DEPARTMENT OF THE AIR FORCE
Headquarters United States Air Force
Washington, DC
20332-5000

LEEE 15 Oct 1986

Engineering Technical Letter (ETL) 86-14: Solar Applications

| | | | |
|---|---|---|---|
| ALMAJCOM/DEE/DEP | AFRCE-WR | AFRCE-CR | AFRCE-ER |
| AFRCE-BMS | AFRCE-SAC | AFIT/DET/DEM | HQ AFCC/DEO |
| HQ AFRES/DE | AAFES/ENC | ANGSC/DEE | HQ AFESC/DEM |
| NAVFAC Code 04/05 | 1100 ABG/DE | DAEN-ECC/ECE/ECE-S | |

1. Purpose. This letter:

a. Is mandatory per AFR 8-7, Engineering Technical Letters, Jan 86.

b. Supersedes ETL 86-13, dated 18 Jul 1986, and indicates changes by an * along the margin.

c. Implements the Military Construction Codification Act, of 10 USC 2801, Para 2857.

(1) Requires design of all new facilities to include consideration of solar energy systems where they have the potential for significant savings of fossil-fuel-derived energy.

(2) Requires consideration be given to heating and/or cooling active and passive solar systems.

(3) Authorizes additional scope and cost per square foot of the project for the solar applications(s) "by such amount as may be necessary for such purpose...in addition to any other administrative increase in cost per square foot or variation in floor area authorized by law."

(4) Requires contracts for construction to include solar system installation when proven cost effective during the design process.

d. Establishes guidelines for the host Major Command for preliminary solar assessments.

e. Establishes design guidelines for the designer.

f. Establishes guidelines for the design manager to input data into a design solar screen in the Program, Design, and Construction (PDC) system.

g. Provides guidance to the construction manager on acceptance of the

solar system.

2. Effective Date. Is effective staring with those projects which have not
reached the 10% design concept stage of the date of this letter.

3. Exception. Active solar systems do not have to be installed in remote or
overseas locations where local maintenance capability does not exist.

4. Definitions. Reference atch 1 for definitions.

5. Applications. This ETL applies to:

a. All owned buildings at Air Force installations and activities accomplished by either appropriated or non-appropriated funds, where part or all of the heating equipment maintenance and operations costs are funded from appropriated funds.

b. Buildings which meet the following criteria:

(1) Unique Passive Solar Applications: All sizes.

(2) Normal Passive Solar Applications: All sizes.

(3) Active Solar Applications for Space Heating: Basic building is 20,000 SF minimum.

c. Additions to existing facilities which meet the criteria of paragraph b.

d. Alterations to existing facilities which meet the criteria of b. and the criteria for ECIP projects per ETL 84-7: Energy Conservation Investment Program, dated 12 June 1984.

6. Programming Requirements. The requirements for including solar applications in projects are as follows:

a. Preliminary Solar Assessments.

(1) General. The active and passive solar assessments are described respectively in atchs 2 and 3. These have been incorporated into PDC to simplify the solar assessments.

(2) Host Major Command.

(a) Every January, the host MAJCOM will update the fuel costs of screen BASE SOLAR/ENERGY COST (ZPBASEC) under "Non-Project Info: in "PDC Inquiry." The costs will be in $ per MBTU for each fuel at the respective bases. References atch 4 for a copy of this screen. The PDC element names for these costs are ESELEC (electricity), ESOID (distillate oil), ESOILR (residual oil), ESNGAS (natural gas), ESCOAL (coal), and ESOFUEL (other). Include the description of the "other" fuel under ESDFUEL.

(b) Include in this screen, the Annual Insulation/SF Collector (SINS), the Solar Savings Fraction (ESSSF), and Heating Degree Days (ESHDD) from atch 5. These three elements will eventually become automatic inputs

from tables in the base files.

(c) Include an active solar "System Unit Cost/SF" (ESUSF) of $50 unless another cost is available at the local level.

(d) Include on this screen the efficiency for each different system in ESELECE (electricity), ESCOILDE (distillate), ESOILRE (residual), ENGAGE (natural gas), ESCOALE (coal), and ESOFUELE (other fuel). Except for "other" fuel, all efficiencies will eventually be automatic inputs.

(e) Include under "Unique Passive Solar Savings to Investment Ratio" (ESUP1SIR and ESUP2SIR), the displaced fuel type 1 (ES1FUEL) and type 2 (ES2FUEL). One of these must be "E" (electricity). The SIR computed for "E" will be used to evaluate daylighting. Finally, include the electrical demand charges at the base in element ESDCHRG.

(f) If the active and/or passive solar SIR's are 1.0 or greater against the fuel or energy to be consumed at the facility, then active and/or passive solar applications must be included in the programming documents. The base should be advised by the MAJCOM of the solar requirements so they can include solar applications in their project development and programming documentation.

b. Command Submittal DD Form 1391's.

(1) When the Base Solar/Energy Cost screen shows active and/or passive solar to be cost effective for a particular base (SIR equal to or greater than 1.0), then the Base and/or MAJCOM comprehensive planners and design engineers must decide which projects must be analyzed by the A-E for solar applications. The buildings which lend themselves to passive solar applications are maintenance (high and low bay), training, admin, dining, dormitories, community type (BX, commissaries, child care center, etc...), recreational (field houses, gymnasiums, etc.), storage, industrial, and laboratory facilities. This is to an all inclusive list. The best candidates for active solar applications are heavy users of hot water, such as, gymnasiums, dormitories, dining, and industrial type facilities. Again, this is not an all inclusive list.

