PASSIVE AND HYBRID SOLAR MANUFACTURED

HOUSING AND BUILDINGS

PON - DE - PNO2 - 79CS - 30143

FINAL REPORT

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I. INTRODUCTION

This document constitutes the final presentation of work conducted under SERI contract number DE-FC02-80CS30384. Included in the scope of work was the design/development of three, and final design of one passive and hybrid solar manufactured home.

The final presentation summarizes the final design work on a passive solar two story modular home to be built by Unibilt Industries. This report is intended as a companion document to the preliminary presentation. As such references are made within the text below to the information included within the preliminary presentation.

The work developed in the preliminary design phase and presented to SERI and MASEC at the contractor's preliminary presentation meeting identified a number of design objectives for the final design phase of the two-story home. These include:

1. Refinement of the insulation package for floor, wall and ceiling/roof components;
2. Reconsideration of the market and economic viability of utilizing water wall;
3. Investigation of the cost effectiveness of triple glazing; and,
4. Refinements of the spatial organization and mechanical and structural components.

Points one through three are discussed below in the economic analysis. The final designs (attached) clearly delineate the point four design refinements.

II. ENERGY USE ANALYSIS

The preliminary report identified areas in which reduction in energy use by the two story design were anticipated. These areas included insulation levels, number of glazings, and use of water wall as a passive solar collector. Furthermore, the preliminary marketing analysis indicated that the incorporation of a solarium with night insulation was justifiable from a marketing standpoint alone. Therefore, the base case used for the subsequent evaluation of the energy savings techniques included the solarium package.

After reviewing alternative insulation, glazing, and water wall schemes, five options were identified for detailed energy use and life cycle cost analysis. These options are listed on Table 1. Using the PASCALC/SLR analysis procedure, the performance of the

Table 1.

Final Life Cycle Cost Analysis

	Total Annual Aux. Load in BTUs w/ 25% Correction Factor	Btu/sf/dd/yr	Energy Savings in BTUs	Incremental Costs	Aux Energy Cost Savings in Dollars	Solar Savings/ Investment Ratio
Base Case #1	43.19×10^6	2.90	0	0	0	0
Case #2	41.14×10^6	2.78	4.01×10^6	\$ 400 ⁰⁰	\$ 58.76	3.37
Case #3	33.82×10^6	2.29	7.49×10^6	\$ 1125.70	\$ 109.75	2.24
Case #4	33.07×10^6	2.24	0.75×10^6	\$ 200 ⁰⁰	\$ 10.99	1.26
Case #5	29.28×10^6	1.98	3.19×10^6	\$ 1057.66	\$ 46.01	1.0
Case #6	23.50×10^6	1.59	5.78×10^6	\$ 207.19	\$ 89.70	.97

Base Case #1

2"x4" wall construction. Solarium with night insulation

Case #2

See Case #1 2"x6" wall replaces 2"x4" wall construction

Case #3

See Case #2 Night insulation added to all windows

Case #4

See Case #3 Floor insulation levels increased to 'R' 19

Case #5

See Case #4 Triple glazing replaces double glazed windows
(all windows except solar apertures)

Case #6

See Case #5 Water wall with night insulation added to south
wall

base case home and each of the energy conservation options was calculated. A subsequent life cycle cost (LCC) analysis of each option was similarly performed. This procedure identifies the effectiveness of each individual option but does not reflect the cumulative impact of implementing a combination of options. However, the individual LCC analysis results indicate the implementation sequence for the options (i.e. from most to least cost effective). For example, of the options evaluated, changing from 2" X 4" construction with 3½" of batt insulation to 2" X 6" construction with 5½" of insulation was determined to be most cost effective. The resultant ordering is illustrated on Table 1.

The first three columns indicate the energy use levels of each case. The base case, for example, has an annual auxiliary load requirement of 45.15×10^6 BTU/Yr for heating. This translates into a 2.90 BTU/SF/Degree Day/Yr energy demand. Adding the energy conservation option described in case #2 reduces the demand to 41.14 BTU/Yr, a reduction of 4.01×10^6 BTU/Yr. Adding night insulation to each of the windows (case #3) reduces the energy demand, an additional 7.49×10^6 BTU/Yr, a cumulative reduction of 11.50×10^6 BTU/Yr. The other cases are similarly evaluated and illustrated on Table 1.

III. ECONOMIC ANALYSIS

The economic analysis consists of three parts. The first part is an identification of the incremental costs of each of the energy conservation options (ECO's) described in Table One. These are listed in column four of the table. The second part of the analysis involves a determination of the cost savings attributable to the ECO's. These are displayed in column five of Table 1. The final step of the analysis is the life cycle cost analysis (LCC).

Essentially, an LCC analysis equates incremental costs with the energy savings expressing their relationship in a format appropriate to the type of design decision process involved. For the work described here, the so-called Savings/Investment Ratio (SIR) method was used. This method is described in detail in the preliminary presentation. In essence, an ECO with an SIR value in excess of 1.0 is considered cost effective.

The initial ordering of the ECO's were based upon SIR value (structured in descending order). The base case was used to compute the energy cost savings for all the ECO's at this initial stage.

A life cycle cost analysis was performed once again, only each case was compared not against a standard base case, but against the previous case; each case representing the addition of one component to the base house. For example, case #1 is a house constructed with 2" X 4" frame walls with a solarium direct gain space. In case #2, 2" X 6" wall construction with 5½" is substituted for the 2" X 4" walls and an SIR determined. With each

additional option, the SIR decreases until the value is below 1.0. For example, in case #6, the SIR is 0.97 indicating a savings/investment ratio that is not cost effective.

Referring to table 1 again, it is clear from Column Six that all ECO's except Case #6 should be implemented.

IV. CONCLUSIONS

The following list indicates those items added to UNIBILT's standard package that have demonstrated cost effectiveness and anticipated market acceptability.

1. Frame wall construction increased to 2" X 6" @ 24" o.c. with 5½" batt insulation between the studs. New stud spacing required an alternate exterior siding material.
2. Insulation levels for the floor over the crawl space increased to 'R'19 batt (6").
3. Solarium w/ an 8" concrete slab and tile floor added to increase the total living area and provide a direct gain space.
4. Solarium windows to have night insulation. Hi 'R' shades with an 'R' value of 15 were selected due to cost consideration, effective 'R' value, maintenance and performance.
5. Night insulation to be installed on all non-solar apertures. Hi 'R' shades are recommended for reasons stated in point 4.

The total incremental cost for items 1 through 5 is \$3,718. The cost of the solarium was not considered a part of the incremental cost as it became a marketing feature indifferent to its use as a passive solar component. The building performance for the two-story house with those passive solar features 1 through 5 is 2.24 BTU/SF/DD/Yr.

V. BUILDER PROFILE

Unibilt Industries

P.O. Box 373
Vandalia, Ohio 45377
(513) 890-7578

Key Personnel

Douglas Scholz - President
Curt Bowling - Vice President

Gross Revenues

1978 - estimated \$3.0 million
1977 - actual \$2.5 million
1976 - \$2.0 million

Housing Unit Production

	<u>Modular Homes</u>
1978 - planned	230
1977	110
1976	150
1975	75

BACKGROUND OF UNIBILT INDUSTRIES

Since its incorporation in 1968, Unibilt Industries has built over 1200 single family code conforming modular homes. In 1979, Unibilt sold 210 homes for a total sales volume of \$5,500,000. The average size home is 1300 sq. ft.--three bedrooms with two baths. The principal style is the basic two section ranch.

Unibilt markets its homes exclusively through Builder-Dealers in the states of Ohio, Kentucky, Indiana and West Virginia. In 1979, 90% of the sales were made in Ohio. Currently, there are 40 Dealerships. Each Dealership is required to purchase a model home and pre-sell homes from that model. Realtors, small contractors, and mobile home salesmen with experience in conventional construction financing are the primary source for new dealer prospects.

