modification to the building envelope reduces the heat load on the HVAC system. Therefore, if the building envelope project is evaluated first, the energy savings potential for the HVAC system would be less than if it had been evaluated first. As the simple payback is based on the amount of energy cost savings, the order in which projects are evaluated will have an impact on its simple payback.

B. Order of Project Evaluation

The baseline energy use of the facility is determined in Appendix A. This baseline use is then reduced after implementation of the O&M measures. After implementing the O&M measures, a new baseline energy use is established for the facility. This "new" baseline energy use will be the basis of evaluation for the next EEMs, such as building envelope and lighting projects. Once the building envelope and lighting projects are identified, the energy use is further reduced for the facility. This "new" energy use will be the baseline for evaluating the next projects, domestic hot water and HVAC projects. Figure 3-1 shows the order of project evaluation for various energy efficiency technologies. A discussion of each of these technologies follows the figure.

Figure 3-1
Overall Order of Energy Project Evaluation



1. O&M Measures

The first step is to identify the cost-effective O&M measures affecting all energy using systems in the facility. The facility's baseline energy use will be reduced as a result of implementing these O&M measures. This new baseline will serve as the starting point for all subsequent related EEMs in calculating energy savings. For example, if a recommended O&M measure requires installation of night heating setback thermostats, then all subsequent heating EEMs requiring nighttime temperature in the formula must use the O&M night setback temperature.

2. Building Envelope

Figure 3-2 gives the order of evaluation of the building envelope EEMs. The baseline energy use for the building envelope measures assumes that all the O&M measures that affect building loads have already been implemented.

Figure 3-2
Order of Evaluation of
Building Envelope EEMs

O&M Measures

↓

Insulation, Infiltration Control and Windows

↓

Other openings

3. Lighting

Figure 3-3 shows the order for evaluating lighting EEMs. The following is a discussion of the order in which lighting projects must be evaluated:

a. Assume that all O&M measures affecting lighting are implemented and the energy savings realized.

b. Improve the energy efficiency of the existing lighting fixtures through either conversions or modifications to higher efficiency types (e.g., fluorescent and high pressure sodium lamps).

c. Install equipment to control the operating hours of equipment.

Figure 3-3
Order of Evaluation of Lighting EEMs

O&M Measures

↓

Modify fixtures by installing energy efficient lamps and/or electronic ballast, or optical reflectors	Convert to more efficient light source (e.g., fluorescent, high pressure sodium lamps)

↓

Install lighting controls, such as, occupancy sensors, photocells and/or twist timers

4. Domestic Hot Water, including Swimming Pools

Figure 3-4 shows the order for evaluating domestic hot water (DHW) projects. The following is a discussion of the order of evaluation:

a. Assume the O&M measures affecting the DHW system are implemented and the savings realized.

b. Improve the efficiency of the existing equipment.

c. Replace or down-size existing equipment.

d. Install equipment controls.

Figure 3-4
Order of Evaluation of DHW EEMs

O&M Measures

↓

Improve the efficiency of existing equipment (variable speed pumping, swimming pool cover)

↓

Replace or downsize equipment (decentralize domestic hot water, install high efficiency equipment)

↓

Install equipment controls (recirculation controls)

5. HVAC Systems

The order of analysis for HVAC EEMs is shown in Figure 3-5. The following is a discussion of the order of project evaluation:

a. Assume that all O&Ms affecting the HVAC system are implemented and the energy savings realized.

b. Assume that all cost-effective lighting and building envelope EEMs affecting the HVAC system are implemented and the energy savings realized.

c. Improve the energy efficiency of the existing domestic hot water if it affects the HVAC system.

d. Improve the energy efficiency of the existing HVAC system through installation or modification of components, such as economizers and motors.

e. Install equipment to control the operating hours of HVAC equipment (e.g., energy management systems). Controls will be considered only when the existing HVAC equipment will **not** be replaced within five years. If the HVAC equipment will be replaced, then the feasibility study must assume that HVAC equipment replacement occurs first, before the installation of the controls.

f. Replace the existing HVAC equipment (e.g., boilers, chillers, package units, cooling towers) with more efficient equipment.

g. Consider the installation of a thermal energy storage system (TES) if the project is feasible and maintains or reduces the energy required for chilling.

6. On-Site Electricity and Energy Generation Projects

The hierarchy to be used for energy generation projects assumes that all the cost-effective projects indicated in Figure 3-5 have been implemented already. The resulting energy use after implementation of these projects forms the baseline from which the energy generation project will be considered.

Figure 3-5
Order of Evaluation of HVAC EEMs

Implement O&M Measures (including those involving HVAC, lighting, domestic hot water and building envelope)

↓

Implement lighting, building envelope and DHW EEMs

↓

Implement HVAC efficiency improvements by installing or modifying components such as:
(the following is not a hierarchy)

- Economizers
- Variable speed motors
- Energy efficient motors
- Heat recovery
- Air handler conversions (VAV)
- Cooling tower efficiency improvements

↓

Install HVAC Controls*

- Energy management system
- Programmable time clocks

↓

Replace HVAC Equipment*

- Boiler, chiller or packaged unit replacement
- Cooling tower conversions

↓

Consider Thermal Energy Storage and Energy Generation

* Refer to page 3-5, item 5.e.

4. TYPICAL ENERGY EFFICIENCY MEASURES

The following is a list of typical energy efficiency measures. The three letter acronyms to the left of each measure are for Energy Commission use.

BUILDING ENVELOPE: (B)

Insulation (R)

BRB - Reflective Barriers (Reflective Films, Paints, High Emissivity Coating, Etc.)
BRC - Combination of Roof/Ceiling and/or Wall Insulation
BRO - Other Insulation Measures

Infiltration Control (I)

BIZ - Infiltration Control (Indicate Exterior or Interior)

Fenestration/Windows (F)

BFC - Combination Insulating Panel and Glazing
BFD - Double Glazing
BFE - Spectrally Selective (Low Emissivity) Glazing(s)
BFF - Reflective Film (Specify Orientation of the Windows)
BFI - Replace Glass With Insulated Panels
BFS - Storm Windows
BFT - Triple Glazing
BFW - Wall Up or Close Off
BFX - Other Window Measures

Other Openings (O)

BOA - Air Locks or Vestibules
BOS - Storm Doors
BOW - Wall Up or Close Off
BOX - Other Door/Miscellaneous Measures

MECHANICAL SYSTEMS: (M)

Conversion (C)

MCE - Conversion to Electricity
MCG - Conversion to Natural Gas
MCX - Conversion to Another Non-Renewable Fuel

Controls (K)

MKC - Central Control/Automated Energy Management
MKE - Enthalpy Controls
MKK - Other Control Devices
MKO - Oxygen (O_2) Trim Controls
MKS - Shut Down/Shut Off Devices
MKT - Temperature Reset Devices
MKU - Upgrade Existing Energy Management Systems
MKV - Radiator Control Valves

Air Conditioning (A)

MAA - Adiabatic Cooling
MAB - Chiller Conversion to Absorption (Indicate the Type, i.e. Steam, Hot Water, Direct Fire, Number of Stages, etc.)
MAC - Chiller Efficiency Improvement
MAD - Chiller Conversion to Electric Drive (Indicate compressor type, i.e., centrifugal, screw, reciprocating)
MAE - Install Economizer
MAF - Install a Flat Plate Heat Exchanger
MAU - Package Unit Application
MAV - Evaporative Cooling
MAX - Other Air Conditioning Measures

Other (O)

MOE - Install Energy Recovery Devices
MOG - Cogeneration Application

Heating Modifications (H)

MHA - Install Automatic Ignition Device
MHB - Replace Burner
MHD - Downsize System
MHE - Install Stack Economizer Heat Recovery System
MHF - Install Automatic Flue Damper
MHH - Install Humidification Device
MHO - Replace Boiler
MHP - Preheat Combustion Air/Make Up Water
MHR - Convert to Radiant Heating
MHT - Install Turbulators
MHX - Other Heating Modifications

Distribution System Modification (D)

MDA - Reduce Air Volume and/or Adding Return Air Systems
MDI - Insulate Pipes or Ductwork

MDO - Damper Modification
MDS - Prevent Air Stratification
MDV - Install Variable Air Volume
MDX - Other Distribution System Modifications
MDZ - Zoning Modifications

Water (W)

MWD - Decentralized Hot Water Heater
MWF - Install Flow Restrictors
MWI - Insulate Tanks/DHW Pipes
MWP - Swimming Pool Covers
MWS - Water-related Controls/Heat Recovery Projects for Special Use Areas Such As Kitchens, Laundries and Pools
MWX - Other Water Measures

ELECTRICAL AND LIGHTING SYSTEMS: (E)

Lighting Conversion (C)

ECE - Convert from Fluorescent to Higher Efficiency Fluorescent Lights (T8 and electronic ballast)
ECF - Convert from Incandescent to Fluorescent Lights
ECH - Convert from Incandescent or Mercury Vapor to Metal Halide or High Pressure Sodium Lights
ECX - Convert to Other High Efficiency Lights

Lighting Modification (M)

EMF - Delamp and install reflectors
EMR - Reduce Numbers of Fixtures/Task Lighting (Reduce Overall Lighting Levels)
EMZ - Other Lighting Modifications

Controls (K)

EKL - Load Management Control Measures
EKM - Submetering Systems
EKP - Power Factor Correction
EKV - Variable Frequency Controls (Motor Drives)
EKZ - Electrical System Control Devices (Motion Detectors, Photocells, Occupancy Sensors, Etc.)

Other Electrical (E)

EEM - Improve Motor Efficiency
EES - Multi Speed Electrical Motors
EEZ - Other Electrical Applications

RENEWABLE: (R)

Solar (S)

RSA - Active Solar Space Conditioning
RSP - Passive Solar Space Conditioning
RSV - Photovoltaic Application
RSW - Solar Hot Water

Wind (B)

RBZ - Utilization of Wind Energy (Detail How)

Hydro (G)

RGZ - Utilization of Water Power (Detail How)

Conversion (C)

RCB - Conversion to Biomass
RCR - Conversion to Refuse
RCW - Conversion to Wood
RCX - Conversion to Other Renewable(s)

OTHER (O)

OTH - Other (Projects that cannot be classified as Building Envelope, Electrical, Mechanical, or Renewable in nature.)

5. EXAMPLE EQUIPMENT LOADS AND EFFICIENCIES

This section contains examples of equipment loads and efficiencies. These examples are presented for information only. References are provided for sources of new equipment efficiencies.

A. Load Factor

1. General Information

A load factor is used to determine the operating electric demand for electrical equipment. It is the ratio of the actual work the equipment is performing to the nameplate rated work the equipment is capable of performing. Examples of equipment to which a load factor would apply include fan motors, pump motors and chillers.

2. Typical Formulae Incorporating the Load Factor

$$kW = \frac{(HP)(0.746)(LF)}{FLE}$$

Where:

kW	=	kilowatt
HP	=	nameplate horsepower
0.746	=	conversion factor for kW to horsepower
LF	=	load factor
FLE	=	motor full load efficiency

$$kW = \left[\frac{(volts)(FLA)\left(\sqrt{phase}\right)(PF)}{1000}\right](LF)$$

Where:

kW	=	kilowatt
FLA	=	full load amps
PF	=	power factor
LF	=	load factor

3. Methods of Calculating Equipment Load Factor

a. Measured kW versus full load kW

b. Measured amps versus full load amps

c. Calculated brake horsepower (BHP) from fan or pump curves versus motor rated horsepower/motor efficiency

d. Calculated fan BHP:

$$BHP = \frac{(CFM)(P)(HP)}{6356}$$

Where:

BHP	=	brake horsepower
CFM	=	air flow in cubic feet per minute
P	=	static pressure in inches of water
HP	=	nameplate horsepower
6356	=	conversion factor in cfm-inches of water/BHP

$$Load = \frac{BHP}{HP}(100)$$

Where:

Load	=	percent fan load
HP	=	nameplate horsepower

e. Calculated pump BHP

$$BHP = \frac{(Flow)(Pressure)}{3965}$$

Where:

Flow	=	fluid flow in gallons per minute
Pressure	=	fluid head pressure in feet
3965	=	conversion factor (ft/hp)

$$Load = \frac{BHP}{HP}(100)$$

Where:

Load	=	percent pump load
BHP	=	brake horsepower
HP	=	nameplate horsepower

B. HVAC Equipment Efficiencies

1. Chiller Energy

• New Centrifugal	0.50 to 0.65 kW/ton
• New Screw	0.60 to 0.90 kW/ton
• New Reciprocating	1.10 kW/ton

Other sources of new chiller efficiency data:

- *California's 1999 LNSPC Program Procedures Manual*, *Appendix B: Minimum Equipment Efficiency Standards*.
  Web Site: <www.scespc.com/lnrspc/appen-v2.pdf>
  This Web Site contains information on minimum energy efficiencies for small (<150 tons), medium (150-300 tons) and large (>300 tons) electric/water chillers. These minimums are based on California's building and equipment standards. Chiller performance curves and characteristics based on ASHRAE Standard 90.11R-PRD1 are also contained in the appendix. The appendix is available from Southern California Edison, Pacific Gas and Electric or San Diego Gas and Electric.

- *Energy Efficiency Recommendations*
  U. S. Department of Energy
  Web Site: <www.eren.doe.gov/femp/procurement/begin.html>
  This Web Site contains information on recommended energy efficiencies for chillers greater than 150 tons.

2. Cooling Tower Energy

- Cooling tower--typically 20% of estimated heating and cooling energy

3. Boiler Efficiency

• New	80-90%
• Existing	70-80%

Other sources of new boiler efficiency data:

- *California's 1999 LNSPC Program Procedures Manual*, *Appendix B: Minimum Equipment Efficiency Standards*.
  Web Site: <www.scespc.com/lnrspc/appen-v2.pdf>
  This Web Site contains information on minimum energy efficiencies for small (<300,000 Btu/hour) to large (>300,000 Btu/hour) boilers. These minimums are based on California's building and equipment standards. The appendix is available from Southern California Edison, Pacific Gas and Electric or San Diego Gas and Electric.

- *Energy Efficiency Recommendations*
  U. S. Department of Energy
  Web Site: <www.eren.doe.gov/femp/procurement/begin.html>
  This Web Site contains information on recommended energy efficiencies for boilers greater than 300,000 Btu/hour.

4. Air Conditioning Units

- New package 10-12 SEER (1-1.2 kW/ton)

Other sources of new commercial air conditioning data:

- *California's 1999 LNSPC Program Procedures Manual*, *Appendix B: Minimum Equipment Efficiency Standards*.
  Web Site: <www.scespc.com/lnrspc/appen-v2.pdf>
  Information is provided on minimum energy efficiencies for:

  - unitary air conditioners
  - heat pumps
  - air cooled and electric, water cooled air conditioners
  - heat pumps
  - evaporatively-cooled unitary air conditioners and heat pumps
  - packaged terminal air conditioners
  - room air conditioners
  - large electric condensing units (greater than 135,000 Btu/hour).

  Minimum efficiencies are provided for small (less than 65,000 Btu/hour) to large units (greater than 135,000 Btu/hour) units. These minimums are based on California's building and equipment standards. The appendix is available from Southern California Edison, Pacific Gas and Electric or San Diego Gas and Electric.

- *Energy Efficiency Recommendations*
  U. S. Department of Energy
  Web Site: <www.eren.doe.gov/femp/procurement/begin.html>
  This Web Site contains information on recommended energy efficiencies for air and water source air conditioners and heat pumps larger than 65,000 Btu/hour.

5. Gas Furnaces

- New furnaces 80 percent

Other sources of new gas/oil furnace:

- *California's 1999 LNSPC Program Procedures Manual*, *Appendix B: Minimum Equipment Efficiency Standards*.
  Web Site: <www.scespc.com/lnrspc/appen-v2.pdf>

This Web Site contains information on minimum energy efficiencies for central furnaces, oil furnaces, wall furnaces, duct furnaces and unit heaters. These minimums are based on California's building and equipment standards. The appendix is available from Southern California Edison, Pacific Gas and Electric or San Diego Gas and Electric or from this Web Site.

6. Air Distribution Efficiency (air handler energy loss)

- 25 percent of heating and cooling energy for regular duct system
- 6 percent of heating and cooling energy for tight duct system with leak testing

7. HVAC Pumping Energy

- 10% of estimated heating and coolign energy

C. Motor Efficiencies

The preferred source for existing motor efficiency is the manufacturer's performance data. Tables 5-1 and 5-2 contain example efficiencies for existing motors. Table 5-3 contains efficiencies for high and premium efficiency motors. Other sources for motor efficiencies include the following:

- *MotorMaster*
  U.S. Department of Energy,
  Web Site: <www.motor.doe.gov/mcsnew.shtml>
  This software program assists organizations in the selection and maintenance of motor inventories. The software features multi-user access, variable load capability, motor load and efficiency estimation capability, updated values for energy efficient and premium efficient motors, a manufacturer's database and savings tracker.

- California's 1999 LNSPC Program Procedures Manual, *Appendix B: Minimum Equipment Efficiency Standards*
  Web Site: <www.scespc.com/lnrspc/appen-v2.pdf>
  This appendix provides the minimum efficiencies for motors that are at least one horsepower in size. These efficiencies are based on California's Title 24 and the National Electric Manufacturers Association's (NEMA) Table 12-10. The appendix is available from Southern California Edison, Pacific Gas and Electric or San Diego Gas and Electric or from the Web Site.

- Energy Efficiency Recommendations
  U. S. Department of Energy
  Web Site: <www.eren.doe.gov/femp/procurement/begin.html>
  This Web Site contains information on recommended energy efficiencies for motors.

Table 5-1
Example Existing Motor Efficiency

	Installed Motor Stock Average Efficiency (1)			
	Open Drip-Proof Motors		Totally Enclosed Fan-Cooled Motors	
hp	75% load	100% load	75% load	100% load
1	74.1	75.4	73.8	75.6
1.5	76.3	77.4	76.2	77.2
2	77.8	78.3	78.2	78.8
3	80.5	80.3	79.6	80.0
5	82.1	81.8	82.4	82.0
7.5	83.6	83.1	84.4	83.8
10	84.9	83.9	85.4	84.6
15	87.0	86.1	85.8	85.0
20	87.1	86.2	87.6	86.7
25	88.0	87.1	88.1	87.6
30	88.5	87.5	88.8	88.1
40	88.6	88.3	88.7	88.4
50	89.1	88.6	89.7	89.4
60	89.4	89.0	89.7	89.4
75	90.1	89.8	89.9	90.1
100	90.3	90.0	90.0	90.3
125	91.3	90.8	90.2	90.6
150	90.9	90.8	90.8	91.2
200	91.3	91.0	92.1	92.0
250	91.4	91.2	91.5	91.6
300	91.3	91.0	91.3	91.6

(1) Derived from the "compare" section of Motor Master. A speed of 1800 rpm is assumed for all. Motor Master is a product of the Washington State Energy Office.

