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ABSTRACT

This pamphlet offers a preview of information services available from Solcost, a research and development project. The first section explains that Solcost calculates system and costs performance for solar heated and cooled new and retrofit constructions, such as residential buildings and single zone commercial buildings. For a typical analysis, Solcost calculates the portion of load supplied by solar, the optimum size for the collector, and the payback period for the solar system investment compared to a conventional system. An example is given of an analysis for a residence. Titles and sources of Solcost handbooks are listed. The second section introduces the operational and technical details for those familiar with solar system engineering and computer technologies. (Author/MLF)

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Solcost

Solar Hot Water Handbook

A simplified design method for sizing and costing residential and commercial solar service hot water systems

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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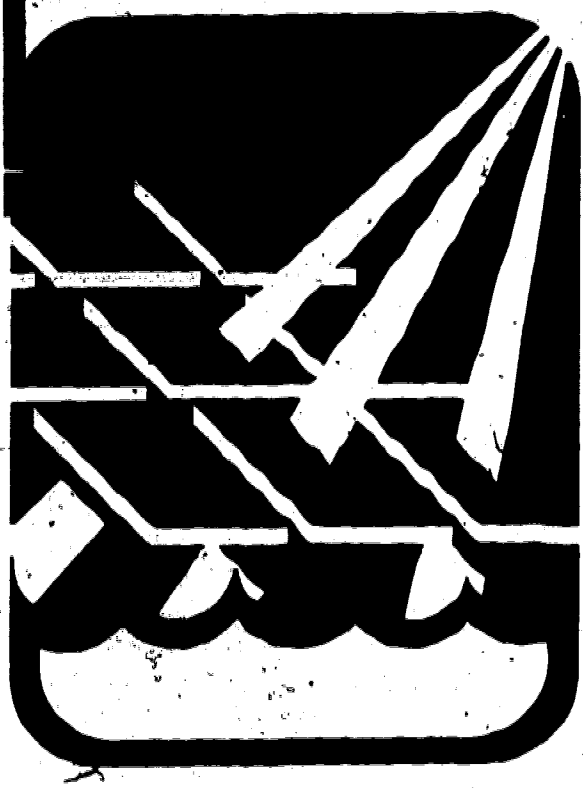

Second Edition

Energy Research and Development Administration
Division of Solar Energy
Technology Transfer
Washington, D.C. 20545
September 1977

Who can use SOLCOST?

Contractors/Builders
HVAC Engineers
Architects/Designers
Manufacturers/Suppliers
Educators
Researchers
Mortgage Lenders/Bankers

You can use SOLCOST with or without a background in engineering and/or computer technology.

Section I — Introduction
Introduces you to SOLCOST — how it can be used and what SOLCOST can do.

Section II — Technical Details
Introduces the operational and technical details for those familiar with solar system engineering and computer technologies.

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Section I — Introduction

What can SOLCOST do?

For Design and Financial Uses

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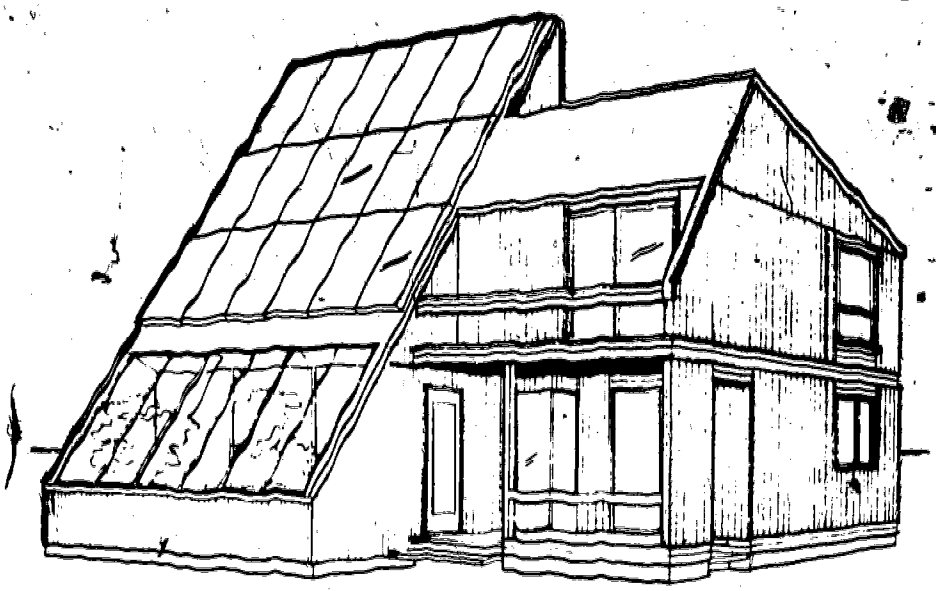
SOLCOST calculates system and costs performance for solar heated and cooled new and retrofit constructions, such as:

