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PERFORMANCE AND ECONOMICS OF EIGHT ALTERNATIVE SYSTEMS FOR RESIDENTIAL HEATING, COOLING, AND WATER HEATING IN 115 U.S. CITIES

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ACRONYMS AND INITIALISMS

AC	air conditioner
ACES	annual cycle energy system
ACOP	annual coefficient of performance
ARI	Air-Conditioning and Refrigeration Institute
A.S.	air source
COPC	cooling coefficient of performance
COPH	heating coefficient of performance
COP	coefficient of performance
DF	degradation factor
DSWH	desuperheater water heater
EER	energy efficiency ratio
FYC	first-year energy cost of HVAC system
FOM	figure-of-merit
GWH	gas water heater
HVAC	heating, ventilating, and air conditioning
I^2R	electric resistance water heater
PV	present value
PVC	polyvinyl chloride
PWF	present worth factor
SEER	seasonal energy efficiency ratio
SPFC	seasonal performance factor in cooling
SPFH	seasonal performance factor in heating

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ABSTRACT

This study updates the results of a previous report, ORNL/CON-52, to take into account the effects of 1981 costs and technology on the performance and economics of five electrically driven heating, ventilating, air-conditioning, and water-heating systems for residences. In addition, the present study extends the analysis to include three fossil-fuel-fired systems. Current life-cycle costs and annual efficiencies are presented for 115 cities in the United States for each of the following residential systems: (1) an electric furnace, central air conditioner, and electric resistance water heater; (2) a high-performance air-to-air heat pump with electric resistance water heater; (3) a high-performance air-to-air heat pump with desuperheater water heater; (4) a minimum annual cycle energy system (ACES) of the brine-chiller type; (5) a full ACES of the brine-chiller type; (6) an advanced gas furnace, central air conditioner, and gas water heater; (7) an oil furnace, central air conditioner, and electric resistance water heater; and (8) a pulse gas furnace, central air conditioner, and gas water heater. Of the electrically driven systems, the full ACES is found to exhibit the highest annual efficiency and the highest life-cycle costs for most regions of the nation. The gas furnace system generally exhibits lower life-cycle costs than any of the other residential heating, ventilating, and air-conditioning systems and yields reasonably good annual efficiency.

1. INTRODUCTION

This study supplements ORNL/CON-52, *Performance and Economics of the ACES and Alternative Residential Heating and Air Conditioning Systems in 115 U. S. Cities*, which compared the efficiencies and life-cycle costs of five different electrically driven systems that supply space heating, air conditioning, and water heating to a single-family residence.[1] In the present study these costs and performance factors are calculated using January 1981 cost and technology data, and the new life-cycle costs of these systems in different U.S. cities are determined. Comparing the 1979 and 1981 life-cycle costs of the electric heating, ventilating, and air-conditioning (HVAC) systems will show how rising equipment and power costs have affected the relative economics of these efficient systems.

The present study extends the HVAC systems comparisons to include three advanced fossil-fuel systems that are commercially available or soon will become so: (1) a high-efficiency, pilot-free gas furnace that has automatic venting, a central electric air conditioner, and a well-insulated, energy-efficient gas water heater; (2) a vented floor furnace operating on No. 2 heating oil, a central electric air conditioner, and an energy-efficient elec-

tric water heater; and (3) a high-efficiency advanced pulse gas furnace, a central electric air conditioner, and a well-insulated, energy-efficient gas water heater. This study will clearly reveal the economic competitiveness of fossil-fuel systems vis-à-vis electrically driven systems throughout the United States.

The two-year period since the previous study (ORNL/CON-52) has been a time of rapidly changing economic conditions, characterized by a 27% rise in the consumer price index and sharp increases in all energy prices. In addition, deregulation is beginning to cause the price of natural gas to rise in relation to other fuels. Because energy prices (in constant dollars) are still in a state of flux, we present two types of life-cycle costs in this study. The first type, average life-cycle cost, is based on the price a consumer must actually pay for energy. The utility determines the price of energy from estimates of required revenues, averaged over its old and new plants, needed to defray the fixed and variable costs of the utility and to provide equitable profit. On the other hand, the marginal price is the price of energy from new plants only, built at today's costs; this price is used in computing the marginal life-cycle costs of the alternative HVAC systems.

This study differs slightly from the previous one in some details. The period of analysis was increased from 20 to 25 years and the real discount rate was changed from 2 to 3.5%/year. Modifications were also made in the estimations of system performance, including the use of higher insulation values for water heaters and higher Air-Conditioning and Refrigeration Institute (ARI) ratings that reflect improved heat pumps and air conditioners.[2]

The sources of cost data are the same as those for the previous study. Materials and labor costs for installation are obtained from publications of the R. S. Means Company, Inc., and energy costs are obtained from published government surveys.[3-6] The prices of components and equipment for the eight HVAC systems are obtained primarily from the *Sears Fall Winter 1980 Catalog*, which contains readily verifiable prices and equipment available throughout the United States.[7] References to specific manufacturers, trade names, and distributors are for convenience and do not constitute endorsements.

2. METHODS OF HVAC SYSTEMS COMPARISON

2.1 Problem Definition

The energy services that the eight heating plants can supply to a single-family residence vary widely. Two of the plants, the minimum and full ACESs, can supply space heating, space cooling, water heating, and possibly refrigeration. The electric resistance and fossil-fuel furnaces can supply only space heating. The air-to-air heat pump can deliver both space heating and space cooling, and the heat pump with a desuperheater water heater can supply space heating, space cooling, and water heating. To evaluate and compare such disparate plants, a common set of deliverable energy services must be defined. For this study, these services are space heating, space cooling, and domestic hot water production. Each home-heating plant has auxiliary equipment to be used as needed for supplying these services. The life-cycle costs and efficiencies of the overall systems are then calculated and compared.

The heating and cooling requirements of a single-family house depend on the quality of construction, the climate, and the occupants' life-style. In this study, the computer program MAD computes the monthly energy services required by a typical single-family house in different regions of the country.[8] The reference house is typical of well-insulated dwellings currently being built.[1] The MAD program, which uses data for the dwelling's location (i.e., solar intensity, outdoor air temperature, wind speed, and ground temperature) in computations of building loads and HVAC system energy consumption, has been verified by field tests of conventional and advanced electric HVAC systems in a house in Knoxville, Tennessee.

The reference house, for which MAD computes the heating and cooling loads, is a 167-m^2 (1800-ft^2), single-family, frame dwelling that has a thermal envelope of the type now commonly being built to conserve energy. The floors and exterior walls are insulated to a nominal thermal resistance of 3.35 $m^2 \times$ °C/W, or 19.0 $ft^2 \times$ °F $\times$ h/Btu (R-19). Half of the roof area is over a cathedral ceiling and insulated to a thermal resistance of R-19. The flat ceiling under the remaining portion of the roof area is insulated to a thermal resistance of R-38. The windows and glass doors have double-pane glass, and the building is equipped with storm doors. The hot water consumption rate is 300 L/d (80 gal/d), corresponding to that of a typical family, and heat from lights and appliances is assumed to be supplied at a rate of 1040 W (3548 Btu/h). Indoor temperatures are maintained at 21°C (70°F) during the heating season and 25.5°C (78°F) during the cooling season. The major assumptions affecting calculation of the building's thermal loads are given in Tables 1 and 2.

Table 1. Description of single-family reference house

Foundation (10.36 $\times$ 10.97 m)	Full basement
Floor area (with mezzanine second floor), m^2	167
Ceiling area, m^2	107.3
Window area, m^2	11.06
Floor (nominal thermal resistance), $m^2 \times$ °C/W	3.35
Half ceiling area (nominal thermal resistance), $m^2 \times$ °C/W	3.35
Half ceiling area (nominal thermal resistance), $m^2 \times$ °C/W	6.70
Walls (nominal thermal resistance), $m^2 \times$ °C/W	3.35
Window type	Double glazed
Storm doors	Yes
Heated garage	No

Table 2. Assumed building and occupancy characteristics

Window-shading factor	0.42
Absorption coefficient, outside walls	0.78
Absorption coefficient, roof	0.87
Internal heat sources, W	1040
Air infiltration,[a] air changes/h	1.15
Number of occupants, adults/children	2/2
Winter	
Indoor air temperature, °C	21
Occupant sensible heat emission, W/adult	87.9
Indoor relative humidity control	None
Summer	
Indoor air temperature, °C	25.5
Occupant sensible heat emission, W/adult	64.5
Occupant latent heat emission, W/adult	58.6
Extraneous moisture sources (water), kg/d	2.27
Maximum indoor relative humidity, %	52

[a]Air infiltration normalized to 1.15 changes per hour at conditions of 24 km/h wind speed and a 38.8°C temperature difference across the building thermal envelope.

2.2 Computer Program MAD

2.2.1 Description

The MAD computer program for calculating the thermal loads of a single-family, frame house and the annual energy consumed by its HVAC system in supplying standard amenities of space heating, space cooling, and water heating is detailed in ref. 8. The program calculates the required capacities of eight different HVAC systems (five electric and three fossil fuel) and their components for meeting the design-day loads of a specific house design and local climatic conditions. Performance simulation models and economic analysis models for each system are built into the MAD program enabling calculation of monthly power consumptions, annual coefficients of performance (COPs), initial system costs, and life-cycle costs. This report does not propose to detail all the algorithms employed in the program; the methods and assumptions used in the calculation are briefly described here, and more detailed information is given in the program listing in Appendix B.

2.2.2 Revisions

Several changes have been made in the MAD computer program since publication of ref. 1.

ACES heat exchanger coil length. The computation of the ice bin heat exchanger coil length in ref. 1 was based on the assumption that the thermal conductivity of the coil material is approximately equal to that of ice. This assumption unnecessarily restricts the choice of materials and precludes the use of inexpensive plastic tubing. Therefore, the coil-sizing procedures of Subroutine ACECOS of MAD have been changed to allow the use of any

arbitrary material (e.g., plastic or copper tubing). The program requires data for the thermal conductivity of the material selected, the inner and outer diameters of the tubing, and the tube's cost per unit length. This program revision increases by about 30% the calculated length of plastic (but not copper) tubing required in the ice bin.