(2) The Base of MAJCOM will include a separate line item under "Supporting Utilities" for the solar applications. This should read: "Unique Passive Solar Application" and/or "Active Solar Application." Both applications should be listed separately whenever possible for easy identification of scope and cost. This separate listing is necessary because both scope and cost are vastly different. Active is mainly mechanical while passive is mainly structural. The cost estimates are now provided in the Air Force Pricing Guide. Reference atch 6.

c. Project Booklet (PB).

(1) General. For the Base of MAJCOM. When the Base Solar/Energy

Cost screen shows active and/or passive solar to be cost effective, then the
Base and/or host MAJCOM will include the SIR figure(s) of the screen in the PB
together with a brief description of the requirements as noted below.
Daylighting is usually cost effective and provides a significant return on the
investment. Fuel "E" under unique passive solar is the key to daylighting.
If the SIR is 1.0 or greater, daylighting must be analyzed by the A-E. If
active and/or passive solar applications are not cost effective per the Base
Solar/Energy Cost screen, then the PB should contain such statement along with
the applicable SIR(s).

* (2) TAB B. Project Description Summary, under 1c, Work Definition.
When the SIR(s) in the Base Solar/Energy Cost screen is 1.0 or greater,
include a statement that "Active Solar" and/or "Unique Passive Solar
applications will be analyzed by the A-E firm."

* (3) TAB C. Site Description. Include information on the suitability of the terrain for wind breaks, solar screens, proper orientation, proximity to existing buildings and their access to solar energy.

* (4) TAB D. Architectural and Structural Considerations, paragraph 1b. Include specific unique passive solar features which the A-E should analyze such as atriums, sunspaces, berming, extensive daylighting techniques, cooling techniques and thermal mass storage applications, etc., or a combination of all.

* (5) TAB E. Mechanical Consideration, paragraph 1e. Include the active solar applications, DHW and/or space heating. Include words such as, "The size will be optimized based on a least life cycle study."

(6) Cost. Reference the Air Force Pricing Guide for programming cost estimates of active and passive solar application to include in the PB. Passive solar is usually estimated at two dollars per square foot times the building scope for non-storage type buildings. The costs for active solar depend on the building type and type of solar application. Reference atch 6.

d. Design Instruction (DI) in PDC.

(1) The MAJCOM will ensure that the Solar PA's are included in the Command submittals. This will ensure that the Air Staff includes the PA's in the initial Design Instruction, and will simplify not only the programming process, but the A-E selection and design process as well.

(2) The MAJCOM or AFRCE must reference the Solar Overview Screen (SPSOLAR) to determine which application (active, passive, or both) will be analyzed by the A-E. Reference atch 7. Active and/or passive solar PA's should be indicated, otherwise, contact LEEEU for this information.

7. Design Requirements. The design requirements for including solar applications in projects are as follows:

a. Design Manager (DM):

(1) General.

(a) The solar PA will not be used to support any nonsolar part of the project unless the solar application proves not to be cost effective.

(b) At the time of contract award, the solar CWE will be updated to reflect the true cost of the solar application.

(c) Unique passive solar applications cannot be designed as an additive to the project because they are inherent in the structure of the building; therefore, early in the design stage (10%), the designer must be able to determine if this additional cost will be cost effective.

(d) Active solar applications require a mechanical system which can easily be deleted from the project design by the 35% design stage if process is not cost effective. Therefore, it could be designed as a stand-alone system.

(2) CBD Announcement. The Design Manager must review the Base Solar/Energy Cost screen (Atch 4) before issuing an announcement to the Commerce Business Daily (CGD) on any project where a building will be designed. If the SIR is one or greater for active or passive solar applications against the fuels or energy to be consumed at the proposed facility, then the CBD announcement must include a requirement for that type of A-E expertise. If the Base Solar/Energy Cost screen shows the SIR's with a string of .0's, 1.0's, or 0.1's, that is an indication that the MAJCOM's have not updated their screens. Contact them at once. The MAJCOM's will update this screen and their corrections will be transmitted overnight through the PDC system.

* (3) A-E Analysis Requirement. If the Base Solar/Energy Cost Screen indicates that the SIR is one or greater, then the Air Force Design Manager must ensure that the A-E analyzes active and/or passive solar applications, whether or not a solar PA is shown on the Design Instruction, DD Form 1391, or Project Booklet (PB). Passive solar applications costs, in this case, can be trade-offs between a normal wall and a glass wall, thicker wall for heat storage and a smaller mechanical system, etc. Also in this case, the active solar application can be an additive. However, if the active solar systems are proven cost effective, then per Congressional law, the Air force Design Manager and MAJCOM representative must ensure these additional costs are included in the Congressional submittals.

(4) Project Booklet (PB). If the Base Solar/Energy cost screen indicates that solar applications are cost effective, and if the PB does not indicate justification against usage of active and/or unique passive solar applications, then the AFRCE must determine if the type facility lends itself to solar applications. The A-E must then be directed to analyze solar, if applicable.

(5) PDC Updates.

(a) Unique Passive Solar Applications. When applicable, the DM will input the following data in screen ZPSOLAR (Atch 7) or send it via message to LEEEU (if ZPSOLAR is not in operation) at the 35% design stage (1 August): PASSCWE (passive solar CWE) ($000), PASSCOPE (passive solar scope) (SF), PASSAPLE (type of solar applications), PASSEWO (building energy consumed without solar) (MBTU), PASSEW (building energy consumed with

solar)
(MBTU), PASSIF1DP and PASSF2DP (Fuels 1 and 2 displaced by solar), PASSF1CO
and PASSF2CO (Fuel 1 &/or 2 costs) ($/MBTU), PASSANA (type of energy analysis), PASSFYS (first year savings) ($000), PASSIR (total Design SIR),
PASSSPB (simple payback) (yrs), PASSDPB (discounted payback) (yrs), and SOLDMRMK (DM remarks, if applicable). If necessary, the DM will update this
information at the 95% design stage.

