# 18-554 BUREAU OF GENERAL SERVICES

Chapter 3 PUBLIC IMPROVEMENTS INCLUDING PUBLIC SCHOOL PROJECTS

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PREFACES

 These instructions pertain to an Act Passed by the 108th Legislature which enacted Sub-Chapter 153, Public Laws of 1977, authorizing the Bureau of General Services to implement the "Energy Conservation in Buildings Act'; and revised in 1981, Chapter 353 L.D. 1363 An Act Concerning Energy Efficiency in Buildings Financed with Public Funds".

 These rules and procedures have been promulgated by the Bureau of General Services in consultation and coordination with the Department of Education and Cultural Services and the Office of Energy Resources to achieve these purposes.

Section I History - Laws and Rule making

I.A. Responsibilities and Duties

 The law requires that there shall be no public improvement constructed in excess of 5,000 square feet, leased in excess of 10,000 square feet without verification of life cycle costs that will meet or exceed the energy efficiency standards promulgated by the Office of Energy Resources under Title 10, Chapter 214, and the Bureau of Public improvements under Title 5, Section 1764.

 The Bureau of Public improvements shall review and approve life cycle costs for the following:

(1) All state government construction work regardless of source of funding.

(2) All state government leased space where more than 5,000 square feet of combined leased area occurs in one building, life cycle costs shall comply.

I.B. History

 The 108th legislature required that life cycle costing become a part of public improvement projects to assure that energy considerations, first cost, operating costs and long term costs are consistently analyzed and approved by the Bureau of Public improvements. The law was later amended to include compliance with energy efficiency building performance standards (building envelope energy loss) promulgated by the Office of Energy Resources.

 Life cycle energy evaluation required by the Bureau of Public improvements addresses the total energy used by a facility (envelope, equipment, process, etc.). Because of Maine's climatic economic and social conditions, As efficient use of energy in all forms must be promoted in all new, renovated and leased buildings. Energy efficient buildings should be less expensive to own and operate over its expected life.

Section II General

II.A. General Instructions

(1) All public improvement projects must have life cycle analysis developed by the Architect and/or Engineer to select the best alternative total energy system that will serve the project needs at the minimum energy cost over the project life.

(2) Designer has the option of selecting designated band calculation method or computer system to provide the desired comparative information, In the event the designer desires to use other alternative system(s), he must secure prior approval from the Bureau of General Services.

(3) Copies of sample calculations and base data tables showing typical comparative information can be obtained by request from the B.P.I.

II.B. Life Cycle Costs

(1) Other factors to be considered influencing life cycle costs shall include, but not be limited to:

A. Design Code for the State of Maine: As a minimum, energy conservation standards as called for in "The BOCA Basic Energy Conservation Code" or its approved successor. This code is a part of the BOCA Code or its approved successor which is the design code for the State of Maine and implements the recommendations contained in the ASHRAE, Energy Conservation Standards.

B. Maine Office of Energy Resources: As a minimum, the design shall meet the building performance standard set for in O.E.R. "Maine Energy Conservation Building Standards".

C. For these studies, the useful life of the building structure will be assumed at 30 years unless otherwise approved by the Bureau of General Services and/or the Department of Education. The study will reflect the parts of the building such as roof, mechanical and electrical system, exterior finishes and other components as applicable with the appropriate life in accordance with industry standards.

(2) Alternate Conformance: All General Services under 5,000 square feet and leased space under 5,000 square feet, if certified to B.P.I. that construction is in conformance with the "Manual of Accepted Practices" issued by the Maine Office of Energy Resources, will be acceptable in lieu of life cycle analysis.

II.C. Energy Performance Index

 See Section III.B. for energy performance indexes to be used in the evaluation of design proposals submitted for public improvement and for public school construction.

Section III Application

III.A. Introduction

 The Maine Life Cycle Energy Evaluation Technique

A.1.0 Purpose: The procedures have been developed in response to actions taken by the Maine Legislature requiring the life cycle costing become a part of the evaluation process for public improvements to assure that energy considerations, first cost, operating costs and long term costs are consistently analyzed as public improvement projects are being considered for approval.

A.1.1 Goals: It is readily recognized that the life long energy usage of a building is largely determined by the original design and selection of detail equipment. once a building has been erected, it becomes very expensive and difficult to modify construction to accommodate more energy conservation equipment.

(1) Energy Performance Index (EPI) Target goals have been established to limit total building energy usage.

(2) Analysis of Energy: The Maine Life Cycle Energy Evaluation Technique Program is intended to help the designer quickly evaluate his alternative designs to determine those which may save the most energy.

(3) Life Cycle Economic Analysis: An evaluation format to be used -in the. final design selection. This procedure identifies the initial capital cost and the owning cost (energy cost and equipment maintenance cost) to determine the life cycle costs throughout the project life.