Table 5-2
Example Efficiencies for Motors that Meet California's Title 24 Standards and the National Electric Manufacturer's Association Table 12-10

		Open Drip-Proof			Totally Enclosed Fan-Cooled		
hp	**kW**	**3600 RPM**	**1800 RPM**	**1200 RPM**	**3600 RPM**	**1800 RPM**	**1200 RPM**
1	0.8		82.5%	80.0%	75.5%	82.5%	80.0%
1.5	1.1	82.5%	84.0%	84.0%	82.5%	84.0%	85.5%
2	1.5	84.0%	84.0%	85.5%	84.0%	84.0%	86.5%
3	2.2	84.0%	86.5%	86.5%	85.5%	87.5%	87.5%
5	3.7	85.5%	87.5%	87.5%	87.5%	87.5%	87.5%
7.5	5.6	87.5%	88.5%	88.5%	88.5%	89.5%	89.5%
10	7.5	88.5%	89.5%	90.2%	89.5%	89.5%	89.5%
15	11.1	89.5%	91.0%	90.2%	90.2%	91.0%	90.2%
20	14.9	90.2%	91.0%	91.0%	90.2%	91.0%	90.2%
25	18.7	91.0%	91.7%	91.7%	91.0%	92.4%	91.7%
30	22.4	91.0%	92.4%	92.4%	91.0%	92.4%	91.7%
40	29.8	91.7%	93.0%	93.0%	91.7%	93.0%	93.0%
50	37.3	92.4%	93.0%	93.0%	92.4%	93.0%	93.0%
60	44.8	93.0%	93.6%	93.6%	93.0%	93.6%	93.6%
75	56.0	93.0%	94.1%	93.6%	93.0%	94.1%	93.6%
100	74.6	93.0%	94.1%	94.1%	93.6%	94.5%	94.1%
125	93.3	93.6%	94.5%	94.1%	94.5%	94.5%	94.1%
150	111.9	93.6%	95.0%	94.5%	94.5%	95.0%	95.0%
200	149.2	94.5%	95.0%	94.5%	95.0%	95.0%	95.0%

Source: California's 1999 LNSPC Program Procedures Manual, Appendix B: Minimum Equipment Efficiency Standards

Table 5-3
Examples of High and Premium Efficiency Motors

Totally Enclosed Fan-Cooled Motors

hp	kW	3600 RPM		1800 RPM		1200 RPM	
		1999 Util Rebate (1)	Best Avail (2)	1999 Util Rebate (1)	Best Avail (2)	1999 Util Rebate (1)	Best Avail (2)
1	0.8	78.5%	80.4%	85.5%	86.5%	82.5%	85.5%
1.5	1.1	85.5%	87.5%	86.5%	87.5%	87.5%	87.5%
2	1.5	86.5%	87.5%	86.5%	86.5%	88.5%	88.5%
3	2.2	88.5%	89.5%	89.5%	89.5%	89.5%	90.2%
5	3.7	89.5%	89.5%	89.5%	90.2%	89.5%	90.2%
7.5	5.6	91.0%	91.7%	91.7%	91.7%	91.7%	91.7%
10	7.5	91.7%	91.7%	91.7%	91.7%	91.7%	92.4%
15	11.1	91.7%	91.7%	92.4%	93.0%	92.4%	92.4%
20	14.9	92.4%	92.4%	93.0%	93.6%	92.4%	93.0%
25	18.7	93.0%	93.6%	93.6%	94.1%	93.0%	93.0%
30	22.4	93.0%	93.6%	93.6%	94.5%	93.6%	93.6%
40	29.8	93.6%	94.1%	94.1%	94.5%	94.1%	94.5%
50	37.3	94.1%	94.1%	94.5%	95.0%	94.1%	94.5%
60	44.8	94.1%	94.5%	95.0%	95.4%	94.5%	95.0%
75	56.0	94.5%	95.0%	95.4%	95.4%	95.0%	95.0%
100	74.6	95.0%	95.8%	95.4%	95.4%	95.4%	95.4%
125	93.3	95.4%	95.8%	95.4%	96.2%	95.4%	95.8%
150	111.9	95.4%	96.2%	95.8%	96.2%	95.8%	96.2%
200	149.2	95.8%	96.2%	96.2%	96.5%	95.8%	95.8%

Sources:
(1) PG&E 1999 Express Efficiency Rebate Web Site <www.pge.com>.
(2) U. S. Department of Energy, Energy Efficiency Recommendations Web Site <www.eren.doe.gov/femp/procurement/begin.html>.

Table 5-3 (continued)
Examples of High and Premium Efficiency Motors

Open Drip-Proof Motors

hp	kW	3600 RPM		1800 RPM		1200 RPM	
		1999 Util Rebate (1)	Best Avail (2)	1999 Util Rebate (1)	Best Avail (2)	1999 Util Rebate (1)	Best Avail (2)
1	0.8	80.0%	84.0%	85.5%	86.5%	82.5%	82.5%
1.5	1.1	85.5%	86.5%	86.5%	86.5%	86.5%	87.5%
2	1.5	86.5%	86.5%	86.5%	88.5%	87.5%	88.5%
3	2.2	86.5%	87.5%	89.5%	90.2%	89.5%	90.2%
5	3.7	89.5%	91.0%	89.5%	90.2%	89.5%	90.2%
7.5	5.6	89.5%	90.2%	91.0%	91.7%	91.7%	91.7%
10	7.5	90.2%	91.7%	91.7%	91.7%	91.7%	92.4%
15	11.1	91.0%	91.7%	93.0%	93.0%	92.4%	92.4%
20	14.9	92.4%	93.0%	93.0%	93.6%	92.4%	93.0%
25	18.7	93.0%	93.0%	93.6%	94.1%	93.0%	93.6%
30	22.4	93.0%		94.1%		93.6%	
40	29.8	93.6%	94.5%	94.1%	94.1%	94.1%	94.5%
50	37.3	93.6%	94.1%	94.5%	95.0%	94.1%	94.5%
60	44.8	94.1%	94.5%	95.0%	95.4%	95.0%	95.4%
75	56.0	94.5%	95.4%	95.0%	95.4%	95.0%	95.8%
100	74.6	94.5%	95.8%	95.4%	95.8%	95.0%	95.4%
125	93.3	95.0%	95.4%	95.4%	95.8%	95.4%	95.8%
150	111.9	95.4%	96.2%	95.8%	96.2%	95.8%	95.8%
200	149.2	95.4%	96.2%	95.8%	96.2%	95.4%	96.2%

Sources:

(1) PG&E 1999 Express Efficiency Rebate Web Site <www.pge.com>.

(2) U. S. Department of Energy, Energy Efficiency Recommendations Web Site <www.eren.doe.gov/femp/procurement/begin.html>.

D. Variable Frequency Drives

1. kW Calculation

The source of the following calculation is Newcomb Anderson Associates and DOE 2.1 California Compliance Supplement:

$$kW(X) = kW(Y)(X)$$

Where:

X = percent motor speed (proportional to percent flow)
Y = part load energy modifier
kW = full load kilowatts. Account for maximum % load (bhp), motor efficiency and speed control efficiency. The following speed control efficiencies are derived from the Electric Power Research Institute (EPRI): inlet vanes = 92%, outlet damper = 90%, and VFD = 95%

2. Part Load Equation

The source of the following calculation is Newcomb Anderson Associates and DOE 2.1 California Compliance Supplement:

Y = a + bX + cX^2

Where:

X = percent motor speed (proportional to percent flow)
Y = part load energy modifier
BI = Backward inclined
AF = air foil
FC = Forward curved

Fan Type	BI/AF: Outlet dampers or no control	BI/A: Inlet Vanes	FC: Outlet dampers or no control	FC: Inlet Vanes	Vane Axial Variable Pitch	Variable Frequency Drive
Coefficient:						
a	0.2271429	0.5843452	0.1906667	0.3396190	0.2120476	0.2197619
b	1.1789286	-0.5791670	0.3100000	-0.8481390	-0.5692860	-0.874784
c	-0.4107140 (min Y=0.68)	0.9702381	0.5000000	1.4956710	1.3452381	1.6525947

3. Additional Resource

The Electric Power Research Institute (EPRI) in conjunction with the Bonneville Power Administration has developed the ASDMaster software. This program assists users in analyzing the energy and production benefits of adjustable speed drives and contains a specification tool to assist in writing performance specifications. For information on the software, call the EPRI ASDP at 1-800-982-9294 or go to <www.motor.doe.gov/mcsnew.shtml>.

E. Lighting

1. Sources of Lighting Loads Information

a. *Guidelines for Energy Simulation of Commercial Buildings*, Bonneville Power Administration, March 1992. Building simulations track both the direct electric lighting consumption and the indirect effect of lighting on HVAC equipment. The direct electric consumption can be inputted as watts per square foot. For surface mounted or suspended fixtures, the electricity used by the lights ends up as heat in the conditioned space, increasing the cooling load or decreasing the heating load accordingly. Recessed fixtures may loose heat to an unconditioned attic in small buildings or to an unconditioned air plenum in large buildings. If the attic is well vented, or if the HVAC system in large buildings uses an air plenum return, part of the heat generated by lighting may escape from the building without contributing to HVAC loads. For that reason, most computer simulation programs ask for the fraction of the heat from the lights that goes into the space. Other programs ask whether or not the lighting is "vented."

The most common method for cooling fluorescent fixtures is to pass the return air through them to an air plenum above the ceiling tiles. In some cases, the air passes through slots on the side of the fixture; in other cases, the air passes through the interior of the fixture to a ducted return. The percent of heat from the lights which goes to the space is a strong function of the fixture design, the air flow rate through each fixture, and whether or not there is ducted return. With a variable air volume system, the air flow rate varies. Air flow rates can also vary due to the location of the fixtures relative to the fans.

b. Rundquist, R.A., Johnson, K.F., and Aumann, D. J., “Calculating Lighting and HVAC Interactions,” *ASHRAE Journal*, November 1993. This article provides a method for estimating the effects of lighting retrofits on heating, ventilating and air conditioning energy and installation costs.

2. Lighting Efficiencies

Table 5-4 provides examples of fixture wattages for various types of lamps. The source of this table is the 1999 Large Nonresidential Standard Performance Contracting Program offered by PG&E, SCE and SDG&E (see Web Site: www.scespc.com/largenonresmanuals.htm).

F. Plug Load Energy Consumption

Plug loads include electrical equipment that are plugged into outlets. These loads are about 15 to 20 percent of the total cooling load. The major plug loads in office buildings that use the most energy are computers and related equipment, such as printers, copiers and monitors. In the past, engineers and HVAC system designers used two to five watts per square feet to account for plug load usage in office buildings. Measured data on actual plug loads from 44 office buildings indicate a range of 0.4 to 1.1 watts per square feet with an average of 0.83. The office buildings ranged in size from 10,000 to 400,000 square feet. If plug loads are estimated to be greater than 1.25 watts/square feet, then there must be justification that the actual plug loads will be higher than typical loads. Office equipment power densities will likely decrease in the next decade because of technical advances promoted by Energy Star and other similar programs.

Source: Komar, P., “Space Cooling Demands from Office Plug Loads,” *ASHRAE Journal*, December 1997

Table 5-4
Examples of Fixture Wattages for Various Lamps

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	LAMPS/ FIXT	WATTS/ LAMP	KW/FIXT
		Compact Fluorescent Fixtures				
CF10/2D	CFD10W	Compact Fluorescent, 2D, (1) 10W lamp	Mag-STD	1	10	0.016
CF16/2D	CFD16W	Compact Fluorescent, 2D, (1) 16W lamp	Mag-STD	1	16	0.026
CF21/2D	CFD21W	Compact Fluorescent, 2D, (1) 21W lamp	Mag-STD	1	21	0.026
CF28/2D	CFD28W	Compact Fluorescent, 2D, (1) 28W lamp	Mag-STD	1	28	0.035
CF38/2D	CFD38W	Compact Fluorescent, 2D, (1) 38W lamp	Mag-STD	1	38	0.046
CFQ10/1	CFQ10W	Compact Fluorescent, quad, (1) 10W lamp	Mag-STD	1	10	0.015
CFQ13/1	CFQ13W	Compact Fluorescent, quad, (1) 13W lamp	Mag-STD	1	13	0.017
CFQ13/1-L	CFQ13W	Compact Fluorescent, quad, (1) 13W lamp, BF=1.05	Electronic	1	13	0.015
CFQ13/2	CFQ13W	Compact Fluorescent, quad, (2) 13W lamp	Mag-STD	2	13	0.031
CFQ13/2-L	CFQ13W	Compact Fluorescent, quad, (2) 13W lamp, BF=1.0	Electronic	2	13	0.028
CFQ13/3	CFQ13W	Compact Fluorescent, quad, (3) 13W lamp	Mag-STD	3	13	0.048
CFQ15/1	CFQ15W	Compact Fluorescent, quad, (1) 15W lamp	Mag-STD	1	15	0.020
CFQ17/1	CFQ17W	Compact Fluorescent, quad, (1) 17W lamp	Mag-STD	1	17	0.024
CFQ17/2	CFQ17W	Compact Fluorescent, quad, (2) 17W lamp	Mag-STD	2	17	0.048
CFQ18/1	CFQ18W	Compact Fluorescent, quad, (1) 18W lamp	Mag-STD	1	18	0.026
CFQ18/1-L	CFQ18W	Compact Fluorescent, quad, (1) 18W lamp, BF=1.0	Electronic	1	18	0.020
CFQ18/2	CFQ18W	Compact Fluorescent, quad, (2) 18W lamp	Mag-STD	2	18	0.045
CFQ18/2-L	CFQ18W	Compact Fluorescent, quad, (2) 18W lamp, BF=1.0	Electronic	2	18	0.038
CFQ18/4	CFQ18W	Compact Fluorescent, quad, (4) 18W lamp	Mag-STD	2	18	0.090
CFQ20/1	CFQ20W	Compact Fluorescent, quad, (1) 20W lamp	Mag-STD	1	20	0.023
CFQ20/2	CFQ20W	Compact Fluorescent, quad, (2) 20W lamp	Mag-STD	2	20	0.046
CFQ22/1	CFQ22W	Compact Fluorescent, Quad, (1) 22W lamp	Mag-STD	1	22	0.024
CFQ22/2	CFQ22W	Compact Fluorescent, Quad, (2) 22W lamp	Mag-STD	2	22	0.048
CFQ22/3	CFQ22W	Compact Fluorescent, Quad, (3) 22W lamp	Mag-STD	3	22	0.072
CFQ25/1	CFQ25W	Compact Fluorescent, Quad, (1) 25W lamp	Mag-STD	1	25	0.033
CFQ25/2	CFQ25W	Compact Fluorescent, Quad, (2) 25W lamp	Mag-STD	2	25	0.066
CFQ26/1	CFQ26W	Compact Fluorescent, quad, (1) 26W lamp	Mag-STD	1	26	0.033
CFQ26/1-L	CFQ26W	Compact Fluorescent, quad, (1) 26W lamp, BF=0.95	Electronic	1	26	0.027
CFQ26/2	CFQ26W	Compact Fluorescent, quad, (2) 26W lamp	Mag-STD	2	26	0.066
CFQ26/2-L	CFQ26W	Compact Fluorescent, quad, (2) 26W lamp, BF=0.95	Electronic	2	26	0.050
CFQ26/3	CFQ26W	Compact Fluorescent, quad, (3) 26W lamp	Mag-STD	3	26	0.099
CFQ26/6-L	CFQ26W	Compact Fluorescent, quad, (6) 26W lamp, BF=0.95	Electronic	6	26	0.150

Note: This table extracted from the 1999Large Nonresidential Standard Performance Contracting Program Manual and Forms Web Site: <www.scespc.com/largenonresmanuals.htm>.

Table 5-4 (continued)
Examples of Fixture Wattages for Various Lamps

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	LAMPS/ FIXT	WATTS/ LAMP	KW/FIXT
CF23333Q28/1	CFQ28W	Compact Fluorescent, quad, (1) 28W lamp	Mag-STD	1	28	0.033
CFQ9/1	CFQ9W	Compact Fluorescent, Quad, (1) 9W lamp	Mag-STD	1	9	0.014
CFQ9/2	CFQ9W	Compact Fluorescent, Quad, (2) 9W lamp	Mag-STD	2	9	0.023
CFT13/1	CFT13W	Compact Fluorescent, twin, (1) 13W lamp	Mag-STD	1	13	0.017
CFT13/2	CFT13W	Compact Fluorescent, twin, (2) 13W lamp	Mag-STD	2	13	0.031
CFT13/3	CFT13W	Compact Fluorescent, twin, (3) 13 W lamp	Mag-STD	3	13	0.048
CFT18/1	CFT18W	Compact Fluorescent, Long twin., (1) 18W lamp	Mag-STD	1	18	0.024
CFT22/1	CFT22W	Compact Fluorescent, twin, (1) 22W lamp	Mag-STD	1	22	0.027
CFT22/2	CFT22W	Compact Fluorescent, twin, (2) 22W lamp	Mag-STD	2	22	0.054
CFT22/4	CFT22W	Compact Fluorescent, twin, (4) 22W lamp	Mag-STD	4	22	0.108
CFT24/1	CFT24W	Compact Fluorescent, long twin, (1) 24W lamp	Mag-STD	1	24	0.032
CFT28/1	CFT28W	Compact Fluorescent, twin, (1) 28W lamp	Mag-STD	1	28	0.033
CFT28/2	CFT28W	Compact Fluorescent, twin, (2) 28W lamp	Mag-STD	2	28	0.066
CFT32/1-L	CFM32W	Compact Fluorescent, twin or multi, (1) 32W lamp	Electronic	1	32	0.034
CFT32/2-L	CFM32W	Compact Fluorescent, twin or multi, (2) 32W lamp	Electronic	2	32	0.062
CFT32/6-L	CFM32W	Compact Fluorescent, twin or multi, (2) 32W lamp	Electronic	6	32	0.186
CFT36/1	CFT36W	Compact Fluorescent, long twin, (1) 36W lamp	Mag-STD	1	36	0.051
CFT40/1	CFT40W	Compact Fluorescent, twin, (1) 40W lamp	Mag-STD	1	40	0.046
CFT40/1-L	CFT40W	Compact Fluorescent, long twin, (1) 40W lamp	Electronic	1	40	0.043
CFT40/2	CFT40W	Compact Fluorescent, twin, (2) 40W lamp	Mag-STD	2	40	0.085
CFT40/2-L	CFT40W	Compact Fluorescent, long twin, (2) 40W lamp	Electronic	2	40	0.072
CFT40/3	CFT40W	Compact Fluorescent, twin, (3) 40 W lamp	Mag-STD	3	40	0.133
CFT40/3-L	CFT40W	Compact Fluorescent, long twin, (3) 40W lamp	Electronic	3	40	0.105
CFT5/1	CFT5W	Compact Fluorescent, twin, (1) 5W lamp	Mag-STD	1	5	0.009
CFT5/2	CFT5W	Compact Fluorescent, twin, (2) 5W lamp	Mag-STD	2	5	0.018
CFT7/1	CFT7W	Compact Fluorescent, twin, (1) 7W lamp	Mag-STD	1	7	0.010
CFT7/2	CFT7W	Compact Fluorescent, twin, (2) 7W lamp	Mag-STD	2	7	0.021
CFT9/1	CFT9W	Compact Fluorescent, twin, (1) 9W lamp	Mag-STD	1	9	0.011
CFT9/2	CFT9W	Compact Fluorescent, twin, (2) 9W lamp	Mag-STD	2	9	0.023
CFT9/3	CFT9W	Compact Fluorescent, twin, (3) 9 W lamp	Mag-STD	3	9	0.034
		EXIT Sign Fixtures				
ECF5/1	CFT5W	EXIT Compact Fluorescent, (1) 5W lamp	Mag-STD	1	5	0.009
ECF5/2	CFT5W	EXIT Compact Fluorescent, (2) 5W lamp	Mag-STD	2	5	0.020
ECF7/1	CFT7W	EXIT Compact Fluorescent, (1) 7W lamp	Mag-STD	1	7	0.010

Note: This table extracted from the 1999Large Nonresidential Standard Performance Contracting Program Manual and Forms Web Site: <www.scespc.com/largenonresmanuals.htm>.