(b) Active Solar Applications. When applicable, the DM will
input the following data in screen ZPSOLAR or via message (if ZPSOLAR is not
in operation) at the 35% design state (1 August): ACTIVCWE (active solar CWE)
($000), ACTSCOPE (active solar scope) (SF), ACTAPL (type of active solar applications), ACTW (building energy consumption with the active solar application), ACTWO (building energy consumption without the active solar
application), ACTF1DP and ACTF2DP (fuels 1 ans 2 displaced by active solar),
ACTF1CO and ACTF2CO (cost (&/MBTU) of fuels 1 and 2 displaced by active

solar), ACTANA (type of energy analysis used by the A-E for active solar), ACTFYS (first year savings due to the active solar system) ($000), ACTSIR (total design SIR), ACTSPB (simple payback due to active solar) (yrs), and ACTDPB (discounted payback due to active solar). If necessary, the DM will update this information at the 95% design stage.

(6) Concept Reviews. At the concept review state, the DM will ensure that both the MAJCOM and the Base review and select the preferred of at least two unique passive solar concepts developed by the A-E. Aesthetics will be secondary to energy efficiency.

(7) Design Review Stages.

(a) Concept Review. Two or three concepts of unique passive solar applications will be presented by the A-E for MAJCOM and/or Base review. The DM will ensure the A-E designs the concept selected. If the applications are cost effective, they will continue to the 95% design review stage, otherwise they will be deleted at the 10% stage.

(b) 35% Review. If the active solar applications is cost effective, it will continue in design to the 95% design stage. If not, a note will be included in the design documents that "Active solar applications proved not to be cost effective," and the application will be deleted from the project.

(c) 95% Review. The DM will ensure that the PDC screen solar data (Atch 7) is updated, if necessary, based on the final design information.

b. Designer. The designer will include the following in the design:

(1) Normal Passive Solar Applications. Reference ETL 82-6: Normal Passive Solar Applications, dated 30 December 1982. As a minimum, all projects must be analyzed for normal passive solar applications. These applications include optimum siting, orientation and building shape, zoning of interior spaces according to energy consumption, spacing of facilities to ensure solar access by existing facilities, limited daylighting or clerestory techniques, solar shading devices, protected entrances, optimum insulation values for the envelope of the building, and berming where cost effective and

practical. All these applications are considered standard for every design and should cost within the programmed amount.

(2) Unique Passive Solar Applications.

(a) General. Reference ETL 82-7: Unique Passive Solar Applications, dated 30 November 1982. These applications will be considered only if the Base Solar/Energy Cost screen shows and SIR greater than 1.0 for "E" (daylighting) and for any other fuel used for heating, use thermal mass heating and or natural convection for cooling. These applications consist of direct, indirect, and isolated solar gain/storage using masonry, water or phase-change for thermal storage, sunspaces, atria, solar chimney, convective loops, extensive daylighting and/or a combination of all.

(b) Design Requirements.

1 Passive solar analyses will be performed by the designer per atch 8. Because unique passive solar applications are inherent in the structure of the building, they cannot be easily deleted from the project like active solar systems, if not cost effective by the 35% design stage. Therefore, the A-E must make a preliminary estimate of cost effectiveness by the 10% or concept stage. If the preliminary analysis indicates that the unique passive solar applications are cost effective at the concept stage, then the applications will become part of the basic project, per Congressional law.

2 Active Solar Applications. The designer will determine the optimum size of the solar system. He will not use the active solar PA as a convenient stopping place to size the system, but will optimize the size based on a least life cycle cost analysis. The analyses will be performed per attachment 9.

(3) At the 30% design stage, the A-E will provide the following information on the active and/or passive solar application(s): Building energy consumed with and without the solar application (MBTU) per year), the type(s) of fuel or energy displaced, the fuel costs in $/MBTU, the type of energy analysis used to compute the energy savings, the first year savings due to the solar application, the savings to investment ratio (SIR), the simple payback (yrs), the discounted payback (yrs), the current working estimate for the solar portion ($000), the solar scope (SF), and the type of solar application(s).

8. Construction Requirements. The requirements for accepting a solar system are as follows:

b. Active Solar Systems.

(1) Designer. The designer must provide for the solar system six copies of: catalog data, an equipment and material list, maintenance instructions, operating instructions, performance curves, quality control tests, shop drawings, wiring diagrams, and computations.

(2) Construction Manager (CM). The CM will ensure that the Base

maintenance personnel are present during the operational test. The test will
include:

(a) Operation in each possible mode of operation.

(b) Differential controller turns the solar loop pump on/off at
the design differential temperature settings.

(c) The pump produces the required collector array flowrate as
described in the Construction documents (Chp 7 of Active Solar Energy System
Design, Instl & Maint, DEB-TR-86-01, April 1986. This manual can be obtained
from the National Technical Information Service, 5285 Port Royal Rd,
Springfield, VA, 222161.

(d) Flow in collector array is balanced properly.

(e) Drainback systems actually drain back when the solar loop pump is off.

(f) Mixing valves are mixing fluid streams to the proper temperature.

(3) The Construction Contractor will hold an instructional seminar, with "hands-on" experience for the Base maintenance personnel per Chapter 10 of the active solar manual mentioned in para (2) (c) above.

(4) Required spare parts requirements will be provided by the Construction Contractor per para 3, Chapter 10 of mentioned manual.

b. Unique Passive Solar System.

(1) The designer must provide, where applicable, 6 copies of the following: catalog data, equipment and material list, maintenance instructions, operating instructions, quality control tests, shop drawings, wiring diagrams, and computations.

(2) Construction Manager.