A.1.2 Summary: The purpose of the design standards is not to limit architectural freedom, but is intended to create an awareness that all designs must effectively minimize the use of energy.

(1) Hand Calculations: It is anticipated that the hand calculation method of analyzing the technical portion and the hand calculation method of financial analysis for life cycle costing will be adequate for most of the anticipated construction in the area of public education and state facilities.

(2) Computer Models: Computer programming for the analysis of both or either the technical or financial portions of the study will be acceptable to the Bureau if the Base Model meets the following requirements:

A. The Bureau has on file the operation manual of the program.

B. Base Model to be evaluated by B.P.I. or certified by a third party professional acceptable to B.P.I. and the applicant.

C. Submits unmodified base data runs of the analysis.

(3) Submissions: The following is the minimum requirements for submission of life cycle analysis to B.P.I.:

A. Building Energy Form "LCA-1"

B. Life Cycle Cost Form "LCA-2"

C. Solar Analysis (if applicable)

D. All backup calculations and data for all the above submitted energy and cost analysis.

E. Preparer’s information to include name, affiliation, telephone number, registration (stamp or number), and date.

III.B Energy Performance Index (EPI)

B.1.0 Energy Performance Index (EPI)

B.1.1 Introduction: The goal of this program is to encourage the development of the most energy conservative building that is consistent with current standards, codes and practices for the buildings intended use.

B.1.2 Limits: In no instance will total building designed energy consumption exceed the following standards:

(1) Maximum Energy Goals: Goals are established from recent construction experience utilizing passive and active solar, energy recovery, alternate energy use and other innovated techniques.

 A. Elementary and Junior High, Schools 40,000 BTU/s.f.

 B. High Schools 45,000 BTU/s.f.

 C. Vocational Technical Schools 50,000 BTU/s.f.

D. Office Buildings (12 month use)

i. New Construction 65,000 BTU/s.f.

ii. New Leased/Renovated 70,000 BTU/s.f.

E. Dormitories (9 month use)

i. Regular 45,000 BTU/s.f.

ii. Apartment Style 46,000 BTU/s.f.

(2) Base Energy Usage

A. Forty (40) hour week occupancy time. (The equipment-and lighting usage Shall reflect the hours required to maintain occupancy requirements for 40 hours. As a rule lighting and equipment hours are longer.)

B. The above listed BTU/s.f. limits are based on 100% system and equipment efficiency and shall be increased by an appropriate factor representing seasonal efficiency of the selected system and equipment to reflect estimated annual fuel use.

C. Values based on 8,000 degree days. Additional allowances will be allowed in locations where total degree days exceed 8,000 degree days according to the following table:

 8,000 Degree Days 0

 9,000 Degree Days 1,750 BTU/s.f.

 10,000 Degree Days 3,500 BTU/s.f.

 11,000 Degree Days 5,250 BTU/s.f.

 12,000 Degree Days 7,000 BTU/s.f.

D. The Director, upon staff recommendations, may increase the above energy goals by 10% for historic buildings hardship occurrences, facility reuse and other non-reoccurring and unique circumstances.

FORM "LCA-1" B.2.0 Required Energy Items (Reporting Format)

Energy Conservation in Buildings

Building Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Building I.D. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Location \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(1) Average Number of Occupants \_\_\_\_\_\_.

(2) Degree Days \_\_\_\_\_\_\_\_\_\_\_ /year

(3) Design Temperature \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

(4) Building Area \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

 Energy/Point of Use Per Year

(5) Lighting \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Base \_\_\_\_\_\_\_\_\_ Units #1 \_\_\_\_\_\_\_\_\_\_ MBTU \_\_\_

(6) Heating " MBTU

(7) Cooling " MBTU

(8) Water Heating " MBTU

(9) Equipment " MBTU

(10) Other " MBTU

(11) Total Energy " MBTU

(12) Yearly Energy Usage " MBTU Per Building Square Foot Area

 #1 Base Units of Energy - KWH of electricity, gallons of oil (#2, #4, #5 or #6), tons of coal, etc. shall be evaluated a N = 100% to determine annual energy consumption (BTU/square foot), Note: Apply factors on Page 8 Val and "N" to develop projected fuel usage (gallons of oil, tons of coal, etc.) to report on Form "LCA-2".

III.C. Analysis of Energy

C.1.0 Approved Systems: The ASHRAE's Modified Degree Day Procedure will be used in analyzing the simple heating and ventilation systems. For those systems which involve computing cooling and night setback loads, internal and solar gains, the bin method or computer modeling is required.

 Both methods are included in this document (see C.2.0 and C.4.0).

 A sample is included in the Appendix A of the Modified Degree Day calculation.