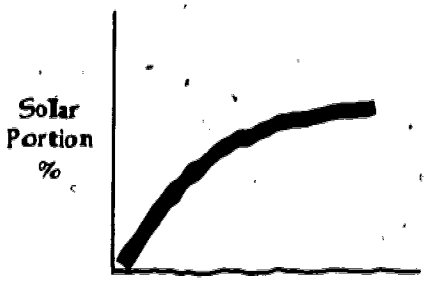
- **Residential buildings**
- **Single zone commercial buildings**

SOLCOST can:

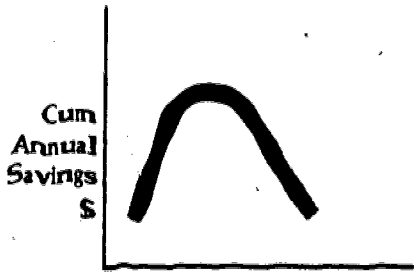
1. Show optimum size and performance characteristics for solar heating, cooling, and service hot water systems
2. Show the cost comparison between solar and conventional systems
3. Perform heat loads analysis for buildings (optional)



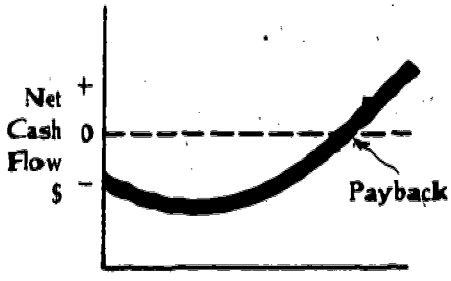
For a typical analysis, SOLCOST calculates the portion of load supplied by solar,



the optimum size for the collector,



and the payback period for the solar system investment compared to a conventional system.



For research and development

SOLCOST can be used for comparative energy and economic analysis for:

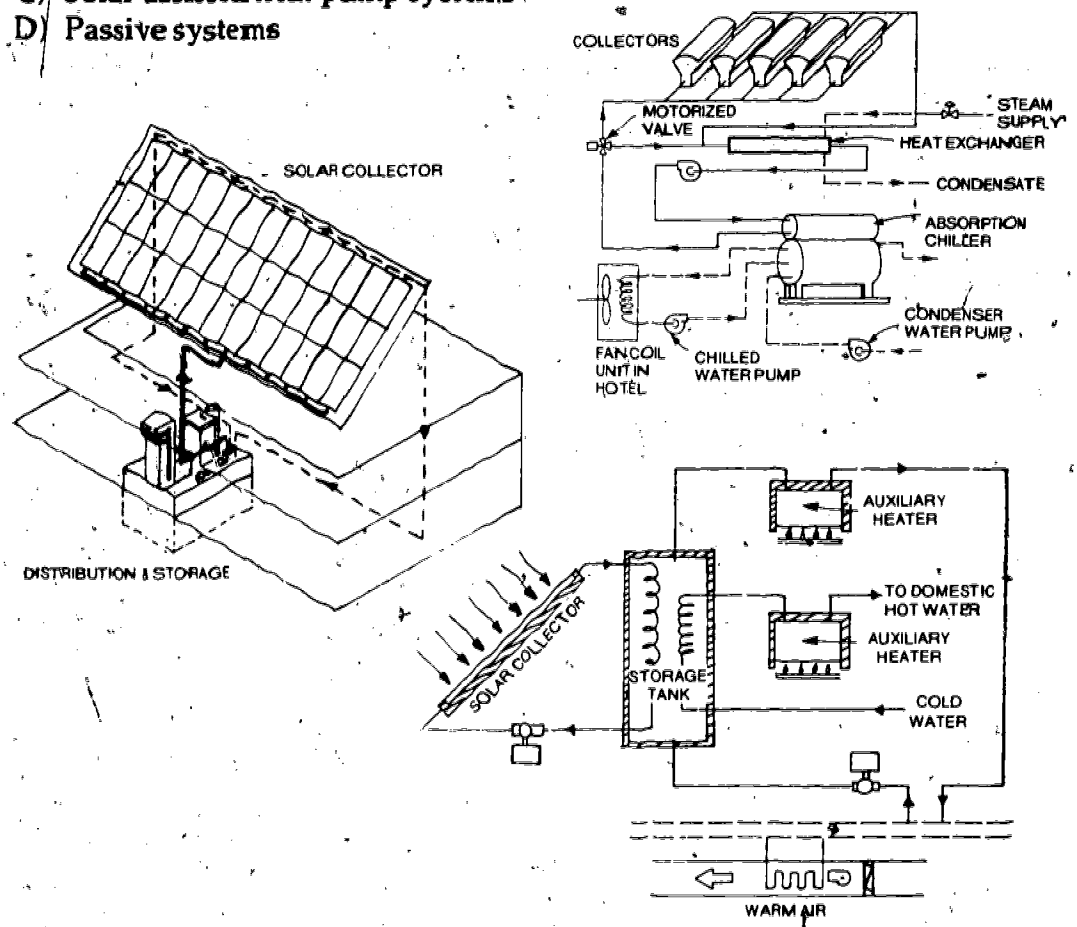
- **Geographic Regions**
- **Different HVAC/Solar Systems**
- **Energy Alternatives**