(a) The CM must ensure that the contractor provides an instructional seminar not only to maintenance personnel, but also for the occupants as well, to inform them of features of the building and their intended purposes. The occupants may have to be given layman explanations of the working of passive solar techniques.

(b) Maintenance. The contractor will provide a listing of equipment and frequency for maintainability of the passive solar applications.

FOR THE CHIEF OF STAFF

JARRELL S. MITCHELL, Colonel, USAF
Chief, Engineering Division
Directorate of Engineering & Services

10 Atch
1. Definitions for Solar Applications
2. Active Solar Feasibility Assessments
3. Passive Solar Assessment
4. Base Solar/Energy Cost Screen
5. Solar Evaluation Data
6. Solar System Costs
7. Solar Applications Overview
8. Design Criteria for Unique Passive Solar Analysis
9. Design Criteria for Active

Solar Analysis

cc: OASD (A&L)C

Definitions
for
Solar Applications

1. Active Solar System: This type of system generally consists of roof or ground mounted solar collectors, a piping system, a liquid or air heat transfer medium, pumps, heat exchangers, and thermal storage tank or mass.

2. Active Solar Programmed Amount (PA) (ACTIVEPA): This is the portion of the Solar, PA, which is identified in the Design Instruction (DI) screen ZPSOLAR, in the Programming Design and Construction System (PDC) for an active solar system. This information will be input by LEEEU at ($000).

3. Solar Applications Overview Screen (ZPSOLAR) (Atch 7). This is the screen in PDC which will be used by the Design Manager to report the status of solar applications. If the ZPSOLAR screen has not been activated when this ETL reaches the field, then the information on this screen will be provided via message at the required percent design stages.

4. Passive Solar System: This type of system collects and transmits heat by non-mechanical means such as convection, conduction, radiation, and/or transmits, reflects, or shades sunlight for illumination purposes. Basically, the building structure itself serves as collector or storage of heat and provides shade from, or reflection of sunlight.

5. Normal Passive Solar Applications: These passive solar applications are those which normally fall within the programmed amount and must be considered in every design to optimize energy efficiency. They include considerations for siting, orientation, building shape, spacing of facilities to ensure existing buildings are not blocked from direct sunlight, solar shading devices, protected entrances, landscaping to shade or allow sunlight on the building or to block winter prevailing winds, insulation, limited amount of berming, and daylighting applications which will not increase the programmed amount.

6. Unique Passive Solar Applications: These types of applications are those which normally require additional funding or scope above the programmed amounts and require additional analyses. These are the ones which fall under Congressional law and must be proven cost effective before they can be part of

the basic project. These applications include direct and indirect solar gain
to supplement the heating system with masonry, water, or phase-change thermal
mass storage, sunspaces, solar chimney for natural cooling, atriums, extensive
daylighting techniques, and/or a combination of all these.

7. Passive Solar PA (PASSPA): This is the portion of the Solar PA in ($000),
which is identified in the DI, for unique passive solar applications. This
information will be input into screen ZPSOLAR by LEEEU.

8. Active Solar Scope (ACTSCOPE): This is the area of the solar collectors
in square feet (SF). It will be input by the Design Manager (DM) in PDC
screen ZPSOLAR.

Atch 1

9. Passive Solar Scope (PASSCOPE): This is the additional SF of building space attributed to the unique passive solar applications. It will be input into screen ZPSOLAR by the DM.

10. Design Manager (DM): This is the Design Manager defined by PDC, and is usually at the AFRCE.

11. PDC: The Programming, Design, and Construction System (WANG) used to manage and track the programming, design, and construction status of Air Force projects.

12. Active Solar Savings to Investment Ratio (SIR) (ACTSIR): This is the A-E calculated SIR for the Active solar application. This value is input into screen ZPSOLAR by the DM.

13. Active Solar Discounted Payback (ACTDPB): This is the A-E calculated discounted payback in years for the active solar system. The DM inputs this value into screen ZPSOLAR.

14. Active Solar Analysis (ACTANA): This is the type of analysis used by the A-E (DOE2, FCHART, TRACE, or others) to determine the energy usages or savings of the active solar system. The DM inputs this information into screen ZPSOLAR.

15. Active Solar Application (ACTAPL): This is the type operation(s) (domestic hot water or space heating, or both) being performed by the active solar system. The DM will input this information into screen ZPSOLAR as DHW, SH or DHW/SH.

16. Active Solar Fuel 1 Cost (ACTF1CO): This is the cost of fuel 1 in $ per MBTU being displaced by the active solar system. The DM will input this data into screen ZPSOLAR.

17. Active Solar Fuel 2 cost (ACTF2CO): This is the cost of fuel 2 in $ per MBTU being displaced by the active solar system. The DM will input this data into screen ZPSOLAR.

18. TYPE Fuel 1 Displaced by Active Solar (ACTF1DP): This is the type fuel 1 being displaced by the active solar system and is input by the DM into ZPSOLAR as E (Electricity), D (Distillate Fuel), G (Gas), P (Propane), S

(Steam), R
(Residual Fuel), C (Coal), or RDF (Refuse Derived Fuel).

19. Type Fuel 2 Displaced by Active Solar (ACTF2DP): Same description as
ACTF2DP above.

20. First Year Savings by Active Solar (ACTFYS): This is the A-E estimated
first year's energy dollar savings due to the active solar system. It is input
as $000 by the DM into ZPSOLAR.

21. Active Solar Current Working Estimate (ACTIVCWE): This is the A-E current
working estimate of the active solar system cost and is input as $000 by the DM
into ZPSOLAR.

22. Energy Consumed with the Active Solar System (ACTW): This is the annual building energy consumed with the active solar system and is input by DM in ZPSOLAR as MBTU per year.