To date, the basic affordable home in rural Ohio has been the market segment that Unibilt has directed most of its sales efforts towards. However, Unibilt feels that in 1981 and particularly in 1982, the affordable home located in small suburban subdivisions will increasingly become an attractive market for modular home producers. Coming out of the current housing recession, the demand for the affordable house by the post WWII baby boom generation combined with the inability of the conventional "Stick" builder to cope with inflation and control the quality of the subcontractors, will greatly enhance the marketability of the modular home to the small subdivision contractor. Unibilt plans to capitalize on this trend.

Steven Winter Associates, Inc.
Building Systems Consultants

6100 Empire State Building New York N.Y. 10001 Phone (212) 564 5800

VI. Solar Consultant Profile

ORGANIZATIONAL PROFILE

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I. PROFESSIONAL SERVICES AND CAPABILITIES

A. Historical Sketch

Steven Winter Associates was established in 1972 as a building systems consulting and Architectural/Engineering firm. In the early years it serviced primarily the manufactured housing industry by providing various technical and design capabilities. In late 1976 the firm added structural engineering and energy conservation research to an active agenda of code compliance work and design/research projects.

Between 1976 and 1978 the firm's growth proved to be considerable and services expanded to include such disciplines as computer systemization, production systems consultation and value engineering. A more comprehensive listing of professional services presently offered by S.W.A. follows.

B. Professional Services

1. Architecture/Interior Design
2. Energy Conservation Analysis and Design
3. Code Compliance Review and Approval
4. Structural Engineering Analysis and Design
5. Mechanical Engineering Analysis and Design
6. Value Engineering and Cost Reduction
7. Planning and Construction Management
8. Marketing Research and Development
9. Technical Assessment for Existing Buildings
10. Computerized Production Systematization
11. Representation and Liaison in Washington D.C.
12. Expert Testimony Service

PROFESSIONAL SERVICES AND CAPABILITIES

C. Building Types

S.W.A. has successfully completed or is currently working on projects involving the following building types.

1. Panelized and pre-cut commercial and residential buildings
2. Log and post/beam heavy timber construction.
3. Urban commercial and residential renovations and conversions
4. Office and commercial interior design
5. Modular housing
6. Mobile homes
7. Low and High-rise concrete building systems
8. Specialized buildings system technologies intended for commercial and/or residential use.
9. Low cost housing systems for developing countries
10. Systemized single and multi-family conventional construction

D. Clientele

S.W.A.'s clients range from multi-million dollar building system manufacturers and government agencies to individual, single family home buyers and builders. Most typically, however our clients are within these categories.

1. Housing Manufacturers
2. Builders and Developers
3. Real Estate Investors
4. Individual Housing Consumers
5. Commercial Retail Store Chains
6. Industry Associations
7. Government Agencies
8. Foreign Manufacturers and Investors
9. International Development Agencies

PROFESSIONAL SERVICES AND CAPABILITIES

E. Partial List of Clients

Urban Rehabilitation and Design

- * Blimpie Industries Ltd., New York, NY
- * David H. Yeoman Real Estate, New York, NY
- * Helmsley-Spear, Inc., New York, NY
- * Steven Green Properties, New York, NY
- * 205 West 19th Street Cooperative Corporation, New York, NY
- * Catawba Corporation, New York, NY
- * Coward Shoe, New York and Washington D.C.
- * The City of Patterson, New Jersey
- * Taino Towers, East Harlem, NY
- * Kenai Natives Association, Kenai, Alaska
- * John Avlon, Inc., New York, NY

Housing Design and Delineation

- * Feifer and Associates, Atlanta, GA
- * Orr Corporation, Iowa City, IO
- * Presley Company of New Mexico, Albuquerque, NM
- * Virgil Mott Investments, Houston, TX
- * Sheppard Ellenberg Associates, New York, NY
- * Northern Homes, Hudson Falls, NY
- * Benedict Yedlin, Princeton, NJ
- * Boise Cascade Coporation, Atlanta, GA

Value Engineering

- * Feifer and Associates, Atlanta, GA
- * Empire West Inc. , Tucson, AR
- * Toll Brothers, Inc., Harsham, PA
- * Freure Homes of Canada, Kitchener, ONT
- * U.S. Home Corporation, Houston, TX
- * Wick Homes, Madison, WI
- * Unibilt Industries, Vandalia, OH

PROFESSIONAL SERVICES AND CAPABILITIES

E. Partial List of Clients

Energy Conservation Design and Analysis

- * American Institute of Architects/Research Corporation
- * Southern Solar Energy Center
- * U.S. Department of Energy
- * Gas Research Institute
- * Mid-American Solar Energy Complex
- * National Rural Electric Cooperative Association
- * Improta, Passive Solar Home
- * Mayhill Homes Passive Design
- * U.S. Department of Housing and Urban Development
- * National Concrete Masonry Association
- * National Association of Home Manufacturers
- * Energy Utilization Systems, Inc.

Research and Development Projects

- * The Zinc Institute
- * American Iron and Steel Institute
- * Industrialized Housing Manufacturers Association
- * National Association of Home Builders
- * U.S. Department of Housing and Urban Development
- * Macmillan - Bloedell Research
- * U.S. Army Corps of Engineers

International Projects

- * United Nations Development Programme: South Yemen
- * United Nations Development Programme: Burundi
- * Quatro Rodas, Brazil
- * CETHAC, Brazil
- * ATEC, Argentina

PROFESSIONAL SERVICES AND CAPABILITIES

E. Partial List of Clients

Modular and Mobile Housing Projects

- * Unibilt Industries, Vandalia, OH
- * Fisher Housing Systems, Studio City, CA
- * Marlette Homes, Marlette, MI
- * Burlington Homes, Inc., St. Clair, PA
- * Muncy Homes, Inc., Muncy, PA
- * New England Homes, Inc., Portsmouth, NH
- * Continental Homes, Nashua, NH
- * Key-Loc Modular Homes, Suncook, NH
- * Champion Homebuilders, Dryden, MI
- * Ritzcraft Corporation, Mifflinburg, PA
- * Simplex Industries, Scranton, PA

Panelized and Pre-Cut Building Projects

- * Wickes Corporation, Saginaw, MI
- * Miles Homes, Minneapolis, MN
- * Boise Cascade Corporation, Atlanta, GA
- * Costamagna International, Plaisir, France
- * Fabricon Corporation, Lancaster, PA
- * Levitt Construction, Greenvale, NY
- * Northern Homes, Hudson Falls, NY
- * Multi - Element Systems, Drammen, Norway
- * Poloron Homes, Inc., Middleberg, PA
- * Commercial Buildings - Bally Case and Cooler Corporation, Bally, PA
- * U.S. Army Corps of Engineers, Champaign, IL
- * Wick Homes, Madison, WI
- * Deck House, Inc., Acton, MA
- * Mayhill Homes, Inc., Gainesville, GA

PROFESSIONAL SERVICES AND CAPABILITIES

E. Partial List of Clients

Log Housing Projects

- * Air-Lock Log Homes, Las Vegas, NM
- * Alta Industries, Ltd., Halcottsville, NY
- * Authentic Log Homes, Laramie, WY
- * Beaver Log Homes, Clairmore, OK
- * Boyne Falls Log Homes, Boyne Falls, MI
- * Colorado Log Homes, Denver, CO
- * Green Mountain Cabins, Chester, VT
- * Justus Company, Tacoma, WA
- * Model Log Homes, Bozeman, MT
- * New England Log Homes, Inc., Hamden, CT
- * Northeastern Log Homes, Kenduskeag, ME
- * Northern Products Log Homes, Bangor, ME
- * Traditional Management Co., Inc., Hanover, NH
- * Ward Cabin Company, Houlton, ME
- * National Log Construction Company, Thompson Falls, MT
- * Bellaire Log Homes, Bellaire, MI
- * Cedar Homes, Inc., Bellevue, WA
- * Crockett Log Homes, Chesterfield, NH
- * Lok-N-Logs, Inc., Sherburne, NY
- * Rocky Mountain Log Homes, Hamilton, MT
- * Rustics of Lindbergh Lake, Seeley Lake, MT
- * Timber Log Homes, Inc., Marborough, CT