Storage bin height. The dimensions of the ACES ice storage bin are calculated in subroutine DIGEST. In the current version of the program, the required height of the bin has been increased by 15 cm (6 in.) to provide free space between the water level and the underside of the bin cover. This freeboard space allows room for anchoring the bin liner, as described in the ACES design manual.[9] This program change increases the calculated first cost of both the minimum and full ACESs over that reported in ref. 1.

2.3 Systems Performance Simulation Models

This section briefly describes the performance simulation models used in the MAD computer program for calculating the annual energy consumptions of the following HVAC systems: (1) an electric furnace, central air conditioner, and electric resistance water heater; (2) a high-performance air-to-air heat pump with an electric resistance water heater; (3) a high-performance air-to-air heat pump with a desuperheater water heater; (4) a minimum brine-chiller-type ACES; (5) a full brine-chiller type ACES; (6) an advanced gas furnace, central air conditioner, and gas water heater; (7) an oil furnace, central air conditioner, and electric water heater; and (8) a pulse gas furnace, central air conditioner, and gas water heater. A more complete description of these systems is in ref. 1, and the MAD computer program is listed in Appendix B of this report.

2.3.1 Electrical Systems Efficiencies

Resistance water heater. The electric water heater used with systems 1, 2, and 7 is assumed to be in an unconditioned space of the building. The unit is a Kenmore Power Miser 10; it has a 200-L (52-gal) capacity and a pressure relief valve. The electric water heater is described in ref. 7 (p. 1145), which states that the estimated annual energy cost of the unit, for 450 gal/week of water and a 32°C (90°F) temperature rise, is $287 at an assumed power rate of 4.97¢/kWh. Calculated from these data, the unit's efficiency is 89%. For the hot water delivery rate, 318 L/d of 49°C water (80 gal/d of 120°F water), the electric water heater's efficiency is 92%. The variability of water heater efficiency with hot water consumption rate is obtained from ref. 10 (p. 31).

Central air conditioner. The air conditioners used with systems 1, 6, 7, and 8 are assumed to be Sears Best Series air conditioners, described in ref. 7 (p. 1166). The efficiencies of the central air conditioners and their prices and capacities are shown in Table 3.

Table 3. Sears Best Series air-conditioning systems[a]

Cooling capacity		Power (kW)	EER[b]	SEER[c]	Price[d]
kW	Btu/h				
6.7	23,000	2.20	10.5	9.8	1,129
8.1	27,500	2.70	10.2	9.9	1,279
9.4	32,000	3.20	10.0	9.6	1,379
10.0	34,000	3.35	10.1	9.6	1,479
10.7	36,500	3.75	9.7	9.3	1,509
12.3	42,000	3.90	10.8	10.3	1,679
13.8	47,000	4.60	10.2	9.8	1,779
16.7	57,000	5.80	9.8	9.2	1,879
			10.2[e]	9.7[e]	

[a]Ref. 7, p. 1166.
[b]Energy efficiency ratio at 35°C (95°F).
[c]Seasonal energy efficiency ratio.
[d]In 1980 dollars.
[e]Average.

The energy efficiency ratio (EER) of an air conditioner is defined as the ratio of its rate of cooling at a given ambient temperature, in British thermal units per hour, to its rate of power consumption in watts. Similarly, the seasonal energy efficiency ratio (SEER) is the ratio of the total cooling delivered by the air conditioner, in British thermal units, to the energy consumed by the unit, in watt hours, during the cooling season as a whole. [The SEER is closely related to another performance index, the seasonal performance factor in cooling (SPFC), which is the ratio of the total cooling to the total consumption, in consistent units.] In Table 3, the average value of the SEER is about 95% of the average value of the EER. This degradation occurs because of cycling losses and because the average ambient temperature during summertime operation of the unit is less than 35°C (95°F), for which the EER values are given. In this study, we assume that the air conditioner's SEER is 86% of the EER at 35°C (95°F). Consequently, for systems 1, 6, 7, and 8, the SPFC is 2.55.

Heat pump. The heat pumps employed in systems 2 and 3 are typical split systems in which the indoor coil is mounted within the fan unit. The heat pumps are available from Sears, Roebuck and Company at various prices and capacities, as shown in Table 4.[7] Table 4 also lists the steady-state heating coefficient of performance (COPH) of each unit at selected ambient temperatures. These data are used by the MAD program to estimate the steady-state and dynamic COPs of the units at other ambient temperatures. In the estimation process, the heating COPs shown in Table 4 are averaged to obtain a figure of merit (FOM) that characterizes the technology level of the heat pumps used in systems 2 and 3. This FOM is used to renormalize a table of steady-state heating COPs versus the ambient air temperature that is built into the MAD program. In this way, the COPH of the heat pump, at any ambient temperature, can be obtained if the technology FOM of the unit is known.

Heat pump simulation model. A heat pump's seasonal performance factor of heating (SPFH) is the ratio of the heating load delivered to a building during the heating season to the electricity consumed by the heat pump during the same period of time. The delivered load includes heat from the heat pump compressor and from auxiliary resistance heaters.

Table 4. Sears split-system heat pumps with an indoor coil and housing for use with a fan unit and an outdoor coil, compressor, and fan unit[a]

Cooling capacity (kW)	Cooling capacity (Btu/h)	Heating capacity (kW)	Heating capacity (Btu/h)	EER[b] [35°C (95°F)]	COPH[c] [−8.3°C (17°F)]	COPH [8.3°C (47°F)]	Price ($)
7.2	24,500	7.2	24,500	7.5	2.0	2.8	1,199
8.5	29,000	8.8	30,000	8.3	2.0	2.8	1,329
10.1	34,500	10.6	36,000	8.0	2.1	2.9	1,479
11.7	40,000	12.3	42,000	7.7	2.0	2.7	1,549
14.1	48,000	14.4	49,000	7.5	1.9	2.6	1,899
17.0	58,000	18.8	64,000	7.2	2.0	2.7	2,459
					7.7[d]	2.0[d]	2.75[d]

[a]Ref. 7, p. 1174.
[b]Energy efficiency ratio.
[c]Heating coefficient of performance. Data obtained from ref. 2, p. 167.
[d]Average.

Auxiliary heat is needed when the outdoor temperature falls below the balance temperature, the ambient temperature at which the heat output from the compressor just equals the building heating demand. Below the balance temperature, the compressor alone cannot maintain the building at a desired temperature, so the shortfall is supplied from resistance heaters. The MAD program calculates, for successive time periods when the outdoor air temperature is constant (temperature bins), the heating demand of the building, the amount of compressor heat available, and the amount of resistance heating needed. These quantities are totalled over all the temperature bins to obtain annual values used to compute the ACOP of the system.

Heating mode operation. In calculating the heat pump energy consumption during the heating season, MAD takes into account decreases in the capacity and COP of the unit caused by outdoor temperature as well as degradations in steady-state performance caused by frost buildup on the outdoor air coil and cycling losses at partial load operation. The degradation in compressor heat output and in steady-state COP that results from frosting is assumed to be 8%. An additional 15% reduction in steady-state COP is assumed to occur when the heat pump operates at partial load factors by cycling on and off. (See ref. 11 for a discussion of the dynamic performance of air-to-air heat pumps and the results of field tests of dealer-installed units.)

For heat pumps equipped with desuperheater water heaters, it is assumed that only 15% of the heat from the compressor can be used to produce domestic hot water. Auxiliary resistance heating is used to meet any remaining demands for hot water.

Cooling mode operation. The seasonal cooling COP of the heat pump is calculated in MAD by the expression

$$\mathrm{COPC} = (\mathrm{FOM}/2.88)(2.65)(\mathrm{DF}) \tag{1}$$

FOM characterizes the technology level of the selected heat pump, and 2.88 is the FOM of a standard heat pump in the MAD program that has a steady-state COPC of 2.65 at 35°C

(95°F). The degradation factor (DF) is estimated to be 0.86; it accounts for cycling losses and for the heat pump's operation in the summer at an average ambient temperature lower than 35°C. Equation 1 yields the seasonal performance of this study's Sears heat pumps; this performance equals a SEER of 6.4 Btu/h of cooling output per watt of electrical input to the heat pump. The calculated seasonal performance is in reasonable agreement with measured values.[11,12]

ACES performance parameters. The ACES must be able to operate in a variety of modes to meet changing load demands. Throughout the year the system is called upon to supply space heating, space cooling, and water heating. The efficiency with which the system meets these demands depends, in part, on whether the demand occurs during the ice phase or during the supplemental phase of the annual cycle. The ice phase is that portion of the year when the storage bin contains ice, so heating or cooling loads are met by generating or melting the ice in the bin. The supplemental phase occurs in late summer when the bin's latent and sensible cooling capacity has been exhausted. Demands for space cooling must then be satisfied by operating the compressor at night to reject heat from the storage bin, thereby producing chilled water. During the day, the chilled water is circulated through the house fan coil so that heat from the house is deposited in the storage bin. The COP of each of these modes of operation must be known in order to predict accurately the annual energy consumption of the system. Table 5 lists the values of the modal COPs used in this study.

Table 5. Modal COPs of the ACES as established during comprehensive field tests in Knoxville, Tennessee[a]

Space-heating mode	2.55
Water-heating mode	2.40
Space cooling by ice melt mode	19.00
Space cooling by chilled water circulation	10.00
Heat rejection from ice storage bin	2.05

[a]See ref. 9, pp. 7–21 for a description of the ACES operating modes and refs. 13–15 for descriptions of the ACES field tests.