Table 5-4 (continued)
Examples of Fixture Wattages for Various Lamps

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	LAMPS/ FIXT	WATTS/ LAMP	KW/FIXT
ECF7/2	CFT7W	EXIT Compact Fluorescent, (2) 7W lamp	Mag-STD	2	7	0.021
ECF8/1	F8T5	EXIT T5 Fluorescent, (1) 8W lamp	Mag-STD	1	8	0.012
ECF8/2	F8T5	EXIT T5 Fluorescent, (2) 8W lamp	Mag-STD	2	8	0.024
ECF9/1	CFT9W	EXIT Compact Fluorescent, (1) 9W lamp	Mag-STD	1	9	0.012
ECF9/2	CFT9W	EXIT Compact Fluorescent, (2) 9W lamp	Mag-STD	2	9	0.020
EI10/2	I10	EXIT Incandescent, (2) 10W lamp		2	10	0.020
EI15/1	I15	EXIT Incandescent, (1) 15W lamp		1	15	0.015
EI15/2	I15	EXIT Incandescent, (2) 15W lamp		2	15	0.030
EI20/1	I20	EXIT Incandescent, (1) 20W lamp		1	20	0.020
EI20/2	I20	EXIT Incandescent, (2) 20W lamp		2	20	0.040
EI25/1	I25	EXIT Incandescent, (1) 25W lamp		1	25	0.025
EI25/2	I25	EXIT Incandescent, (2) 25W lamp		2	25	0.050
EI34/1	I34	EXIT Incandescent, (1) 34W lamp		1	34	0.034
EI34/2	I34	EXIT Incandescent, (2) 34W lamp		2	34	0.068
EI40/1	I40	EXIT Incandescent, (1) 40W lamp		1	40	0.040
EI40/2	I40	EXIT Incandescent, (2) 40W lamp		2	40	0.080
EI5/1	I5	EXIT Incandescent, (1) 5W lamp		1	5	0.005
EI5/2	I5	EXIT Incandescent, (2) 5W lamp		2	5	0.010
EI50/2	I50	EXIT Incandescent, (2) 50W lamp		2	50	0.100
EI7.5/1	I7.5	EXIT Tungsten, (1) 7.5 W lamp		1	7.5	0.008
EI7.5/2	I7.5	EXIT Tungsten, (2) 7.5 W lamp		2	7.5	0.015
ELED2/1	LED2W	EXIT Light Emmitting Diode, (1) 2W lamp, Single Sided		1	2	0.006
ELED2/2	LED2W	EXIT Light Emmitting Diode, (2) 2W lamp, Dual Sided		2	2	0.009
		Linear Fluorescent Fixtures				
F1.51LS	F15T8	Fluorescent, (1) 18" T8 lamp	Mag-STD	1	15	0.019
F1.51SS	F15T12	Fluorescent, (1) 18" T12 lamp	Mag-STD	1	15	0.019
F1.52LS	F15T8	Fluorescent, (2) 18" T8 lamp	Mag-STD	2	15	0.036
F1.52SS	F15T12	Fluorescent, (2) 18", T12 lamp	Mag-STD	2	15	0.036
F21HS	F24T12/HO	Fluorescent, (1) 24", HO lamp	Mag-STD	1	35	0.062
F21ILL	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	17	0.020
F21ILL/T2	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	17	0.017
F21ILL/T2-R	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 2 Lamp Ballast	Electronic	1	17	0.015

Note: This table extracted from the 1999Large Nonresidential Standard Performance Contracting Program Manual and Forms Web Site: <www.scespc.com/largenonresmanuals.htm>.

Table 5-4 (continued)
Examples of Fixture Wattages for Various Lamps

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	LAMPS/ FIXT	WATTS/ LAMP	KW/FIXT
F21ILL/T3	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	17	0.016
F21ILL/T3-R	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 3 Lamp Ballast	Electronic	1	17	0.014
F21ILL/T4	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	17	0.015
F21ILL/T4-R	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 4 Lamp Ballast	Electronic	1	17	0.014
F21LL	F17T8	Fluorescent, (1) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	1	17	0.016
F21LL/T2	F17T8	Fluorescent, (1) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	17	0.016
F21LL/T3	F17T8	Fluorescent, (1) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	17	0.017
F21LL/T4	F17T8	Fluorescent, (1) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	17	0.017
F21LL-R	F17T8	Fluorescent, (1) 24", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	1	17	0.015
F21LS	F17T8	Fluorescent, (1) 24", T8 lamp, Standard Ballast	Mag-STD	1	17	0.024
F21SS	F20T12	Fluorescent, (1) 24", STD lamp	Mag-STD	1	20	0.028
F22HS	F24T12/HO	Fluorescent, (2) 24", HO lamp	Mag-STD	2	35	0.090
F22ILL	F17T8	Fluorescent, (2) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	17	0.033
F22ILL/T4	F17T8	Fluorescent, (2) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	17	0.031
F22ILL/T4-R	F17T8	Fluorescent, (2) 24", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 4 Lamp Ballast	Electronic	2	17	0.028
F22ILL-R	F17T8	Fluorescent, (2) 24", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	17	0.029
F22LL	F17T8	Fluorescent, (2) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	2	17	0.031
F22LL/T4	F17T8	Fluorescent, (2) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	17	0.034
F22LL-R	F17T8	Fluorescent, (2) 24", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	2	17	0.028
F22SS	F20T12	Fluorescent, (2) 24", STD lamp	Mag-STD	2	20	0.056
F23ILL	F17T8	Fluorescent, (3) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	17	0.047
F23ILL-H	F17T8	Fluorescent, (3) 24", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	3	17	0.049
F23ILL-R	F17T8	Fluorescent, (3) 24", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	3	17	0.043
F23LL	F17T8	Fluorescent, (3) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	3	17	0.052

Note: This table extracted from the 1999Large Nonresidential Standard Performance Contracting Program Manual and Forms Web Site: <www.scespc.com/largenonresmanuals.htm>.

Table 5-4 (continued)
Examples of Fixture Wattages for Various Lamps

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	LAMPS/ FIXT	WATTS/ LAMP	KW/FIXT
F23LL-R	F17T8	Fluorescent, (3) 24", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	3	17	0.041
F23SS	F20T12	Fluorescent, (3) 24", STD lamp	Mag-STD	3	20	0.062
F24ILL	F17T8	Fluorescent, (4) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	17	0.061
F24ILL-R	F17T8	Fluorescent, (4) 24", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	4	17	0.055
F24LL	F17T8	Fluorescent, (4) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	4	17	0.068
F24LL-R	F17T8	Fluorescent, (4) 24", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	4	17	0.057
F24SS	F20T12	Fluorescent, (4) 24", STD lamp	Mag-STD	4	20	0.112
F26SS	F20T12	Fluorescent, (6) 24", STD lamp	Mag-STD	6	20	0.146
F31EE/T2	F30T12/ES	Fluorescent, (1) 36", ES lamp, Tandem wired	Mag-ES	1	25	0.033
F31EL	F30T12/ES	Fluorescent, (1) 36", ES lamp	Electronic	1	25	0.026
F31ES	F30T12/ES	Fluorescent, (1) 36", ES lamp	Mag-STD	1	25	0.042
F31ES/T2	F30T12/ES	Fluorescent, (1) 36", ES lamp, Tandem wired	Mag-STD	1	25	0.037
F31ILL	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	25	0.026
F31ILL/T2	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	25	0.023
F31ILL/T2-H	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, HLO (BF: .96-1.1), Tandem 2 Lamp Ballast	Electronic	1	25	0.024
F31ILL/T2-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, RLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	25	0.023
F31ILL/T3	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	25	0.022
F31ILL/T3-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 3 Lamp Ballast	Electronic	1	25	0.022
F31ILL/T4	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	25	0.022
F31ILL/T4-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 4 Lamp Ballast	Electronic	1	25	0.022
F31ILL-H	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	1	25	0.028
F31ILL-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	1	25	0.027
F31LL	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	1	25	0.024
F31LL/T2	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	25	0.023
F31LL/T3	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	25	0.024

Note: This table extracted from the 1999Large Nonresidential Standard Performance Contracting Program Manual and Forms Web Site: <www.scespc.com/largenonresmanuals.htm>.

Table 5-4 (continued)
Examples of Fixture Wattages for Various Lamps

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	LAMPS/ FIXT	WATTS/ LAMP	KW/FIXT
F31LL/T4	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	25	0.022
F31LL-H	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1)	Electronic	1	25	0.026
F31LL-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	1	25	0.023
F31SE/T2	F30T12	Fluorescent, (1) 36", STD lamp, Tandem wired	Mag-ES	1	30	0.037
F31SHS	F36T12/HO	Fluorescent, (1) 36", HO lamp	Mag-STD	1	50	0.070
F31SL	F30T12	Fluorescent, (1) 36", STD lamp	Electronic	1	30	0.031
F31SS	F30T12	Fluorescent, (1) 36", STD lamp	Mag-STD	1	30	0.046
F31SS/T2	F30T12	Fluorescent, (1) 36", STD lamp, Tandem wired	Mag-STD	1	30	0.041
F32EE	F30T12/ES	Fluorescent, (2) 36", ES lamp	Mag-ES	2	25	0.066
F32EL	F30T12/ES	Fluorescent, (2) 36", ES lamp	Electronic	2	25	0.050
F32ES	F30T12/ES	Fluorescent, (2) 36", ES lamp	Mag-STD	2	25	0.073
F32ILL	F25T8	Fluorescent, (2) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	25	0.046
F32ILL/T4	F25T8	Fluorescent, (2) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	25	0.044
F32ILL/T4-R	F25T8	Fluorescent, (2) 36", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 4 Lamp Ballast	Electronic	2	25	0.043
F32ILL-H	F25T8	Fluorescent, (2) 36", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	2	25	0.048
F32ILL-R	F25T8	Fluorescent, (2) 36", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	25	0.046
F32LL	F25T8	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	2	25	0.046
F32LL/T4	F25T8	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	25	0.045
F32LL-H	F25T8	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1)	Electronic	2	25	0.050
F32LL-R	F25T8	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	2	25	0.042
F32LL-V	F25T8	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, VHLO (BF>1.1)	Electronic	2	25	0.070
F32SE	F30T12	Fluorescent, (2) 36", STD lamp	Mag-ES	2	30	0.074
F32SHS	F36T12/HO	Fluorescent, (2) 36", HO, lamp	Mag-STD	2	50	0.114
F32SL	F30T12	Fluorescent, (2) 36", STD lamp	Electronic	2	30	0.058
F32SS	F30T12	Fluorescent, (2) 36", STD lamp	Mag-STD	2	30	0.081
F33ES	F30T12/ES	Fluorescent, (3) 36", ES lamp	Mag-STD	3	25	0.115
F33ILL	F25T8	Fluorescent, (3) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	25	0.067
F33ILL-R	F25T8	Fluorescent, (3) 36", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	3	25	0.066
F33LL	F25T8	Fluorescent, (3) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	3	25	0.072
F33LL-R	F25T8	Fluorescent, (3) 36", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	3	25	0.062

Note: This table extracted from the 1999Large Nonresidential Standard Performance Contracting Program Manual and Forms Web Site: <www.scespc.com/largenonresmanuals.htm>.

Table 5-4 (continued)
Examples of Fixture Wattages for Various Lamps

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	LAMPS/ FIXT	WATTS/ LAMP	KW/FIXT
F33SE	F30T12	Fluorescent, (3) 36", STD lamp, (1) STD ballast and (1) ES ballast	Mag-ES	3	30	0.120
F33SS	F30T12	Fluorescent, (3) 36", STD lamp	Mag-STD	3	30	0.127
F34ILL	F25T8	Fluorescent, (4) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	25	0.087
F34ILL-R	F25T8	Fluorescent, (4) 36", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	4	25	0.086
F34LL	F25T8	Fluorescent, (4) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	4	25	0.089
F34LL-R	F25T8	Fluorescent, (4) 36", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	4	25	0.084
F34SE	F30T12	Fluorescent, (4) 36", STD lamp	Mag-ES	4	30	0.148
F34SL	F30T12	Fluorescent, (4) 36", STD lamp	Electronic	4	30	0.116
F34SS	F30T12	Fluorescent, (4) 36", STD lamp	Mag-STD	4	30	0.162
F36EE	F30T12/ES	Fluorescent, (2) 36", ES lamp	Mag-ES	6	25	0.198
F36ILL-R	F25T8	Fluorescent, (6) 36", T-8 lamp, Instant Start Ballast, RLO (BF<.85)	Electronic	6	25	0.134
F36SE	F30T12	Fluorescent, (2) 36", STD lamp	Mag-ES	6	30	0.342
F40EE/D1	None	Fluorescent, (0) 48" lamp, Completely delamped fixture with (1) hot ballast	Mag-ES	1	0	0.004
F40EE/D2	None	Fluorescent, (0) 48" lamp, Completely delamped fixture with (2) hot ballast	Mag-ES	1	0	0.008
F41EE	F40T12/ES	Fluorescent, (1) 48", ES lamp	Mag-ES	1	34	0.043
F41EE/D2	F40T12/ES	Fluorescent, (1) 48", ES lamp, 2 ballast	Mag-ES	1	34	0.043
F41EE/T2	F40T12/ES	Fluorescent, (1) 48", ES lamp, tandem wired, 2-lamp ballast	Mag-ES	1	34	0.036
F41EHS	F48T12/HO/ES	Fluorescent, (1) 48", ES HO lamp	Mag-STD	1	55	0.080
F41EIS	F48T12/ES	Fluorescent, (1) 48" ES Instant Start lamp. Magnetic ballast	Mag-STD	1	30	0.051
F41EL	F40T12/ES	Fluorescent, (1) 48", T12 ES lamp, Electronic Ballast	Electronic	1	34	0.032
F41IAL	F25T12	Fluorescent, (1) 48", F25T12 lamp, Instant Start Ballast	Electronic	1	25	0.025
F41IAL/T2-R	F25T12	Fluorescent, (1) 48", F25T12 lamp, Instant Start, Tandem 2-Lamp Ballast, RLO (BF<0.85)	Electronic	1	25	0.019
F41IAL/T3-R	F25T12	Fluorescent, (1) 48", F25T12 lamp, Instant Start, Tandem 3-Lamp Ballast, RLO (BF<0.85)	Electronic	1	25	0.020
F41ILL	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	32	0.031
F41ILL/T2	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	32	0.030
F41ILL/T2-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1), Tandem 4 Lamp Ballast	Electronic	1	32	0.033
F41ILL/T2-R	F32T8	Fluorescent, (1) 48", T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 2 Lamp Ballast	Electronic	1	32	0.026
F41ILL/T3	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem	Electronic	1	32	0.030

Note: This table extracted from the 1999Large Nonresidential Standard Performance Contracting Program Manual and Forms Web Site: <www.scespc.com/largenonresmanuals.htm>.

Table 5-4 (continued)
Examples of Fixture Wattages for Various Lamps

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	LAMPS/ FIXT	WATTS/ LAMP	KW/FIXT
		3 Lamp Ballast				
F41ILL/T3-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1), Tandem 4 Lamp Ballast	Electronic	1	32	0.031
F41ILL/T3-R	F32T8	Fluorescent, (1) 48", T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 3 Lamp Ballast	Electronic	1	32	0.026
F41ILL/T4	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	32	0.028
F41ILL/T4-R	F32T8	Fluorescent, (1) 48", T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	1	32	0.026
F41ILL-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	1	32	0.036
F41LE	F32T8	Fluorescent, (1) 48", T-8 lamp	Mag-ES	1	32	0.035
F41LL	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	1	32	0.032
F41LL/T2	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	32	0.030
F41LL/T2-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1), Tandem 2 Lamp Ballast	Electronic	1	32	0.035
F41LL/T2-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85), Tandem 2 Lamp Ballast	Electronic	1	32	0.027
F41LL/T3	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	32	0.031
F41LL/T3-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1), Tandem 3 Lamp Ballast	Electronic	1	32	0.033
F41LL/T3-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85), Tandem 3 Lamp Ballast	Electronic	1	32	0.025
F41LL/T4	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	32	0.030
F41LL/T4-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	1	32	0.026
F41LL-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1)	Electronic	1	32	0.039
F41LL-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	1	32	0.027
F41SHS	F48T12/HO	Fluorescent, (1) 48", STD HO lamp	Mag-STD	1	60	0.085
F41SIL	F40T12	Fluorescent, (1) 48", STD IS lamp, Electronic ballast	Electronic	1	39	0.046
F41SIL/T2	F40T12	Fluorescent, (1) 48", STD IS lamp, Electronic ballast, tandem wired	Electronic	1	39	0.037
F41SIS	F40T12	Fluorescent, (1) 48", STD IS lamp	Mag-STD	1	39	0.060

Note: This table extracted from the 1999Large Nonresidential Standard Performance Contracting Program Manual and Forms Web Site: <www.scespc.com/largenonresmanuals.htm>.