Barn and Post/Beam Projects

- * Timberpeg, Inc., Clairmont, NH
- * Yankee Barn Homes, Grantham, NH
- * American Barn Homes, Deerfield, MA
- * Barn Homes, Woodstock, NY
- * David Howard Barns, Alstead, NH

PROFESSIONAL SERVICES AND CAPABILITIES

F. Memberships and Affiliations

1. American Institute of Architects
2. National Council of Architectural Registration Boards
3. American Society of Heating, Refrigeration and Air Conditioning Engineers
4. Architectural League of New York
5. Building Officials Code Administration
6. American Society of Testing Materials
7. Construction Research Council
8. Association of Energy Engineers
9. National Institute of Building Sciences
10. National Conference of States on Building Codes and Standards
11. National Association of Home Manufacturers
12. American Association of Small Research Companies
13. Forest Products Research Society
14. Industrialized Housing Manufacturer's Association

G. Government and Professional Contacts

S.W.A. meets regularly and maintains active communication with the following individuals, departments, bureaus and agencies.

1. Thirty-five State Building Departments
2. Fifteen Federal Agencies
3. Congressmen, Senators and key committee members involved in design/building legislation.
4. Over one hundred and thirty-five National Associations representing the design/building industry.
5. Building Research Organizations (NBS, AIA, NFPL)
6. Standard Setting Agencies (ASTM, ASHRAE)
7. Code Promulgation Agencies (ICBO, SSBC, BOCA, FHA)

II. DEPARTMENTAL ORGANIZATION

A. The Staff

S.W.A. was established in 1972 and currently maintains offices in New York and in Washington D.C. The firm is composed of highly trained professionals with backgrounds in architecture, engineering, planning, energy conservation, construction technology and forestry. The firm's principal is registered in thirty states in the U.S. and also in Australia.

STEVEN WINTER, Principal

Education and Academic Background

M.S. Arch. Tech., Columbia University, 1968

B. Arch., Sydney University, Australia, 1966

- * Adjunct Associate Professor of Architecture, Columbia, University.
- * Visiting Associate Professor of Architecture, Pratt Institute.
- * Visiting Lecturer: Harvard University, M.I.T., Hunter College, City University of New York, Carnegie-Mellon University, Syracuse University and Bucknell University.
- * Seminar Leader, New York University; Continuing Education.

Professional Organizations/ Activities

- * Royal Australian Institute of Architects; Affiliate.
- * Architectural Association, London; Member.
- * Architectural League of New York; Treasurer.
- * U.S./USSR Housing Program; Steering Committee.
- * Automation In Housing; Editorial Board.
- * Industrialization Forum; Advisory Panel.
- * ASHRAE; Professional Member.
- * ASTM; Professional Member.

DEPARTMENTAL ORGANIZATION

STEVEN WINTER (cont'd)

Editorial Coverage

Steven Winter has appeared in more than thirty journals and publications, of which the more prominent are listed.

- * The New York Times Magazine; February, 1975
- * Progressive Architecture; July 1977
- * Architectural Record; January, 1976
- * Automation In Housing; February, 1977; March, 1976.
- * Professional Builder; March 1976; March 1978.
- * Building Design and Construction; May, 1976.
- * Industrialization Forum; Volume 8, 1977.
- * Multi-Housing News; August, 1978.
- * Housing America; January 1979.
- * How To Buy An Energy Efficient Home; Steven Winter, Author.

Speeches, Seminars and Conferences

- * National Association of Home Manufacturers; March, 1977.
- * New York University Seminars; 1977 to present.
- * Farmers Home Administration - Energy Conference; May, 1977.
- * Low-Cost Housing in Developing Countries, Dewit; May, 1978.
- * National Building Show, Chicago; November, 1975.
- * Australian Housing Industry Association; December, 1975.
- * Order of Architects, Quebec; October, 1978.
- * Engineering Foundation Conference; May, 1978.
- * Multi-Housing Conference, New Orleans; May, 1979
- * AIA/ASC Forum, Idaho; November, 1978.
- * NAHB Value Engineering Seminars, 1979.
- * NAHM Energy Workshop, Columbus; January, 1979.
- * NBS - NCSBCS Joint Conferences, Bozeman; 1977. and St. Louis; 1979.
- * ICEUM - II Conference, Los Angeles; October, 1979.
- * IDORT Housing Conference, Rio de Janeiro; January, 1978.
- * Industrialized Housing Seminar, Moscow; December, 1978.
- * Building Officials' Conference, Washington D.C.; May, 1979.

DEPARTMENTAL ORGANIZATION

B. Departmental Breakdown

Steven Winter Associates, Inc.'s approach to servicing clients' needs is based upon the assignment of projects to one of the firm's professional teams. The Senior Associates heading these teams are as follows:

Energy Design and Research

M. Emanuel Levy: M. Architecture, 1975, Carnegie Mellon University.
B. Architecture, 1973, Syracuse University.

Design and Value Engineering

Alexander Grinnell: M. Architecture, 1960; B.A. 1957; Yale University

Engineering Analysis and Design

Andrew Bachman: M. Engineering, 1967; B. Engineering 1974; University of Buffalo .

Code Compliance and Market Research

Philip Mitnick: B. Architecture, 1975, Pratt Institute.

APPENDIX A

1. Pascalc worksheet
2. 25% correction factor
3. Life cycle cost analysis
worksheets

PASCALC WORKSHEET

PROJECT FERI - FINAL PRESENTATIONLOCATION OHIODATE 13 MAY '80

UA_{ns} 983.05 Btu/hr⁰F A
 A_s 670 ft² R/S
 U_{np} .13 Btu/hr·ft²·°F R/S
 T_{set} 66 °F B
 Q 3333 Btu/hr R/S
 N 1 C

PASSIVE SYSTEM	1. DIRECT GAIN / NI	D
SYSTEM TYPE	<u>2</u>	R/S
SOUTH FRACTION	<u>.24</u>	R/S
SYSTEM "U"	<u>.29</u> Btu/hrft ²⁰ F	R/S

2.	D
	R/S
	R/S
	R/S

3.	D
	R/S
	R/S
	R/S

FACTORS \ MONTHS	1	2	3	4	5	6	9	10	11	12	1	2	3	4	5	6	9	10	11	12	1	2	3	4	5	6	9	10	11	12
a TRANSMITTANCE	<u>1.0</u>																													
b TILT/ORIENTATION	<u>1.0</u>																													
c ABSORPTANCE	<u>.9</u>																													
d SHADING	<u>1.0</u>																													
e REFLECTOR	<u>1.0</u>																													
$C_i = (a)(b)(c)(d)(e)$	<u>09</u>	<u>09</u>	<u>09</u>	<u>09</u>	<u>09</u>																									
Rounded to Nearest Tenth						<u>09</u>	<u>09</u>	<u>09</u>	<u>09</u>	<u>09</u>																				

NOTE: DO NOT ENTER DECIMAL POINTS WHEN ENTERING C_i 's.