SOLCOST can:

Show the cost of the optimum solar system in terms of annualized — dollars per million BTU.

Types of solar systems evaluated by SOLCOST

A) Space and domestic water heating systems with air or liquid collectors
B) Absorption cycle air conditioning systems
C) Solar assisted heat pump systems
D) Passive systems



Solar Collector Types Available in SOLCOST

1. SOLCOST can evaluate any flat plate collector for which the efficiency is known.
2. SOLCOST can evaluate one-axis tracking and evacuated tubular type collectors.

How can SOLCOST be used?

If you do not have background in computer technology, The SOLCOST Handbook *will provide all the assistance you need.*

If you have a familiarity with computers, The SOLCOST Users' Guide explains how SOLCOST can be used by remote terminal on National Timesharing Networks*

CYBERNET (Control Data Corporation) or
GEIS (General Electric Information Service)

To obtain

- **The SOLCOST Solar Heating Handbook** ***with Building Heat Load Analysis (Conservation)***
- **The SOLCOST Solar Heating and Cooling Handbook** ***with Absorption Cycle Cooling***
- **The SOLCOST Solar Heating Handbook** ***with Solar Boosted Heat Pump***
- **The SOLCOST Solar Passive Heating Handbook**
- **The SOLCOST Solar Hot Water Handbook**
- **The SOLCOST Users' Guide**

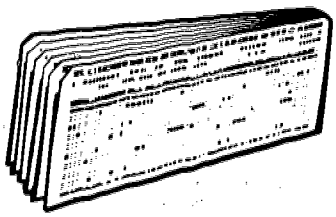
contact:

International Business Services, Inc.
Solar Group
1010 Vermont Avenue
Washington, D.C. 20005
Tel: (202) 628-1450

SOLCOST software copies are also available.

To obtain

- SOLCOST Software (FORTRAN IV for CDC, IBM, UNIVAC)
- SOLCOST Technical Reference Manual



or for immediate SOLCOST engineering design service, contact:

Solar Environmental Engineering Co., Inc.
SOLCOST Service Center
P.O. Box 1914
Ft. Collins, Colorado 80522
Tel: (303) 221-4370

* Users' Guides for remote terminal operations will also be available from CYBERNET and GEIS Sales Representatives as of August, 1977.

An Example of SOLCOST Use for Residential Homeowner*

INPUT

Input Parameter	User Input
Solar System Type	1
Fuel Type for Reference Heating System	2
Fuel Type for Solar Auxiliary Heating System	2
Collector Type	3
Collector Tilt Angle	55. (Degrees)
Collector Azimuth Angle	+10. (Degrees)
Site Location	DENVER
Building Heat Loss Coefficient	8.3 (BTU/Sq. Ft./Deg.-Day)
Building Floor Area	1950. (Sq. Feet)
Solar System Fixed Initial Cost	$1000.
Solar Collector Installed Cost/Sq. Ft.	$12.00
Loan Interest Rate	.09 (9 percent)
Loan Term	20. (Year)
Loan Down Payment	.22 (22 percent)
Property Tax Rate	.02 (2 percent)
Income Tax Rate	.30 (30 percent)
Inflation of Maint., Insur. Property Taxes	.04 (4 percent)
Present Electricity Cost $/Kw-hr	$.0
Electricity Cost Escalation Per Year	.10 (10 percent)

Explanation of Selected Input Values

Solar System Type
This input parameter covers different types of solar systems used for heating & cooling of buildings. For example, the indicator (1) above signifies space heating with liquid collectors, collector/storage heat exchanger, fan coils or air duct heat exchanger systems.