Table 5-4 (continued)
Examples of Fixture Wattages for Various Lamps

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	LAMPS/ FIXT	WATTS/ LAMP	KW/FIXT
F41SIS/T2	F40T12	Fluorescent, (1) 48", STD IS lamp, tandem to 2-lamp ballast	Mag-STD	1	39	0.052
F41SVS	F48T12/VHO	Fluorescent, (1) 48", STD VHO lamp	Mag-STD	1	110	0.135
F41TS	F40T10	Fluorescent, (1) 48", T-10 lamp	Mag-STD	1	40	0.051
F42EE	F40T12/ES	Fluorescent, (2) 48", ES lamp	Mag-ES	2	34	0.072
F42EE/D2	F40T12/ES	Fluorescent, (2) 48", ES lamp, 2 Ballasts (delamped)	Mag-ES	2	34	0.076
F42EHS	F42T12/HO/ES	Fluorescent, (2) 42", HO lamp (3.5' lamp)	Mag-STD	2	55	0.135
F42EIS	F48T12/ES	Fluorescent, (2) 48" ES Instant Start lamp. Magnetic ballast	Mag-STD	2	30	0.082
F42EL	F40T12/ES	Fluorescent, (2) 48", T12 ES lamps, Electronic Ballast	Electronic	2	34	0.060
F42IAL/T4-R	F25T12	Fluorescent, (2) 48", F25T12 lamp, Instant Start, Tandem 4-Lamp Ballast, RLO (BF<0.85)	Electronic	2	25	0.040
F42IAL-R	F25T12	Fluorescent, (2) 48", F25T12 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	25	0.039
F42ILL	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	32	0.059
F42ILL/T4	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	32	0.056
F42ILL/T4-R	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	2	32	0.051
F42ILL-H	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	2	32	0.065
F42ILL-R	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	32	0.052
F42ILL-V	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, VHLO (BF>1.1)	Electronic	2	32	0.079
F42LE	F32T8	Fluorescent, (2) 48", T-8 lamp	Mag-ES	2	32	0.071
F42LL	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	2	32	0.060
F42LL/T4	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	32	0.059
F42LL/T4-R	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	2	32	0.053
F42LL-H	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1)	Electronic	2	32	0.070
F42LL-R	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	2	32	0.054
F42LL-V	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, VHLO (BF>1.1)	Electronic	2	32	0.085
F42SHS	F48T12/HO	Fluorescent, (2) 48", STD HO lamp	Mag-STD	2	60	0.145
F42SIL	F40T12	Fluorescent, (2) 48", STD IS lamp, Electronic ballast	Electronic	2	39	0.074
F42SIS	F40T12	Fluorescent, (2) 48", STD IS lamp	Mag-STD	2	39	0.103
F42SVS	F48T12/VHO	Fluorescent, (2) 48", STD VHO lamp	Mag-STD	2	110	0.242
F43EE	F40T12/ES	Fluorescent, (3) 48", ES lamp	Mag-ES	3	34	0.115

Note: This table extracted from the 1999Large Nonresidential Standard Performance Contracting Program Manual and Forms Web Site: <www.scespc.com/largenonresmanuals.htm>.

Table 5-4 (continued)
Examples of Fixture Wattages for Various Lamps

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	LAMPS/ FIXT	WATTS/ LAMP	KW/FIXT
F43EHS	F42T12/HO/ES	Fluorescent, (3) 42", HO lamp (3.5' lamp)	Mag-STD	3	55	0.215
F43EIS	F48T12/ES	Fluorescent, (3) 48" ES Instant Start lamp. Magnetic ballast	Mag-STD	3	30	0.133
F43EL	F40T12/ES	Fluorescent, (3) 48", T12 ES lamps, Electronic Ballast	Electronic	3	34	0.092
F43IAL-R	F25T12	Fluorescent, (3) 48", F25T12 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	3	25	0.060
F43ILL	F32T8	Fluorescent, (3) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	32	0.089
F43ILL/2	F32T8	Fluorescent, (3) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), (2) ballast	Electronic	3	32	0.090
F43ILL-H	F32T8	Fluorescent, (3) 48", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	3	32	0.093
F43ILL-R	F32T8	Fluorescent, (3) 48", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	3	32	0.078
F43ILL-V	F32T8	Fluorescent, (3) 48", T-8 lamp, Instant Start Ballast, VHLO (BF>1.1)	Electronic	3	32	0.112
F43LE	F32T8	Fluorescent, (3) 48", T-8 lamp	Mag-ES	3	32	0.110
F43LL	F32T8	Fluorescent, (3) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	3	32	0.093
F43LL/2	F32T8	Fluorescent, (3) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), (2) ballast	Electronic	3	32	0.092
F43LL-H	F32T8	Fluorescent, (3) 48", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1)	Electronic	3	32	0.098
F43LL-R	F32T8	Fluorescent, (3) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	3	32	0.076
F43SHS	F48T12/HO	Fluorescent, (3) 48", STD HO lamp	Mag-STD	3	60	0.230
F43SIL	F40T12	Fluorescent, (3) 48", STD IS lamp, Electronic ballast	Electronic	3	39	0.120
F43SVS	F48T12/VHO	Fluorescent, (3) 48", STD VHO lamp	Mag-STD	3	110	0.377
F44EE	F40T12/ES	Fluorescent, (4) 48", ES lamp	Mag-ES	4	34	0.144
F44EE/D4	F40T12/ES	Fluorescent, (4) 48", ES lamp, 4 Ballasts (delamped)	Mag-ES	4	34	0.152
F44EHS	F48T12/HO/ES	Fluorescent, (4) 48", ES HO lamp	Mag-STD	4	55	0.270
F44EIS	F48T12/ES	Fluorescent, (4) 48" ES Instant Start lamp. Magnetic ballast	Mag-STD	4	30	0.164
F44EL	F40T12/ES	Fluorescent, (4) 48", T12 ES lamps, Electronic Ballast	Electronic	4	34	0.120
F44EVS	F48T12/VHO/ES	Fluorescent, (4) 48", VHO ES lamp	Mag-STD	4	0	0.420
F44IAL-R	F25T12	Fluorescent, (4) 48", F25T12 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	4	25	0.080
F44ILL	F32T8	Fluorescent, (4) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	32	0.112
F44ILL/2	F32T8	Fluorescent, (4) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), (2) ballast	Electronic	4	32	0.118
F44ILL-R	F32T8	Fluorescent, (4) 48", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	4	32	0.102
F44LE	F32T8	Fluorescent, (4) 48", T-8 lamp	Mag-ES	4	32	0.142
F44LL	F32T8	Fluorescent, (4) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	4	32	0.118
F44LL/2	F32T8	Fluorescent, (4) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), (2) ballast	Electronic	4	32	0.120
F44LL-R	F32T8	Fluorescent, (4) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	4	32	0.105

Note: This table extracted from the 1999Large Nonresidential Standard Performance Contracting Program Manual and Forms Web Site: <www.scespc.com/largenonresmanuals.htm>.

Table 5-4 (continued)
Examples of Fixture Wattages for Various Lamps

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	LAMPS/ FIXT	WATTS/ LAMP	KW/FIXT
F44SHS	F48T12/HO	Fluorescent, (4) 48", STD HO lamp	Mag-STD	4	60	0.290
F44SIL	F40T12	Fluorescent, (4) 48", STD IS lamp, Electronic ballast	Electronic	4	39	0.148
F44SVS	F48T12/VHO	Fluorescent, (4) 48", STD VHO lamp	Mag-STD	4	110	0.484
F45ILL	F32T8	Fluorescent, (5) 48", T-8 lamp, (1) 3-lamp IS ballast and (1) 2-lamp IS ballast, NLO (BF: .85-.95)	Electronic	5	32	0.148
F46EE	F40T12/ES	Fluorescent, (6) 48", ES lamp	Mag-ES	6	34	0.216
F46EL	F40T12/ES	Fluorescent, (6) 48", ES lamp	Electronic	6	34	0.186
F46ILL	F32T8	Fluorescent, (6) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	6	32	0.175
F46ILL-R	F32T8	Fluorescent, (6) 48", T-8 lamp, Instant Start Ballast, RLO (BF< .85)	Electronic	6	32	0.156
F46LL	F32T8	Fluorescent, (6) 48", T-8 lamp, NLO (BF: .85-.95)	Electronic	6	32	0.182
F48EE	F40T12/ES	Fluorescent, (8) 48", ES lamp	Mag-ES	8	34	0.288
F48ILL	F32T8	Fluorescent, (8) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	8	32	0.224
F48ILL-R	F32T8	Fluorescent, (8) 48", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	8	32	0.204
F51ILL	F40T8	Fluorescent, (1) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	40	0.036
F51ILL/T2	F40T8	Fluorescent, (1) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	40	0.036
F51ILL/T3	F40T8	Fluorescent, (1) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	40	0.035
F51ILL/T4	F40T8	Fluorescent, (1) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	40	0.034
F51ILL-R	F40T8	Fluorescent, (1) 60", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	1	40	0.043
F51SHE	F60T12/HO	Fluorescent, (1) 60", STD HO lamp	Mag-ES	1	75	0.088
F51SHL	F60T12/HO	Fluorescent, (1) 60", STD HO lamp	Electronic	1	75	0.069
F51SHS	F60T12/HO	Fluorescent, (1) 60", STD HO lamp	Mag-STD	1	75	0.092
F51SL	F60T12	Fluorescent, (1) 60", STD lamp	Electronic	1	50	0.044
F51SS	F60T12	Fluorescent, (1) 60", STD lamp	Mag-STD	1	50	0.063
F51SVS	F60T12/VHO	Fluorescent, (1) 60", VHO ES lamp	Mag-STD	1	135	0.165
F52ILL	F40T8	Fluorescent, (2) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	40	0.072
F52ILL/T4	F40T8	Fluorescent, (2) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	2	40	0.067
F52ILL-H	F40T8	Fluorescent, (2) 60", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	2	40	0.080
F52ILL-R	F40T8	Fluorescent, (2) 60", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	40	0.073
F52SHE	F60T12/HO	Fluorescent, (2) 60", STD HO lamp	Mag-ES	2	75	0.176
F52SHL	F60T12/HO	Fluorescent, (2) 60", STD HO lamp	Electronic	2	75	0.138

Note: This table extracted from the 1999Large Nonresidential Standard Performance Contracting Program Manual and Forms Web Site: <www.scespc.com/largenonresmanuals.htm>.

Table 5-4 (continued)
Examples of Fixture Wattages for Various Lamps

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	LAMPS/ FIXT	WATTS/ LAMP	KW/FIXT
F52SHS	F60T12/HO	Fluorescent, (2) 60", STD HO lamp	Mag-STD	2	75	0.168
F52SL	F60T12	Fluorescent, (2) 60", STD lamp	Electronic	2	50	0.088
F52SS	F60T12	Fluorescent, (2) 60", STD lamp	Mag-STD	2	50	0.128
F52SVS	F60T12/VHO	Fluorescent, (2) 60", VHO ES lamp	Mag-STD	2	135	0.310
F53ILL	F40T8	Fluorescent, (3) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	40	0.106
F53ILL-H	F40T8	Fluorescent, (3) 60", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	3	40	0.108
F54ILL	F40T8	Fluorescent, (4) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	40	0.134
F54ILL-H	F40T8	Fluorescent, (4) 60", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	4	40	0.126
F61ISL	F72T12	Fluorescent, (1) 72", STD lamp, IS electronic ballast	Electronic	1	55	0.068
F61SHS	F72T12/HO	Fluorescent, (1) 72", STD HO lamp	Mag-STD	1	85	0.120
F61SS	F72T12	Fluorescent, (1) 72", STD lamp	Mag-STD	1	55	0.076
F61SVS	F72T12/VHO	Fluorescent, (1) 72", VHO lamp	Mag-STD	1	160	0.180
F62ISL	F72T12	Fluorescent, (2) 72", STD lamp, IS electronic ballast	Electronic	2	55	0.108
F62SE	F72T12	Fluorescent, (2) 72", STD lamp	Mag-ES	2	55	0.122
F62SHE	F72T12/HO	Fluorescent, (2) 72", STD HO lamp	Mag-ES	2	85	0.194
F62SHS	F72T12/HO	Fluorescent, (2) 72", STD HO lamp	Mag-STD	2	85	0.220
F62SL	F72T12	Fluorescent, (2) 72", STD lamp	Electronic	2	55	0.108
F62SS	F72T12	Fluorescent, (2) 72", STD lamp	Mag-STD	2	55	0.122
F62SVS	F72T12/VHO	Fluorescent, (2) 72", VHO lamp	Mag-STD	2	160	0.330
F63ISL	F72T12	Fluorescent, (3) 72", STD lamp, IS electronic ballast	Electronic	3	55	0.176
F63SS	F72T12	Fluorescent, (3) 72", STD lamp	Mag-STD	3	55	0.202
F64ISL	F72T12	Fluorescent, (4) 72", STD lamp, IS electronic ballast	Electronic	4	55	0.216
F64SE	F72T12	Fluorescent, (4) 72", STD lamp	Mag-ES	4	55	0.244
F64SHE	F72T12/HO	Fluorescent, (4) 72", HO lamp	Mag-ES	4	85	0.388
F64SS	F72T12	Fluorescent, (4) 72", STD lamp	Mag-STD	4	56	0.244
F81EE/T2	F96T12/ES	Fluorescent, (1) 96", ES lamp, tandem to 2-lamp ballst	Mag-ES	1	60	0.062
F81EHL	F96T12/HO/ES	Fluorescent, (1) 96", ES HO lamp	Electronic	1	95	0.080
F81EHS	F96T12/HO/ES	Fluorescent, (1) 96", ES HO lamp	Mag-STD	1	95	0.112
F81EL	F96T12/ES	Fluorescent, (1) 96", ES lamp	Electronic	1	60	0.069
F81ES	F96T12/ES	Fluorescent, (1) 96", ES lamp	Mag-STD	1	60	0.075
F81ES/T2	F96T12/ES	Fluorescent, (1) 96", ES lamp, tandem to 2-lamp ballast	Mag-STD	1	60	0.064
F81EVS	F96T12/VHO/	Fluorescent, (1) 96", ES VHO lamp	Mag-STD	1	185	0.205

Note: This table extracted from the 1999Large Nonresidential Standard Performance Contracting Program Manual and Forms Web Site: <www.scespc.com/largenonresmanuals.htm>.

Table 5-4 (continued)
Examples of Fixture Wattages for Various Lamps

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	LAMPS/ FIXT	WATTS/ LAMP	KW/FIXT
	ES					
F81ILL	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	59	0.058
F81ILL/T2	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	59	0.055
F81ILL/T2-R	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 2 Lamp Ballast	Electronic	1	59	0.049
F81ILL-H	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	1	59	0.068
F81ILL-R	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	1	59	0.057
F81ILL-V	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, VHLO (BF>1.1)	Electronic	1	59	0.071
F81LHL/T2	F96T8/HO	Fluorescent, (1) 96", T8 HO lamp, tandem wired to 2-lamp ballast	Electronic	1	86	0.080
F82EE	F96T12/ES	Fluorescent, (2) 96", ES lamp	Mag-ES	2	60	0.123
F82EHE	F96T12/HO/ES	Fluorescent, (2) 96", ES HO lamp	Mag-ES	2	95	0.207
F82EHL	F96T12/HO/ES	Fluorescent, (2) 96", ES HO lamp	Electronic	2	95	0.173
F82EHS	F96T12/HO/ES	Fluorescent, (2) 96", ES HO lamp	Mag-STD	2	95	0.227
F82EL	F96T12/ES	Fluorescent, (2) 96", ES lamp	Electronic	2	60	0.110
F82ES	F96T12/ES	Fluorescent, (2) 96", ES lamp	Mag-STD	2	60	0.128
F82EVS	F96T12/VHO/ES	Fluorescent, (2) 96", ES VHO lamp	Mag-STD	2	185	0.380
F82ILL	F96T8	Fluorescent, (2) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	59	0.109
F82ILL-R	F96T8	Fluorescent, (2) 96", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	59	0.098
F82LHL	F96T8/HO	Fluorescent, (2) 96", T8 HO lamp	Electronic	2	86	0.160
F83EE	F96T12/ES	Fluorescent, (3) 96", ES lamp	Mag-ES	3	60	0.210
F83EHE	F96T12/HO/ES	Fluorescent, (3) 96", ES HO lamp, (1) 2-lamp ES Ballast, (1) 1-lamp STD Ballast	Mag-ES/STD	3	95	0.319
F83EHS	F96T12/HO/ES	Fluorescent, (3) 96", ES HO lamp	Mag-STD	3	95	0.380
F83EL	F96T12/ES	Fluorescent, (3) 96", ES lamp	Electronic	3	60	0.179
F83ES	F96T12/ES	Fluorescent, (3) 96", ES lamp	Mag-STD	3	60	0.203
F83EVS	F96T12/VHO/ES	Fluorescent, (3) 96", ES VHO lamp	Mag-STD	3	185	0.585
F83ILL	F96T8	Fluorescent, (3) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	59	0.167

Note: This table extracted from the 1999Large Nonresidential Standard Performance Contracting Program Manual and Forms Web Site: <www.scespc.com/largenonresmanuals.htm>.

Table 5-4 (continued)
Examples of Fixture Wattages for Various Lamps

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	LAMPS/ FIXT	WATTS/ LAMP	KW/FIXT
F84EE	F96T12/ES	Fluorescent, (4) 96", ES lamp	Mag-ES	4	60	0.246
F84EHE	F96T12/HO/ES	Fluorescent, (4) 96", ES HO lamp	Mag-ES	4	95	0.414
F84EHL	F96T12/HO/ES	Fluorescent, (4) 96", ES HO lamp	Electronic	4	95	0.346
F84EHS	F96T12/HO/ES	Fluorescent, (4) 96", ES HO lamp	Mag-STD	4	95	0.454
F84EL	F96T12/ES	Fluorescent, (4) 96", ES lamp	Electronic	4	60	0.220
F84ES	F96T12/ES	Fluorescent, (4) 96", ES lamp	Mag-STD	4	60	0.256
F84EVS	F96T12/VHO/ES	Fluorescent, (4) 96", ES VHO lamp	Mag-STD	4	185	0.760
F84ILL	F96T8	Fluorescent, (4) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	59	0.219
F84LHL	F96T8/HO	Fluorescent, (4) 96", T8 HO lamp	Electronic	4	86	0.320
F86EHS	F96T12/HO/ES	Fluorescent, (6) 96", ES HO lamp	Mag-STD	6	95	0.721
F86ILL	F96T8	Fluorescent, (6) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	6	59	0.328
		Circline Fluorescent Fixtures				
FC12/1	FC12T9	Fluorescent, (1) 12" circular lamp, RS ballast	Mag-STD	1	32	0.031
FC12/2	FC12T9	Fluorescent, (2) 12" circular lamp, RS ballast	Mag-STD	2	32	0.062
FC16/1	FC16T9	Fluorescent, (1) 16" circular lamp	Mag-STD	1	40	0.035
FC20	FC6T9	Fluorescent, Circlite, (1) 20W lamp, Preheat ballast	Mag-STD	1	20	0.020
FC22	FC8T9	Fluorescent, Circlite, (1) 22W lamp, preheat ballast	Mag-STD	1	22	0.020
FC32	FC12T9	Fluorescent, Circline, (1) 32W lamp, preheat ballast	Mag-STD	1	32	0.040
FC40	FC16T9	Fluorescent, Circline, (1) 32W lamp, preheat ballast	Mag-STD	1	32	0.042
FC6/1	FC6T9	Fluorescent, (1) 6" circular lamp, RS ballast	Mag-STD	1	20	0.025
FC8/1	FC8T9	Fluorescent, (1) 8" circular lamp, RS ballast	Mag-STD	1	22	0.026
FC8/2	FC8T9	Fluorescent, (2) 8" circular lamp, RS ballast	Mag-STD	2	22	0.052
		U-Tube Fluorescent Fixtures				
FU1EE	FU40T12/ES	Fluorescent, (1) U-Tube, ES lamp	Mag-ES	1	35	0.043
FU1ILL	FU31T8/6	Fluorescent, (1) U-Tube, T-8 lamp, Instant Start ballast	Electronic	1	32	0.031
FU1LL	FU31T8/6	Fluorescent, (1) U-Tube, T-8 lamp	Electronic	1	32	0.032
FU1LL-R	FU31T8/6	Fluorescent, (1) U-Tube, T-8 lamp, RLO (BF<0.85)	Electronic	1	31	0.027
FU2EE	FU40T12/ES	Fluorescent, (2) U-Tube, ES lamp	Mag-ES	2	35	0.072
FU2ILL	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, Instand Start Ballast	Electronic	2	32	0.059

Note: This table extracted from the 1999Large Nonresidential Standard Performance Contracting Program Manual and Forms Web Site: <www.scespc.com/largenonresmanuals.htm>.