THERMAL ANALYSIS

HOUSE NO. Two Story

CORRECTION FACTOR = 0.25

Case #1

AREA OF SOUTH FACING WINDOW
w/o STORAGE =

MONTH	SOLAR RAD ON HORIZ BTU/SF	HORIZ TO VERT	SOLAR RAD AVAIL* BTU x 10 ⁶	AUX HEAT LOAD BTU x 10 ⁶	CORR* AUX LOAD
SEPT	39570	.88	.67	—	—
OCT	30039	1.28	.72	.33	—
NOV	16920	1.4	.51	6.13	5.62
DEC	12417	1.84	.44	10.91	10.43
JAN	13609	1.72	.44	11.92	11.48
FEB	20300	1.38	.53	9.07	8.54
MAR	31773	.98	.58	6.36	5.78
APR	42090	.71	.56	1.47	.91
MAY	52469	.52	.51	—	—
JUN	54220	.47	.50	—	—
TOTAL					42.80

$$\frac{42.80 \times 10^6}{2620.5 \times 1064} = 2.90 \text{ BTU/SF/DD/YR}$$

* Col 3 = Col 1 x Col 2 x Corr. Factor x Area

** Col 5 = Col 4 - Col 3

PASCALC WORKSHEET

PROJECT SERI-FINAL
 LOCATION OHIO
 DATE 13 MAY '80

UA_{ns} 474.80 Btu/hr⁰F A
 A_s 070 ft² R/S
 U_{np} 12 Btu/hr·ft²·°F R/S
 T_{set} 66 °F B
 Q 3333 Btu/hr R/S
 N 1 C

PASSIVE SYSTEM	1. DG/NI	D
SYSTEM TYPE	2	R/S
SOUTH FRACTION	24	R/S
SYSTEM "U"	29 Btu/hrft ²⁰ F	R/S

2.	D
	R/S
	R/S
	R/S

3.	D
	R/S
	R/S
	R/S

FACTORS \ MONTHS	1	2	3	4	5	6	9	10	11	12	1	2	3	4	5	6	9	10	11	12	1	2	3	4	5	6	9	10	11	12
a TRANSMITTANCE	1.0																													
b TILT/ORIENTATION	1.0																													
c ABSORPTANCE	90																													
d SHADING	1.0																													
e REFLECTOR	1.0																													
$C_1 = (a)(b)(c)(d)(e)$	09	09	09	09	09																									
Rounded to Nearest Tenth							09	09	09	09																				

NOTE: DO NOT ENTER DECIMAL POINTS WHEN ENTERING C_1 's.

THERMAL ANALYSIS

HOUSE NO. Two Story

Case #2

CORRECTION FACTOR = 0.25

AREA OF SOUTH FACING WINDOW
w/o STORAGE = 754

MONTH	SOLAR RAD ON HORIZ BTU/SF	HORIZ TO VERT	SOLAR RAD AVAIL* BTU x 10 ⁶	AUX HEAT LOAD BTU x 10 ⁶	CORR* AUX LOAD
SEPT	39570	.88	.45	—	—
OCT	30039	1.28	.72	.28	.28
NOV	10920	1.10	.51	5.89	5.38
DEC	12617	1.89	.44	10.41	10.17
JAN	13609	1.72	.44	11.93	11.09
FEB	20300	1.38	.43	8.74	8.21
MAR	31775	.98	.58	6.08	5.5
APR	42090	.71	.50	1.35	.79
MAY	52669	.52	—	—	—
JUN	56220	.47	—	—	—
					TOTAL = 41.14

$$\frac{41.14 \times 10^6}{2620.7 \times 9641} = 2.78 \text{ BTU/SF/DD/YR}$$

* Col 3 = Col 1 x Col 2 x Corr. Factor x Area

** Col 5 = Col 4 - Col 3

PASSIVE SOLAR FINANCIAL EVALUATION

- A. Conventional House Costs \$
- B. Incremental Solar Costs \$
- C. Total Construction Costs
(C = A+B) \$
- D. Annual Heating Load Supplied
by Solar (from Page BTU's
 % of Load
- E. Annual Auxiliary Heating Load
(from Page BTU's
- F. Total Annual Heating Load
(F = D+E) BTU's
- G. Regional Assumptions
1. Economic Life Years
 2. Discount or Interest Rate %
 3. Real Energy Growth Rate %
 4. Average Cost of Conventional Fuel \$
- H. To determine the annual energy savings from solar:

$$\frac{\text{Solar Load in BTU's (from D. Above)}}{\text{BTU Equivalency Factor} \times \text{Efficiency Factor (Table 1)}} = \text{Conventional Fuel Requirement}$$

$$\frac{\text{401 BTU's}}{\text{3412 BTU's} \times \text{1.0}} = \text{1175.26 Load in KWH}$$

$$\text{Conventional Fuel Requirement} \times \text{Average Cost of Conventional Fuel (From G.4 Above)} = \text{Annual Energy Cost Savings in \$}$$

$$\text{1175.26 Load in KWH} \times \$ \text{.05} / \text{KWH} = \$ \text{58.76 /Year}$$

- I. Select from Table 2 the appropriate Discount/Energy Growth Factor based on the discount rate, real energy growth rate, and economic life as determined in G. above. 22.97

To determine the present value of energy cost savings from the passive solar system:

Discount/Energy Growth Factor $\times$ Annual Energy Cost Savings in \$ = Present Value of Energy Savings from Solar

$$\begin{array}{ccc} \boxed{22.97} & \times \$ \boxed{58.76} & = \$ \boxed{1349.72} \\ \text{(From I)} & \text{(From H)} & \end{array}$$

- J. To determine the savings/investment ratio for the project:

$\frac{\text{Present Value of Energy Savings}}{\text{Incremental Solar Costs}} = \text{Solar Savings/Investment Ratio}$

$$\frac{\boxed{1349.72}}{\boxed{400}} = \boxed{3.37} \text{ SIR}$$

If the Savings/Investment Ratio is equal to or greater than 1, the system is cost effective and indicates that the project will return on capital at a rate greater than the discount rate.

This figure does not take into account considerations that would make the cost less expensive, such as tax incentives, deduction of interest payments and business depreciation, or considerations that can make it more expensive, such as property tax evaluation increases and fuel cost deductions (business expense).

References:

Life Cycle Costing Emphasizing Energy Conservation: Guidelines for Investment Analysis, September, 1976, ERDA Publication No. 76/130

ERDA Facilities Solar Design Handbook, August, 1977, ERDA Publication No. 77-65

PASCALC WORKSHEET

PROJECT SERI-FINALLOCATION OHIODATE 13 MAY '80

UA _{ns}	<u>430.11</u>	Btu/hr ⁰ F	<input type="text" value="A"/>
A _s	<u>670</u>	ft ²	<input type="text" value="R/S"/>
U _{np}	<u>.08</u>	Btu/hr·ft ² ·°F	<input type="text" value="R/S"/>
T _{set}	<u>66</u>	°F	<input type="text" value="B"/>
Q	<u>3333</u>	Btu/hr	<input type="text" value="R/S"/>
N	<u>1</u>		<input type="text" value="C"/>

PASSIVE SYSTEM	1. <u>D6/N1</u>	<input type="text" value="D"/>
SYSTEM TYPE	<u>2</u>	<input type="text" value="R/S"/>
SOUTH FRACTION	<u>.24</u>	<input type="text" value="R/S"/>
SYSTEM "U"	<u>.29</u> Btu/hr ft ² °F	<input type="text" value="R/S"/>

2.	<input type="text" value="D"/>
	<input type="text" value="R/S"/>
	<input type="text" value="R/S"/>
	<input type="text" value="R/S"/>

3.	<input type="text" value="D"/>
	<input type="text" value="R/S"/>
	<input type="text" value="R/S"/>
	<input type="text" value="R/S"/>

FACTORS \ MONTHS	1	2	3	4	5	6	9	10	11	12	1	2	3	4	5	6	9	10	11	12	1	2	3	4	5	6	9	10	11	12
a TRANSMITTANCE	<u>1.0</u>																													
b TILT/ORIENTATION	<u>1.0</u>																													
c ABSORPTANCE	<u>.09</u>																													
d SHADING	<u>1.0</u>																													
e REFLECTOR	<u>1.0</u>																													
C ₁ = (a)(b)(c)(d)(e)	<u>.09</u>	<u>.09</u>	<u>.09</u>	<u>.09</u>	<u>.09</u>																									
Rounded to Nearest Tenth						<u>.09</u>	<u>.09</u>	<u>.09</u>	<u>.09</u>	<u>.09</u>																				