2.3.2 Fossil-Fuel Systems Efficiencies

Gas-fired water heater. The gas-fired water heater used with systems 6 and 8 is a 150-L (40-gal) Kenmore Power Miser 10 fast recovery unit. This water heater (described in ref. 7, p. 1147) has two-step ignition; a low input pilot comes on low and then jumps to high. The unit is equipped with extra baffling to give it high heat transfer efficiency and to lower gas consumption. According to the manufacturer, the annual energy cost of the unit delivering hot water at a rate of 450 gal/week is $120, at a gas rate of 3.7¢/therm. The temperature rise of the water is given as 32°C (90°F). From these data, the efficiency of the water heater is 54% for a water delivery rate of 240 L/d (64 gal/d). The efficiency of the gas water heater at other delivery rates is obtained by linear interpolation between the data listed in Table 6. The efficiency of the gas water heater for the 300 L/d (gal/d) delivery rate assumed in this study is 57%.

Table 6. Efficiency of gas-fired water heater as a function of the delivery rate of water heated through a 50°C (90°F) temperature rise[a]

Domestic hot water delivery rate		Appliance efficiency
L/d	gal/d	(%)
76	20	32.5
110	30	40.0
150	40	47.0
190	50	50.5
240	64	54.0
300	80	57.0
340	90	59.0

[a]Data from ref. 10, p. 33, normalized to appliance efficiency of 57% at 240-L/d (64-gal/d) delivery rate.

Advanced gas furnace. The gas furnace used in system 6 is a Sears pilot-free furnace that has automatic power venting. A space-heating thermostat initiates burner operation, causing an air-aspirating blower and a gas valve to open. An electric spark ignites the flame and the air-aspirating blower exhausts the waste gases through a vent pipe. When the burner cycles to off, the blower stops running so that less heated air is lost from the building. The heating efficiency of the fully loaded gas furnace is 80%, and the efficiencies of the partially loaded furnace are shown in Table 7. Table 8 lists the heating capacities and prices of units currently available.

Table 7. Assumed full and partial load efficiency of advanced gas furnace Kenmore-20, with power venting and electric ignition[a]

Percentage of full load	Furnace efficiency (%)
0	55
2	59
5	65
10	68
15	70
20	72
50	75
100	80[b]

[a]Partial load efficiencies obtained from ref. 16, pp. 2–43.

[b]Full load efficiency obtained from ref. 7, p. 1160.

Table 8. Kenmore-20 advanced gas furnace capacities and prices[a]

Heating capacity		Price[b]
kW	Btu/h	
18.8	64,000	745
24.6	84,000	775
29.3	100,000	815

[a]Ref. 4, p. 1160.
[b]In 1980 dollars.

Sears oil furnaces. The oil furnaces used with system 7 are selected from the Sears units available at the prices shown in Table 9. It is assumed that all the furnaces listed in Table 9 have the same heating efficiencies when operating at partial or full load conditions. In Table 10, the furnace efficiencies are shown as a function of load fraction. The MAD computer program interpolates linearly between these data to obtain furnace efficiencies at arbitrary load fractions.

Table 9. Capacities, efficiencies, and prices of Sears oil furnaces[a]

Furnace heating capacity		Full load efficiency (%)	Price[b]
kW	Btu/h		
23.2	79,000	75.3	690
30.8	105,000	73.2	720
38.4	131,000	78.0	1,040
46.3	158,000	76.9	1,140

[a]Ref. 7, p. 1162.
[b]In 1980 dollars.

Table 10. Assumed oil furnace efficiencies

Percentage of full load	Furnace heating efficiency (%)
1	30
5	50
6	55
8	58
10	60
15	61
20	62
50	64
85	67
91	68
94	69
97	72
100	75

Pulse gas furnace. The pulse gas furnace used with system 8 is representative of those expected to be marketed in the near future (e.g., by Lennox Industries, Inc.). It operates by igniting small quantities of a gas and air mixture at a rate of 60 or more times per second. Each pulse releases a small amount (about 1/2 Btu) of heat. As gas and air are admitted into the combustion chamber, an electric spark ignites the mixture, causing a pressure buildup that closes off the air and gas inlets. The combustion products are forced down a tailpipe, creating suction that draws in air and gas for the next ignition.

At the same instant that the new fuel charge enters the chamber, part of the initial pressure pulse is reflected back from the end of the tailpipe. It re-enters the combustion chamber, causing the new fuel charge to ignite and continue the cycle. Once combustion is started, it feeds on itself, allowing the combustion blower and spark igniter to be turned off. The efficiency of the pulse combustion furnace generally ranges from 92 to 96%.

A disadvantage of the pulse gas furnace is that it produces up to 38 L (10 gal) of condensate daily during normal operation in midwinter. Safe disposal of this waste product, which may have a pH of 4.5 to 6.0, must be provided for in the system design.

We assume the efficiency of the pulse gas furnace (representative of expected market developments) to be 93%, and the cost is $1125. Both quantities are assumed to be independent of the heating output capacity of the furnace.

3. ECONOMIC ANALYSIS

In this study, the alternative heating and cooling systems for residences are compared on the basis of their life-cycle costs, defined as the present discounted value of all ownership and operating costs associated with a system over some specified period of time, usually its physical lifetime. Each of the eight space-conditioning systems is assumed to have a lifetime of 25 years. (Major components may, of course, require replacement one or more times during a period.) The value of each system at the end of this period is assumed to be negligible. The discount rate used to calculate the present value is the opportunity cost of capital, that is, the after-tax, after-inflation market interest rate. The value of the real discount rate is assumed to be 3.5%/year.

The life-cycle cost concept provides a fair and convenient basis for assessing the potential economic viability of alternative residential space-conditioning systems. The life-cycle costs presented, however, are not intended to indicate the probable success of any of the systems in the marketplace. Actual sales would depend on many other factors such as the availability and future price of fuels, the size and hookup requirements of the space-conditioning system, and the financial status, special needs, and objectives of the home builder or buyer. These life-cycle costs will help to identify the economic and energy conservation potential of promising alternative HVAC systems.

The average life-cycle costs are calculated using projected energy prices based on the average production and distribution costs of the utility and on current actual prices to the consumer in a given locality. It is to the homeowner's advantage to minimize these average life-cycle costs by selecting the HVAC system that best meets his particular needs. Marginal life-cycle costs would result if the annual energy needs were supplied by newly constructed power stations, transmission lines, and synthetic fuel plants. These marginal life-cycle costs represent the present value of the total national investment in new plant construction that would have to be made to deliver the space-conditioning amenities to a single-family home. That is, the analysis includes the costs of energy supply and distribution resulting from the construction of new generating plants and distribution facilities today. Further information on this total systems approach is given in ref. 17.

3.1 Average Life-Cycle Costs

The projected variations in energy prices for the next 25 years for electricity, heating oil, and natural gas are shown in Table 11. These price projections, derived from forecasts by Data Resources, Inc., are used in the present study only for estimating the present worth factors (PWFs) of each of the three energy sources.[18] The PWF associated with each fuel depends on the variation in time but not on the magnitude of the prices shown in Table 11. Actual energy prices (as of the end of 1980) that apply in each of the 115 localities of the study are listed in Appendix A.[5,6]

Table 11. Projected national energy prices for residential applications

In 1980 dollars. Based on price projections in ref. 18

Year	Electricity (¢/kWh)	Heating oil ($/bbl)	Natural gas (¢/therm)
1980	5.06	33.60	34.71
1	5.30	39.52	36.16
2	5.36	39.35	37.32
3	5.38	39.49	40.70
4	5.40	40.35	44.12
5	5.35	41.27	47.77
6	5.41	42.73	52.18
7	5.47	44.19	56.59
8	5.54	45.65	61.00
9	5.60	47.11	65.41
1990	5.67	48.57	69.82
1	5.69	50.61	72.31
2	5.71	52.66	74.81
3	5.73	54.70	77.30
4	5.75	56.75	79.80
5	5.77	58.79	82.29
6	5.84	59.89	83.38
7	5.91	60.98	84.46
8	5.98	62.08	85.55
9	6.06	63.17	86.63
2000	6.13	64.27	87.72
1	6.20	65.37	88.81
2	6.27	66.46	89.89
3	6.35	67.56	90.98
4	6.42	68.65	92.06
5	6.49	69.75	93.15
PV[a]	94.06	848.47	1099.40
PWF[b]	18.59	25.25	31.67

[a]Present value.
[b]Present worth factor.

3.1.1 Calculated PWFs

The present value (PV) of a unit of energy purchased annually, beginning in 1981 and ending in 2005, is given by the relation

$$\mathrm{PV} = \sum_{j=1}^{j=25} \frac{P(j + 1980)}{(1 + r_d)^j} \tag{2}$$

where $P(j + 1980)$ is the price of a unit of fuel in year $j + 1980$, as listed in Table 11, and r_d is the annual real discount rate, or 3.5%. The factor PWF is then given by

$$\mathrm{PWF} = \mathrm{PV}/P(1980) \ , \tag{3}$$

where $P(1980)$ is the price of the fuel at the end of the year 1980.

Applying Eqs. 2 and 3 to the energy price data given in Table 11 yields the following PWFs: 18.59 for electricity, 25.25 for heating oil, and 31.67 for natural gas. These values reflect the fact that the expected real escalation rates in heating oil and natural gas prices are greater than for electricity. (As is shown in Sect. 3.2, a PWF of 16.48 would have resulted for any fuel having a real annual escalation rate of zero.)

3.1.2 Empirical PWFs

The preceding calculated energy PWFs are based on projected energy prices and arbitrary values for the time period and the annual discount rate. Because the values these parameters should be given in life-cycle cost analyses is in question, a recent study at Oak Ridge National Laboratory—in which energy PWFs are determined directly, without specifying either the system lifetime or the annual discount rate—is of particular interest.[19] The study employs a hedonic price equation, in which different characteristics of a house have their own implicit or hedonic price. The technique allows measurement of implicit prices of goods; that is, the price is regressed on specified components, such as the annual energy bill, and the coefficient of the particular variable is determined.