23. Energy Consumed with the Passive Solar System (PASSW): Same description as ACTW.

24. Energy Consumed without the Active Solar System (ACTWO): This is the annual building energy consumed without the active solar system as is input by the DM in ZPSOLAR as MBTU per year.

25. Energy Consumed without the Passive Solar System (PASSWO): Same description as ACTWO.

26. Active Solar System Simple Payback (ACTSPB): This is the A-E calculated simple payback in years for the active solar system and is input by the DM in ZPSOLAR.

27. Passive Solar System Simple Payback (PASSSPB): Description is same as ACTSPB.

28. Passive Solar SIR: Same description as ACTSIR.

29. Passive Solar Analysis (PASSANA): Same description as ACTANA.

30. Passive Solar Application (PASSAPL): Same as description as ACTAPL.

31. Passive Solar Discounted Payback (PASSDPB): Same description as ACTDPB.

32. Passive Solar Current Working Estimate (PASSCWE): Same description as ACT1CWE.

33. Cost of Fuel No. 1 Displaced by Passive Solar (PASSF1CO): Same description as for ACTF1CO.

34. Cost of fuel No. 2 Displaced by Passive Solar (PASSF2CO): Same description as for ACTF2CO.

35. Type Fuel 1 Displaced by Passive Solar (PASSF1DP): Same description as ACTF1DP.

36. Type Fuel 2 Displaced by Passive Solar (PASSF2DP): Same description as ACTF2DP.

Active Solar Feasibility Assessments (Note 1)

1. Introduction. This is a quick, simple assessment procedure for active solar applications to be used only during the project development stage. It combines Congressional life-cycle costing criteria with state-of-the-art solar system performance to indicate the relative potential of active solar at each base, according to fuel type and cost.

2. General. The PDC screen ZPBASEC (Atch 4) will calculate for each base and for each of its fuels, the savings to investment ratio (SIR) according to the following basic equation:

SIR = [(0.50*A*F/Ef)*(Cf)*(UPWF) - 0.01* (S) * (BCF)] /0.90S.

a. Assumptions:

(1) 50% solar hearing fraction.

(2) 1% of total investment for recurring annual O&M expenses.

(3) 10% investment credit.

(4) 0% differential inflation rate for O&M (UPWF for 25 yrs = 11.65)

(5) 7% discount rate

(6) 25 year system lifetime

b. Nomenclature

(1) SIR = Savings to investment ratio (must be equal to or greater than 1.0 for consideration and design.)

(2) A = Available annual insulation/SF of collector (MBTU/SF) (Atch 4) (Based on a 40% system efficiency)

(3) F = Energy saved equivalent factor (1BTU)

(4) Ef = Heating plant system efficiency

(5) Cf = Cost per unit of fuel saved ($/MBTU) (Reference Table 2 for energy conversion factors.)

(6) UPWF = Uniform present worth factor for fuel type (UPW*) (Atch 2, 2 of 3)

(7) BCF = Benefit cost factor for O&M (11.65)

(8) S = System unit cost per SF of collector ($50.00 per collector square footage, unless different at the local level)

Note 1. Procedure was obtained from the Solar Retrofit Program of the mid 1970's.

Atch 2

Table 1
UPW Discount Factors Adjusted for Energy Price Escalation

The following 25 year "modified" uniform present worth discount (UPW) factors are based on a 7% discount rate and include the DOE projected escalation rated in energy priced developed from the mid-term energy forecasting system (MEFS), for the period from 1985 through 2010.

REGION 1: Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island.
REGION 2: New York, New Jersey, Puerto Rico, Virgin Islands.
REGION 3: Pennsylvania, Maryland, West Virginia, Virginia, District of Columbia, Delaware.
REGION 4: Kentucky, Tennessee, North Carolina, South Carolina, Mississippi, Alabama, Georgia, Florida, Canal Zone.
REGION 5: Minnesota, Wisconsin, Michigan, Illinois, Indiana, Ohio.
REGION 6: Texas, New Mexico, Oklahoma, Arkansas, Lousiana.
REGION 7: Kansas, Missouri, Iowa, Nebraska.
REGION 8: Montana, North Dakota, South Dakota, Wyoming, Utah, Colorado.
REGION 9: California, Nevada, Arizona, Hawaii, Trust Territory of the Pacific Islands, American Samoa, Guam.
REGION 10: Washington, Oregon, Idaho, Alaska.
REGION 11: United States Average (for Overseas).

| REGION | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Elec | 12.90 | 11.91 | 11.83 | 11.04 | 11.26 | 13.41 | 11.05 | 11.44 | 13.27 | 12.18 | 11.88 |
| Dis-tillate Oil | 16.51 | 16.52 | 16.64 | 16.75 | 16.59 | 16.89 | 16.73 | 16.79 | 16.90 | 16.73 | 16.70 |
| Resi-dual Oil | 16.20 | 16.26 | 16.54 | 16.83 | 17.59 | 17.23 | 17.67 | 17.92 | 16.52 | 15.82 | 16.72 |
| Nat. & LP Gas | 20.10 | 17.99 | 17.82 | 19.97 | 18.54 | 20.62 | 19.32 | 17.90 | 17.88 | 17.36 | 19.21 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Coal | 13.36 | 13.40 | 13.19 | 13.50 | 13.01 | 13.72 | 13.47 | 13.24 | 13.15 | 13.13 | 13.85 |

*Extracted from November 1985, 1985 Edition, Annual Supplement to NBS Handbook 135 and NBS Special Publication 709, Nol NBSIR 85-3273.