THERMAL ANALYSIS

HOUSE NO. Two Story

Case#3

CORRECTION FACTOR = 0.25

AREA OF SOUTH FACING WINDOW
w/o STORAGE = 754

MONTH	SOLAR RAD ON HORIZ BTU/SF	HORIZ TO VERT	SOLAR RAD AVAIL* BTU x 10 ⁶	AUX HEAT LOAD BTU x 10 ⁶	CORR* AUX LOAD
SEPT	39570	.88	.05	—	—
OCT	30039	1.28	.72	.12	—
NOV	11420	1.0	.51	4.86	4.35
DEC	12617	1.84	.44	9.07	8.63
JAN	13609	1.72	.44	9.86	9.42
FEB	20300	1.38	.53	7.32	6.79
MAR	31775	.98	.58	4.90	4.32
APR	42090	.71	.56	.87	.3
MAY	52649	.52	.51	—	—
JUN	56220	.47	.50	—	—
TOTAL = 33.82					

$$\frac{33.82 \times 10^6}{2620.9 \times 9041} = 2.29 \text{ BTU/SF/DO/YR}$$

* Col 3 = Col 1 x Col 2 x Corr. Factor x Area
 ** Col 5 = Col 4 - Col 3

PASSIVE SOLAR FINANCIAL EVALUATION

- A. Conventional House Costs \$
- B. Incremental Solar Costs \$
- C. Total Construction Costs
(C = A+B) \$
- D. Annual Heating Load Supplied
by Solar (from Page BTU's
 % of Load
- E. Annual Auxiliary Heating Load
(from Page BTU's
- F. Total Annual Heating Load
(F = D+E) BTU's
- G. Regional Assumptions
1. Economic Life Years
 2. Discount or Interest Rate %
 3. Real Energy Growth Rate %
 4. Average Cost of Conventional Fuel \$
- H. To determine the annual energy savings from solar:

$$\frac{\text{Solar Load in BTU's (from D. Above)}}{\text{BTU Equivalency Factor} \times \text{Efficiency Factor (Table 1)}} = \text{Conventional Fuel Requirement}$$

$$\frac{\frac{7.99 \times 10^6}{3912} \text{ BTU's}}{\times 1.0} = 2195.19 \text{ Load in KWH}$$

$$\text{Conventional Fuel Requirement} \times \text{Average Cost of Conventional Fuel (From G.4 Above)} = \text{Annual Energy Cost Savings in \$}$$

$$2195.19 \text{ Load in KWH} \times \$.05 / \text{KWH} = \$ 109.76 / \text{Year}$$

- I. Select from Table 2 the appropriate Discount/Energy Growth Factor based on the discount rate, real energy growth rate, and economic life as determined in G. above. 22.97

To determine the present value of energy cost savings from the passive solar system:

Discount/Energy Growth Factor $\times$ Annual Energy Cost Savings in \$ = Present Value of Energy Savings from Solar

$$\begin{array}{ccc} \boxed{22.97} & \times \$ \boxed{109.74} & = \$ \boxed{2521.19} \\ \text{(From I)} & \text{(From H)} & \end{array}$$

- J. To determine the savings/investment ratio for the project:

$\frac{\text{Present Value of Energy Savings}}{\text{Incremental Solar Costs}} = \text{Solar Savings/Investment Ratio}$

$$\frac{\boxed{2521.19}}{\boxed{1129.70}} = \boxed{2.24} \text{ SIR}$$

If the Savings/Investment Ratio is equal to or greater than 1, the system is cost effective and indicates that the project will return on capital at a rate greater than the discount rate.

This figure does not take into account considerations that would make the cost less expensive, such as tax incentives, deduction of interest payments and business depreciation, or considerations that can make it more expensive, such as property tax evaluation increases and fuel cost deductions (business expense).

References:

Life Cycle Costing Emphasizing Energy Conservation: Guidelines for Investment Analysis, September, 1976, ERDA Publication No. 76/130

ERDA Facilities Solar Design Handbook, August, 1977, ERDA Publication No. 77-65

PASCALC WORKSHEET

PROJECT SERIAL-FINAL
 LOCATION OHIO
 DATE 13 MAY '80

UA_{ns} 424.82 Btu/hr⁰F
 A_s 670 ft²
 U_{np} .09 Btu/hr·ft²·°F
 T_{set} 66 °F
 Q 3333 Btu/hr
 N 1

☐ A
☐ R/S
☐ R/S
☐ B
☐ R/S
☐ C

Case #4

PASSIVE SYSTEM	1. <u>DO/NL</u>
SYSTEM TYPE	<u>2</u>
SOUTH FRACTION	<u>.24</u>
SYSTEM "U"	<u>.29</u> Btu/hrft ² °F

☐ D
☐ R/S
☐ R/S
☐ R/S

2.	
	Btu/hrft ² °F

☐ D
☐ R/S
☐ R/S
☐ R/S

3.	
	Btu/hrft ² °F

☐ D
☐ R/S
☐ R/S
☐ R/S

FACTORS \ MONTHS	1	2	3	4	5	6	9	10	11	12	1	2	3	4	5	6	9	10	11	12	1	2	3	4	5	6	9	10	11	12
a TRANSMITTANCE	1.0																													
b TILT/ORIENTATION	1.0																													
c ABSORPTANCE	.09																													
d SHADING	1.0																													
e REFLECTOR	1.0																													
$C_i = (a)(b)(c)(d)(e)$	.09	.09	.09	.09	.09																									
Rounded to Nearest Tenth						.09	.09	.09	.09	.09																				

NOTE: DO NOT ENTER DECIMAL POINTS WHEN ENTERING C_i 's.

THERMAL ANALYSIS

HOUSE NO. Two Story

CORRECTION FACTOR = 0.25

Case #4

AREA OF SOUTH FACING WINDOW
w/o STORAGE =

MONTH	SOLAR RAD ON HORIZ BTU/SF	HORIZ TO VERT	SOLAR RAD AVAIL* BTU x 10 ⁶	AUX HEAT LOAD BTU x 10 ⁶	CORR* [†] AUX LOAD
SEPT	39510	.88	.65	—	—
OCT	30039	1.28	.72	.11	—
NOV	16920	1.6	.51	4.75	4.24
DEC	12417	1.84	.44	8.91	8.47
JAN	13009	1.72	.44	9.69	9.25
FEB	20300	1.38	.53	7.17	6.44
MAR	31775	.98	.58	4.78	4.2
APR	42090	.71	.50	.83	.27
MAY	52669	.52	.51	—	—
JUN	50220	.47	.50	—	—
TOTAL = 33.07					

$$\frac{33.07 \times 10^4}{26205 \times 5641} = 2.24 \text{ BTU/SF/DD/YR}$$

* Col 3 = Col 1 x Col 2 x Corr. Factor x Area

** Col 5 = Col 4 - Col 3

PASSIVE SOLAR FINANCIAL EVALUATION

- A. Conventional House Costs \$
- B. Incremental Solar Costs \$
- C. Total Construction Costs (C = A+B) \$
- D. Annual Heating Load Supplied by Solar (from Page BTU's
 % of Load
- E. Annual Auxiliary Heating Load (from Page BTU's
- F. Total Annual Heating Load (F = D+E) BTU's
- G. Regional Assumptions
1. Economic Life Years
 2. Discount or Interest Rate %
 3. Real Energy Growth Rate %
 4. Average Cost of Conventional Fuel \$
- H. To determine the annual energy savings from solar:

$$\frac{\text{Solar Load in BTU's (from D. Above)}}{\text{BTU Equivalency Factor} \times \text{Efficiency Factor (Table 1)}} = \text{Conventional Fuel Requirement}$$

$$\frac{\text{0.75 x 10}^4 \text{ BTU's}}{\text{312 BTU's} \times \text{1.0}} = \text{219.81 Load in KWH}$$

$$\text{Conventional Fuel Requirement} \times \text{Average Cost of Conventional Fuel (From G.4 Above)} = \text{Annual Energy Cost Savings in \$}$$

$$\text{219.81 Load in KWH} \times \$ \text{0.05 / KWH} = \$ \text{10.99 / Year}$$