Johnson analyzed the 1978 selling prices of 1317 houses in the Knoxville metropolitan area using a regression equation with 33 parameters.[19] For the overall housing sample, a utility bill coefficient of −20.73 was found; that is, an investment in an energy-saving durable good resulting in a $1.00 reduction in the annual fuel bill will increase the market value of the house and its contents by $20.73. In other words, the study suggests that buyers respond collectively as though they implicitly accept a PWF for energy equal to 20.73. Using disaggregated samples, the PWF was found to be 19.75 for new houses (166 units) and 16.64 for existing houses (1151 units). These empirical values for energy PWFs are in close agreement with the calculated values used in this study.

3.2 Marginal Life-Cycle Costs

3.2.1 PWF for Stable Energy Prices

The marginal life-cycle costs calculated in this study are based on the assumption that energy prices (in constant dollars) will eventually stabilize. That is, the real annual escalation in energy prices will become zero as the supply base gradually shifts from scarce toward abundant or renewable energy sources. The marginal life-cycle costs are calculated from estimated prices of electricity, synthetic gas, and oil produced from coal conversion processes. Because coal is plentiful in the United States, its price will probably stabilize and remain constant in real dollars for some significant period of time. Assuming a zero real rate of price escalation, the applicable equilibrium PWF is

$$\mathrm{PWF} = \sum_{j=1}^{N} \frac{1}{(1 + r_d)^j} ,$$

where N is the length of the study period in years and r_d is the real annual discount rate. Using the values assumed in this study, $N = 25$ and $r_d = 3.5\%$, the value of the equilibrium PWF is 16.48.

3.2.2 Prices of Electricity and Synthetic Fuels from Coal

The asymptotic price of the energy (electricity, gas, and oil) required by the eight residential systems is estimated by assuming that each is produced from domestic coal resources. The price of power from a coal-fired central power station and of synthetic fuel from coal gasification and liquefaction plants can be estimated by the revenue requirement technique. The basic financial assumptions of this technique are discussed in ref. 20, where its application is illustrated. The revenue requirement is the price that customers must be charged for services in order to compensate a utility for all expenditures associated with the ownership and operation of its energy production and distribution facilities. The methodology for estimating coal-based electricity, synthetic gas, and synthetic oil prices is shown in Appendix D. Based on Sillin's plant capital, operating, and maintenance cost data, which have been increased by 20% to account for inflation, the asymptotic energy prices in Table 12 are estimated.[17]

Table 12. Estimated asymptotic energy prices

In 1980 dollars

Form of processed energy	Commercial units	$/10^6 Btu	$/kWh
Electricity	$0.085/kWh	24.90	0.085
Synthetic gas	$0.815/therm	8.15	0.028
Synthetic oil	$1.460/gal	9.54	0.033

4. RESIDENTIAL SYSTEMS

4.1 System 1—Electric Resistance Furnace, Central Air Conditioner, and Electric Resistance Water Heater

This space-conditioning system is comprised of a fan unit with electric resistance heaters, an air conditioner, a hot water tank, an air distribution system, and auxiliary equipment. The initial installed cost of the system includes all expenditures for components, materials, and labor. The cost of the air distribution system includes outlays for fabricating and installing the ducts and for purchasing diffusers, boots, transitions, and returns needed for connecting the fan unit into the system. Because field fabrication of ducts is necessary, the costs of the ducts include materials and labor.

4.1.1 Equipment Costs

Fan unit. The fan unit contains the electrical resistance heating elements as well as the indoor fan, control relays, and filter assemblies. The fan units are sold by Sears as a separate item for use with heating-only systems, heating- and air-conditioning systems, or with heat pumps (Table 13).

Table 13. Cost of Sears fan units[a]

Heating capacity		Price[b]
kW	Btu/h	
10.3	35,290	280
15.4	52.697	310
20.4	69,762	350
24.7	84,199	380
28.4	96,793	400
34.0	115,905	420

[a]Ref. 7.
[b]In 1980 dollars.

Air conditioner. The air conditioner is comprised of an indoor air coil and an outdoor unit. The refrigerant lines and controls that must be provided are discussed in Sect. 4.2.1. The size of the air conditioner, which is one of those in Table 3, is based on the design-day cooling load of the house.

Controls. The basic control unit for the electric resistance heating system with an air conditioner is a heating and cooling thermostat that is used with all system sizes and costs $48 (ref. 7, p. 1163). The control system wiring is included with other electrical costs, to be described later.

Auxiliaries. The auxiliary equipment includes the refrigerant lines needed to connect the indoor cooling coil to the outdoor compressor package and the electrical equipment and wiring for installing the system. Materials and equipment include wire, circuit breakers, switch

boxes, and miscellaneous wiring hardware. Table 14 shows the cost of providing the refrigerant lines assumed in this study.

Table 14. Estimated costs of providing refrigerant lines[a]

Air conditioner cooling capacity		Line length		Cost[b]
W	Btu/h	m	ft	
5,422 to 10,698	18,500 to 36,500	16	50	160
11,723 to 16,999	40,000 to 58,000	16	50	200

[a]Ref. 7, p. 1167.
[b]In 1980 dollars.

Wiring and hardware. Table 15 presents Sears catalog costs of the wiring and associated hardware required to supply electrical services to system 1.

Table 15. Estimated costs of electrical services wiring[a]

Heating capacity of unit		Wiring cost[b]
kW	Btu/h	
10.3	35,290	76
15.4	52,697	93
20.4	69,762	145
24.7	84,199	234
28.4	96,793	234
34.0	115,905	234

[a]Ref. 7.
[b]In 1980 dollars.

Water heater. The electric resistance water heater is a Kenmore Power Miser 10 unit with a storage capacity of 200 L (52 gal) that employs two 3.8-kW staged heating elements. The temperature recovery capability of the water heater is 65 L/h at 50°C rise (17.3 gal/h at 90°F rise) and 59 L/h at 56°C rise (15.6 gal/h at 100°F rise). The Sears price of the water heater equipped with a pressure relief valve is $275 (ref. 7, p. 1145).

Air ducts. Table 16 presents the estimated cost of the air duct system as a function of the space-conditioning system capacity. The data in ref. 1 (p. 18) have been updated to account for the effects of inflation.

4.1.2 Installation Costs

Hot water storage tank. The hot water storage tank must be transported to the building site where it is plumbed and electrically connected to the house wiring. Installation costs of $170 are assumed for each hot water tank, regardless of its storage capacity.

Table 16. Duct system costs as a function of HVAC system capacity

HVAC (heating, ventilating, and air-conditioning) system cooling capacity used to size ducts for all systems except the ACES, systems 4 and 5. Ducts for the minimum and full ACES are sized according to the system heating capacity

HVAC system capacity		Duct cost[a]
kW	Btu/h	
2.9	10,000	514
3.7	12,500	590
7.8	26,500	885
11.7	40,000	1,180
15.7	53,500	1,416
19.5	66,500	1,623
23.4	80,000	1,770
29.3	100,000	1,947
33.7	115,000	2,000

[a]Total installed costs (in 1980 dollars) for the ducts include costs for materials, insulation, diffusers, boots, elbows, plenums, transitions, supports, and labor.

Air conditioner. The estimated costs of installing a split-system air conditioner and indoor fan unit are shown in Table 17.

Table 17. Estimated costs of installing a split-system air conditioner

Cooling capacity of HVAC[a] system		Installation time[b] (man-hours)	Cost[c]
kW	Btu/h		
2.9 to 6.4	10,000 to 21,700	12	312
6.4 to 9.8	21,700 to 33,500	14	364
9.8 to 16.1	33,500 to 55,000	18	468

[a]Heating, ventilating, and air-conditioning.
[b]Ref. 1, p. 18.
[c]Labor rate equals $26/man-hour, in 1980 dollars.

4.1.3 Maintenance Costs

Table 18 presents the maintenance and components replacement cost schedule assumed for system 1. The data in ref. 1 (p. 20) have been updated to account for the effects of inflation.

Table 18. Schedule of annual maintenance costs for system 1

In 1980 dollars

Year	Routine service	Refrigerant system	Electrical system	Hot water tank	Total
1981	12				12
2	12				12
3	12				12
4	12				12
5	12				12
6	25	65			90
7	12				12
8	12				12
9	12			350	362
1990	12				12
1	12				12
2	25	65			90
3	12		125		137
4	12				12
5	12				12
6	12				12
7	12				12
8	25	65		350	440
9	12				12
2000	12				12
1	12				12
2	12				12
3	12				12
4	25	65			90
5	12				12
					914[a]

[a]Present value at an annual discount rate of 3.5%.

4.1.4 System 1 Costs for Knoxville, Tennessee

The reference house in Knoxville, Tennessee, can be used to illustrate the methods described in Sects. 4.1.1-4.1.3 for selecting the sizes and costs of components for system 1. The design-day loads of the house have been computed as 9529 W (32,513 Btu/h) for heating and 6783 W (23,144 Btu/h) for cooling. The equipment, installation, maintenance, and energy consumption costs of the system designed to meet these loads are shown in Table 19.

4.2 System 2—High-Performance Air-to-Air Heat Pump with Electric Resistance Water Heater

This space-conditioning system is comprised of a high-performance air-to-air heat pump, a fan unit, an air distribution system, an electric water heater, controls, and auxiliary equipment. The installed cost of this system includes all expenditures for materials, components, and installation. The fan unit contains the auxiliary resistance heating elements, as in system 1, and its capacities and prices are listed in Table 13.