Fuel Type for Reference (Conventional) Heating System
Fuel types include natural gas, electricity, fuel oil, LP gas and coal. When you input an indicator (2) as above, it means electricity is the fuel used for the reference or conventional heating system.

Fuel Type for Solar Auxiliary Heating System
These fuel types are usually the same as those for the reference heating system input parameter — natural gas, electricity, fuel oil, LP gas and coal. The indicator (2) represents electricity.

Collector Type
All collector types including liquid, air, evacuated tube, and others can be defined by this parameter. The indicator (3) represents a liquid, flat plate, 1 cover, selective absorber collector.

OUTPUT

COLLECTOR SIZE OPTIMIZATION BY SOLCOST

Collector type = flat plate 1 glass selective
Best solar collector size for tilt angle of 55 degrees is 400 sq. ft.
Solar costs = 1000 fixed + 4800 collector + 900 storage
Input conventional system costs = 0
Initital solar investment = $6700 Down payment = $1500
Financial scenario — residence

CASH FLOW SUMMARY

Yr.	(A) Fuel/Utility Savings	(B) Maint. + Insur.	(C) Property Tax	(D) Annual Interest	(E) Tax Savings	(F) Loan Payment	(G) Net Cash Flow
							-1500 (Down Paymen
1	500	70	135	468	181	570	-94
2	550	73	140	459	180	570	-53
3	605	76	146	449	178	570	-8
4	665	79	152	438	177	570	42
5	732	82	158	426	175	570	98
6	805	85	164	413	173	570	159
7	886	89	171	399	171	570	228
8	974	92	178	384	168	570	303
9	1072	96	185	367	166	570	387
10	1179	100	192	349	162	570	480
11	1297	104	200	329	159	570	582
12	1427	108	208	307	155	570	696
13	1569	112	216	284	150	570	821
14	1726	117	225	258	145	570	960
15	1899	121	234	230	139	570	1113
16	2089	126	243	199	133	570	1283
17	2297	131	253	166	126	570	1470
18	2527	136	263	130	118	570	1676
19	2780	142	273	90	109	570	1904
20	3058	147	284	47	99	570	2156
Totals	28637	2086	4020	6192	3064	11400	12703

Payback time for fuel savings to equal total investment	8.9 years
Payback time for net cash flow to equal down payment	9.9 years
Rate of return on net cash flow	16.3 percent
Annual portion of load provided by solar.	72.0 percent
Annual energy savings with solar system	91.3 million btus

Tax savings = income tax rate x (C + D)
Net cash flow = A — B — C + E — F

* Similar calculations can be made for businesses and non-profit organizations where special considerations such as depreciation and tax deductions are accounted for.

Section II — Technical Details
Operation of SOLCOST

SOLCOST calculates and compares life cycle costs of a solar system versus a reference (conventional) HVAC system.

The approach used is to perform one day long computations for each month of the year. This computation utilizes historical weather data including minimum and maximum temperatures, average degree days, and percent sunshine values.

Solar and weather data required for the solar analysis is stored in SOLCOST for 124 cities in the U.S. The user accesses this data simply by entering a three letter code for the city nearest his location.

Figure 1, below, shows the flow chart for the SOLCOST analysis which computes the cost optimized solar collector size. Three types of analysis are coupled together in SOLCOST to evaluate active solar collection systems. They are:

(a) A building heating/cooling loads analysis
(b) A life cycle cost analysis
(c) The solar collector/system performance analysis