- I. Select from Table 2 the appropriate Discount/Energy Growth Factor based on the discount rate, real energy growth rate, and economic life as determined in G. above. 22.97

To determine the present value of energy cost savings from the passive solar system:

Discount/Energy Growth Factor $\times$ Annual Energy Cost Savings in \$ = Present Value of Energy Savings from Solar

$$\begin{array}{ccc} \boxed{22.97} & \times \$ \boxed{10.99} & = \$ \boxed{252.44} \\ \text{(From I)} & \text{(From H)} & \end{array}$$

- J. To determine the savings/investment ratio for the project:

$\frac{\text{Present Value of Energy Savings}}{\text{Incremental Solar Costs}} = \text{Solar Savings/Investment Ratio}$

$$\frac{\boxed{252.44}}{\boxed{200}} = \boxed{1.26} \text{ SIR}$$

If the Savings/Investment Ratio is equal to or greater than 1, the system is cost effective and indicates that the project will return on capital at a rate greater than the discount rate.

This figure does not take into account considerations that would make the cost less expensive, such as tax incentives, deduction of interest payments and business depreciation, or considerations that can make it more expensive, such as property tax evaluation increases and fuel cost deductions (business expense).

References:

Life Cycle Costing Emphasizing Energy Conservation: Guidelines for Investment Analysis, September, 1976, ERDA Publication No. 76/130

ERDA Facilities Solar Design Handbook, August, 1977, ERDA Publication No. 77-65

PASCALC WORKSHEET

PROJECT SEPI-FINAL
 LOCATION DHID
 DATE 13 MAY '80

UA_{ns} 409.32 Btu/hr⁰F
 A_s 670 ft²
 U_{np} .06 Btu/hr·ft²·°F
 T_{set} 66 °F
 Q 3333 Btu/hr
 N 1

☐ A
☐ R/S
☐ R/S
☐ B
☐ R/S
☐ C

Case #5

PASSIVE SYSTEM	1. DG/NI
SYSTEM TYPE	2
SOUTH FRACTION	.24
SYSTEM "U"	.29 Btu/hrft ² °F

☐ D
☐ R/S
☐ R/S
☐ R/S

2.
Btu/hrft ² °F

☐ D
☐ R/S
☐ R/S
☐ R/S

3.
Btu/hrft ² °F

☐ D
☐ R/S
☐ R/S
☐ R/S

FACTORS	MONTHS	1	2	3	4	5	6	9	10	11	12	1	2	3	4	5	6	9	10	11	12	1	2	3	4	5	6	9	10	11	12
a TRANSMITTANCE		1.0																													
b TILT/ORIENTATION		1.0																													
c ABSORPTANCE ^c		09																													
d SHADING		1.0																													
e REFLECTOR		1.0																													
C _i = (a)(b)(c)(d)(e)		09	09	09	09	09																									
Rounded to Nearest Tenth																															

NOTE: DO NOT ENTER DECIMAL POINTS WHEN ENTERING C_i's.

THERMAL ANALYSIS

HOUSE NO. Two Story

Case #5

CORRECTION FACTOR = 0.25

AREA OF SOUTH FACING WINDOW
w/o STORAGE = 754

MONTH	SOLAR RAD ON HORIZ BTU/SF	HORIZ TO VERT	SOLAR RAD AVAIL* BTU x 10 ⁶	AUX HEAT LOAD BTU x 10 ⁶	CORR* † AUX LOAD
SEPT	39570	.88	.65	—	—
OCT	30039	1.28	.72	.05	—
NOV	14920	1.60	.51	4.21	3.7
DEC	12617	1.84	.44	8.10	7.00
JAN	13609	1.72	.44	8.82	8.38
FEB	20300	1.38	.53	6.43	5.90
MAR	31775	.98	.58	7.16	3.58
APR	42090	.71	.56	.62	.06
MAY	52669	.52	.51	—	—
JUN	50220	.47	.50	—	—
TOTAL = 29.28					

$$\frac{29.28 \times 10^6}{2020.5 \times 5041} = 1.48 \text{ BTU/SF/DD/HR}$$

* Col 3 = Col 1 x Col 2 x Corr. Factor x Area

** Col 5 = Col 4 - Col 3

PASSIVE SOLAR FINANCIAL EVALUATION

- A. Conventional House Costs \$
- B. Incremental Solar Costs \$
- C. Total Construction Costs
(C = A+B) \$
- D. Annual Heating Load Supplied
by Solar (from Page BTU's
 % of Load
- E. Annual Auxiliary Heating Load
(from Page BTU's
- F. Total Annual Heating Load
(F = D+E) BTU's
- G. Regional Assumptions
1. Economic Life Years
 2. Discount or Interest Rate %
 3. Real Energy Growth Rate %
 4. Average Cost of Conventional Fuel \$

H. To determine the annual energy savings from solar:

$$\frac{\text{Solar Load in BTU's (from D. Above)}}{\text{BTU Equivalency Factor} \times \text{Efficiency Factor (Table 1)}} = \text{Conventional Fuel Requirement}$$

$$\frac{\frac{3.14 \times 10^4 \text{ BTU's}}{3412 \text{ BTU's}} \times 1.0}{1.0} = 920.28 \text{ Load in kWh}$$

$$\text{Conventional Fuel Requirement} \times \text{Average Cost of Conventional Fuel (From G.4 Above)} = \text{Annual Energy Cost Savings in \$}$$

$$920.28 \text{ Load in kWh} \times \$.05 / \text{kWh} = \$ 46.01 / \text{Year}$$

- I. Select from Table 2 the appropriate Discount/Energy Growth Factor based on the discount rate, real energy growth rate, and economic life as determined in G. above. 22.97

To determine the present value of energy cost savings from the passive solar system:

Discount/Energy Growth Factor $\times$ Annual Energy Cost Savings in \$ = Present Value of Energy Savings from Solar

$$\begin{array}{ccc} \boxed{22.97} & \times \$ \boxed{46.01} & = \$ \boxed{10576.85} \\ \text{(From I)} & \text{(From H)} & \end{array}$$

- J. To determine the savings/investment ratio for the project:

$\frac{\text{Present Value of Energy Savings}}{\text{Incremental Solar Costs}} = \text{Solar Savings/Investment Ratio}$

$$\frac{\boxed{10576.85}}{\boxed{10571.66}} = \boxed{.999} \text{ SIR}$$

If the Savings/Investment Ratio is equal to or greater than 1, the system is cost effective and indicates that the project will return on capital at a rate greater than the discount rate.

This figure does not take into account considerations that would make the cost less expensive, such as tax incentives, deduction of interest payments and business depreciation, or considerations that can make it more expensive, such as property tax evaluation increases and fuel cost deductions (business expense).