C.2.0 Modified Degree Day Procedure: (Chapter 43, ASHRAE 1980 System Handbook) The general equation for calculating the probable energy consumption by the modified degree day method is as follows:

E = (Hl x D x 24) (Cd)

(At x N x V)

 where

E = Fuel or energy consumption for the estimate period.

 Hl = Design heat loss, including infiltration, BTU per hour.

 D = Number of 65° F degree days for the estimate period.

 t = Design temperature difference, Fahrenheit.

 N = Correction factor for equipment efficiency.

 V = Heating value of fuel, consistent with H1 and E.

 Cd = Interim correction factor for heating effect vs. degree days.

 Values of heating load. Hl must be determined for the particular building for which the estimate is being made. It must account for size, building materials, architectural features, use, and climatic conditions. Table 1 gives values for Cd and N.

Table I

Correction Factor Vs. Degree Days Interim Factor Cd

Design Degree Days 6,000 7,000 8,000 9,000 l0,000

Factor Cd 60 .64 .68 .71 .71

 The correction factor N is empirical and should not be confused with any ratings for "seasonal efficiency" The following values shall be used:

 N = 1 - Electric Resistance Heating

 N = .75 - Pressurized Gas Fired Boiler or System

 N = .70 - Oil Fired Boiler with Air Atomizing or Flame Retention

 Burner

 N = . 65 - Atmospheric Gas Fired System

 N = .50 - Coal Fired Boiler Conventional Stoker

 N = .65 - Coal Fired Boiler Pressurized Forced Draft Firing System

 N = .55 - Old Oil Fired Systems

 Note: If other values are to be used, submit verification and backup data.

C.2.1 Table/Degree Data/Maine

Maine Monthly and Annual HEAting Degree Day Normals

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Station | July | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | annual |
| BarHarbor | 47 | 49 | 193 | 459 | 741 | 1153 | 1280 | 1137 | 998 | 669 | 381 | 133 | 7240 |
| Caribou | 84 | 122 | 327 | 657 | 1008 | 1516 | 1683 | 1459 | 1283 | 849 | 474 | 170 | 9632 |
| EastPort | 117 | 109 | 246 | 499 | 762 | 1175 | 1314 | 1162 | 1048 | 744 | 499 | 258 | 7833 |
| Farm-ington | 40 | 75 | 239 | 555 | 891 | 1361 | 1500 | 1296 | 1107 | 705 | 364 | 104 | 8237 |
| Gard-iner | 29 | 51 | 204 | 502 | 816 | 1274 | 1414 | 1232 | 1060 | 681 | 364 | 99 | 7726 |
| Green-ville | 86 | 119 | 321 | 639 | 978 | 1460 | 1628 | 1417 | 1249 | 837 | 481 | 172 | 9387 |
| Houl-ton | 61 | 91 | 271 | 592 | 936 | 1426 | 1584 | 1369 | 1181 | 780 | 409 | 127 | 8827 |
| Lewis-ton | 12 | 33 | 163 | 456 | 798 | 1234 | 1383 | 1196 | 1035 | 657 | 331 | 76 | 7374 |
| Madi-son | 29 | 59 | 214 | 530 | 864 | 1339 | 1482 | 1285 | 1101 | 702 | 370 | 96 | 8071 |
| Millin-ocket | 38 | 65 | 245 | 580 | 912 | 1398 | 1553 | 1352 | 1147 | 741 | 398 | 104 | 8533 |
| Old TownFAA | 53 | 83 | 273 | 595 | 900 | 1380 | 1531 | 1347 | 1159 | 756 | 431 | 140 | 8648 |
| Port-land | 27 | 55 | 200 | 493 | 792 | 1218 | 1349 | 1179 | 1029 | 669 | 381 | 106 | 7498 |
| Pres-que Is. | 66 | 98 | 283 | 614 | 969 | 1473 | 1624 | 1408 | 1231 | 804 | 431 | 134 | 9135 |
| Ripog-enus Dam | 76 | 106 | 277 | 605 | 957 | 1466 | 1637 | 1450 | 1265 | 831 | 471 | 147 | 9288 |
| Rock-land | 41 | 57 | 195 | 481 | 765 | 1175 | 1293 | 1142 | 1008 | 672 | 397 | 127 | 7353 |
| Rum-ford Pwr. Plant | 36 | 64 | 216 | 521 | 858 | 1305 | 1438 | 1246 | 1076 | 693 | 361 | 98 | 7912 |
| Water-villePumpStation | 20 | 32 | 181 | 477 | 810 | 1277 | 1417 | 1224 | 1039 | 642 | 319 | 75 | 7513 |
| Wood-land | 37 | 82 | 218 | 539 | 846 | 1305 | 1454 | 1294 | 1107 | 723 | 397 | 119 | 8121 |

C.3.0 Hand Calculations Method for Life Cycle Analysis

DATE: ARCHITECT ENGINEER: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

LOCATION: DATA OBTAINED BY:

 Energy needs for buildings can be divided into three basic categories: (1) Base Electrical Loads; (2) Comfort Conditioning System; (3) Domestic Hot Water. The calculation sequence has been segmented accordingly. The analysis must start with an understanding of the proposed building usage and will require detailed data on the sub-components of the electrical and HVAC system. This detailed data should be available as a result of (1) preliminary design and (2) analysis of methods that will optimize energy conservation within the building.