Table 5-4 (continued)
Examples of Fixture Wattages for Various Lamps

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	LAMPS/ FIXT	WATTS/ LAMP	KW/FIXT
FU2ILL/T4	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, Instand Start Ballast, tandem wired	Electronic	2	32	0.056
FU2ILL/T4-R	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, Instand Start Ballast, RLO, tandem wired	Electronic	2	32	0.051
FU2ILL-H	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, Instand Start HLO Ballast	Electronic	2	32	0.065
FU2ILL-R	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, Instand Start RLO Ballast	Electronic	2	32	0.052
FU2LL	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp	Electronic	2	32	0.060
FU2LL/T2	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, Tandem 4 lamp ballast	Electronic	2	32	0.059
FU2LL-R	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, RLO (BF<0.85)	Electronic	54	31	0.054
FU3EE	FU40T12/ES	Fluorescent, (3) U-Tube, ES lamp	Mag-ES	3	35	0.115
FU3ILL	FU31T8/6	Fluorescent, (3) U-Tube, T-8 lamp, Instand Start Ballast	Electronic	3	32	0.089
FU3ILL-R	FU31T8/6	Fluorescent, (3) U-Tube, T-8 lamp, Instand Start RLO Ballast	Electronic	3	32	0.078
		Halogen Incandescent Fixtures				
H100/1	H100	Halogen Incandescent, (1) 100W lamp		1	100	0.100
H150/1	H150	Halogen Incandescent, (1) 150W lamp		1	150	0.150
H150/2	H150	Halogen Incandescent, (2) 150W lamp		2	150	0.300
H300/1	H300	Halogen Incandescent, (1) 300W lamp		1	300	0.300
H42/1	H42	Halogen Incandescent, (1) 42W lamp		1	42	0.042
H45/1	H45	Halogen Incandescent, (1) 45W lamp		1	45	0.045
H45/2	H45	Halogen Incandescent, (2) 45W lamp		2	45	0.090
H50/1	H50	Halogen Incandescent, (1) 50W lamp		1	50	0.050
H50/2	H50	Halogen Incandescent, (2) 50W lamp		2	50	0.100
H500/1	H500	Halogen Incandescent, (1) 500W lamp		1	500	0.500
H52/1	H52	Halogen Incandescent, (1) 52W lamp		1	52	0.052
H55/1	H55	Halogen Incandescent, (1) 55W lamp		1	55	0.055
H55/2	H55	Halogen Incandescent, (2) 55W lamp		2	55	0.110
H60/1	H60	Halogen Incandescent, (1) 60W lamp		1	60	0.060
H72/1	H72	Halogen Incandescent, (1) 72W lamp		1	72	0.072
H75/1	H75	Halogen Incandescent, (1) 75W lamp		1	75	0.075
H75/2	H75	Halogen Incandescent, (2) 75W lamp		2	75	0.150
H90/1	H90	Halogen Incandescent, (1) 90W lamp		1	90	0.090
H90/2	H90	Halogen Incandescent, (2) 90W lamp		2	90	0.180
HLV50/1	H50/LV	Halogen, (1) Low Voltage MR16 lamp		1	50	0.060
		High Pressure Sodium Fixtures				
HPS100/1	HPS100	High Pressure Sodium, (1) 100W lamp		1	100	0.138
HPS1000/1	HPS1000	High Pressure Sodium, (1) 1000W lamp		1	1000	1.100

Note: This table extracted from the 1999Large Nonresidential Standard Performance Contracting Program Manual and Forms Web Site: <www.scespc.com/largenonresmanuals.htm>.

Table 5-4 (continued)
Examples of Fixture Wattages for Various Lamps

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	LAMPS/ FIXT	WATTS/ LAMP	KW/FIXT
HPS150/1	HPS150	High Pressure Sodium, (1) 150W lamp		1	150	0.188
HPS200/1	HPS200	High Pressure Sodium, (1) 200W lamp		1	200	0.250
HPS250/1	HPS250	High Pressure Sodium, (1) 250W lamp		1	250	0.295
HPS310/1	HPS310	High Pressure Sodium, (1) 310W lamp		1	310	0.365
HPS35/1	HPS35	High Pressure Sodium, (1) 35W lamp		1	35	0.046
HPS360/1	HPS360	High Pressure Sodium, (1) 360W lamp		1	360	0.414
HPS400/1	HPS400	High Pressure Sodium, (1) 400W lamp		1	400	0.465
HPS50/1	HPS50	High Pressure Sodium, (1) 50W lamp		1	50	0.066
HPS70/1	HPS70	High Pressure Sodium, (1) 70W lamp		1	70	0.095
		Standard Incandescent Fixtures				
I100/1	I100	Incandescent, (1) 100W lamp		1	100	0.100
I100/2	I100	Incandescent, (2) 100W lamp		2	100	0.200
I100/3	I100	Incandescent, (3) 100W lamp		3	100	0.300
I100/4	I100	Incandescent, (4) 100W lamp		4	100	0.400
I100/5	I100	Incandescent, (5) 100W lamp		5	100	0.500
I1000/1	I1000	Incandescent, (1) 1000W lamp		1	1000	1.000
I100E/1	I100/ES	Incandescent, (1) 100W ES lamp		1	90	0.090
I100EL/1	I100/ES/LL	Incandescent, (1) 100W ES/LL lamp		1	90	0.090
I120/1	I120	Incandescent, (1) 120W lamp		1	120	0.120
I120/2	I120	Incandescent, (2) 120W lamp		2	120	0.240
I125/1	I125	Incandescent, (1) 125W lamp		1	125	0.125
I135/1	I135	Incandescent, (1) 135W lamp		1	135	0.135
I135/2	I135	Incandescent, (2) 135W lamp		2	135	0.270
I15/1	I15	Incandescent, (1) 15W lamp		1	15	0.015
I15/2	I15	Incandescent, (2) 15W lamp		2	15	0.030
I150/1	I150	Incandescent, (1) 150W lamp		1	150	0.150
I150/2	I150	Incandescent, (2) 150W lamp		2	150	0.300
I1500/1	I1500	Incandescent, (1) 1500W lamp		1	1500	1.500
I150E/1	I150/ES	Incandescent, (1) 150W ES lamp		1	135	0.135
I150EL/1	I150/ES/LL	Incandescent, (1) 150W ES/LL lamp		1	135	0.135
I170/1	I170	Incandescent, (1) 170W lamp		1	170	0.170
I20/1	I20	Incandescent, (1) 20W lamp		1	20	0.020
I20/2	I20	Incandescent, (2) 20W lamp		2	20	0.040
I200/1	I200	Incandescent, (1) 200W lamp		1	200	0.200

Note: This table extracted from the 1999Large Nonresidential Standard Performance Contracting Program Manual and Forms Web Site: <www.scespc.com/largenonresmanuals.htm>.

Table 5-4 (continued)
Examples of Fixture Wattages for Various Lamps

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	LAMPS/ FIXT	WATTS/ LAMP	KW/FIXT
I200/2	I200	Incandescent, (2) 200W lamp		2	200	0.400
I2000/1	I2000	Incandescent, (1) 2000W lamp		1	2000	2.000
I200L/1	I200/LL	Incandescent, (1) 200W LL lamp		1	200	0.200
I25/1	I25	Incandescent, (1) 25W lamp		1	25	0.025
I25/2	I25	Incandescent, (2) 25W lamp		2	25	0.050
I25/4	I25	Incandescent, (4) 25W lamp		4	25	0.100
I250/1	I250	Incandescent, (1) 250W lamp		1	250	0.250
I300/1	I300	Incandescent, (1) 300W lamp		1	300	0.300
I34/1	I34	Incandescent, (1) 34W lamp		1	34	0.034
I34/2	I34	Incandescent, (2) 34W lamp		2	34	0.068
I36/1	I36	Incandescent, (1) 36W lamp		1	36	0.036
I40/1	I40	Incandescent, (1) 40W lamp		1	40	0.040
I40/2	I40	Incandescent, (2) 40W lamp		2	40	0.080
I400/1	I400	Incandescent, (1) 400W lamp		1	400	0.400
I40E/1	I40/ES	Incandescent, (1) 40W ES lamp		1	34	0.034
I40EL/1	I40/ES/LL	Incandescent, (1) 40W ES/LL lamp		1	34	0.034
I42/1	I42	Incandescent, (1) 42W lamp		1	42	0.042
I448/1	I448	Incandescent, (1) 448W lamp		1	448	0.448
I45/1	I45	Incandescent, (1) 45W lamp		1	45	0.045
I50/1	I50	Incandescent, (1) 50W lamp		1	50	0.050
I50/2	I50	Incandescent, (2) 50W lamp		2	50	0.100
I500/1	I500	Incandescent, (1) 500W lamp		1	500	0.500
I52/1	I52	Incandescent, (1) 52W lamp		1	52	0.052
I52/2	I52	Incandescent, (2) 52W lamp		2	52	0.104
I54/1	I54	Incandescent, (1) 54W lamp		1	54	0.054
I54/2	I54	Incandescent, (2) 54W lamp		2	54	0.108
I55/1	I55	Incandescent, (1) 55W lamp		1	55	0.055
I55/2	I55	Incandescent, (2) 55W lamp		2	55	0.110
I60/1	I60	Incandescent, (1) 60W lamp		1	60	0.060
I60/2	I60	Incandescent, (2) 60W lamp		2	60	0.120
I60/3	I60	Incandescent, (3) 60W lamp		3	60	0.180
I60/4	I60	Incandescent, (4) 60W lamp		4	60	0.240
I60/5	I60	Incandescent, (5) 60W lamp		5	60	0.300
I60E/1	I60/ES	Incandescent, (1) 60W ES lamp		1	52	0.052

Note: This table extracted from the 1999Large Nonresidential Standard Performance Contracting Program Manual and Forms Web Site: <www.scespc.com/largenonresmanuals.htm>.

Table 5-4 (continued)
Examples of Fixture Wattages for Various Lamps

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	LAMPS/ FIXT	WATTS/ LAMP	KW/FIXT
I60EL/1	I60/ES/LL	Incandescent, (1) 60W ES/LL lamp		1	52	0.052
I65/1	I65	Incandescent, (1) 65W lamp		1	65	0.065
I65/1	I65	Incandescent, (1) 65W lamp		1	65	0.065
I65/2	I65	Incandescent, (2) 65W lamp		2	65	0.130
I67/1	I67	Incandescent, (1) 67W lamp		1	67	0.067
I67/2	I67	Incandescent, (2) 67W lamp		2	67	0.134
I67/3	I67	Incandescent, (3) 67W lamp		3	67	0.201
I69/1	I69	Incandescent, (1) 69W lamp		1	69	0.069
I7.5/1	I7.5	Tungsten exit light, (1) 7.5 W lamp, used in night light application		1	7.5	0.008
I7.5/2	I7.5	Tungsten exit light, (2) 7.5 W lamp, used in night light application		2	7.5	0.015
I72/1	I72	Incandescent, (1) 72W lamp		1	72	0.072
I75/1	I75	Incandescent, (1) 75W lamp		1	75	0.075
I75/2	I75	Incandescent, (2) 75W lamp		2	75	0.150
I75/3	I75	Incandescent, (3) 75W lamp		3	75	0.225
I75/4	I75	Incandescent, (4) 75W lamp		4	75	0.300
I750/1	I750	Incandescent, (1) 750W lamp		1	750	0.750
I75E/1	I75/ES	Incandescent, (1) 75W ES lamp		1	67	0.067
I75EL/1	I75/ES/LL	Incandescent, (1) 75W ES/LL lamp		1	67	0.067
I80/1	I80	Incandescent, (1) 80W lamp		1	80	0.080
I85/1	I85	Incandescent, (1) 85W lamp		1	85	0.085
I90/1	I90	Incandescent, (1) 90W lamp		1	90	0.090
I90/2	I90	Incandescent, (2) 90W lamp		2	90	0.180
I90/3	I90	Incandescent, (3) 90W lamp		3	90	0.270
I93/1	I93	Incandescent, (1) 93W lamp		1	93	0.093
I95/1	I95	Incandescent, (1) 95W lamp		1	95	0.095
I95/2	I95	Incandescent, (2) 95W lamps		2	95	0.190
		LED Traffic Signal Fixtures				
LED12GA	LED 12" Green Arrow	LED Traffic Signal Light, 12" Green Arrow		1	5.1	0.005
LED12GB	LED 12" Green Ball	LED Traffic Signal Light, 12" Green Ball		1	16.7	0.017
LED12RA	LED 12" Red Arrow	LED Traffic Signal Light, 12" Red Arrow		1	9.7	0.010

Note: This table extracted from the 1999Large Nonresidential Standard Performance Contracting Program Manual and Forms Web Site: <www.scespc.com/largenonresmanuals.htm>.

Table 5-4 (continued)
Examples of Fixture Wattages for Various Lamps

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	LAMPS/ FIXT	WATTS/ LAMP	KW/FIXT
LED12RB	LED 12" Red Ball	LED Traffic Signal Light, 12" Red Ball		1	15	0.015
LED8GB	LED 8" Green Ball	LED Traffic Signal Light, 8" Green Ball		1	8	0.008
LED8RB	LED 8" Red Ball	LED Traffic Signal Light, 8" Red Ball		1	9.7	0.010
LEDPH	LED Ped Hand	LED Traffic Signal Light, Pedestrian Head - Hand		1	10	0.010
		Metal Halide Fixtures				
MH100/1	MH100	Metal Halide, (1) 100W lamp		1	100	0.128
MH1000/1	MH1000	Metal Halide, (1) 1000W lamp		1	1000	1.080
MH150/1	MH150	Metal Halide, (1) 150W lamp		1	150	0.190
MH1500/1	MH1500	Metal Halide, (1) 1500W lamp		1	1500	1.610
MH175/1	MH175	Metal Halide, (1) 175W lamp		1	175	0.215
MH250/1	MH250	Metal Halide, (1) 250W lamp		1	250	0.295
MH32/1	MH32	Metal Halide, (1) 32W lamp		1	32	0.043
MH400/1	MH400	Metal Halide, (1) 400W lamp		1	400	0.458
MH400/2	MH400	Metal Halide, (2) 400W lamp		2	400	0.916
MH50/1	MH50	Metal Halide, (1) 50W lamp		1	50	0.072
MH70/1	MH70	Metal Halide, (1) 70W lamp		1	70	0.095
MH750/1	MH750	Metal Halide, (1) 750W lamp		1	750	0.850
		Mercury Vapor Fixtures				
MV100/1	MV100	Mercury Vapor, (1) 100W lamp		1	100	0.125
MV1000/1	MV1000	Mercury Vapor, (1) 1000W lamp		1	1000	1.075
MV175/1	MV175	Mercury Vapor, (1) 175W lamp		1	175	0.205
MV250/1	MV250	Mercury Vapor, (1) 250W lamp		1	250	0.290
MV40/1	MV40	Mercury Vapor, (1) 40W lamp		1	40	0.050
MV400/1	MV400	Mercury Vapor, (1) 400W lamp		1	400	0.455
MV400/2	MV400	Mercury Vapor, (2) 400W lamp		2	400	0.910
MV50/1	MV50	Mercury Vapor, (1) 50W lamp		1	50	0.074
MV700/1	MV700	Mercury Vapor, (1) 700W lamp		1	700	0.780
MV75/1	MV75	Mercury Vapor, (1) 75W lamp		1	75	0.093
		Removed Fixture				
Removed	None	Fixture completely removed from service		0	0	0.000

Note: This table extracted from the 1999Large Nonresidential Standard Performance Contracting Program Manual and Forms Web Site: <www.scespc.com/largenonresmanuals.htm>.

6 . ADDITIONAL INFORMATION

This section contains a partial list of references that could be consulted for additional information on some of the topics discussed in this Guide.

A. **Project Management Handbooks** - The Energy Commission has developed a series of handbooks designed to help public agencies and others implement energy efficiency projects. The following handbooks are currently available:

- *How to Hire an Energy Services Company*
- *How to Hire an Energy Auditor to Identify Energy Efficiency Projects*
- *How to Finance Public Sector Energy Efficiency Projects*
- *Energy Accounting: A Key Tool in Managing Energy Costs*
- *How to Procure Electricity and Natural Gas in a Competitive Market Environment* (available Summer 2000)

These documents can be downloaded through the Energy Commission's Web Site at <www.energy.ca.gov/efficiency/reports/html> or contact the Energy Commission at the following address for a copy:

California Energy Commission
Energy Efficiency Division
Nonresidential Buildings Office
1516 Ninth Street, MS-26
Sacramento, CA 95814
Telephone: 916-654-4008
Fax: 916-654-4304
e-mail: nonres@energy.state.ca.us

B. **Cost Estimating Guides**

- *Means Building Construction Cost Data Manual*
  Means Electrical Cost Data Manual
  Means Mechanical Cost Data Manual
  R. S. Means Company, Inc.
  Construction Plaza, 63 Smiths Lane
  Kingston, MA 02364-0800
  (800) 334-3509
  www.rsmeans.com

- *Dodge Cost Guides*
  Dodge Unit Cost Guide, *Dodge Electrical Cost Guide*, and *Dodge Repair and Remodel Cost Guide*
  Marshall and Swift
  911 Wilshire Boulevard, Suite 1600
  Los Angeles, CA 90017-3409
  1-800-421-8042
  www.marshallswift.com

- *General Prevailing Wage Determinations*
  State of California, Department of Industrial Relations
  Division of Labor Statistics and Research
  P. O. Box 420603
  San Francisco, CA 94142-0603
  (415) 703-4780
  This organization compiles and publishes general prevailing wage determinations and schedules for basic and subtrades. Information on the schedules can be found at:<www.dir.ca.gov/dlsr/statistics_research.html>.

C. Technical Guides

- *Lighting Handbook, Reference and Application*
  9th Edition, 1999
  Illuminating Engineering Society of North America
  Publications Department
  120 Wall Street, 17th Floor
  New York, NY 10005
  (212) 248-5000
  This handbook is known as the “Bible of Lighting” and includes explanations of concepts, techniques, applications, procedures, systems and definitions, task, clients, and diagrams. Information about the handbook and other publications can also be found at their Web Site: <www.iesna.org/>.

- *Lighting Power Density*
  http://206.5531.90/cgi-bin/lpd/lpd
  This Web Site has information on a method for determining lighting power densities for individual spaces and whole buildings.