References:

Life Cycle Costing Emphasizing Energy Conservation: Guidelines for Investment Analysis, September, 1976, ERDA Publication No. 76/130

ERDA Facilities Solar Design Handbook, August, 1977, ERDA Publication No. 77-65

PASCALC WORKSHEET

PROJECT SEPI - FINAL
 LOCATION OHIO
 DATE 13 MAY '80

UA_{ns} 409.32 Btu/hr⁰F A
 A_s 670 ft² R/S
 U_{np} 07 Btu/hr·ft²·°F R/S
 T_{set} 66 °F B
 Q 3333 Btu/hr R/S
 N 2 C

Case #6

PASSIVE SYSTEM	1. DG/NI
SYSTEM TYPE	2
SOUTH FRACTION	.29
SYSTEM "U"	.29 Btu/hrft ²⁰ F

D
R/S
R/S
R/S

2. WW/NI
4
.18
.18 Btu/hrft ²⁰ F

D
R/S
R/S
R/S

3.
Btu/hrft ²⁰ F

D
R/S
R/S
R/S

FACTORS \ MONTHS	1	2	3	4	5	6	9	10	11	12	1	2	3	4	5	6	9	10	11	12	1	2	3	4	5	6	9	10	11	12
a TRANSMITTANCE	10										10																			
b TILT/ORIENTATION	10										10																			
c ABSORPTANCE	90										90																			
d SHADING	10										10																			
e REFLECTOR	10										10																			
C _i = (a)(b)(c)(d)(e)	09	09	09	09	09						09	09	09	09	09															
Rounded to Nearest Tenth																														

DO NOT ENTER DECIMAL POINTS WHEN ENTERING C_i's.

THERMAL ANALYSIS

HOUSE NO. Two Story

CORRECTION FACTOR = 0.25

Case #6

AREA OF SOUTH FACING WINDOW
w/o STORAGE = 754

MONTH	SOLAR RAD ON HORIZ BTU/SF	HORIZ TO VERT	SOLAR RAD AVAIL* BTU x 10 ⁶	AUX HEAT LOAD BTU x 10 ⁶	CORR* † AUX LOAD
SEPT	39570	.88	.45	—	—
OCT	30039	1.28	.72	0	—
NOV	16920	1.40	.51	3.33	2.82
DEC	12617	1.84	.44	7.17	6.73
JAN	13609	1.72	.44	7.73	7.29
FEB	20300	1.38	.53	9.04	7.51
MAR	31775	.98	.58	2.73	2.15
APR	42090	.71	.56	.34	—
MAY	52669	.52	.51	—	—
JUN	56220	.47	.50	—	—
TOTAL = 33.50					

$$\frac{23.50 \times 10^6}{2420.5 \times 9641} = 1.59 \text{ BTU/SF/DD/TR}$$

* Col 3 = Col 1 x Col 2 x Corr. Factor x Area

** Col 5 = Col 4 - Col 3

PASSIVE SOLAR FINANCIAL EVALUATION

- A. Conventional House Costs \$
- B. Incremental Solar Costs \$
- C. Total Construction Costs
(C = A+B) \$
- D. Annual Heating Load Supplied
by Solar (from Page BTU's
 % of Load
- E. Annual Auxiliary Heating Load
(from Page BTU's
- F. Total Annual Heating Load
(F = D+E) BTU's
- G. Regional Assumptions
1. Economic Life Years
 2. Discount or Interest Rate %
 3. Real Energy Growth Rate %
 4. Average Cost of Conventional Fuel \$
- H. To determine the annual energy savings from solar:

$$\frac{\text{Solar Load in BTU's (from D. Above)}}{\text{BTU Equivalency Factor} \times \text{Efficiency Factor (Table 1)}} = \text{Conventional Fuel Requirement}$$

$$\frac{\text{5.78 x 10^4 BTU's}}{\text{3912 BTU's} \times \text{1.0}} = \text{1099.02 Load in KWH}$$

$$\text{Conventional Fuel Requirement} \times \text{Average Cost of Conventional Fuel (From G.4 Above)} = \text{Annual Energy Cost Savings in \$}$$

$$\text{1099.02 Load in KWH} \times \$ \text{.05 / KWH} = \$ \text{84.70 / Year}$$

- I. Select from Table 2 the appropriate Discount/Energy Growth Factor based on the discount rate, real energy growth rate, and economic life as determined in G. above. 22.97

To determine the present value of energy cost savings from the passive solar system:

Discount/Energy Growth Factor $\times$ Annual Energy Cost Savings in \$ = Present Value of Energy Savings from Solar

$$\boxed{22.97} \times \$ \boxed{84.70} = \$ \boxed{1954.56}$$

(From I) (From H)

- J. To determine the savings/investment ratio for the project:

$\frac{\text{Present Value of Energy Savings}}{\text{Incremental Solar Costs}} = \text{Solar Savings/Investment Ratio}$

$$\frac{\boxed{1954.56}}{\boxed{2015.49}} = \boxed{.97} \text{ SIR}$$

If the Savings/Investment Ratio is equal to or greater than 1, the system is cost effective and indicates that the project will return on capital at a rate greater than the discount rate.

This figure does not take into account considerations that would make the cost less expensive, such as tax incentives, deduction of interest payments and business depreciation, or considerations that can make it more expensive, such as property tax evaluation increases and fuel cost deductions (business expense).

References:

Life Cycle Costing Emphasizing Energy Conservation: Guidelines for Investment Analysis, September, 1976, ERDA Publication No. 76/130

ERDA Facilities Solar Design Handbook, August, 1977, ERDA Publication No. 77-65

FOUNDATION AND EXCAVATION

Note: All foundation and excavation work to be performed by others (unless otherwise specified) in accordance with local building codes and subject to inspection by local building officials.

All foundation work must be level and square.

Grade at time of delivery must be 24" from top of sill plate.

Provide termite protection where required.

Backfilling must be done on day of delivery prior to setting of house.

Adequate drainage must be provided.

Stoops and steps must be poured after house is set.

MISCELLANEOUS METAL

Continuous aluminum ridge vent to be installed along top of roof as indicated. Provide weather guard with weep holes.

Nail 20 gauge, 1" X 6" metal stops to both sides of alternate trusses at roof ridge as indicated.

Hurricane straps; Simpson H 2.5 or equal; Simpson Company, San Leandro, Calif. 94577.

Metal Straps; Simpson ST. 2115 or equal, Simpson Company, San Leandro, Calif. 94577.

Corrugated aluminum sheet, 12" wide.

Ductwork:

Main branch: Square ducts @ 24 gauge sheet metal or equal with rigid insulation cover.

Secondary

branch: Round ducts @ 24 gauge (except when flexible duct is used) to be insulated with fiberglass batt taped to duct.

CARPENTRY, MILLWORK AND ROOFING

Solarium: roof and exterior wall

2" X 8" roof rafters, S.Y.P. #2 K.D. @ 24" o.c. nailed to modular building with 6@ 10d nails, one side.

Use ½" exterior grade plywood roof sheathing fastened with 8d nails @ 12" o.c. field, 8d nails @ 6" edge.

Use 235# seal-down asphalt shingles fastened with 7/8" galvanized nails over lapped 15# A.S. felt.

6" batt insulation to be installed as per manufacturer's specifications.

2" rigid insulation ("R"11) to be installed as per manufacturer's specifications.

2" X 4" exterior wall @ 16" o.c. 2-2" X 4" post between all windows, nailed to 2" X 4" base plate.

Modular Building: roof and exterior wall

Use 2" X 4" gangnail roof trusses @ 2'-0" o.c.

Use ½" exterior grade plywood roof sheathing fastened with 1½" staples 4" o.c. edge, 8" o.c. field.

Use 235# seal down asphalt shingles fastened with 7/8" galvanized nails overlapped 15# A.S. felt.

Siding:

Beams: 2" X 12". See 1st and 2nd floor plans. To be glued and nailed to trusses with 6-16d nails @ each truss.

Use 3/8" exterior plywood on all-weather upson sheathing, as indicated, glued and stapled with 1½" staples, 4" o.c. edge, 8" o.c. field.

LOWER BOX GENERAL CONSTRUCTION

Perimeter joists to be 2-2" X 10" with ½" plywood filler, glued and nailed with 16d nails @ 8" o.c. staggered.