Table 19. Estimated costs for system 1 in Knoxville, Tennessee

Item	Basis of estimation	Cost[a]
	Equipment costs	
Fan unit	Table 13, building design-day heating load	280
Air conditioner	Table 3, building design-day cooling load	1,279
Controls	Constant, fixed cost	48
Air ducts	Table 16, system cooling capacity	907
Water heater	Constant, fixed cost	275
Refrigerant lines	Table 14, system cooling capacity	160
Electrical wiring	Table 15, system heating capacity	76
	Installation costs	
Air conditioner	Table 17, system cooling capacity	364
Hot water tank	Constant, fixed cost	170
	Maintenance costs	
Present worth	Table 18, based on 3.5% discount rate	914
	Energy costs	
Present worth	$618.05 (FYC) × 18.59 (PWF)	11,490
Life-cycle cost		15,963

[a]In 1980 dollars.

4.2.1 Equipment Costs

Heat pump. The refrigeration package is a typical split system in which the indoor coil is mounted in the fan unit; available models are listed in Table 4. The size of the heat pump is selected to meet the design-day cooling load of the house, and auxiliary resistance heating capacity is provided to meet high heating demands.

Controls. The indoor thermostat for the heat pump must have two heating stages, a cooling stage, and an emergency switch that activates the auxiliary heaters if the compressor fails. An outdoor thermostat is required to activate supplemental heaters, improving system performance. Table 20 lists the components and prices of the heat pump control system.

Table 20. Components and prices of the heat pump control system

Outdoor thermostat (kW)	Fan unit capacity (Btu/h)	Price[a]
0 to 10.3	0 to 35,260	0.00
10.3 to 20.4	35,260 to 69,758	32.00
20.4 to 34.0	69,758 to 115,906	53.00
Indoor thermostat (all heat pump systems), two-stage heating/cooling		45.00

[a]In 1980 dollars.

Auxiliaries. Auxiliary equipment required for the air-to-air heat pump includes refrigerant lines and wiring to provide electrical services to the power components of the system. The electrical wiring to the indoor fan unit must be capable of delivering the power rating of the unit. The costs of the wiring are given in Table 15, and the costs of refrigerant tubing for system 2 are given in Table 14.

Water heater. The water heater conventionally used with the air-to-air heat pump is an electric-resistance-heated storage tank. The unit selected for system 2 is a 200-L (52-gal) storage tank heated by two-staged 3.8-kW heating elements. Sears prices this unit equipped with a pressure relief valve at $275.[7]

Air ducts. The duct system size is selected to accommodate the cooling capacity of the heat pump, and its cost is estimated using the data in Table 16.

4.2.2 Installation Costs

The installation cost of the air-to-air heat pump system with an electric water heater is assumed to be identical to that of a split air conditioner system and, therefore, is projected according to the data in Table 17.

4.2.3 Maintenance Costs

System 2 requires routine service, refrigerant system repairs, and replacement (as needed) of electrical components, the compressor, and the hot water storage tank. Routine servicing for this system consists of filter changes, equipment inspection, and indoor coil brushing. The estimated cost is about $25/year. Maintenance of the refrigerant system is assumed to cost about $65 every six years, and replacement of electrical components (including contactors, fan motors, and starting capacitors) is assumed to cost $140 in the thirteenth year. The hot water tank is assumed to need replacement every nine years, at a cost of $350. The compressor is assumed to need replacement at a cost of $710 every nine years. Table 21 gives the maintenance cost schedule assumed for system 2; the present value of the costs, based on a 25-year period and a real annual discount rate of 3.5%, is $2162.

4.2.4 System 2 Costs for Knoxville, Tennessee

A reference house in Knoxville, Tennessee, is used to illustrate the methods described in Sects. 4.2.1–4.2.3 for selecting the sizes and costs of components for system 2. The design-day loads of the house are calculated to be 9529 W (32,513 Btu/h) for heating and 6783 W (23,144 Btu/h) for cooling. The calculated annual energy consumption of the system is 13,206 kWh. The equipment, installation, maintenance, and energy consumption costs are shown in Table 22.

4.3 System 3—High-Performance Air-to-Air Heat Pump with Desuperheater Water Heater

This space-conditioning system is the same as system 2 (Sect. 4.2), except that a desuperheater heat exchanger and a water circulating pump are used to produce domestic hot water.

Table 21. Schedule of annual maintenance costs for system 2

In 1980 dollars

Year	Routine service	Refrigerant system	Electrical system	Replace compressor	Replace water tank	Total
1981	25					25
2	25					25
3	25					25
4	65					65
5	25					25
6	25	65				90
7	25					25
8	65					65
9	25			710	350	1,085
1990	25					25
1	25					25
2	65	65				130
3	25		140			165
4	25					25
5	25					25
6	65					65
7	25					25
8	25	65		710	350	1,150
9	25					25
2000	65					65
1	25					25
2	25					25
3	25					25
4	65	65				130
5	25					25
						2,162[a]

[a]Present value at an annual discount rate of 3.5%.

4.3.1 Equipment Costs

Desuperheater package. The cost of a 2.0-kW desuperheater package is estimated from information provided by several independent manufacturers to be about $400, exclusive of installation.

Hot water tank. The lower temperature recovery rate of a desuperheater water-heating system requires the installation of a larger hot water tank than is normally used. This tank, for residences, should have a capacity of at least 310 L (82 gal) to ensure a sufficient supply of hot water at all times. The catalog price for this size tank is $335 (ref. 7, p. 1145).

4.3.2 Installation Costs

Installation of the desuperheater water-heating system requires additional plumbing and additional electric wiring for system controls. The cost of materials and labor is estimated to be $100 above the cost of the components.

Table 22. Estimated costs for system 2 in Knoxville, Tennessee

Item	Basis of estimation	Cost[a]
	Equipment costs	
Fan unit	Table 13, building design-day heat load	280
Heat pump	Table 4, building design-day cooling load	1,199
Controls	Table 20, indoor thermostat	45
Air ducts	Table 16, system cooling capacity	843
Water heater	Fixed cost for 200-L (52-gal) tank	275
Refrigerant lines	Table 14, system cooling capacity	160
Electrical wiring	Table 15, system heating capacity	76
	Installation costs	
Heat pump	Table 17, system cooling capacity	364
Hot water tank	Constant, fixed cost	170
	Maintenance costs	
Present worth	Table 21, based on 3.5% discount rate	2,162
	Energy costs	
Present worth	$499.55 (FYC) × 18.59 (PWF)	9,287
Life-cycle cost		14,861

[a]In 1980 dollars.

4.3.3 Maintenance Costs

The maintenance requirements of a heat pump equipped with a desuperheater water-heating system differ slightly from those of conventional heat pumps because of the need to descale and clean the desuperheater heat exchanger at regular intervals. In addition, the hot water circulating pump will probably need to be replaced or rebuilt about every ten years. The larger and more expensive hot water tank required by this system also adds to the maintenance cost because the tank will need to be replaced about every nine years. Table 23 shows the maintenance schedule assumed for the heat pump with desuperheater water-heating system. The present value of the maintenance costs, based on a 25-year time period and a real annual discount rate of 3.5%, is $2468.

4.3.4 System 3 Costs for Knoxville, Tennessee

The equipment, installation, maintenance, and energy consumption costs of system 3—properly sized to meet the heating and cooling loads of the reference house in Knoxville, Tennessee—are shown in Table 24.

4.4 System 4—ACES with Small-Size Storage Tank (Minimum ACES)

The concept of this space-conditioning and water-heating system has been described extensively elsewhere. For details of system design and descriptions of operating experience acquired during the field tests, consult refs. 1, 9, 13, 14, and 15. Briefly, the ACES uses an

Table 23. Schedule of annual maintenance costs for system 3

In 1980 dollars

Year	Routine service	Refrigerant system	Electrical system	Replace compressor	Replace water tank	Clean desuperheater	Total
1981	25						25
2	25						25
3	25						25
4	65						65
5	25						25
6	25	65				75	165
7	25						25
8	65						65
9	25			710	410		1,145
1990	25		65				90
1	25						25
2	65	65				75	205
3	25		140				165
4	25						25
5	25						25
6	65						65
7	25						25
8	25	65		710	410	75	1,285
9	25						25
2000	65						65
1	25						25
2	25						25
3	25						25
4	65	65				75	205
5	25						25
							2,468[a]

[a]Present value at an annual discount rate of 3.5%.

electrically driven heat pump that extracts heat from water stored in an insulated underground tank and delivers it to a building for use in space and water heating. The ice that is formed in the storage tank (as heat is extracted) is used to provide air conditioning to the building in the summer. In this manner, both the heating and cooling outputs of the heat pump are used, and the resulting ACOP of the system is quite high.

4.4.1 Equipment Costs

The major components of the ACES are the heat pump mechanical package, the ice storage bin, conventional equipment (such as air ducts, hot water tank, thermostats, etc.), and, in some climates, a solar collector panel for melting ice generated in excess of summer cooling needs. It is not yet possible to order from any commercial source the packaged components required for constructing an ACES; the components must be assembled from subcomponents such as heat exchangers, pumps, compressors, and other commercially available equipment. The solar collector panel and the ice storage bin must be built or assembled on site. In this study, the costs of the solar collector panel and the ice storage bin are based on

Table 24. Estimated costs for system 3 in Knoxville, Tennessee

Item	Basis of estimation	Cost[a]
	Equipment costs	
Fan unit	Table 13, building design-day heat load	280
Heat pump	Table 4, building design-day cooling load	1,199
Controls	Table 20, indoor thermostat	45
Air ducts	Table 16, system cooling capacity	843
Hot water tank	Fixed cost for 310-L (82-gal) tank	335
Refrigerant lines	Table 14, system cooling capacity	160
Electrical wiring	Table 15, system heating capacity	76
Desuperheater heater and pump	Fixed cost	400
	Installation costs	
Heat pump	Table 17, system cooling capacity	364
Hot water tank	Constant, fixed cost	170
Desuperheater heater and pump	Constant, fixed cost	100
	Maintenance costs	
25-year present value	Table 23, based on 3.5% discount rate	2,468
	Energy costs	
25-year present value	$436.28 (FYC) × 18.59 (PWF)	8,110
Life-cycle cost		14,550

[a]In 1980 dollars.

estimated costs of materials and labor, and the costs of the heat pump mechanical package and other system equipment are derived from estimates by some manufacturers of the probable cost of the component when it is in full-scale production.