- *Advanced Lighting Guidelines* (#400-93-014)
  California Energy Commission, Publications
  1516 9th Street, MS-13
  Sacramento, CA 95814
  (916) 654-5200
  This handbook contains guidelines on advanced energy efficient lighting technologies. Guidelines are provided on lighting design practices, computer-aided lighting design, luminaries, and lighting systems, energy efficient and electronic ballasts, full-size fluorescent lamps, compact fluorescent lamps, conventional shape tungsten halogen lamps, compact metal halide and white high-pressure sodium lamps. This handbook is being

revised and a final version is scheduled in December 2000. Information on the revision can be found at: <www.newbuildings.org>.

- *Appliance Efficiency Database*
  www.energy.ca.gov/efficiency/appliances/index.html
  This Energy Commission Web Site contains information on how to obtain a database containing all appliances certified to meet the current efficiency standards. The database can be downloaded at: <ftp://energy.ca.gov/pub/efftech/appliances>. The files are in a database format which can be manipulated in most database or spreadsheet software. The databases can be obtained by calling 916-654-4064 or at the Web Site.

  The following appliances are on the database:

  Fluorescent Lamp Ballasts
  Boilers
  Central Air Conditioners and Heat Pumps
  Lighting and Ventilation Control Devices
  Cooking and Washing Appliances
  Central Fan-Type Furnaces
  Gas Space Heaters
  Plumbing Fittings and Fixtures
  Pool Heaters
  Refrigerators/Freezers, freezers, wine chillers
  Room Air Conditioners, Package Terminal A/C, Package Terminal Heat Pumps
  Spot Air Conditioners and Computer Room Air Conditioners
  Water Heaters (Electric)
  Water Heaters (Gas)

- *Non-Residential Manual for Compliance with 1998 Energy Efficiency Standards* (#400-98-005)
  California Energy Commission, Publications
  1516 9th Street, MS-13
  Sacramento, CA 95814
  (916) 654-5200
  The Energy Efficiency Standards for Residential and Nonresidential Buildings were established in 1978 in response to a State mandate to reduce California's energy demand. The standards are updated periodically to consider and incorporate new energy efficiency technologies and methods. The standards may be obtained through the Publications Office or downloaded at: <www.energy.ca.gov/title24/index.html>.

- *ASHRAE Handbook*
  1997 Fundamentals
  1996 HVAC Systems and Equipment
  1999 HVAC Applications
  1998 Refrigeration
  American Society of Heating, Refrigerating and Air Conditioning Engineers
  1791 Tullie Circle, N.E.
  Atlanta, GA 30329
  (404) 636-8400
  www.ashrae.org

D. Commissioning and Operation and Maintenance Resources

- *Model Commission Plan and Guide Specifications*
  PECI
  921 SW Washington Street, Suite 312
  Portland, Oregon
  (503) 248-4636
  www.peci.org/cx/
  This web site by the Portland Energy Conservation Incorporated contains information on building commissioning, operation and maintenance strategies and links to other organizations that have developed commissioning plans and specifications.

E. Life Cycle Cost Program

- *Building Life Cycle Cost (BLCC)*
  National Institute of Standards and Technology
  Office of Applied Economics
  Building 226, Room B226
  Gaithersburg, Maryland 20899-1000
  (301) 975-6134
  This software program, developed by the National Institute of Standards and Technology, provides an analysis of proposed capital investments that are expected to reduce long term operating costs of buildings or building systems. The program can be downloaded at no cost at: <www.eren.doe.gov/femp/techassist/softwaretools/soft>.

F. Building Software Programs

- *Building Energy Software Tools*
  www.eren.doe.gov/buildings/tools_directory/
  This Web Site lists 184 energy-related software tools for buildings. Categories include whole building analysis, materials components and systems, codes and standards, and other applications. Under the whole building analysis category, information is provided on the following types of software: energy simulation, load calculation, renewable energy, retrofit analysis, sustainability and green buildings. All major building simulation

software programs, such as DOE 2.1E, HAP and Trace 600, are reviewed and information provided on their strengths and weaknesses.

- *California Nonresidential Building Compliance Programs*
  The Energy Commission approved the following energy analysis computer programs for Nonresidential Buildings. Please refer to the following Web Site for future updates:
  <www.energy.ca.gov/efficiency/computer_prog_list.html>.
  - Energy Pro, Version 2.0
    Gabel/Dodd Associates
    100 Galli Drive, Suite 1
    Novato, CA 94949
    (415) 883-5900
    www.energysoft.com

  - Perform 98
    California Energy Commission
    Publications, MS-13
    1516 Ninth Street
    Sacramento, CA 95814
    (916) 654-5106
    www.energy.ca.gov

- *Insulation Thickness Computer Program*
  http://pipeinsulation.org
  This program, by the North American Insulation Manufacturers Association, calculates insulation thickness to determine energy savings for piping and equipment. The program can be downloaded through their Web Site.

- *Analytical Software Tools*
  www.eren.doe.gov/femp/techassist/softwaretools/softwaretools.html
  Several energy project evaluation software programs can be downloaded from this Web Site. The software tools include programs for determining building life cycle cost and for comparing potential energy conservation measures. The tools are designed to assist project managers in choosing cost-effective and environmentally friendly projects.

- *RSPEC (Reduce Swimming Pool Energy Cost)* Simulation Program
  www.eren.doe.gov/rspec/software.htm.
  The U. S. Department of Energy has developed a computer software program called Energy Smart Pools. The program is designed to give pool owners an analysis of their pool's current energy consumption and estimate the savings to be realized by implementing a variety of energy management systems. The Web Site also contains information on evaporation studies and a directory of manufacturers of pool covers and solar pool collectors.

G. Equipment Specifications

- *Building Specifications for Energy Efficient Equipment*
  www.eley.com
  As a contractor in the Energy Commission's Public Interest Energy Research Program, Eley Associates is developing equipment specifications for energy efficient equipment. A draft version of the specifications will be available in late 2000. Information on the specifications will be posted on the Eley Associates Web Site: <www.eley.com>.

7. ECONOMIC EVALUATION: LIFE-CYCLE COST ANALYSIS

Simple payback, measured in years, is calculated by dividing the total project cost by the annual savings. Although using the Life-Cycle Cost (LCC) methodology is **not required** by the Energy Commission for feasibility studies, the decision maker should consider using the LCC methodology when evaluating the cost effectiveness of project alternatives. In many cases, the analyst can complete a LCC analysis of the project alternatives using the same information provided in the feasibility study. To do this, the analyst must have information on equipment life, equipment replacement costs, and operation and maintenance costs. A summary of this information for various EEMs is contained in this section.

A. LCC Analysis

LCC analysis is a comparative method whereby all costs and savings related to a decision are evaluated over a common study period and adjusted for the time value of money. Since LCC incorporates the time value of money, on costs and savings over a given study period, LCC differs sharply from the commonly used "simple payback" method. The use of simple payback should be restricted to that of a screening tool. If the payback period of a project is expected in a relatively short time compared to its expected life and no additional costs are expected after payback is achieved, then a full LCC may not be needed. However, in practice, simple payback is often used to reject projects that may be cost effective in the long run (i.e., from a life-cycle cost standpoint) but do not meet the objectives of the investor.

Most spreadsheet programs can easily compute the LCC of a project by using a function for (net) present value to adjust for the time value of money. The public domain software package, Building Life-Cycle Cost (BLCC) is available as a tool for LCC analysis. Designed for use by federal agencies, BLCC can be used easily by both public and private entities with minor considerations. Information on the BLCC software can be obtained by contacting the National Institute of Standards and Technology at the following address and phone number or download it from their Web Site at <www.eren.doe.gov/femp/techassist/softwaretools/soft.

U.S. Department of Commerce
National Institute of Standards and Technology
Computing and Applied Mathematics Laboratory
Gaithersburg, Maryland 20899-1000
(301) 975-2000

B. General Maintenance, Repair or Overhaul and Replacement Costs for Various Energy Conservation Measures (EEMs)

The information contained in this section was developed for the Energy Commission by Charles Eley and Associates. This section presents costs for general maintenance, repair or overhaul, and replacement for a various EEMs. These costs are intended to be used in life-cycle cost analysis of EEMs. Costs are provided as linear equations that depend on the size of the equipment. Table 7-1 provides formulas for the maintenance cost associated with various types of energy using equipment. This table also provides information on the frequency when maintenance needs to be done.

1. How to Use the Equations in Table 7-1

Consider circulation pumps as an example (Table 7-1, page 7-7). There are three cost items associated with circulation pumps: general maintenance, repair or overhaul and replacement. The general maintenance cost is expected to occur each year and the cost is "m" times the size of the pump motor in horsepower (hp) plus "b". For a 2 hp pump the general maintenance cost would be:

General Maintenance = (m * hp) + b = (5.49 * 2)+ 3.02 = $14.00/year

The pump must be repaired or overhauled every 5 years. This cost is given by the following calculation:

Repair or Overhaul = (m * hp) + b
= (2.92 * 2) + 40.14 = $45.98 every 5 years

The pump is expected to last 20 years. At the end of this period, the replacement cost would be:

Replacement = (m * hp) + b = (1904.09 * 2) + 490.09 = $4298.27

Note that the costs for repair and replacement are not annual costs, but discrete costs that occur at the frequency noted. These costs were not annualized, because the annualized value of these costs is dependent on the discount rate, which may change.

Maintenance, overhaul and replacement costs are considered future expenses in life-cycle cost analysis. Since the study period for most energy efficiency projects is 15 years or less, the replacement cost is generally not applicable for new equipment. The more common use of replacement costs in life cycle analysis is in the base case. This is especially true when the existing equipment is near the end of its life. For instance, if an existing pump were 15 years old, the base case would include a replacement cost at year 5 (equipment life of 20 years (Table 7-1) less the age of the equipment [(20 years equipment life) - 15 years = 5 years remaining on existing pump)].

The costs which result from the use of Table 7-1 represent "in-house" costs, without mark up. If outside service companies are used to perform maintenance and repair, the resulting cost estimates should be increased by 20 percent.

Maintenance and repair costs will vary significantly from project to project, and costs determined using the equations should be interpreted as "typical" values. It is recommended, however, that cost estimates used in LCC analysis be within ±30 percent of the results in Table 7-1 with the 2 percent markup when appropriate. Cost estimates that vary by more than 30 percent and cost estimates for items not included in Table 7-1, should be supported by cost estimates.

2. Measures with LCC Cost Components

A preliminary list of the energy efficiency measures or equipment with significant LCC cost components is contained in Table 7-2. Envelope energy efficiency measures were considered, but were determined to have little impact on operation and maintenance costs and were excluded. Items not included in Table 7-1 or 7-2 were determined to have negligible maintenance and repair costs. The following discusses some of the assumptions used in Tables 7-1 and 7-2:

a. **Occupant Sensors** - Costs are considered to be negligible.

b. **LED Exit Signs** - These have an expected life of 20 to 30 years and maintenance costs are considered negligible. The maintenance costs of the existing fixture should be considered in the analysis. This will increase the LCC of the base case and affect the results.

c. **Electronic Ballasts** - There are no maintenance costs. Since they are expected to last at least 15 years, replacement costs are ignored as well.

d. **Energy Management Systems (EMS)** - No cost data available for a general EMS. However, costs are included for a few individual control strategies such as zone controls.

e. **Variable Frequency Drives** - No cost data available. Possible information available from the Florida Solar Energy Center or the Electric Power Research Institute.

f. **Electronic Ignition on Heating Units** - Costs are considered negligible.

g. **Compact Heat Exchangers** - Costs were found negligible.

h. **Fluorescent Lamps** - These are grouped into four categories: fluorescent, slimline fluorescent, high output fluorescent, and very high output fluorescent. No distinction is made between T-8 or T-12.

i. **Evaporative Coolers** - This equipment type is divided into two size categories: low capacity (<15,000 cfm) and high capacity (>15,000 cfm).

3. Data Sources and Methodology

The equations in Table 7-1 were developed by making a regression against data collected from a variety of sources. These sources included:

a. *Means Facilities Maintenance and Repair Cost Data, 1994*
b. *Means Mechanical Cost Data, 1994*
c. Xenergy's *1994 Measure Cost Study*
d. Pacific Gas and Electric Company's *Customized Incentives Program Documentation Resource Binder*
e. ASHRAE *HVAC Systems and Applications Handbook*, 1987
f. IES *Lighting Handbook*, 8th Edition
g. HVAC equipment representatives
h. Lighting equipment representatives
i. Grainger catalog

Table 7-1 indicates the source for the cost data for each item. The last column titled "Source" includes an integer relating to one of the references listed above. Maintenance, repair, and replacement costs were collected from the above sources for a range of sizes for each equipment type. A linear regression was then performed for each equipment type using the "least-squares" method. The result of the regression was a general equation that could be used to predict the maintenance and repair costs for a variety of sizes of a given piece of equipment. The regression results are included as Table 7-3.

4. Validation of Method

A 1989 EPRI study entitled *Handbook of High-Efficiency Electric Equipment and Cogeneration System Options for Commercial Buildings* (CU-6661) documents the results of a survey based on comprehensive maintenance contracts covering both routine and emergency service. Using this Handbook, the total maintenance cost for a 300 ton hermetic, centrifugal chiller ranges from $3,000 to $10,500. Alternatively, representative maintenance cost can be also obtained from surveying facilities with similar equipment.

A comparable cost to that shown in the EPRI report derived from Tables 7-1 to 7-3 would include both maintenance and repair costs. These costs are calculated as follows:

a. **Maintenance**: The equation listed in the table for the maintenance of hermetic centrifugal chiller is $ = const. This means that the cost for annual preventative maintenance for a chiller of this type is independent of chiller size. The cost for annual preventative maintenance for this chiller is $1,225.00.

b. **Repair:** The equation listed in the table for the repair of a hermetic centrifugal chiller is $ = m * (tons)+b. The size of the chiller in question is 300 tons. The slope (m) determined for this type of equipment is listed in Table 7-1 as $258.01. The y-intercept (b) is listed as $7,988.21. Therefore, according to the equation, the repair cost is $85,391.21.

In this study, repair costs for this item are shown to occur every 10 years. In order to compare these results with the EPRI study, it is necessary to annualize these costs. Assuming a discount rate of 3.1 percent, the annualized repair costs are calculated according to the equation:

$$\textit{annual cost} = 85391.21(0.031/(1.031^{10}-1))$$

The result of this equation is an annual repair cost of $7,414.48. Thus, the total annual maintenance cost for this chiller, including emergency repair, is $8,639.48. This corresponds well with the values given in the EPRI report.

c. **Replacement**: At the end of this chiller's useful life, it will need to be replaced. The EPRI study indicates that the replacement cost for this chiller will range from $105,000 to $165,000. The equation listed in Table 7-1 for the replacement of a hermetic, centrifugal chiller is $ = (m * (tons)) + b. The size of the chiller, as above, is 300 tons. The slope (m) listed in the table for this cost item is $248.72. The y-intercept (b) is $45,880.60. Therefore, the replacement cost is calculated as $120,496.60.

The value obtained using the equation in Table 7-1 corresponds well with the value listed in the EPRI study.

Table 7-1
Maintenance Costs for Various Energy Efficiency Measures

Equipment	Units	Cost Item	Frequency (hours)	Cost/Equipment	m	b
Lamp Types						
Fluorescent	feet	Maintenance	20000	$ = m * (feet)+b	1	1.64
		Disposal	20000	$=m * (feet)	0.07	
Slimline Fluorescent	feet	Maintenance	12000	$ = const		10.13
		Disposal	20000	$ = m* (feet)	0.07	
HO Fluorescent	feet	Maintenance	12000	$ = const		11.61
		Disposal	20000	$ = m* (feet)	0.07	
VHO Fluorescent	feet	Maintenance	12000	$ = const		19.21
		Disposal	20000	$ = m* (feet)	0.07	
Twin Tube Compact Fluorescent	Watts	Maintenance	10000	$ = const		6.75
Quad Tube Compact Fluorescent	Watts	Maintenance	10000	$ = m * (Watts) + b	0.15	8.55
Mercury Vapor	Watts	Maintenance	24000	$ = m * (Watts) + b	0.05	27.35
Metal Halide	Watts	Maintenance	20000	$ = m * (Watts) + b	0.07	22.81
High Pressure Sodium	Watts	Maintenance	24000	$ = m * (Watts) + b	0.08	24.56
Low Pressure Sodium	Watts	Maintenance	18000	$ = m * (Watts) + b	0.3	42.12
Quartz	Watts	Maintenance	3000	$ = m * (Watts) + b	0.03	11.83
Incandescent, A Lamp	Watts	Maintenance	750	$ = m * (Watts) + b	0.01	2.17
Incandescent, R Lamp	Watts	Maintenance	2000	$ = const		6.84
Incandescent, MR Lamp	Watts	Maintenance	3000	$ = const		5.86
High Power Twin Tube, T5	Watts	Maintenance	20000	$ = const		13.92
Halogen PAR Lamp	Watts	Maintenance	4000	$ = const		9.24
Magnetic Ballast	Watts	Maintenance	15 years	$/ballast = m * (# of ballasts)	2.5	
Mechanical Equipment						
Circulation Pump	hp	General Maintenance	1	$=m*(hp)+b	5.49	$3.02
Circulation Pump	hp	Repair or Overhaul	5	$=m*(hp)+b	2.92	$40.14
Circulation Pump	hp	Replacement	20	$=m*(hp)+b	1904.09	$490.09
Gas/Oil Water Heater	gal	General Maintenance	1	$=const.		$95.50
Gas/Oil Water Heater	gal	Repair or Overhaul	5	$=const.	0.21	$57.61
Gas/Oil Water Heater	gal	Replacement	10	$=m*(gal)+b	26.93	($267.28)
Electric Water Heater	gal	General Maintenance	1	$=const.		$1.26
Electric Water Heater	gal	Repair or Overhaul	7	$=const.		$143.00
Electric Water Heater	gal	Replacement	15	$=m*(gal)+b	21.26	$18,935.81
Fuel Fired Boiler	MBH	General Maintenance	1	$=const.		$790.00
Fuel Fired Boiler	MBH	Repair or Overhaul	7	$=m*(MBH)+b	0.63	$996.47
Fuel Fired Boiler	MBH	Replacement	30	$=m*(MBH)+b	14.04	($5,756.49)