Floor joists to be 2" X 10", #2 S.Y.P. or hemlock @ 16" o.c.

Joist hangers to be 18 gauge

Ceiling joists to be 2" X 6" @ 16" o.c., S.Y.P. #2

Beam, 2-2" X 6", S.Y.P. #2 glued to perimeter joist and nailed with 6-16d nails.

UPPER BOX GENERAL CONSTRUCTION

Perimeter joists to be 2-2" X 8" with ½" plywood filler, glued and nailed with 16d nails @ 8" o.c. staggered.

Floor joists to be 2" X 8", SYP #2 or hemlock @ 16" o.c.

Joist hangers to be 18 gauge.

Beam 2-2" X 8", SYP #1 glued to perimeter joist and nailed w/6-16d nails.

FINISHES

Drywall on exterior walls to be ½" foil-backed glued and nailed.

Drywall on ceilings (except lower level) to be ½" foil-backed glued and nailed @ 9" o.c. field, 7" single=nailed @ joints.

Interior drywall to be ½" glued to studs and nailed.

All drywall to be painted with two coats of primer paint

All drywall to be treated with Gold Bond Quick-Weld system.

Drywall in garage to be 5/8" firecode on all surfaces adjacent to living spaces.

All trim to be prefinished.

Finished floor to be F.H.A. approved; vinyl linoleum (stapled) or carpet and pad, as per finished schedule.

Ceramic tile to be thin set and installed as per recommendations of the Tile Council Handbook, latest edition.

SPECIALTIES

Return air duct to be 12" diameter round insulated duct. Install under batt insulation in unheated attic space

Damper to be located at air intake.

Mechanical control assembly, room bi-pass assembly, model LS-MB low pressure, 21" X 22" X 20" motor controlled; Titus Products, Kopper's Company, Inc.

Thermal shades to be Insulating Shade Company, Inc. IS High "R" shade recommendations. Standard head, standard jambs, and pull chair mechanism (or equal) to be by IS company, P.O. Box 282, Branford, Ct., 06405. Installed at windows as per drawings, according to manufacturers.

Fireplace to be heatilater zero clearance (or equal) as manufactured by Veg Industries. Fireplace and component to be listed by Underwriters Laboratories.

Fireplace to have outside air intake.

Fireplace to be constructed as a single complete assembly, including damper and fire screen, plus a separate chimney starter section. Each component shall be a complete assembly readily attachable to each other appropriate component.

Installation shall be in accordance with fireplace manufacturer's instructions.

Exhaust fan - 10 DN 8 X 700 CFM - 15½" X 14½" with louvres = LWL 12 exterior cover by Powerline Fan Company, Division of Allied Thermal Corp., New Britain, Ct., 06050

Canvas Awning - Harosol 4200, Roll-up awning system, hand-operated 10'-0" in length, by Hamel, Inc., 999 Airport Road, Lakewood, New Jersey, 08701.

GENERAL CONSTRUCTION

1-2" X 6" plate, site installed @ location between upper and lower box.

Exterior walls to be 2" X 6" @ 24" o.c.

Interior partitions to be 2" X 4" @ 16" o.c. nailed to 2" X 4" bottom plate.

Marriage wall, 2-2" X 3" @ 16" o.c. nailed to 2" X 4" plate.

Subfloor to be 3/4" C.D. exterior glue T. and G. plywood, fastened with glue and nailed @ 6" o.c. edge, 10" o.c. field.

Header over exterior openings to be 2-2" X 6" with 2½" on blocking, nailed with 16d nails, unless otherwise indicated.

All windows to be Anderson Perma-shield as per window schedule, installed as per manufacturer's specifications.

All glue, PFS tested construction adhesive.

Plywood indexes to be as follows: 3/8" - 24/0; ½" = 32/16; 3/4" - 48/24.

Fixed glass to be insulating glass

All exterior doors, steel craft and perma-door as per door schedule.

All interior doors, hollow core, prehung units as per door schedule.

All exterior doors and windows to be fully caulked and weather stripped.

Use Conwed Sill Sealer by Conwed Corporation, or equal, at all sills and plates as per manufacturer's specifications.

Install all insulation as per drawings in accordance with manufacturer's specifications.

High density foam board to be installed behind all 3" X 10" ducts in 2" X 6" exterior walls. Use Rmax thermashield, 2½" @ "R" 20 by Rmax, Inc., Dallas, Texas, 75240.

Perimeter joists @ exterior wall opening: size varies; for sizes, see 1st floor plan, drawing 3.

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Vandalia, Ohio 45377

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material specifications

scale: NO SCALE
date: 22 JULY 80

PASSIVE SOLAR HOME

water supply diagram

NOTE:
NO AND SOME MAY NOT VENTED AS PER CODE.

sanitary riser diagram

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PASSIVE SOLAR HOME

**Plumbing
Diagrams**

scale: NO SCALE
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NOTE:
 DRAWN TO BE SIZED SO THAT DUCT OPENING
 IS LARGER THAN DUCT TO SOLARium.

SCHEMATIC MECHANICAL LAYOUT

--- DUCT BELOW FLOOR - IN CRAWL SPACE
 --- DUCT IN CEILING / FLOOR OF BOX

SCHEMATIC MECHANICAL LAYOUT

Electrical Layout

SYMBOL	DESCRIPTION
	light fixture
	bath fan
	duplex receptical 120 V.
	duplex receptical 1/2 switched 120 V.
	240 V. outlet
	light w/ pull chain
	switch
	three-way switch
	doorbell transformer
	doorbell chimes
	doorbell switch
	smoke detector - heat & smoke activated
	four-way switch

NOTES:

All wire to be Romex type N-M non-metallic sheathed cable 600 V.
 If range has self-cleaning oven, amps to be (60).
 All electrical material is to have Underwriters Laboratories, Inc. approval and be installed to National Electric Code.
 200 amp service panel to be by Federal Pacific Electric Co.

Electrical Schedule

symbol	description	wire size	amps	volts	symbol	description	wire size	am	
①	lights	14	15A	120	①2	dishwasher	12	20A	120
②	lights	14	15A	120	①3	dryer	10	30A	240
③	lights	14	15A	120	①4	DHWH	10	30A	240
④	lights	14	15A	120	①5	furnace			
⑤	lights	14	15A	120	①6	air conditioner			
⑥	small appliances	12	20A	120	①7	lights	14	15A	120
⑦	small appliances	12	20A	120	①8	general use	12	20A	120
⑧	GFI	12	20A	120	①9	general use	12	20A	120
⑨	small appliances	12	20A	120	②0	lights	14	15A	120
⑩	general use	12	20A	120	②1	general use	12	20A	120
11	range	6	40A	240	②2	lights	14	15A	120
					②3	GFI	12	20A	120

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Electrical Layout

scale:
 date:

PASSIVE SOLAR HOME

Electrical Layout

Building Section A-A

SCALE: 1/2" = 1'-0"

Detail 2/9

SCALE: 1" = 1'-0"

Detail 1/9

SCALE: 1" = 1'-0"

Building Section B-B

SCALE: 1" = 1'-0"

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Details

scale: SEE DRAWING
date: 20 MAY 1980

PASSIVE SOLAR HOME

a

North Elevation

West Elevation

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Elevations

scale: 1/4" = 1'
date: 20 MAY '80

South Elevation

East Elevation

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Elevations

scale: 1/4" = 1'-0"
date: 20 MAY 80

PASSIVE SOLAR HOME

Second Floor Plan

PASSIVE SOLAR HOME

Second Floor Plan

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scale: 1/4" = 1'-0"
date: 20 MAY 80

First Floor Plan

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First Floor Plan

scale: 1/4" = 1'-0"
date: 20 MAY 80

PASSIVE SOLAR HOME

643-1

July 23, 1980

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scale: NO SCALE
date: 28 MAY '80

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