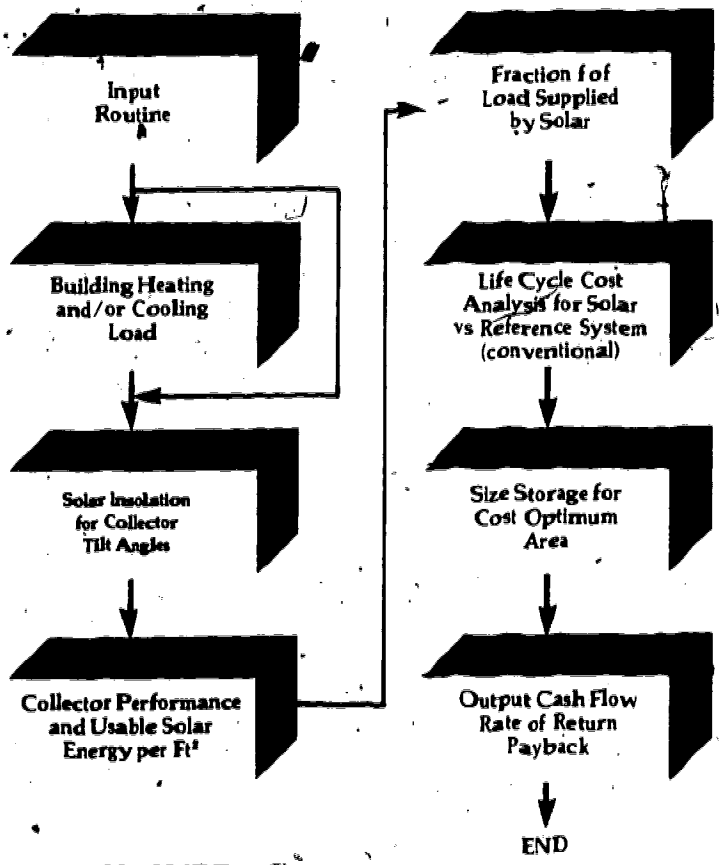


Figure 1: SOLCOST Flow Chart

SOLCOST Analysis options

Given the appropriate input data, SOLCOST can make the following analyses:

Type of Analysis	Input Data	Output
Standard solar analysis	A) Physical description of building B) Cost and performance details for the proposed solar system	• Cost optimum collector area • Tilt angle • Storage size • Heating and cooling loads • Payback • Rate of return • Detailed cash flow for cost optimum area
Collector Trade Study Analysis	User specifies up to three collector types	• Program outputs cost optimum area for each type (payback or internal rate of return determines best choice.)
Financial analysis • Homeowners • Business/Investor owners • Non-profit institutions	Complete solar system definition including loads and collector area	• SOLCOST computes system performance and generates a detailed life cycle cost analysis for the input collector size. • Calculations include tax and depreciation deduction in the cases of business and non-profit organizations.
Passive structure analysis	Passive structure description	• Program estimates annual fuel requirements based on a transient analysis which uses "average" conditions for the 15th day of each month.

SOLCOST Space Heating and Cooling Loads Calculation

The user has a choice of entering his own estimate of heating and/or cooling loads, or using one of the following four methods available in SOLCOST:

1. Entry of annual fuel usage records and existing HVAC system description by the retrofit user. SOLCOST will estimate space heating loads using reasonable assumptions on equipment deficiencies.

2. Specification that the building will meet ASHRAE Standard 90-75 energy conservation in new building design. The user inputs the building dimensions and SOLCOST computes the overall thermal conductance which meets the ASHRAE standard. Inputs required from the user for the ASHRAE Standard 90-75 method are floor area, window area and exterior wall areas.

3. User input of the building UA in BTU/hr-°f. This approach assumes that the user (or his engineer) has analyzed his building with a conventional loads calculation procedure such as the method described in the ASHRAE Handbook of Fundamentals.

4. Thermal network solution in SOLCOST. For the user who needs a complete loads calculation, SOLCOST uses a thermal network which has been pre-defined in the program. From the user's description building, SOLCOST sets the appropriate conductor values and control constants for the network solution to proceed. The network accounts for all modes of heat transfer including radiation, convection, and conduction. Thermal capacitance of the structure is modeled with diffusion nodes having thermal capacitance. The standard analysis solves the network rapidly with a steady rate method to find a design heat loss rate which is then used with degree days to estimate the heating load. The passive analysis solves the network for transient conditions to estimate energy requirements.

Domestic hot water loads calculation

The user has a choice of entering his domestic hot water heating load directly (in BTU's per day) or using one of the following methods available in SOLCOST.

1. Retrofit users enter fuel usage records and a description of the existing hot water heating equipment. SOLCOST will estimate a hot water load using reasonable assumptions for the equipment efficiency.

2. User specifies residential application and enters number of occupants. SOLCOST estimates hot water demand based on average residential usage data.

Sample cash flow output

Internal rates of return on the investment before and after taxes are computed and printed on the cash flow output sheet. This rate of return is the interest rate which makes the present worth of the cash flow in time equal to the initial investment. This interest rate gives the user a yardstick which he can use to compare the relative merit of the solar investment against other possible investments.

Simple payback periods on the solar investment before and after taxes are also printed on the output sheet. The payback period is the number of years required to generate a cumulative savings (due to reduced fuel costs) which equals the initial outlay for the solar system. The user is cautioned that the payback method neglects the "time value" of money (a dollar in hand today is worth more than a dollar generated in fuel savings five years from now).

☆ U.S. Government Printing Office: 1977—244-755/6558

SOLCOST is a Research and Development Project of the Division of Solar Energy

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Denver Division
P.O. Box 179, Mail Stop 0484
Denver, Colorado

Testing and validation:
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P.O. Box 1914
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