Table 7-1 (Continued)
Maintenance Costs for Various Energy Efficiency Measures

Equipment	Units	Cost Item	Frequency (hours)	Cost/Equipment	m	b
Furnace	MBH	General Maintenance	1	$=const.		$350.00
Furnace	MBH	Repair or Overhaul	10	$=m*(MBH)+b	6.4	$275.52
Furnace	MBH	Replacement	15	$=m*(MBH)+b	9.38	$122.15
DX Air Conditioner	Ton	General Maintenance	1	$=m*(tons)+b	1.24	$127.38
DX Air Conditioner	Ton	Repair or Overhaul	10	$=m*(tons)+b	650.93	($388.17)
DX Air Conditioner	Ton	Replacement	20	$=m*(tons)+b	616.64	$3,533.93
Window Air Conditioner	Ton	General Maintenance	1	$=construction		$0.00
Window Air Conditioner	Ton	Repair or Overhaul	8	$=m*(tons)+b	6.43	$32.26
Window Air Conditioner	Ton	Replacement	10	$=m*(tons)+b	1543.75	($1,249.25)
Pkg. Multizone Air Conditioner	Ton	General Maintenance	1	$=m*(tons)+b	2.34	$96.87
Pkg. Multizone Air Conditioner	Ton	Repair or Overhaul	10	$=m*(tons)+b	270.33	$4,361.41
Pkg. Multizone Air Conditioner	Ton	Replacement	15	$=m*(tons)+b	916.89	$36,774.94
Pkg. Single Zone Air Conditioner	Ton	General Maintenance	1	$=m*(tons)+b	2.42	$94.97
Pkg. Single Zone Air Conditioner	Ton	Repair or Overhaul	10	$=m*(tons)+b	540.28	($15.71)
Pkg. Single Zone Air Conditioner	Ton	Replacement	15	$=m*(tons)+b	1118.28	$1,198.88
Pkg. Multizone VAV Air Conditioner	Ton	General Maintenance	1	$=m*(tons)+b	2.21	$87.41
Pkg. Multizone VAV Air Conditioner	Ton	Repair or Overhaul	10	$=m*(tons)+b	195.67	$18,034.24
Pkg. Multizone VAV Air Conditioner	Ton	Replacement	15	$=m*(tons)+b	1199.90	($1,985.20)
Pkg. Single VAV Air Conditioner	Ton	General Maintenance	1	$=m*(tons)+b	2.35	$106.31
Pkg. Single VAV Air Conditioner	Ton	Repair or Overhaul	10	$=m*(tons)+b	565.05	($1,450.15)
Pkg. Single VAV Air Conditioner	Ton	Replacement	10	$=m*(tons)+b	1036.92	$9,796.15
Reciprocating, Air-Cooled Chiller	Ton	General Maintenance	1	$=m*(tons)+b	1.46	$388.98
Reciprocating, Air-Cooled Chiller	Ton	Repair or Overhaul	10	$=m*(tons)+b	713.16	($5,586.98)
Reciprocating, Air-Cooled Chiller	Ton	Replacement	20	$=m*(tons)+b	655.05	$4,688.78

Table 7-1 (Continued)
Maintenance Costs for Various Energy Efficiency Measures

Equipment	Units	Cost Item	Frequency (hours)	Cost/Equipment	m	b
Reciprocating, Water-Cooled Chiller	tons	General Maintenance	1	$=m*(tons)+b	1.46	$388.98
Reciprocating, Water-Cooled Chiller	tons	Repair or Overhaul	10	$=m*(tons)+b	544.61	($1,884.97)
Reciprocating, Water-Cooled Chiller	tons	Replacement	20	$=m*(tons)+b	513.65	$10,559.95
Centrifugal, hermetic chiller and screw chiller	tons	General Maintenance	1	$=const.		$1,225.00
Centrifugal, hermetic chiller and screw chiller	tons	Repair or Overhaul	10	$=m*(tons)+b	258.01	$7,988.21
Centrifugal, hermetic chiller and screw chiller	tons	Replacement	20	$=m*(tons)+b	248.72	$45,880.60
Centrifugal, Open Chiller	tons	General Maintenance	1	$=const.		$1,225.00
Centrifugal, Open Chiller	tons	Repair or Overhaul	10	$=m*(tons)+b	262.65	$4,189.43
Centrifugal, Open Chiller	tons	Replacement	20	$=m*(tons)+b	356.18	($72.00)
Absorption Chiller	tons	General Maintenance	1	$=m*(tons)+b	0.27	$232.09
Absorption Chiller	tons	Repair or Overhaul	10	$=m*(tons)+b	3.15	$9,872.12
Absorption Chiller	tons	Replacement	20	$=m*(tons)+b	377.93	$105,365.94
Air-Cooled Condensing Unit	tons	General Maintenance	1	$=m*(tons)+b	0.86	$148.42
Air-Cooled Condensing Unit	tons	Repair or Overhaul	10	$=m*(tons)+b	18.38	$263.50
Air-Cooled Condensing Unit	tons	Replacement	15	$=m*(tons)+b	234.41	$244.86
Evaporative Condensing Unit	tons	General Maintenance	1	$=m*(tons)+b	0.38	$85.73
Evaporative Condensing Unit	tons	Repair or Overhaul	10	$=m*(tons)+b	14.80	$7,171.21
Evaporative Condensing Unit	tons	Replacement	15	$=m*(tons)+b	153.08	$3,606.89
Cooling Tower	tons	General Maintenance	1	$=m*(tons)+b	0.80	$216.11
Cooling Tower	tons	Repair or Overhaul	10	$=m*(tons)+b	7.30	$877.21
Cooling Tower	tons	Replacement	15	$=m*(tons)+b	48.96	$3,881.25
Water/Steam Fan Coil	tons	General Maintenance	1	$=const.		$141.00
Water/Steam Fan Coil	tons	Repair or Overhaul	10	$=m*(tons)+b	11.51	$231.19
Water/Steam Fan Coil	tons	Replacement	15	$=m*(tons)+b	255.84	$801.76
DX Fan Coil, No Heat	tons	General	1	$=const.		$141.00

Table 7-1 (Continued)
Maintenance Costs for Various Energy Efficiency Measures

Equipment	Units	Cost Item	Frequency (hours)	Cost/Equipment	m	b
		Maintenance				
DX Fan Coil, No Heat	tons	Repair or Overhaul	10	$=m*(tons)+b	529.22	($268.86)
DX Fan Coil, No Heat	tons	Replacement	15	$=m*(tons)+b	300.14	($36.15)
DX Fan Coil, with Heat	tons	General Maintenance	1	$=const.		$141.00
DX Fan Coil, with Heat	tons	Repair or Overhaul	10	$=m*(tons)+b	529.22	($268.86)
DX Fan Coil, with Heat	tons	Replacement	15	$=m*(tons)+b	420.69	($36.15)
One-Row Hot Water Duct Coil	sq. in.	General Maintenance	1	$=const.		$0.00
One-Row Hot Water Duct Coil	sq. in.	Repair or Overhaul	10	$=m*(tons)+b	0.10	$1.57
One-Row Hot Water Duct Coil	sq. in.	Replacement	25	$=m*(tons)+b	0.40	$126.70
Terminal Reheat	sq. in.	General Maintenance	1	$=const.		$0.00
Terminal Reheat	sq. in.	Repair or Overhaul	10	$=m*(tons)+b	0.02	$45.60
Terminal Reheat	sq. in.	Replacement	15	$=m*(tons)+b	0.44	$300.64
Air Handler (incl. Coils)	cfm	General Maintenance	1	$=m*(cfm)+b	0.01	$198.64
Air Handler (incl. Coils)	cfm	Repair or Overhaul	10	$=m*(cfm)+b	0.04	$122.19
Air Handler (incl. Coils)	cfm	Replacement	15	$=m*(cfm)+b	0.77	$1,414.86
Water Source Heat Pump	tons	General Maintenance	1	$=const.		$170.00
Water Source Heat Pump	tons	Repair or Overhaul	10	$=m*(tons)+b	294.93	$457.15
Water Source Heat Pump	tons	Replacement	20	$=m*(tons)+b	1018.56	($84.87)
Air-to-Air Heat Pump	tons	General Maintenance	1	$=const.		$170.00
Air-to-Air Heat Pump	tons	Repair or Overhaul	10	$=m*(tons)+b	538.20	($2,216.15)
Air-to-Air Heat Pump	tons	Replacement	20	$=m*(tons)+b	1301.88	($685.51)
Thru-Wall Heat Pump	tons	General Maintenance	1	$=m*(zones)+b		$147.00
Thru-Wall Heat Pump	tons	Repair or Overhaul	10	$=m*(tons)+b	120.43	$945.26
Thru-Wall Heat Pump	tons	Replacement	20	$=m*(tons)+b	806.86	$1,580.71
Zone Controls	zone	General Maintenance	1	$=m*(zones)+b	38.50	$0.00
Zone Controls	zone	Repair or Overhaul	10	$=m*(zones)+b	120.00	$0.00
Zone Controls	zone	Replacement	15	$=m*(zones)+b	1000.00	$0.00

Table 7-1 (Continued)
Maintenance Costs for Various Energy Efficiency Measures

Equipment	Units	Cost Item	Frequency (hours)	Cost/Equipment	m	b
Axial Fan	cfm	General Maintenance	1	$=const.		$44.67
Axial Fan	cfm	Repair or Overhaul	10	$=const.		$0.00
Axial Fan	cfm	Replacement	15	$=m*(cfm)+b	0.19	$2,010.56
Centrifugal Fan	cfm	General Maintenance	1	$=const.		$39.83
Centrifugal Fan	cfm	Repair or Overhaul	10	$=const.		$0.00
Centrifugal Fan	cfm	Replacement	15	$=m*(cfm)+b	0.35	$636.99
Evaporative Coolers	cfm	General Maintenance	1	$=const.		$70.75
Evaporative Coolers Low Capacity	cfm	Repair or Overhaul	10	$=m*(cfm)+b	0.013	$482.52
Evaporative Coolers <15,000 cfm)	cfm	Replacement	15	$=m*(cfm)+b	0.201	$97.12
Evaporative Coolers	cfm	General Maintenance	1	$=m*(cfm)+b	0.011	($23.00)
Evaporative Coolers High Capacity	cfm	Repair or Overhaul	10	$=m*(cfm)+b	0.065	($430.35)
Evaporative Coolers (>15,000 cfm)	cfm	Replacement	15	$=m*(cfm)+b	0.435	$5,587.26
Pool Heaters	gal	General Maintenance	1	$=const.		$130.00
Pool Heaters	gal	Repair or Overhaul	5	$=const.	0.21	$75.00
Pool Heaters	gal	Replacement	10	$=m*(gal)+b	35.00	($187.00)
Packaged Cogeneration	kWh	General Maintenance	1	$=m*(kWh)	0.02	$0.00
Packaged Cogeneration (not including chiller)	kWh	Repair or Overhaul	10	$=m*(kWh)	700.00	$0.00
Packaged Cogeneration	kWh	Replacement	20	$=m*(kWh)	1250.00	$0.00

Abbreviations:
hp = horsepower
gal = gallon
MBH = million BTU per hour
sq. in. = square inch
cfm = cubic feet per minute
kWh = kilowatt hours

Table 7-2
List of Items with Significant Life Cycle Cost Components*

Equipment	Replacement	Residual	Maintenance
Lighting Systems			
Fluorescent	Ballast (period and cost depends on ballast type)	Lamp, ballast disposal (cost depends on lamp type, ballast type)	Relamp, clean (relamp period and cost depends on lamp type and annual operating hours, cleaning cost depends on luminaire type)
High Intensity Discharge	Ballast	Lamp, ballast disposal (cost depends on lamp type, ballast type)	Relamp, clean (relamp period and cost depends on lamp type and annual operating hours, cleaning cost depends on luminaire type)
Incandescent	**	**	Relamp, clean (relamp period and cost depends on lamp type and annual operating hours, cleaning cost depends on luminaire type)
LED Exit Signs	**	**	**
Manual Wall Switch	**	**	**
Special Controls	Entire unit (cost depends on type)	**	Routine maintenance and adjustment (periods and costs depend on type)
Mechanical Systems			
Chiller	Entire unit (period and cost depends on type and size)	Salvage or dispose (cost depends on type and size)	Routine maintenance, periodic overhaul (periods and costs depend on type and size)
Cooling Tower	Entire unit (cost depends on size)	Salvage or dispose (cost depends on size)	Routine maintenance, periodic overhaul (cost depends on size)
Condenser	Entire unit (cost depends on type and size)	Salvage or dispose (cost depends on type and size)	Routine maintenance, periodic overhaul (periods and costs depend on type and size)
Compressor	Entire unit (cost depends on size)	Salvage or dispose (cost depends on size)	Routine maintenance, periodic overhaul (cost depends on size)
Boiler	Entire unit (period and cost depends on type and size)	Salvage or dispose (cost depends on type and size)	Routine maintenance, periodic overhaul (periods and costs depend on type and size)
Package Air Conditioner	Entire unit (period and cost depends on type and size)	Salvage or dispose (cost depends on type and size)	Routine maintenance, periodic overhaul (periods and costs depend on type and size)
Package Heat Pump	Entire unit (cost depends on size)	Salvage or dispose (cost depends on size)	Routine maintenance, periodic overhaul (cost depends on size)
Evaporative Cooler	Entire unit (cost depends on size)	Salvage or dispose (cost depends on size)	Routine maintenance, periodic overhaul (cost depends on size)
Furnace	Entire unit (period and cost depends on type and size)	Salvage or dispose (cost depends on type and size)	Routine maintenance, periodic overhaul (periods and costs depend on type and size)
Heater, Duct or Terminal	Entire unit (period and cost depends on type and size)	Salvage or dispose (cost depends on type and size)	Routine maintenance, periodic overhaul (periods and costs depend on type and size)
Cogeneration System	Entire unit (period and cost depends on type and size)	Salvage or dispose (cost depends on type and size)	Routine maintenance, periodic overhaul (periods and costs depend on type and size)
Circulation Pump	Entire unit (cost depends on size)	Salvage or dispose (cost depends on size)	Routine maintenance, periodic overhaul (cost depends on size)

Table 7-2 (Continued)
List of Items with Signicant Life Cycle Cost Components*

Equipment	Replacement	Residual	Maintenance
Fan, Air Handler	Entire unit (cost depends on size)	Salvage or dispose (cost depends on size)	Routine maintenance, periodic overhaul (cost depends on size)
Coil	Entire unit (period and cost depends on type and size)	Salvage or dispose (cost depends on type and size)	Routine maintenance, periodic overhaul (periods and costs depend on type and size)
Air Economizer	Entire unit (cost depends on size)	Salvage or dispose (cost depends on size)	Routine maintenance, periodic overhaul (cost depends on size)
Heat Exchanger	Entire unit (period and cost depends on type and size)	Salvage or dispose (cost depends on type and size)	Routine maintenance, periodic overhaul (periods and costs depend on type and size)
Air Terminal	Entire unit (period and cost depends on type and size)	Salvage or dispose (cost depends on type and size)	Routine maintenance, periodic overhaul (periods and costs depend on type and size)
Domestic Hot Water Heater	Entire unit (period and cost depends on type and size)	Salvage or dispose (cost depends on type and size)	Routine maintenance, periodic overhaul (periods and costs depend on type and size)
Pool Heater	Entire unit (period and cost depends on type and size)	Salvage or dispose (cost depends on type and size)	Routine maintenance, periodic overhaul (periods and costs depend on type and size)
Pool Cover	Entire unit (cost depends on size)	**	Routine maintenance (costs depend on if motorized or not)
Controls	Entire unit (period and cost depends on type)	**	Routine maintenance, periodic overhaul (periods and costs depend on type)
Variable Speed Drive Controller Kit	**	**	Routine maintenance
Intermittent Ignition Device Retrofit Kit	**	**	**
Insulation (pipe, duct, tank, equip.)	**	**	**
Thermal Energy Storage	**	Salvage or dispose (cost depends on type and size)	Routine maintenance, periodic overhaul (periods and costs depend on type and size)
Envelope Systems			
Building Insulation	**	**	**
building Insulation, hazardous	**	A wash in most cases	**
Reflective Coating	**	**	**
Radiant Barrier	**	**	Account for dirt in performance of radiant barrier
Window, glazing film	15 year life?	**	**
Window, awning	10 year life?	**	Hose it down couple times a year
Window, sunscreen	10 year life?	**	More difficult to wash windows?
Window/skylight, operable shades, manual	**	**	**
Window/skylight, operable shades, auto	10 year motor life?	**	Adjustment and calibration
Reduce Infiltration	**	**	**

Table 7-2 (Continued)
List of Items with Signicant Life Cycle Cost Components*

* Replacement costs are applicable both to the proposed project and to the base case (existing) systems. For each capital component with an expected service life that will expire within the study period. These costs should be estimated in a manner similar to the procedure for estimating initial costs. Replacements occurring in future years should then be appropriately escalated. Base case replacements should be similar equipment meets current minimum performance requirements.

** Shaded boxes indicate componenets that are not signficant or not applicable.

Table 7-3
Regression Results for Maintenance, Repair and Replacement Costs for Various Lighting Measures

Lamp Type	Size	Maintenance Cost	Frequency (hours)	m	b	r^2
4 ft fluorescent	4	$5.63	20000	1.00	$1.64	
8 ft fluorescent	8	$9.63	20000			
4 ft slimline fluorescent	4	$10.24	12000	0.00	$10.13	
8 ft slimline, energy saving fluorescent	8	$10.02	12000			
4 ft HO fluorescent	4	$11.29	12000	0.00	$11.61	
8 ft HO fluorescent	8	$11.92	12000			
4 ft VHO fluorescent	4	$19.37	12000	0.00	$19.21	
8 ft VHO fluorescent	8	$19.04	12000			
Twin tube Compact Fluorescent	9	$6.73	10000	0.00	$6.75	
Twin Tube Compact Fluorescent	13	$6.77	10000			
Quad Tube Compact Fluorescent	13	$10.51	10000	0.15	$8.55	
Quad Tube Compact Fluorescent	26	$12.47	10000			
Mercury Vapor, Mogul	100	$39.68	24000	0.05	$27.35	0.86
Mercury Vapor, Mogul	175	$29.64	24000			
Mercury Vapor, Mogul	250	$45.38	24000			
Mercury Vapor, Mogul	400	$38.08	24000			
Mercury Vapor, Mogul	1000	$79.80	24000			
Metal Halide, Mogul	175	$40.41	20000	0.07	$22.81	0.945
Metal Halide, Mogul	250	$40.68	20000			
Metal Halide, Mogul	400	$41.37	20000			
Metal Halide, Mogul	1000	$93.43	20000			
High Pressure Sodium	70	$36.51	24000	0.08	$24.56	0.934

Table 7-3 (Continued)
Regression Results for Maintenance, Repair and Replacement Costs for Various Lighting Measures

Lamp Type	Size	Maintenance Cost	Frequency (hours)	m	b	r^2
High Pressure Sodium	100	$37.15	24000			
High Pressure Sodium	175	$37.96	24000			
High Pressure Sodium	250	$41.48	24000			
High Pressure Sodium	400	$43.16	24000			
High Pressure Sodium	1000	$108.46	24000			
Low Pressure Sodium	35	$53.37	18000	0.30	$42.12	0.978
Low Pressure Sodium	55	$58.17	18000			
Low Pressure Sodium	90	$66.16	18000			
Low Pressure Sodium	135	$86.42	18000			
Low Pressure Sodium	180	$94.18	18000			
Quartz	500	$25.05	3000	0.03	$11.83	
Quartz	1500	$51.50	3000			
Incandescent	100	$2.68	750	0.01	$2.17	0.894
Incandescent	150	$3.14	750			
Incandescent	200	$3.25	750			
R30	75	$6.63	2000	0.00	$6.84	
R40	150	$7.04	2000			
MR 16	25	$5.71	3000	0.00	$5.86	
MR 16	35	$5.71	3000			
MR 16	50	$5.71	3000			
MR 16	75	$6.29	3000			
High Power, Twin Tube, T5	All	$13.92	20000	0.00	$13.92	
H PAR	All	$9.24	4000	0.00	$9.24	