TABLE 2
Energy Conservation Factors

a. For purpose of calculation energy savings, the following conversion factors will be used:

| | |
|---|---|
| Site Electric Power | 3,414 BTUH/kwh |
| Distillate Fuel Oil | 138,700 BTU/gal |
| Residual Fuel Oil | 149,760 BTU/gal |
| Natural Gas | 1,031,000 BTU/1000 cu.ft. |
| LPG, Propane, Butane | 95,000 BTU/gal |
| Bituminous Coal | 24,580,000 BTU/Short Ton |
| Anthracite Coal | 25,400,000 BTU/Short Ton |
| Purchased Steam | 1,340 BTY/lb |

The conversion factors for fossil fuels should be used only if actual fuel BTU content is not known. If known, actual values should be used.

b. Purchased energy is defined as being generated off-site. For special cases where electric power or steam is obtained from on-site sources, the actual average gross energy input to the generating plant will be used.

c. The term "coal" does not include lignite. Where lignite is involved, the Bureau of Mines average value for the source field shall be used.

d. Where refuse derived fuel (RDF) is involved, the heat value shall be the average of the RDF being used or proposed or 6,000,000 BTU/Short Ton if not known.

e. Full energy credit may be taken for conversion from fossil fuels or electric power to solar, wind, RDF, or geothermal energy less the calculated average yearly standby requirement.

Preliminary Assessment - Unique Passive Solar Applications (Note 1)

1. Introduction. This is a quick, simple assessment procedure for unique passive solar applications, to be used only during the project development stage. It combines Congressional life cycle costing with engineering analysis to indicate the relative potential of daylighting and/or passive solar heating or cooling at each base, according to fuel cost. It is already included in the Base Solar/Energy Cost Screen of PDC.

2. General. The Base Solar/Energy Cost Screen will calculate for each base, the savings to investment ratio (SIR) according to the following basic equation:

SIR = (.00001 x AxBxCx[D for hearing fuel or energy]) + (.00205 xEx[D for electricity]) + [.0054 xFx(D for electricity]) + .05/1.80

A = Heating Degree Days (HDD)
B = Cost of heating fuel ($ per MBTU) (Ref atch 2 Table 2 for energy conversion rates)
C = Solar Savings Fraction (SSF) from Atch 4
D = Uniform Present Worth Factor (UPWF) (Table 1, atch 2)
E = Cost of electricity ($ per MBTU using 3413 BTU/KW)
F = Demand Charge

Assumptions:

a. Utilizes heating constant of 10BTU/HDD-SF-YR

b. Lighting consumption of 2.5 watts/SF

c. Lighting reduction potential of 8 to 10% as described in Renewable Energy Technology Handbook for Military Engineers.

d. Maintenance cost savings of $0.05/SF

e. Construction cost additive of $2.00/SF which discounts 10% to $1.80.

f. Best available information on Peak Charges from current utility contracts.

3. Sample Calculation.

For Barksdale AFB:

DOE Region: 6 HDD: 2337
UPWF: ELECT 14.40 SSF: .65
GAS 17.45

FY 83 COST/MBTU: ELECT $9.18

(USE LATEST) GAS $4.68

a. Annual Heating Consumption
10 BTU/HDD/SF/YR x 2337 HDD = 0.0234 MBTU/SF/YR (Given)

Atch 3

b. Annual Lighting Consumption

(1) 50 ft-candles/SF at 3ft ht = 2.5 Watts/SF

(2) 2.5 Watts/SF x 1KW/1000 Watts x 10 hrs/day x 300 days/yr - 7.5 KWH/YR/SF

(3) 7.5 KWH/yr/SF x 3413 BTUH/KWH = 0.0256 MBTU/SF/YR

(4) Per DOE and Renewable Energy Manual, an 8$ reduction in lighting can be achieved, therefore, Savings = 0.0256 MBTU/SF/YR x 0.08 = .00205 MBTU/SF/YR

c. Peak Demand Reduction

(1) Due to lighting reduction: 2.5 Watts/SF x .08 = .0002 KW/SF/MO

(2) Due to HVAC size reduction: Assume 10% reduction in equipment sizing. Locations farther north (less than 5000 HDD) would achieve comparable reductions (e.g., 5% reduction in A/C...etc.).

(3) For A/C, use 400SF/TON and 1 KW/TON = .00025 KW/SF

(4) Total Peak Reduction = 0.0002KW/SF/MO + 0.00025KW/SF/MO = .00045 KW/SF/MO

d. Maintenance Savings. Due to reduction of mechanical and lighting equipment sizing, savings will be accumulated over the building life. There should be less service calls and less replacement of equipment components. For purpose of the preliminary analysis, the 25 year life savings will be assumed at $0.05/SF.

e. 25 Year Life Solar Savings

(1) Heating: 0.0234 MBTU/SF/YR x 0.65 (SSF) x 4.68 (FUEL COST) x 17.45 (UPWF = $1.24/SF

(2) Lighting: 0.00205 MBTU/SF/YR x 9.18 (FUEL COST) x 14.40 (UPWF) = 0.27/SF

(3) Peak Demand: .00045 KW/SF/MO x 4 ($/KW) x 12 MO (ANN. SAV.) x 14.40 + .31/SF

(4) Maintenance = .05/SF

(5) Total Savings = $1.87/SF

f. SIR Calculation

(1) Additive construction cost for unique passive solar = $2.00/SF

(2) Construction Cost after 10% investment credit = $1.80/SF

(3) SIR = 1.87/1.80 = 104

g. Conclusion. Unique passive solar programmed amounts can be added to proposed projects at their base for further evaluation by the designer. The proposed facilities which must include passive solar applications will be determined by the Base or MAJCOM.

NOTE 1: Developed by Mr. Eldon Hix of HQ SAC/DEE, Mr. Bruce MacDonald of HQ AFESC/DEB, and Mr. R.S. Fernandez of HQ USAF/LEEEU.