C.3.1 Base Electrical Load: This section analyzes the annual electrical energy consumption due to the lighting systems HVAC system, (fans, pumps, etc.), exhaust fans, kitchens, shops, elevators, and other specialized operations. A "guideline" comment follows each topic area to clarify the type-of data sought. The diversity factor represents the fact that lighting, for instances is rarely all on or all off.

(1) Lights, Miscellaneous Power Usage:

A. KW connected \_\_\_\_\_\_\_\_\_\_\_\_\_\_ KW

B. Usage \_\_\_\_\_ hrs./day x \_\_\_ days/week \_\_\_\_\_\_ hours/month 12 month/year = \_\_\_\_\_\_\_\_\_\_\_ hours/year

C. Diversity \_\_\_\_\_\_\_\_\_\_ %

D. \_\_\_\_\_\_\_\_ KW x \_\_\_\_\_\_\_\_ Diversity = KW

E. \_\_\_\_\_\_\_\_ KW x \_\_\_\_\_\_\_\_ hours/year = KWH/year

Guidelines:

i. Example: 8 hours/day + 4 hours for lunch and cleanup = 12 hours/day.

ii. Weeks/Month - 4.3

iii. 80 - 100% Diversity

(2) Air Distribution System Electrical Usage (Heating, Cooling and Ventilation):

A. HP connected \_\_\_\_\_\_\_\_ HP

B. 746 KW/HP x HP =

 KW Efficiency ------ %

C. Diversity \_\_\_\_\_\_\_\_\_ %

D. Occupied \_\_\_\_\_\_\_\_\_\_ hours/month

E. Unoccupied \_\_\_\_\_\_\_\_\_ hours/month

F. \_\_\_\_\_\_\_\_\_ KW x \_\_\_\_\_\_\_\_\_\_\_\_ Diversity = \_\_\_\_\_\_\_\_\_\_ KW

G. \_\_\_\_\_\_\_\_\_ KW x \_\_\_\_\_\_ hours/month = \_\_\_\_\_\_\_\_\_ KWH/month

H. \_\_\_\_\_\_\_\_\_ KWH/month X \_\_\_\_\_\_\_\_ month/year = \_\_\_\_\_\_\_ KW/year

Guidelines:

i. Hours Operation: 400 hours/month or 4000 to 4800 hours/annum.

ii. 80% Diversity

iii. Will system operate during unoccupied hours?

(3) Exhaust Fan System Usage:

A. HP connected HP

B. .746 KW/HP x HP = KW

 Efficiency

C. Occupied .\_\_\_\_\_\_\_\_\_\_. hours/month

D. Diversity %

 E. Usage: 25% x Occupied Hours hours/month

 F. \_\_\_\_\_\_\_\_\_ KW x Diversity KW

 G. \_\_\_\_\_\_\_\_\_ KW x \_\_\_\_\_ hours/month \_\_\_\_\_\_ KW/month

 H. \_\_\_\_\_\_\_\_\_ KWH/month x ------- month/year KWH/year

 Guidelines:

i. Hours Operation: 300 hours/month 3600 to 4000

ii. 100% Diversity

iii. Will system operate during unoccupied hours?

4. Elevator Usage (if required)

A. HP connected \_\_\_\_\_\_\_\_\_\_\_

B. .746 KW/HP x .\_\_\_\_\_\_\_\_\_. HP = KW

 Efficiency

C. Occupied .\_\_\_\_\_\_\_. hours/month

D. Diversity %

E. Usage: 25% x occupied hours = hours/month

F. \_\_\_\_\_\_\_ KW x \_\_\_\_\_\_\_ Diversity = KW

G. \_\_\_\_\_\_\_ KW x hours/month = KW/month

H. \_\_\_\_\_\_\_ KWH/month x month/year KWH/year

 Guidelines:

i. 50% Diversity for office Buildings

ii. 25% Usage for Office Buildings

C.3.2 Comfort Conditioning System: Similar to the previous section, this section emphasizes the derivation of the annual energy consumption for the HVAC system for space beating and cooling. But since heating and cooling is functionally related to ambient environment, a different technique must be utilized to derive annual energy temperature differential between inside and ambient a separate calculation using "bin" method is necessary. The method statistically arranges weather data in "bins" by day period according to 5° F increments and numbers of hours per year.