Table 7-4
Regression Results for Maintenance, Repair and Replacement Costs for Various Heating, Ventilating and Air Conditioning Measures

									Regressions					
Equipment	**Size**	**Units**	**Gen Maint**	**Gen Maint Freq**	**Repair**	**Repair Freq**	**Replace**	**Replace Freq**	**Maintenance**		**Repair**		**Replace**	
Circulation Pump	0.125	hp	3.92	1	40.7	5	646	20	5.4870	3.0213	2.9235	40.1352	1904.0866	490.0942
Circulation Pump	0.167	hp	3.92	1	40.7	5	884.5	20	0.4008	0.3374	0.7151	0.6020	114.9318	65.3576
Circulation Pump	0.50	hp	5.83	1	40.7	5	1458.5	20	0.9842	0.4701	0.8478	0.8389	0.9928	80.5095
Circulation Pump	1	hp	7.84	1	44.1	5	2383.5	20						
Circulation Pump	1.500	hp	11.66	1	44.1	5		20						
Gas/Oil Water Heater	30	gal	95.5	1	59.91	5	540.7	10	0.0000	95.5000	0.2131	57.6149	26.9325	-267.2750
Gas/Oil Water Heater	70	gal	95.5	1	79.91	5	1618	12	0.0000	0.0000	0.1420	11.6497	0.0000	0.0000
Gas/Oil Water Heater	120	gal	95.5	1	79.91	5			1.0000	0.0000	0.6926	9.0536	1.0000	0.0000
Electric Water Heater	300	gal	1.26	1	143	7	20458	15	0.0000	1.2600	0.0000	143.0000	21.2562	18935.8105
Electric Water Heater	1000	gal	1.26	1	143	7	48445	15	0.0000	0.0000	0.0000	0.0000	8.4086	10952.6581
Electric Water Heater	2000	gal	1.26	1	143	7	58050	15	1.0000	0.0000	1.0000	0.0000	0.8647	10160.0933
Fuel Fired Boiler	250	MBH	595	1	995.6	7	4752.5	30	0.0062	690.9207	0.6275	996.4693	14.0373	-5756.4911
Fuel Fired Boiler	2000	MBH	790	1	2574.95	7	24675	30	0.0062	70.0549	0.0209	234.9805	0.9674	10860.1024
Fuel Fired Boiler	10000	MBH	790	1	7000.63	7	116550	30	0.3335	97.4906	0.9978	327.0064	0.9906	1513.2667
Fuel Fired Boiler	20000	MBH	790	1	13651.3	7	283700	30						
Furnace	25	MBH	310	1	584.15	10	529	15	0.5054	283.5811	6.3529	275.5230	9.3832	122.1486
Furnace	100	MBH	310	1	648.65	10	759	15	0.2387	31.0135	2.5947	337.0622	2.9838	387.6081
Furnace	200	MBH	395	1	1658.45	10	2128	15	0.8176	29.6431	0.8570	322.1687	0.9082	370.4812
DX Air Conditioner	5	Ton	141	1	2758.5	10	6335	20	1.2381	127.3810	650.9333	-388.1667	616.6429	3533.9286
DX Air Conditioner	20	Ton	141	1	12792.5	10	16290	20	0.4289	13.3920	6.2354	194.6998	16.2895	508.6403
DX Air Conditioner	50	Ton	193	1	32104.5	10	34225	20	0.8929	13.8976	0.9999	202.0495	0.9993	527.8410
Window Air Conditioner	1	Ton	0	1	39.76	8	703	10	0.0000	0.0000	6.4257	32.2600	1543.7500	-1249.2500
Window Air Conditioner	2	Ton	0	1	43.5	8	1225.5	10	0.0000	0.0000	0.9304	2.4615	353.7714	935.9911
Window Air Conditioner	4	Ton	0	1	58.5	8	5130	10	1.0000	0.0000	0.9795	2.0098	0.9501	764.2235
Pkg. Multizone Air Conditioner	15	Ton	141	1	8894.5	10	46825	15	2.3380	96.8679	270.3263	4361.4085	916.8933	36774.9365
Pkg. Multizone Air Conditioner	25	Ton	143	1	12612	10	57425	15	0.1565	9.0861	30.2131	1753.5954	93.2107	5410.0356

Table 7-4 (Continued)
Regression Results for Maintenance, Repair and Replacement Costs for Various Heating, Ventilating and Air Conditioning Measures

									Regressions					
Equipment	Size	Units	Gen Maint	Gen Maint Freq	Repair	Repair Freq	Replace	Replace Freq	Maintenance		Repair		Replace	
Pkg. Multizone Air Conditioner	40	Ton	193	1	12675.5	10	81375	15	0.9911	10.9792	0.9756	2118.9582	0.9797	6537.2201
Pkg. Multizone Air Conditioner	105	Ton	343	1	33274	10	131100	15						
Pkg. Single Zone Air Conditioner	15	Ton	141	1	878.64	10	16675	15	2.4209	94.9701	540.2784	-15.7119	1118.2836	1198.8806
Pkg. Single Zone Air Conditioner	25	Ton	143	1	12893.9	10	30825	15	0.4808	18.5190	34.5389	1330.2336	64.2410	2474.1817
Pkg. Single Zone Air Conditioner	60	Ton	243	1	32600.4	10	67925	15	0.9620	16.0680	0.9959	1154.1714	0.9967	2146.7130
Pkg. Multi VAV Air Conditioner	50	Ton	193	1	27249.5	10	57950	15	2.2067	87.4134	195.6701	18034.2402	1199.9022	-1985.1955
Pkg. Multi VAV Air Conditioner	70	Ton	243	1	31175	10	82375	15	0.0968	9.0642	22.0102	2061.8077	5.9130	553.9019
Pkg. Multi VAV Air Conditioner	90	Ton	293	1	37446	10	105600	15	0.9962	6.4730	0.9753	1472.3841	1.000	395.5540
Pkg. Multi VAV Air Conditioner	140	Ton	393	1	44751	10	166100	15						
Pkg. Single VAV Air Conditioner	20	Ton	141	1	10179	10	30350	10	2.3462	106.3077	565.0531	-1450.1462	1036.9231	9796.1538
Pkg. Single VAV Air Conditioner	30	Ton	193	1	15064	10	41150	10	0.7061	28.5385	18.9420	765.5308	10.6588	430.7692
Pkg. Single VAV Air Conditioner	60	Ton	243	1	32562.4	10	71950	10	0.9169	20.7883	0.9989	557.6366	0.9999	313.7858
Recip., Air-Cooled Chiller	20	Ton	385	1	11578.5	10	18425	20	1.4592	388.9796	713.1556	-5586.9847	655.0510	4688.7755
Recip., Air-Cooled Chiller	50	Ton	515	1	25427	10	36425	20	1.1488	75.3325	100.5411	6592.9228	22.0041	1442.9063
Recip., Air-Cooled Chiller	100	Ton	515	1	67470	10	70575	20	0.6173	65.6599	0.9805	5746.4043	0.9989	1257.6399
Recip., Water-Cooled Chiller	20	Ton	710	1	9857	10	22875	20	-3.0867	701.5816	544.6112	-1884.9694	513.6480	10559.9490

Table 7-4 (Continued)
Regression Results for Maintenance, Repair and Replacement Costs for Various Heating, Ventilating and Air Conditioning Measures

									Regressions					
Equipment	**Size**	**Units**	**Gen Maint**	**Gen Maint Freq**	**Repair**	**Repair Freq**	**Replace**	**Replace Freq**	**Maintenance**		**Repair**		**Replace**	
Recip., Water-Cooled Chiller	50	Ton	435	1	23986	10	32975	20	2.4302	159.3571	29.4360	1930.2494	70.7401	4638.7409
Recip., Water-Cooled Chiller	100	Ton	435	1	53086	10	63150	20	0.6173	138.8960	0.9971	1682.4091	0.9814	4043.1356
Centrifugal., Hermetic Chiller	100	Ton	1225	1	35663	10	65850	20	0.0000	1225.0000	258.0146	7988.2090	248.7201	45880.5970
Centrifugal., Hermetic Chiller	300	Ton	1225	1	82984	10	126800	20	0.0000	0.0000	4.6353	2806.8160	12.1308	7345.5754
Centrifugal., Hermetic Chiller	1000	Ton	1225	1	266538	10	293200	20	1.0000	0.0000	0.9997	3097.9186	0.9976	8107.4052
Centrifugal., Open Chiller	300	Ton	1225	1	82984	10	106782	20	0.0000	1225.0000	262.6486	4189.4286	356.1800	-72.0000
Centrifugal., Open Chiller	1000	Ton	1225	1	266838	10	356108	20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
				1										
Absorption Chiller	100	Ton	288		10272	10	136200	20	0.2748	232.0917	3.1533	9872.1179	377.9301	105365.9389
Absorption Chiller	350	Ton	288	1	10856	10	247500	20	0.0821	48.2019	0.2441	143.3619	20.0888	11799.4771
Absorption Chiller	950	Ton	505	1	12903	10	461500	20	0.9181	50.6987	0.9940	150.7878	0.9972	12410.6730
		1												
Air-Cooled Condensing Unit	5	Ton	158	1	331.4	10	1892	15	0.8648	148.4164	18.3795	263.4968	234.4147	244.8565
Air-Cooled Condensing Unit	20	Ton	158	1	718	10	4535	15	0.0938	5.3301	1.2997	73.8802	6.8216	387.7666
Air-Cooled Condensing Unit	50	Ton	194	1	1089	10	11700	15	0.9770	6.8062	0.9901	94.3401	0.9983	495.1524
Air-Cooled Condensing Unit	100	Ton	235	1	2132	10	23875	15						
Evaporative Condensing Unit	20	Ton	69.5	1	6854.5	10	6840	15	0.3793	85.7276	14.7962	7171.2051	153.0817	3606.8910
Evaporative Condensing Unit	100	Ton	157	1	9508.5	10	18675	15	0.2062	37.7286	5.3055	970.5856	1.4850	271.6665
Evaporative Condensing Unit	300	Ton	190	1	11365	10	49600	15	0.7718	42.0641	0.8861	1082.1172	0.9999	302.8841

Table 7-4 (Continued)
Regression Results for Maintenance, Repair and Replacement Costs for Various Heating, Ventilating and Air Conditioning Measures

									Regressions					
Equipment	**Size**	**Units**	**Gen Maint**	**Gen Maint Freq**	**Repair**	**Repair Freq**	**Replace**	**Replace Freq**	**Maintenance**		**Repair**		**Replace**	
Cooling Tower	50	Ton	191	1	580	10	5420	15	0.0801	216.1073	7.3032	877.2086	48.9621	3881.2459
Cooling Tower	100	Ton	405	1	2073.5	10	7925	15	0.1276	66.9922	0.8097	425.1034	2.5164	1321.1317
Cooling Tower	300	Ton	405	1	3368	10	20900	15	0.9517	96.9183	0.9760	615.0015	0.9947	1911.2948
Cooling Tower	1000	Ton	1025		8077	10	52275	15						
Water/Steam Fan Coil	1	Ton	141	1	242	10	931	15	0.0000	141.0000	11.5051	231.1917	255.8398	801.7586
Water/Steam Fan Coil	3	Ton	141	1	275	10	1783.5	15	0.0000	0.0000	1.3738	21.2458	5.3760	83.1393
Water/Steam Fan Coil	5	Ton	141	1	292	10	1974	15	1.0000	0.0000	0.9460	34.7953	0.9982	136.1614
Water/Steam Fan Coil	10	Ton	141	1	360	10	3385	15						
Water/Steam Fan Coil	20	Ton	141	1	402.5	10	5925	15						
Water/Steam Fan Coil	30	Ton	141	1	609.5	10	8465	15						
DX Fan Coil, No Heat	2	Ton	141	1	948.8	10	612	15	0.0000	141.0000	529.2230	-268.8587	300.1373	-36.1490
DX Fan Coil, No Heat	2	Ton	141	1	989.25	10	650	15	0.0000	0.0000	40.8542	360.9799	11.3258	100.0721
DX Fan Coil, No Heat	3	Ton	141	1	1057.75	10	741	15	1.0000	0.0000	0.9711	671.2145	0.9929	186.0765
DX Fan Coil, No Heat	3	Ton	141	1	1012.75	10	843	15						
DX Fan Coil, No Heat	5	Ton	141	1	1347.75	10	1287	15						
DX Fan Coil, No Heat	10	Ton	141	1	5938.25	10	2700	15						
DX Fan Coil, No Heat	20	Ton	141	1	10109.25	10	6120	15						
DX Fan Coil, With Heat	2	Ton	141	1	948.8	10	859.5	15	0.0000	141.0000	529.2230	-268.8587	420.6896	-53.4061
DX Fan Coil, With Heat	2	Ton	141	1	989.25	10	912.5	15	0.0000	0.0000	40.8542	360.9799	16.1943	143.0897
DX Fan Coil, With Heat	3	Ton	141	1	1057.75	10	1039.5	15	1.0000	0.0000	0.9711	671.2145	0.9926	266.0644
DX Fan Coil, With Heat	3	Ton	141	1	1012.75	10	1173	15						
DX Fan Coil, With Heat	5	Ton	141	1	1347.75	10	1799	15						
DX Fan Coil, With Heat	10	Ton	141	1	5938.25	10	3773	15						
DX Fan Coil, With Heat	20	Ton	141	1	10109.25	10	8580	15						
One-Row Hot Water Duct Coil	12 x 24	sq inch	0	1	43	10	240.5	25	0.0000	0.0000	0.1021	1.5701	0.3959	126.7009
One-Row Hot Water Duct Coil	24 x 24	sq inch	0	1	50	10	355.5	25	0.0000.	0	0.0202	17.0033	0.0011	0.8937

Table 7-4 (Continued)
Regression Results for Maintenance, Repair and Replacement Costs for Various Heating, Ventilating and Air Conditioning Measures

									Regressions					
Equipment	**Size**	**Units**	**Gen Maint**	**Gen Maint Freq**	**Repair**	**Repair Freq**	**Replace**	**Replace Freq**	**Maintenance**		**Repair**		**Replace**	
One-Row Hot Water Duct Coil	24 x 36	sq inch	0	1	79	10	468	25	1.0000	0.0000	0.9275	15.0268	1.0000	0.7898
One-Row Hot Water Duct Coil	36 x 36	sq inch	0	1	143	10	640	25						
Terminal Reheat	12 x 24	sq inch	0	1	43	10	392.5	15	0.0000	0.0000	0.0164	45.6010	0.4446	300.6415
Terminal Reheat	18 x 24	sq inch	0	1	50	10	481.5	15	0.0000	0.0000	0.0022	6.7625	0.0104	32.1970
Terminal Reheat	36 x 36	sq inch	0	1	79	10	934	15	1.0000	0.0000	0.9661	10.2829	0.9989	48.9581
Terminal Reheat	48x126	sq inch	0	1	143	10	2980	15						
Air Handler (incl. coils)	1300	cfm	145	1	285.75	10	304	15	0.0056	198.6352	0.0449	122.1883	0.7747	1414.8583
Air Handler (incl. coils)	1900	cfm	145	1	302.75	10	3330	15	0.0018	49.1114	0.0022	62.4383	0.0188	523.5102
Air Handler (incl. coils)	5400	cfm	145	1	370.75	10	6275	15	0.6702	97.4767	0.9877	123.9279	0.9971	1039.0669
Air Handler (incl. coils)	8000	cfm	360	1	413.25	10	7640	15						
Air Handler (incl. coils)	16000	cfm	360	1	620.25	10	12375	15						
Air Handler (incl. coils)	33500	cfm	480	1	1674.75	10	26150	15						
Air Handler (incl. coils)	63000	cfm	480	1	2983.75	10	51150	15						
Water Source Heat Pump	1	Ton					1520.57	20	4.4384	134.5890	294.9301	457.1509	1018.5564	-84.8745
Water Source Heat Pump	1.50	Ton	147	1	1125.9	10	1793.84	20	1.9930	12.9803	78.4113	510.6776	189.4707	1072.8540
Water Source Heat Pump	5	Ton	147	1	1547	10	3355	20	0.8322	12.0410	0.9340	473.7236	0.9353	1362.1807
Water Source Heat Pump	10	Ton	183	1	3564.9	10	10815.82	20						

Table 7-4 (Continued)
Regression Results for Maintenance, Repair and Replacement Costs for Various Heating, Ventilating and Air Conditioning Measures

									Regressions					
Equipment	**Size**	**Units**	**Gen Maint**	**Gen Maint Freq**	**Repair**	**Repair Freq**	**Replace**	**Replace Freq**	**Maintenance**		**Repair**		**Replace**	
Air-to-Air Heat Pump	1.50	Ton	147	1	1125.9	10	2549	20	0.6868	156.0319	538.2004	-2216.1482	1301.8750	-685.5116
Air-to-Air Heat Pump	5	Ton	147	1	1547.4	10	5970	20	0.4139	10.5568	126.6234	3229.3941	42.5025	1083.9812
Air-to-Air Heat Pump	10	Ton	183	1	3564.9	10	12075	20	0.4785	16.4419	0.8576	5029.6766	0.9968	1688.2656
Air-to-Air Heat Pump	25	Ton	183	1	3752.4	10	29525	20						
Air-to-Air Heat Pump	50	Ton	183	1	28174	10	65575	20						
Thru-Wall Heat Pump	1.50	Ton	147	1	1125.9	10	2791	20	0.0000	147.0000	120.4286	945.2571	806.8571	1580.7143
Thru-Wall Heat Pump	5	Ton	147	1	1547.4	10	5615	20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Electro-pneumatic controls			101	1	0.00	10								
DDC Controls				1										
Axial Fan	0-5000	cfm	47	1	0.00	10	2865.782	15	0.0006	44.6667	0.0000	0.0000	0.1912	2010.5624
Axial Fan	5001-10000	cfm	49	1	0.00	10	3359.791	15	0.0000	0.3118	0.0000	0.0000	0.0391	337.8817
Axial Fan	10000+	cfm	51.5	1	0.00	10	4395.615	15	0.9959	0.2041	1.0000	0.0000	0.9599	221.1955
Centrifugal Fan	0-5000	cfm	41.5	1	0.00	10	2096.217	15	0.0004	39.8333	0.0000	0.0000	0.3530	636.9880
Centrifugal Fan	5001-10000	cfm	43.5	1	0.00	10	3366.43	15	0.0000	0.3118	0.0000	0.0000	0.0205	176.8082
Centrifugal Fan	10000+	cfm	45	1	0.00	10	4920.168	15	0.9932	0.2041	1.0000	0.0000	0.9967	115.7481

Abbreviations:
Gen Maint = general maintenance
Gen Maint Freq = general maintenance frequency in years
Repair Freq = Repair Frequency in years
Replace Freq = Replace Frequency in years