Heat pump mechanical package. The ACES mechanical package contains an indoor fan unit, an outdoor fan unit, a compressor, a heat exchanger, and pumps for circulating brine and hot water. The indoor unit is comprised of a fan and coils for heating and cooling, as with conventional heat pump systems. The outdoor unit consists of a fan and a heat rejection coil. The compressor, heat exchanger, and pump package are major cost items of the mechanical package. The cost of assembling an ACES mechanical package, using components currently in quantity production but being sold for other applications, is shown in Table 25 as a function of the heating capacity of the unit.

Table 25. Estimated cost of ACES mechanical package

Heating capacity		Heating COP	Estimated cost[a]
(W)	(Btu/h)		
7,180	24,500	2.55	2,950
9,964	34,000	2.55	3,130
13,189	45,000	2.55	3,500
17,584	60,000	2.55	4,000
21,981	75,000	2.55	4,450

[a]In 1980 dollars.

Ice storage bin. Construction details for the underground storage bin are in refs. 1 and 9. The ice bin is constructed from building materials such as sand, gravel, cement, reinforcing rods, and liner fabric. The insulation is a closed-cell plastic foam suitable for use in wet environments. Polypropylene ropes support the heat-set plastic tubing coils. In estimating the cost of the bin, it is assumed that the bin is located beneath a garage floor, which serves as the top slab of the bin. It is also assumed that the floor and two walls of the basement can serve as an integral part of the bin structure, thus reducing its overall cost. Table 26 lists the unit costs used to price the ACES storage bin.

Table 26. Assumed unit costs for integrated construction of ACES ice storage bin[a]

Ice bin insulated on all surfaces to a thermal resistance value of 7.05 ($m^2 \times$ °C/W), or R-40. Costs in 1980 dollars

Item	Unit costs	
	$/m^2	$/ft^2
Floor insulation, 6 in.[a]	26.48	2.46
Foam-form walls, R-16	40.15	3.73
Block upgrade, to R-16	8.83	0.82
Supplemental insulation, to R-40	17.65	1.64
Top insulation, R-40	26.48	2.46
Hypalon liner	7.43	0.69
Footers	7.74 $/m	2.36 $/ft
Bin heat exchanger tubes[b]	2.62 $/m	0.80 $/ft

[a]Price of installed insulation, $0.41/bd-ft.
[b]Cost of bin heat exchanger is $100 plus cost of tubing.

Solar collector panel. The panel considered for use with the ACES is an unglazed, continuous, flat-sheet, corrugated plastic board, with flow channels through which the brine can circulate. Ambient heat is collected by this type of panel only when the outdoor temperature exceeds 0°C (32°F). The panel is commercially available for $48.01/m^2 ($4.46/ft^2), exclusive of installation, which requires that a support structure be provided for mounting the panel on the house rooftop and that the panel be connected to the ice storage bin by insulated piping. The cost of rooftop installation of an unglazed panel is assumed to be $8.00/m^2 ($0.74/ft^2), and the cost of installing the brine lines from the panel to the storage bin is assumed to be $865.00 for each ACES requiring a solar panel.

Controls. The ACES controller actuates system components according to programmed logic instructions that regulate the ice inventory. The cost of this item is estimated to be about $320 (when produced in small quantities), including the costs of the integrated circuit controller and all sensors and thermostats needed for the control system.

Brine lines. The brine lines for connecting the compressor and pump package to the ice bin heat exchanger and solar panel are of PVC tubing that is insulated to prevent sweating. The size of these lines depends on the heating capacity of the heat pump. The assumed costs of the brine lines are shown in Table 27.

Table 27. Estimated costs of brine lines for ACES

System heating capacity		Cost[a]
W	Btu/h	
0 to 13,335	0 to 45,500	240
13,335 to 21,981	45,500 to 75,000	360

[a]1980 dollars.

Electrical services. The estimated costs of wiring, circuit breakers, switch boxes, miscellaneous hardware, and installation charges for providing electrical services to the ACES are shown in Table 28.

Table 28. Estimated costs of electrical services wiring

System heating capacity		Cost[a]
W	Btu/h	
0 to 10,258	0 to 35,000	76
10,258 to 17,585	35,000 to 60,000	150
17,585 to 21,981	60,000 to 75,000	235

[a]1980 dollars.

Hot water tank. The 310-L (82-gal) tank used with the ACES costs $335.

Air ducts. Air duct sizes are based on the system heating capacity, and the cost of the ducting system is obtained from Table 16.

4.4.2 Installation Costs

Mechanical package. Installing the heat pump mechanical package of the ACES requires setting the indoor unit, outdoor unit, and compressor pump package and connecting the unit to the rest of the system. The complexity of this job is similar to installing a conventional heat pump. Table 29 lists the estimated costs assumed for installation of the mechanical package.

Table 29. Estimated installation costs for the ACES mechanical package

Heating capacity		Man-hours	Cost[a]
W	Btu/h	(h)	
0 to 7,180	0 to 24,500	12	312
7,180 to 10,111	24,500 to 34,500	14	364
10,111 to 21,981	34,500 to 75,000	18	468

[a]Labor cost assumed to be $26/h (in 1980 dollars).

Hot water tank. The cost of installing the ACES hot water tank is assumed to be $170.

4.4.3 Maintenance Costs

The ACES maintenance requirements include routine servicing, heat exchanger cleaning, refrigerant system servicing, electronic component replacement, brine and water pump repair, ice bin servicing, and hot water tank replacement. Annual routine servicing consists of filter changes, equipment inspection, and treatment of the water stored in the bin. The brine-to-refrigerant and hot water heat exchangers should be cleaned at regular intervals, and the refrigerant system charge should be checked and adjusted regularly. The electronic circuitry may require replacement after about ten years, and pumps may need overhauling every seven years. The types, frequencies, and costs of maintenance activities required by an ACES are summarized in Table 30.

Table 30. Schedule of annual maintenance costs for system 4

In 1980 dollars

Year	Routine service	Refrigerant system	Electrical system	Rebuild pumps	Ice bin service	Hot water tank	Total
1981	25						25
2	25						25
3	25						25
4	160						160
5	25				125		150
6	25	65					90
7	25			180			205
8	160						160
9	25					410	435
1990	25				125		150
1	25						25
2	160	65					225
3	25		240				265
4	25			180			205
5	25				125		150
6	160						160
7	25						25
8	25	65				410	500
9	25						25
2000	160				125		285
1	25			180			205
2	25						25
3	25						25
4	160	65					225
5	25						25
							2432[a]

[a]Present value at an annual discount rate of 3.5%.

4.4.4 System 4 Cost for Knoxville, Tennessee

Using the methods described in ref. 9, the ice bin volume of a minimum ACES in Knoxville is calculated to be 13.52 m^3 (477.29 ft^3); the unit cost in Table 26 yields a bin cost of \$2464 (Table 31). The solar collector panel has an area of 14.63 m^2 (157.44 ft^2) and costs \$1684 (according to the data from Sect. 4.4.1).

Table 31. Costs of minimum ACES ice bin, using integrated construction

In 1980 dollars

Item	Unit cost ($/m^2)	Quantity (m^2)	Installed cost
Footers for two walls	7.74 $/m	4.71 m	36
Floor insulation	26.48	5.54	147
Two foam form walls	40.15	12.20	490
Two block wall upgrades	8.82	12.20	107
Four walls, supplied insulation	17.65	24.40	431
Top deck insulation, 15 cm (6 in.)	26.48	5.54	147
Plastic sheet liner	7.43	56.79	422
Bin heat exchanger coil	2.62 $/m	222.50 m	583
Bin heat exchanger fittings	100 $/set	1 set	100
Total installed cost of bin			2464

The methods described in Sects 4.4.1–4.4.3 for selecting the sizes and costs of system 4 components were applied to a reference house in Knoxville, Tennessee. The design-day loads are calculated to be 9529 W (32,513 Btu/h) for space heating and 6783 W (23,144 Btu/h) for space cooling. The calculated annual energy consumption of the minimum ACES in supplying these loads, in addition to an annual load of 32,190 MJ for domestic hot water production, is 8631 kWh. Based on a Knoxville power rate of $0.0378/kWh, the first-year power cost is $326.61. Table 32 summarizes the equipment, installation, maintenance, and operating costs of the minimum ACES in Knoxville, Tennessee.

Table 32. Estimated costs for system 4 in Knoxville, Tennessee

Item	Basis of estimation	Cost[a]
	Equipment costs	
Mechanical package	Table 25, heating capacity	3,130
Air ducts	Table 16, system heating capacity	1,049
Hot water tank	Fixed cost for 310-L (82-gal) tank	335
Ice storage bin	Table 31	2,464
Solar panel, 14.63 m^2	$865 + $56.01/m^2	1,684
Brine lines	Table 27, system heating capacity	240
Electrical wiring	Table 28, system heating capacity	76
Controller, sensors	Fixed cost	320
	Installation costs	
Mechanical package	Table 29, system heating capacity	364
Hot water tank	Fixed cost for 310-L (82-gal) tank	170
	Maintenance costs	
25-year present value	Table 30, annual discount rate of 3.5%	2,432
	Energy costs	
25-year present value	$326.61 (FYC) × 18.59 (PWF)	6,072
Life-cycle cost		18,336

[a]In 1980 dollars.

4.5 System 5—ACES with Full-Size Storage Tank (Full ACES)

The full ACES is identical to the minimum ACES except for the size of the ice storage bin and the solar collector panel. The ice bin volume required for a full ACES is determined by first calculating the amount of ice that can be formed (during winter operation in an average weather year) and stored for use in summer air conditioning. This value is then compared with the ice bin volume required to hold the calculated amount of ice needed for summer air conditioning. The volume selected for the full ACES ice bin is the smaller of these two quantities. If more ice can be generated and stored in the winter than is needed in the summer, a solar panel must be provided in the ACES design to melt surplus ice as it is formed. Calculation of the bin and panel sizes needed for a full ACES is detailed in refs. 1, 8, and 9.