(1) Building Load Information

 A. Winter Heating - Outside Design \_\_\_\_\_\_\_ F°D.B.

 Inside Design \_\_\_\_\_\_ F°D.B.

 Heat Loss BTUH

 Ventilation

 CFM x 1.08 x °FTD = BTUH

 Total Heat Loss BTUH

 B. Summer Cooling - Outside Design °F.D.B. °F.W.B.

 Inside Design °F.D.B.

 Solar Heat Gain BTUH

 Transmission BTUH

 Motors BTUH

 Lights BTUH

 People BTUH

 Other Heat Sources BTUH

 Ventilation BTUH

 CFM x 4.5 x Ah\*\* BTUH

 Total Heat Gain BTUH

 \*Notes: This load information should include both sensible and latent heat requirements.

 \*\*AH - Enthalpy at Saturation BTU Per Pound of Dry Air

C.4.0 Bin Method: See Chapter 43, ASHRAE 1981 Systems Handbook for General Reference

C.4.1 Explanation of Forms

C-1 Heating Form (see Appendix C)

C-2 Cooling Form (see Appendix C)

Column 1 Three eight hour periods during the day.

Column 2 Average monthly temperature from weather data.

Column 3 Temperature difference equals temperature inside minus (AVG) temperature outside.

Column 4 "U" value times area equals heat gain or heat loss per degree of temperature, including infiltration & ventilation or greater of the two.

Column 5 Column 3 times Column 4

Column 6 Hours listed in the weather data of each "bin' of temperature.

Column 7 Column 5 times Column 6

Column 8/8a Peak internal load in MBTU: Peak solar load in MBTU.

Column 9/9a Annual Factor in a percentage of the time that the internal available internal & solar gain must be rejected during day occupied cycle.) or solar loads occur, and are useable. (Note: A percentage of the

Column 10 Estimated hours of internal load.

Column 10a Same as Column 6. (For C-2 Cooling Form Only)

Column 11 Column 8 x 9 x 10.

Column 11a Column A x 9a (For C-1 Heating Form Only)

Column 12 Column 7 + 11 + 11a.

C.4.2 Passive Solar

 Values for t in solar analysis shall be determined using the three eight hour periods above.

C.4.3 Heating Energy

(1) Electric Consumption

A. MBTU/YR. = MBTU/KWH = KWH/YR.

 Guidelines:

(1) Resistance Heating 3.413 MBTU/KWH

(2) Oil Consumption

A. MBTU/YR. x MBTU/GAL. = GAL/YR.

 Boiler Efficiency

 Guidelines:

 i. #2 oil = 140 MBTU/GAL.

(3) Energy Performance Index (Annual)

A. Electrical Heating Consumption.

i. KW/HR: Gross Sq. Ft. = KWH/SQ.FT.

ii. KWH/SQ. FT. x 3.413 MBTU/KWH MBTU/SQ. FT.

B. Heating Consumption (Oil Fired)

 i. \_\_\_\_\_\_\_\_\_ GAL.: x \_\_\_\_\_\_\_\_ Gross Sq. Ft. GAL/SQ. FT.

 ii. \_\_\_\_\_\_\_\_\_ KWH/SQ. FT. x \_\_\_\_\_\_\_\_ MBTU/GAL. = . MBTU/SQ. FT.

C.4.4 COOLING ENERGY

(1) Electrical Consumption

A. MBTU/YR : 12 MBTU/TON = \_\_\_\_\_\_\_\_\_ TON HR/YR.

B. TON/HR/YR x KW/TON = KWH/YR.

 Guidelines:

i. Reciprocating Equipment 1.2 to 1.7 KW/TON

ii. Centrifugal Equipment .75 to 1.1 KW/TON

(2) Absorption System Consumption (Oil Fired)

A. MBTU/YR. : 12 MBTU/TON TON/HR/YR.

B. TON/HR/YR. x GAL/TON = GAL/YR.

Guidelines:

i. High Pressure Absorption .1 GAL/TON

ii. Low Pressure Absorption .13 GAL/TON

(3) Energy Performance Index (Annual)

A. Electric Cooling Consumption

I. KWH : Gross Sq./Ft. = KWH/Sq./Ft.

ii. KWH/SQ.FT. x 3,413 MBTU/KWH = MBTU/Sq./Ft.

B. Absorption System Consumption (Oil Fired)\*

i. GAL x 140 MBTU = MBTU/HR.

ii. MBTU: Gross Sq. Ft. = MBTU/Sq./Ft.