B A S E  S O L A R  /  E N E R G Y  C O S T

Base: Mather MAJCOM: ATC DOE Region: 9 Analysis Date: 851217

ACTIVE SOLAR SAVINGS TO INVESTMENT RATIO (SIR)

Annual Insulation/SF Collector: .63 MBTU/SF-YR Sys Unit Cost/SF: $ 50

| Fuels | Electric (Source) | Oil (Dist) | Oil (Resid) | Natural Gas | Coal (Other) |
|---|---|---|---|---|---|
| Cost/MBTU ($) | 2.95 | 5.91 | | 5.81 | |
| SYS Efficiency | 100 % | 75 % | 75 % | 75 % | 50 % 75 % |
| UPW* | 14.81 | 18.83 | 18.81 | 19.49 | 14.01 |
| SIR | .9 | .9 | .0 | .9 | .0 .0 |

[Note: Use source energy values. Example: Electrical Energy= 11,600BTU/kwh]

UNIQUE PASSIVE SOLAR SAVINGS TO INVESTMENT RATIO (SIR)

Heating Degree Days (HDD) : 2600 Displaced Fuel: Type 1 E Type 2 D

Solar Savings Fraction (SSF): .64 Elec=E Oil(Dist)=D Coal=C

Demand Charge ($/Kilowatt) : NGas=G Oil (Resid)=R Other=F

Passive Solar SIR Fuel Type 1: 1.6 Passive Solar SIR Fuel Type 2: 1.2

Comments:

Record Updated. Transaction Posted. 851021 ZPBASEC

PRINTED BY: ERF ON 85/12/17 AT 16:17:12

Atch 4

AIR FORCE MCP SOLAR PRELIMINARY EVALUATION DATA

(SIDEWAYS)

Atch 5

AIR FORCE MCP SOLAR PRELIMINARY EVALUATION DATA (cont'd)

(SIDEWAYS)

AIR FORCE MCP SOLAR PRELIMINARY EVALUATION DATA (cont'd)

(SIDEWAYS)

AIR FORCE MCP SOLAR PRELIMINARY EVALUATION DATA (cont'd)

(SIDEWAYS)

SOLAR SYSTEM COSTS

FOR

PROGRAMMING PURPOSES

1. Unique Passive Solar (Sunspaces, Atriums, Extensive Daylighting Techniques,
Solar Cooling, & Thermal Mass Storage Combinations).

$2.00 per SF of total building scope (except storage facilities).

$1.00 per SF of total building scope for storage facilities

2. Active Solar (Heating of Domestic Hot Water or Space Heating)

| Type of Facility | % of Facility Cost* | |
|---|---|---|
| | DHW | SH |
| Acft Maint Facility | 0.7 | 5.0 |
| Admin Facility | 0.7 | 10.1 |
| Chapel Center | 0.8 | 8.0 |
| Child Care Center | 2.0 | 10.1 |
| Gymnasium | 11.0 | 5.0 |
| Library and Ed Ctr | 0.8 | 9.2 |
| Sq Ops Facility | 0.5 | 8.0 |
| Sys Mgm't Engineering Facility | 4.0 | 8.0 |
| Tech Training Facility | 1.3 | 8.0 |
| UEPH | 5.5 | 10.1 |
| Vehicle Maint Facility | 0.5 | 5.0 |
| VOQ | 2.5 | 10.1 |

*Without Support Facilities

# S O L A R  A P P L I C A T I O N S  O V E R V I E W

(sideways)
ATCH 7

DESIGN CRITERIA

UNIQUE PASSIVE SOLAR ANALYSIS

1. Type of Analyses:

a. Concept Analysis. The designer will use micro or mini computer programs extensively for quick analysis to determine the energy savings of several unique passive solar techniques. The designer will use software comparable to CADLIGHT1 (Wiley Books), SOLPAS/SUNOP (Solarsoft, Inc.) MICROPAS 2.0 (INERCOMP), BILL/PASODE (Londe, Parker, Michaels Consultants), or CALPAS 3 (Berkeley Solar Group). At the 10% concept stage, the designer should be able to decide which passive solar applications are cost effective.

b. Comprehensive Analysis. BLAST, TRACE, or similar computer analysis will be performed by the Designer to determine the heat transfer qualities of the design. This analysis will incorporate energy savings from the concept analysis where necessary, daylighting in particular. For extensive design, the designer may have to resort to limited modeling to determine and control the amount of glare due to sunlight and to improve distribution of solar illumination. The passive solar application(s) will be evaluated by the designer prior to the 30 percent design stage. The solar analysis can be "BLAST" or similar analysis and must include energy data for solar heating similar to DOE's Passive Solar, Design Handbooks Vol I, dated January 1980 (DOE/CS-0127/1&2), Vol III, dated July 1982 9DOE/CS-0127/3), and Solar Design Workbook dated June 1981 9SERI/SP-62-308). These manuals can be obtained through NTIS, U.S. Dept. of Commerce, 5285 Port Royal Rd., Springfield, VA 22161. The computer analysis must also incorporate energy data for daylighting from established procedures. Sources for daylighting quantification is booklet "How to Predict Interior Daylight Illumination" from Libbey-Owens-Ford Co., 811 Madison Ave, Toledo, OH 43695 and CADLIGHT1 software (Wiley Books).

2. Economic Analysis:

a. A solar energy system for a facility shall be considered cost effective if the difference between the original investment cost of the energy system for the facility with a solar energy system and the original investment cost of the energy system for the facility without a solar energy system can be

recovered
over the expected life of the facility.

b. The determination of whether a cost differential can be recovered over the expected life of a facility shall be made using the life cost analysis procedure implemented by the National Bureau of Standards (NBS) Handbook 135, "Life-Cycle Cost Manual for the Federal Energy Management Program." This procedure shall include:

(1) No maintenance expenses, if determined to be part of normal building or ground maintenance over the expected life of the facility or during a period of 25 years, whichever is shorter.