4.5.1 Equipment Costs

The major components of system 5 are identical with those of system 4, and the estimate of equipment costs is the same as that in previous sections.

Heat pump mechanical package. The design-day heating load is calculated for the given climate, and a heat pump package having a heating capacity equal to or greater than the design-day, peak hourly heating load is selected from Table 25.

Ice storage bin. The required volume of the full ACES ice bin is calculated using the procedures in refs. 1, 8, and 9. Integrated bin construction is assumed, and the cost of the storage bin is determined using the unit costs listed in Table 26.

Solar collector panel. The panel area is calculated using the design procedures described in ref. 9. The cost of the collector panel is estimated on the basis of the following assumptions: the unit cost of materials is $48.01/m^2$, the unit cost of installation is $8.00/m^2$, and the installed cost of connecting brine lines is $865 for each ACES installation.

Brine lines. The cost of other brine lines depends on the heating capacity of the mechanical package, and the installed costs are obtained from Table 27.

Electrical services. The estimated cost of providing electrical services (i.e., installing wiring, circuit breakers, switch boxes, etc.) depends on the heating capacity of the mechanical package and is obtained from Table 28.

Hot water tank. The 310-L (82-gal) tank costs $335 (ref. 7, p. 1145).

Air ducts. The size of the duct system is matched to the heating capacity of the mechanical package, and its cost is obtained from Table 16.

4.5.2 Installation Costs

Mechanical package. Installation of the heat pump mechanical package is estimated to require from 12 to 18 man-hours. The cost is obtained from Table 29.

Hot water tank. The cost of installing the full ACES hot water tank is assumed to be $170.

4.5.3 Maintenance Costs

The maintenance requirements and schedule for the full ACES are assumed to be identical with those listed in Table 30 for the minimum ACES.

4.5.4 System 5 Costs for Knoxville, Tennessee

Using the design methods described in ref. 9, the volume of the ice bin for a full ACES at Knoxville is 76.49 m^3 (2701 ft^3). The dimensions are obtained by assuming it has a square cross section and a height of 2.44 m (8 ft). An additional 0.15 m (6 in.) of wall height is provided to give freeboard access above the water surface. The cost of the full ACES ice bin, calculated using the unit costs listed in Table 26, is $5839 (Table 33).

Table 33. Cost of the full ACES ice bin, assuming integrated construction

In 1980 dollars

Item	Unit cost ($/$m^2$)	Quantity (m^2)	Installed cost
Footers for two walls	7.74 $/m	11.20 m	87
Floor insulation	26.48	31.37	831
Two foam-form walls	40.15	29.01	1165
Two block wall insulation upgrade	8.83	29.01	257
Four walls, added insulation	17.65	58.02	1024
Top deck, 15-cm (6-in.) insulation	26.48	31.37	831
Reinforced plastic liner	7.43	116.29	864
Bin heat exchanger coil	2.62 $/m	259.57 m	680
Bin heat exchanger fittings	100 $/set	1 set	100
Total installed cost of bin			5839

A solar collector panel is not required for the full ACES in Knoxville because all the ice generated during winter operation of the system is needed to supply air conditioning during the summer.

The sizes and costs of other components of system 5 are the same as for system 4. The calculated annual energy consumption of system 5 (while supplying building loads of 32,190 MJ/year for space heating, 24,605 MJ/year for space cooling, and 16,955 MJ/year for water heating) is 6470 kWh. Based on a Knoxville average power rate of $0.0378/kWh, the first-year power cost is $244.83. Table 34 summarizes system 5 costs for Knoxville, Tennessee.

4.6 System 6—Gas Furnace, Central Air Conditioner, and Gas Water Heater

This space-conditioning system consists of an advanced gas furnace, a central electric air conditioner, a gas water heater, an air distribution system, and associated auxiliary equipment. The installed cost includes all expenditures for equipment and installation. Where field fabrication of components is necessary (e.g., for the air ducts), the component cost includes both materials and labor.

4.6.1 Equipment Costs

Advanced gas furnace. The advanced gas furnace is a Kenmore-20 furnace available from Sears, Roebuck and Company. The unit, selected from Table 8, should have a heat output rating equal to or slightly greater than the design-day heating load of the building in a particular climate.

Table 34. Estimated costs for system 5 in Knoxville, Tennessee

Item	Basis of estimation	Cost[a]
	Equipment costs	
Mechanical package	Table 25, heating capacity	3,130
Air ducts	Table 16, system heating capacity	1,049
Hot water tank	Price of 310-L (82-gal) tank	335
Ice storage bin	Table 33	5,839
Solar panel	Panel not required	0
Brine lines	Table 27, system heating capacity	240
Electrical wiring	Table 28, system heating capacity	76
Controller and sensors	Fixed cost	320
	Installation costs	
Mechanical package	Table 29, system heating capacity	364
Hot water tank	Installation cost for 310-L (82-gal) tank	170
	Maintenance costs	
25-year present value	Table 30, annual discount rate of 3.5%	2,432
	Energy costs	
25-year present value	$244.83 (FYC) × 18.59 (PWF)	4,551
Life-cycle cost		18,506

[a]In 1980 dollars.

Gas water heater. The water heater is a 150-L (40-gal) gas-fired unit available from Sears, Roebuck and Company for $270. The unit, a Kenmore Power Miser 10, is described in ref. 7 (p. 1147).

Air conditioner. The air conditioner is a Sears Best Series unit (Table 3). It should have a cooling capacity equal to or slightly greater than the design-day cooling load of the building in a particular climate.

Controls. The basic control system is a heating and cooling thermostat available from Sears, Roebuck and Company for $26. The thermostat has a manual switch for constant or automatic fan use and uses a five-wire hookup. The unit is described in ref. 7 (p. 1163).

Auxiliaries. The auxiliary equipment includes refrigerant lines connecting the cooling coil to the compressor package, electrical components and wiring for installing the system, and accessory items for installing the gas furnace. The cost of providing refrigerant lines, obtained from Table 14, is a function of the system cooling capacity. The cost of providing hookup for electrical services includes a 7.6-cm (3-in.) gas vent pipe that is 6.1 m (20 ft) in length; a vent kit containing a ventilator top, store collar, roof flashing, and vent collar connector; and a pipe collar, a filter rack, and filters. The total price of these accessory items, obtainable from Sears, Roebuck and Company, is $90; prices of the individual items are listed in ref. 7 (p. 1160). An additional $50 is allotted for installation of the accessories.

Air ducts. The duct system is sized to accommodate the cooling capacity of the air conditioner, and its cost is selected from Table 16.

4.6.2 Installation Costs

Hot water tank. The cost of installing the gas-fired water heater is assumed to be $170.

Air conditioner. The estimated cost of installing a split-system central air conditioner is obtained from Table 17 on the basis of the system cooling capacity.

Gas furnace. The cost of installing the advanced gas furnace is assumed to be $50. Note that an additional $50 for installing the gas venting and filtering system has already been included in Sect. 4.6.1 under the subheading "Auxiliaries."

4.6.3 Maintenance Costs

Routine servicing is assumed to cost $12/year for filter changes and equipment inspection, except for the 6th, 12th, and 18th years, when the indoor and outdoor heat exchanger coils require cleaning, thus raising the overall cost to $25. The air conditioner should be inspected and its refrigerant charge adjusted every six years, at a cost of about $65 in 1980 dollars. Replacement of contactors, starting capacitors, and fan motors, at a cost of about $125, is assumed to be required at the end of the tenth year. The hot water tank is assumed to fail every nine years, requiring replacement. Labor costs for water tank replacement are assumed to be $60, as compared with a $170 labor charge for initial installation. Table 35 shows the assumed maintenance costs and schedule for system 6.

Table 35. Schedule of annual maintenance costs for system 6

In 1980 dollars

Year	Routine service	Refrigerant system	Electrical system	Water heater	Total
1981	12				12
2	12				12
3	12				12
4	12				12
5	12				12
6	25	65			90
7	12				12
8	12				12
9	12			330	342
1990	12				12
1	12				12
2	25	65			90
3	12		125		137
4	12				12
5	12				12
6	12				12
7	12				12
8	25	65		330	420
9	12				12
2000	12				12
1	12				12
2	12				12
3	12				12
4	25	65			90
5	12				12
					889[a]

[a]Present value at an annual discount rate of 3.5%.

4.6.4 System 6 Costs for Knoxville, Tennessee

The methods described in Sects. 4.6.1–4.6.3 for sizing and costing components were applied to a reference house in Knoxville, Tennessee. The design-day loads are 9529 W (32,513 Btu/h) for space heating and 6783 W (23,144 Btu/h) for space cooling. The annual energy consumption is computed to be 727 therms of gas and 2783 kWh of electricity. The estimated costs are shown in Table 36.

Table 36. Estimated costs for system 6 in Knoxville, Tennessee

Item	Basis of estimation	Cost[a]
	Equipment costs	
Gas furnace	Table 8, building design-day heating load	745
Air conditioner	Table 3, building design-day cooling load	1,279
Controls	Thermostat price	26
Air ducts	Table 16, system cooling capacity	907
Water heater	Price of 150-L (40-gal) Kenmore Power Miser 10	270
Refrigerant lines	Table 14, system heating capacity	160
Electrical wiring	Table 15, system heating capacity	76
Furnace accessories	Price of vent pipe, filter rack, etc.	140
	Installation costs	
Air conditioner	Table 17, system cooling capacity	364
Hot water tank	Installation cost of water heater	170
Gas furnace	Miscellaneous installation tasks	50
	Maintenance costs	
25-year present value	Table 35, for all locations	889
	Energy costs	
25-year gas present value	$266.63 (FYC) × 31.67 (PWF)	8,444
25-year electric present value	$105.20 (FYC) × 18.59 (PWF)	1,956
Life-cycle cost		15,476

[a]In 1980 dollars.