 \*Absorption system run by 'waste' heat or by solar heat should not be included.

C. Annual Cost for Each System: Electric cost can be calculated on a demand

 commodity. Rate schedule or an average cost per KWH.

Guidelines:

i. Electrical Cost

 KWH/YR. x cents/KWH = $ YR.

ii. Fossil Fuel Cost

a. Fuel Oil Cost

 GALS/YR x cents/GALS = $ YR

 b. Coal

 TON COAL/YR. x $/TON = $ YR.

 c. Steam

 POUNDS OF STEAM/YR. x cents/POUND = $ YR.

C.5.0 Computer Method for Energy Analysis

(1) Computer programs that provide a simulated analysis of a facility for a complete year of usage will be considered by B.P.I. The computer base model will be evaluated by B.P.I. or certified by a third party professional acceptable to B.P.I. and the applicant. The following data must be submitted and kept on file at B.P.I.:

A. Program Operation Manual.

B. A dump of the basic computer program or submission of base data used in the program.

C. A computer run (unmodified) of a base data building. Base data building to be selected by B.P.I.

(2) Computer Programs Now Acceptable

A. "ECM 5" currently running on the University of Maine at Orono main computer.

B. "BPI Model" currently being run on the Bureau of General Services in-house computer "TRS 80".

C.6.0 Passive Solar

 This section analyzes the energy gains and losses due to southern exposed glass. The windows analyzed under this section should not be included in the previous sections, but shall be added on to obtain the total energy usage in the building.

(1) EQ (1) Qtotal Qgain - Qcond

Where:

**Qtotal** = net energy, if positive then it represents a gain in energy and shall be subtracted from the building energy load; if negative then it represents a loss of energy and shall be added to the energy load.

(2) EQ (2) Qgain = (B) (C) (ST) (A) (D)

 Where:

 **Qgain** = solar gain through southern exposed glass.

B = Btu/sq. ft. day, see solar intensity table.

C = Percentage of possible sunshine, see table.

ST = Percentage of solar transmittance, obtained from window manufacturer.

A.= Area of glass.

D = Days in month analyzed.

(3) EQ (3) Qcond = (U1 t1 + U2 t 2 + U2 t3 ) (8) (D) (A)

Where:

Qcond = Energy conducted through the glass.

U 1 = U factor during the day.

U 2 = U factor during the night (if different from U).

t 1 = Inside temperature minus average outdoor temperature during the day.

t 2 = Inside temperature minus average outdoor temperature during early morning period.

t 3 = Inside temperature minus average outdoor temperature during the night.

D = Days in month analyzed.

A = Area of glass.

Values of t are determined using the BM method (see Section C.4.2.)

 SOLAR INTENSITY TABLE

 PORTLAND

 Month \*BTU/square foot day \*\*% of Sunshine

 January 860 55

 February 1,044 59

 March 1,113 56

 April 1,051 56

 May 947 56

 June 904 60

 July 924 64

 August 1,092 65

 September 1,153 61

 October 1,138 58

 November 825 47

 December 735 53

 \* Obtained from Passive Solar Design Handbook. Volume 2.

 \*\* Obtained from Local Climatological Data for Portland, Maine.

 Example Problem: For a southern exposed double glazed window,

 for the month of January.

 January t1 = (68-27) = 41

 t2 = (68-18.7) = 49.3

 t3 = (68-21.4) = 46.6

 B = 860, C = .55, ST = .73

 A = 20

 U1 = .53

 U2 = With panel of R-7 placed over the windows at night - U2 = .14.

 EQ (2) Qgain = (B) (C) (ST) (A) (D)

 = (860) (.55) (.73) (20) (31) = 214,080 BTU/month

With Insulated Panel:

EQ (3) Qcond = U1 t1 + U2 t2 + U2 t3) (8) (D) (A)

= (.53 x 41 + .14 x 49.3 + .14x46.6) (8) (31) (20)

174,374 BTU/month

EQ (1) Qtotal = Qgain - Qcond

= 214,080 - 174,374 = 39,706 BTU/month gain.

This value is to be subtracted from the buildings total energy usage.

Without Insulated Panel:

EQ (2) Qgain = 214,080

EQ (3) Qcond = (41 + 49.3 + 46.6) (.53) (8) (31) (20)

 = 359,883 BTU/month

EQ (1) Qtotal = Qgain = Qcond

 = 214,080 - 359,883 = -145,803 BTU/month loss.

This value is to be added to the buildings total energy usage.

C.7.0 Active Solar Analyzing

 All active solar systems shall be analyzed separate from this rule and submitted to the Bureau of General Services for review. The designer must compare alternate combinations of heating systems and document. An acceptable Life Cycle Analysis shall include, but not be limited to, the following scope: 10% cost of money, total system cost, system efficiency, total estimated available energy/sq. ft. of panel, total estimated useable energy, component life, and operational and maintenance cost.