(2) Actual fossil fuel costs at the facility with a rate of growth IAW latest DOE tables published in the Federal Register included in Atch 2, Table 1. Overseas locations shall use values derived from the tables given for the United States Average.

(3) A discount rate of 7 percent per year for all expenses of the energy system.

(4) Note: Do not size the solar system to accommodate standby power.

c. Reduce the original investment cost of the solar energy system by 10 percent to reflect an allowance for an investment cost credit.

3. System Performance Parameters. The unique passive solar system shall be optimized based on the highest net life cycle savings to investment ratio (SIR). However, the size must provide not less than 25 percent of the required space heating or cooling nor less than 30 percent of lighting (year round basis).

4. Types of Systems. The designer must concentrate his efforts on daylighting, thermal mass storage, and passive solar cooling systems. However, he may include other unique passive solar applications (Ref ETL: Unique Passive Solar Systems) if cost effective.

5. Weather Data. Reference data in Atch 5.

6. Cost Effective. If the solar system is cost effective, the designer will provide the following information at the 30 percent design state: building energy consumed with and without the solar application (MBTU/YR), the type(s) of fuel displaced, the fuel costs in $/MBTU, the type of energy analysis used to compute the energy savings, the first year savings due to the solar application, the savings to investment ratio (SIR), the simple payback (yrs), the discounted payback (yrs), the current working estimate for the solar portion ($000), the solar scope (SF), and the type of solar application (s).

7. Not Cost Effective. The designer must still provide the information of para 6 above if the solar application is not cost effective at the 30 percent design stage. Further design of the solar system will then be terminated.

DESIGN CRITERIA

ACTIVE SOLAR ANALYSIS

1. Type of Energy Analysis. The active solar system will be evaluated by the designer prior to the 30 percent design stage. The solar analysis shall be "BLAST", "F-CHART" or similar solar analysis.

2. Economic Analysis

a. A solar energy system for a facility shall be considered cost effective if the difference between the original investment cost of the energy system for the facility with a solar energy system and the original investment cost of the energy system for the facility without a solar energy system can be recovered over the expected life of the facility or system, whichever is less. The designer may have to analyze the system using two or three collector tilts per Table 3 of Atch 9 (4 of 4).

b. The determination of whether a cost differential can be recovered over the expected of life of a facility shall be made using the life cycle cost analysis procedure described by the latest revision of National Bureau of Standards (NBS) Handbook 135, "Life-Cycle Cost Manual for the Federal Energy Management Program." This procedure shall include:

(1) All capital expenses and all operating and maintenance expenses (1% of system cost) associated with the energy system with and without a solar energy system over the expected life of the facility or system, whichever is shorter.

(2) Actual fossil fuel costs at the facility with a rate of growth for the latest DOE tables of Atch 5, Table 1. Overseas locations shall use values derived from the tables given for the United States average. Use the industrial rates.

(3) A discount rate of 7 percent per year for all expenses of the energy system.

(4) Note: Do not size the solar system to accommodate standby power.

c. Redue the original investment cost of the solar energy system by

10
percent to reflect an allowance for an investment cost credit.

3. System Performance Parameters. The size of the solar system shall be optimized based on the highest net life cycle savings to investment ratio (SIR). However, the size must provide not less than 25 percent of the required space heating or cooling nor less than 35 percent of the domestic water heating (year-round basis).

4. Type of systems. The designer will analyze the following systems:

a. Space heating and domestic water heating.

b. Space heating only.

c. Water heating only.

d. Solar cooling systems where the total air conditioning load is greater than 40 tons.

5. Architectural Compatibility. Whether ground mounted or building mounted, systems shall be designed to be architecturally compatible with the total environment. All projects with solar applications will be designed to be architecturally acceptable if active solar is not constructed.

6. Weather Data. Site specific average monthly and annual daily solar radiation on a horizontal surface tilted by the latitude will be used in the required analysis. Reference atch 7. To convert horizontal radiation to different collector tilts, use Table 2. Reference atch 7 for average seasonal makeup water temperatures. Ambient air temperature data can be obtained from AFM 88-29 on the Local Weather Services.

7. Cost Effective. If the solar system is cost effective, the designer will provide the following information at the 30 percent design stage: Building energy consumed with and without the solar application (MBTU/YR), the type(s) of fuel displaced, the fuel costs in $/MBTU, the type of energy analysis used to compute the energy savings, the first year savings due to the solar application, the savings to investment ratio (SIR), the simple payback (yrs), the discounted payback (yrs), the current working estimate for the solar portion ($000), the solar scope (SF), and the type of solar application. The design of the system can then proceed to 90%. The designer will provide any updated solar information.

8. Not Cost Effective. If the solar system is not cost effective, the designer will provide the solar input data mentioned above at the 30 percent design stage. Design of the solar system will then be terminated.

9. Equipment Selection. The solar components and equipment will be selected per the current version of the Army Corps of Engineers Guide Specification for Military Construction, Solar Equipment CEGS-13985.

10. Standardized Design. System selection, schematic design, and design development should follow the procedures of chapters 3, 4, and 5 of Active Solar Energy System Design, Installation and Maintenance, DEB-TR-86-91, Final

Report, April 1986. Copies can be obtained from the National Technical Information Service, 5285 Port Royal Rd, Springfield, VA 22161. The basic instrumentation that must be included in the design is described in chapter 7.

11. Equipment Details. The pump installation, heat exchangers, expansion tank, storage tank, valve, piping support and sensor installation details will be per chapter 6 of the solar manual in paragraph 10.

TABLE 3
TILT RADIATION
HT/H

(sideways)