 Exclusions to this rule are as follows:

(1) Financing of the total system is from other than State funds.

(2) The system is for education purposes and accepted in writing by DECS,

 Dept. of Educational and Cultural Services. (Single panel for science lab etc.)

 Building energy credits would be applicable at such time the actual cost of the system is known.

III.D. Life Cycle Costing/Financial Analysis

D.1.0 Introduction

 Life Cycle Costing is a conceptual extension of the conventional method for awarding contracts to the lowest bidder. Instead of focusing just on the initial costs Life Cycle Costing takes into account the additional costs for energy, operation and maintenance , and system replacements. In this manner, all costs associated with building ownership are fully taken into account when selecting the best alternative design. The overall objective of Life Cycle Costing is more extensive than conventional first cost analysis since it seeks to evaluate the quality of the building over it s lifetime. This concept is especially important when energy costs are rapidly increasing.

D.2.0 Hand Calculation

 The Life Cycle cost evaluation has been established utilizing the uniform annual cost model.

 The annual cost model has been developed by forecasting all cost, whether positive or negative, involved with the total system over its projected life. These costs are divided into annual payments taking into account the time value of money for an appropriate interest rate associated with the project.

 For the purpose of our project, a 10% rate has been assigned. We have also assigned a 30 year life to the building structure.

 Mathematically we are using a uniform recover rate as follows:

 A = P (1+i)Y)\*

 (1+i)Y-1)

A = uniform end of year sum

P = present value of today’s cost.

i = interest rate for period.

y = number of years.

 Table has been included with values for given interest and applicable years,

 \*Material from text by K and G Associates, Box 7596, Inwood Station, Dallas, Texas 75209.

State of Maine FORM "LCA-2,"

DATE

D.3.0 Life Cycle Cost Benefit Analysis PREPARED BY (Reporting Format)

PROJECT DISCOUNT RATE

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Column Identifi-cation | A | B | C | D | E | F | G |
| Item | EstimatedFirst Cost P | Est. Life | UCR(P-A)Factor | salvage | (1st cost salvage UCR=A | salvage xinterest | remarks |
| Site Development |  |  |  |  |  |  |  |
| BuildingStructure(All itemsexclusive of those listedbelow |  |  |  |  |  |  |  |
| Roofing |  |  |  |  |  |  |  |
| ConveyingSystems |  |  |  |  |  |  |  |
| Mechanical |  |  |  |  |  |  |  |
| Electrical |  |  |  |  |  |  |  |
| Equipment Built-In |  |  |  |  |  |  |  |
| Total Estimated Construction Cost |  |  Sub | Totals | COL. E |  |  |  |
| Energy Usage | Annual Cost |  |  | COL. F |  |  |  |
| amt. | type |  |  |  |  |  |  |  |
|  |  | Heating Fuel (oil, gas, coal, elec. |  |  |  |
|  |  | Electricity (except heat) |  |  |  |
|  | Sewer |  |  |  |  |  |  |
|  | Insurance |  |  |  |  |  |  |
|  | Taxes (Or Loss) |  |  |  |  |  |  |
|  | Maint. & Repair |  |  |  |  |  |  |
|  | Maint. Contracts |  |  |  |  |  |  |
|  | Other |  |  |  |  |  |  |
|  | Total Uniform Annual Sum |  |  |  |  |  |  |
|  | Uniform Annual Sum/Sq. Ft. |  |  |  |  | AIA GROSS | SQ. FT\_\_\_\_\_\_\_ |

D.4.0 Interest Table

10% Interest Factors

 Year SCA SPW UCA USF UCR UPW

 Y P-F F-P A-F F-A P-A A-P

 1 1.100 .9091 1,000 1.000 1.000 0.909

 2 1.210 .8264 2,100 .4762 .5762 1.736

 3 1.331 .7513 3,310 . 3021 .4021 2.487

 4 1.464 .6830 4,641 . 2155 .3155 3.170

 5 1.611 06209 6,105 .1638 .2638 3.791

 6 1.772 .5645 7,716 .1296 .2296 4.355

 7 1.949 .5132 9,487 .1054 .2054 4.868

 8 2.144 .4665 11.44 .0874 .1874 5.335

 9 2.358 .4241 13.58 .0736 .1736 5.759

 10 2.594 .3855 15.94 .0628 .1628 6.144

 11 2.853 .3505 18.53 .0540 .1540 6.500

 12 5.054 .1978 40.54 .0247 .1247 8.022

 15 5.560 . 1799 45.60 .0219 .1219 8.201

 19 6.116 .1635 51.16 .0196 .1196 8.365

 20 6.727 .1486 57.28 .0175 .1175 8.514

 21 7.400 .1351 64.00 .0156 .1156 8.649

 22 8.140 .1228 71.40 .0140 .1140 8.772

 23 8.954 .1117 79.54 .0126 .1126 8.883

 24 9.850 .1015 88.50 .0113 .1113 8.985

 25 10.84 .0923 98.35 .0102 .1102 9.077

 30 17.50 .0573 164.5 .0061 .1061 9.427

 35 28.10 .0356 271.0 .0037 .1037 9.644

 40 45.26 .0221 442.6 .0023 .1023 9.779

 45 72.89 .0137 718.9 .0014 .1014 9.863

 50 117.4 .0085 1164. .0009 .1009 9.915

 60 304.5 .0033 3035. .0003 .1003 9.967

 70 789.7 .0013 7887. .0001 .1001 9.987

 50 2048. .0005 20474. .0001 .1001 995

 90 5313. .0002 53120. .0000 .1000 9.999

APPENDIX A

SAMPLE PROBLEMS

A copy of sample problems is available upon request.

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Hand Calculation - Modified Degree Day procedure 22.1 - 22.11

Hand Calculation - Bin Method 22.12 - 22.28

Computer Method 22.29 - 22.40

Weather Data 22.41 - 22.50

APPENDIX B

REFERENCES

BOCA The BOCA Basic Energy Conservation Code (Maine Design Code)

ASHRAE 55-74 - Thermal Environmental Conditions for Human Occupancy

 62-73 - Natural and Ventilation

 90-75 - Energy Conservation in New Building Design

 ASHRAE Handbook of Fundamentals - Latest Edition

 ASHRAE Systems Handbook - Latest Edition

IES: Lighting handbook - Latest Edition

NBSI 74.452 Evaluation Criteria for Energy Conservation in

 New Buildings; U. S. Department of Commerce,

 National Bureau Standards

KG Assoc. Life Cycle Cost Benefit Analysis

Passive Solar Design Handbook, Volume Two of Two Volumes - January 1980.

Design and Performance of Passive Solar Heating Systems for Maine, By Chad P. Clark, Department of Mechanical Engineering April 1981.

Local Climatological Data, National Oceanic and Atmospheric Administration

APPENDIX C

SAMPLE FORMS

C-1 Heating Form

C-2 Cooling Form

C-2 COOLING FORM

JOB:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ COOLING DESIGN TEMP. : \_\_\_\_\_\_\_\_\_\_\_\_\_\_

DELTA T :\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ BLDG TYPE: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

SPACE TEMP.: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ WEATHER STA.:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

DATE: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ BY: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |  |
| --- | --- | --- |
| COOLING LOAD | INTERNAL LOAD | SOLAR LOAD |
| Period of day (1) | Avg. Temp (2)  | T= Ti -To(3) | UxAHeatGainMBTU(4) | MBTU(5) | Hr.InBin (6) | AnnualMBTU(7) | Peakinter-nal LoadMBTU(8) | AnnualFactor(9) | Hrs.inBin(10) | AnnualMBTU(11) | PeaksolarLoad(8a) | AnnualFactor(10a) | AnnualMBTU (11a) |  |
| 2-9 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 10-5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6-1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2-9 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 10-5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6-1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2-9 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 10-5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6-1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2-9 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 10-5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6-1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | Total |  |  |  | Total |  |  |  | Total |  |

Note: Heating Form C -1, solar and internal annual MBTU for a building must be subtracted from the heating annual MBTU during the hours they occur and if more solar and internal consumption remains, those annual MBTU for solar and internal annual MBTU must be added to the total MBTU for cooling.

C-1 HEATING FORM

JOB:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ HEATING DESIGN TEMP. :\_\_\_\_\_\_\_\_\_\_\_\_\_\_

DELTA T :\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ BLDG TYPE: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

SPACE TEMP.: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ WEATHER STA.:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

DATE: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ BY: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |  |  |
| --- | --- | --- | --- |
| HEATING LOAD | INTERNAL LOAD | SOLAR LOAD | NET LOAD |
| MONNTH | Period of day (1) | Avg Temp (2)  | T= Ti -To(3) | UxAHeatlossMBTU(4) | MBTU(5) | Hrs.InBin (6) | AnnualMBTU(7) | Peakinter-nal LoadMBTU(8) | AnnualFactor(9) | Hrs.inBin(10) | AnnualMBTU(11) | PeaksolarLoad(8a) | AnnualFactor(10a) | AnnualMBTU (11a) | (12) |
|  | 2-9 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 10-5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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|  | 6-1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2-9 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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|  | 6-1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2-9 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 10-5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 6-1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

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