4.7 System 7—Oil Furnace, Central Air Conditioner, and Electric Water Heater

This space-conditioning system consists of an oil furnace, a central electric air conditioner, an electric water heater, and an air distribution system. The installed cost includes all expenditures for equipment, materials, and installation. Where field fabrication of components is necessary, as for the air ducts, the cost of the component includes both materials and labor.

4.7.1 Equipment Costs

Oil furnace. The basement, upflow oil furnace is available from Sears, Roebuck and Company and is fully described in ref. 7 (p. 1162). The unit is selected from Table 9, which summarizes the available prices and capacities, and should have a heat output rating equal to or slightly greater than the design-day heating load of the building in the particular climate.

Electric water heater. The water heater is a Kenmore Power Miser 10 unit available for $275. The 200-L (52-gal) water tank is described in ref. 7 (p. 1145).

Air conditioner. The air conditioner is a Sears Best Series unit selected from Table 3. It should have a cooling capacity equal to or slightly greater than the design-day cooling load of the building in the particular climate.

Controls. The basic control system is a heating and cooling thermostat available from Sears, Roebuck and Company for $26.[7] The thermostat is the same as for system 6.

Auxiliaries. Auxiliary equipment includes the refrigerant lines from the cooling coil to the compressor package (Table 14); electrical items such as switch boxes and circuit breakers, needed for installing the system (Table 15); and accessories associated with the oil furnace. These accessories include a 1040-L (275-gal) oil tank and a venting system consisting of a 15-cm (6-in.) pipe that is 6.1 m (20 ft) long. The oil tank is available from Sears, Roebuck and Company for $156, and materials for the venting system are available for $240.[7]

Air ducts. The ducts are sized to accommodate the cooling capacity of the air conditioner, and the cost is derived from the data in Table 16.

4.7.2 Installation Costs

Hot water tank. The cost of installing the electric water heater is assumed to be $170.

Air conditioner. The cost of installing a split-system, central electric air conditioner is obtained from Table 17.

Oil tank. The cost of installing the oil tank is assumed to be $200.

Vent pipe. The cost of installing the venting system is assumed to be $100.

4.7.3 Maintenance Costs

Routine servicing is associated primarily with the air-conditioning system, and major component replacement on a periodic basis is limited to the water heater. It is assumed that the maintenance costs and schedule of system 7 are identical with those of system 1.

4.7.4 System 7 Costs for Knoxville, Tennessee

The methods described in Sects. 4.7.1–4.7.3 for sizing and costing components of system 7 were applied to a reference house in Knoxville, Tennessee. The design-day loads are 9529 W (32,513 Btu/h) for space heating and 6783 W (23,144 Btu/h) for space cooling. The annual energy consumption is 1440-L (381-gal) of oil and 7493 kWh of electricity. The estimated costs of system 7 for the Knoxville location are summarized in Table 37.

4.8 System 8—Pulse Gas Furnace, Central Air Conditioner, and Gas Water Heater

This space-conditioning system consists of a pulse gas furnace, a central electric air conditioner, a gas water heater, an air duct system, and associated auxiliary equipment. The installed cost includes all expenditures for equipment and installation. Where field fabrication of components is necessary, such as for air ducts, the component cost includes both materials and labor.

Table 37. Estimated costs for system 7 in Knoxville, Tennessee

Item	Basis of estimation	Cost[a]
	Equipment costs	
Oil furnace	Table 9, building design-day heating load	690
Air conditioner	Table 3, building design-day cooling load	1,279
Controls	Price of thermostat	26
Air ducts	Table 16, system cooling capacity	907
Water heater	Price of water heater	275
Refrigerant lines	Table 14, system cooling capacity	160
Electrical wiring	Table 15, system heating capacity	76
Oil tank	Price of 1040-L (275-gal) oil tank	156
Vent system	6-m (20-ft) chimney and accessories	240
	Installation costs	
Air conditioner	Table 17, system cooling capacity	364
Hot water tank	Installation cost of water heater	170
Oil tank	Installation cost of oil storage tank	200
Vent system	Installation of furnace and vent system	100
	Maintenance costs	
25-year present value	Table 18, for all locations	914
	Energy costs	
25-year oil present value	$446 (FYC) × 25.25 (PWF)	11,262
25-year electric present value	$284 (FYC) × 18.59 (PWF)	5,280
Life-cycle cost		22,099

[a]In 1980 dollars.

4.8.1 Equipment Costs

Pulse gas furnace. The pulse gas furnace does not represent any specific model commercially available today; rather, it represents units that should be marketed soon. It is assumed that the cost of a pulse gas furnace is $1125, regardless of its heating output capacity. The furnace, described in Sect. 2.3.2, is assumed to have an operating efficiency of 93%.

Other equipment. All other components, with the exception of furnace accessories listed in Table 36, are identical to those already described for system 6. The sizing and costing methods described in Sect. 4.6.1 also apply for system 8. The furnace accessories listed for system 6 are not required for the pulse gas furnace system.

4.8.2 Installation Costs

The installation costs for system 8 are identical to those already described in Sect. 4.6.2 for system 6.

4.8.2 Maintenance Costs

The maintenance requirements for the pulse gas furnace system are identical to those already described for system 6, except that an additional $100 is required in the tenth

operating year to replace reed valves and the condensate pump of the pulse gas furnace. As a result, the present value of the maintenance costs of system 8 over a 25-year period is $960.

4.8.4 System 8 Costs for Knoxville, Tennessee

The estimated costs for system 8 at the Knoxville location are summarized in Table 38.

Table 38. Estimated costs for system 8 in Knoxville, Tennessee

Item	Basis of estimation	Cost[a]
	Equipment costs	
Pulse gas furnace	Price of pulse gas furnace	1,125
Air conditioner	Table 3, building design-day cooling load	1,279
Controls	Price of Sears thermostat	26
Air ducts	Table 16, system cooling capacity	907
Water heater	Price of 150-L (40-gal) Kenmore Power Miser 10	270
Refrigerant lines	Table 14, system cooling capacity	160
Electrical wiring	Table 15, system heating capacity	76
	Installation costs	
Air conditioner	Table 17, system cooling capacity	364
Hot water tank	Installation cost of water heater	170
Furnace setup	Installation cost	50
	Maintenance costs	
25-year present value	Table 35, plus $100 in year 10	960
	Energy costs	
25-year gas present value	$223.69 (FYC) × 31.67 (PWF)	7,084
25-year electric present value	$105.20 (FYC) × 18.59 (PWF)	1,956
Life-cycle cost		14,427

[a]In 1980 dollars.

5. RESULTS OF SYSTEMS EVALUATIONS

5.1 Description of Computer Output Tables

The estimated costs and performances of eight different HVAC systems in 115 U.S. cities are listed in computer output tables in Appendix C. Table 39, which gives the results of the evaluations of the eight heating and cooling systems for Knoxville, Tennessee, is an example of these computer output tables. It has information about the climate, capacities and costs of the HVAC systems, and their energy consumptions while they supply the estimated building loads. Table 39 will be used to detail the broad categories of information given in each of the tables of Appendix C.

5.1.1 Characteristics of the Locality

Table 39's heading identifies Knoxville as the city for which the eight HVAC systems are evaluated and lists the prevalent prices of electricity, natural gas, and heating oil in that area. It also lists the design ambient temperatures and the ratio of the total to the sensible cooling load for the reference house in Knoxville. The design ambient temperatures are used to calculate the design-day heating and cooling loads of the reference house that are given in the table heading.

Estimations of building space-heating, water-heating, and space-cooling loads for the reference houses are based on much more extensive, site-specific data than are shown in the tables; these data include monthly values for average wind speeds, intensities of solar radiation, and ground temperatures; dry- and wet-bulb air temperatures; and duration times, as presented in ref. 21. A complete description of the weather data set required for each city studied is given in ref. 8.

5.1.2 Building Thermal Performance

The house for which the MAD computer program calculates heating and cooling loads is identified in Table 39 simply as a "167 sq m home, well insulated." The building specified in the calculations is, in fact, the reference house described in Sect. 2.1.1, where major assumptions concerning the occupancy, construction, and operation of the building are detailed. A building with high thermal integrity was used because independent cost/benefit analyses have shown that such measures as providing storm doors, double glazing of windows, and high insulation in floors, walls, and ceilings are economically justifiable on their own merit.[22] Thus, the choice of a particular home heating and cooling system should be made under the assumption that prudent energy conservation measures relating to the building's thermal envelope have already been taken.

The computer program calculates the house's design-day heating and cooling loads for the climate of the given locality. Table 39 lists the calculated design-day loads for the reference house located in Knoxville, Tennessee, as 9529 W (32,513 Btu/h) for heating and 6783 W (23,144 Btu/h) for cooling. The heating and cooling system for that house must be able to supply these loads, so this requirement establishes the size and cost of the components of each of the eight systems, as described in Sect. 3. Also calculated by the computer program and listed in Table 39 are the monthly and annual requirements for water heating, space heating, and space cooling; these demands for energy services must be satisfied by each of the eight systems of the study. Table 39 lists the energy consumed by each system while delivering these services to the building.

Table 39. Sample computer output listing for systems evaluation

KNOXVILLE, TENNESSEE

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 9529.
DESIGN COOLING LOAD (WATTS) = 6783.

EL. ($/KWHR) = 0.0378, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3667, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -10 C 33 C
TOTAL/SENSIBLE COOLING = 1.26

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1808.	9071.	0.	3022.	1909.	1790.	1220.	1185.	151.	29.	101.	531.	123.	29.
FEB	1625.	5345.	0.	1936.	1288.	1203.	801.	759.	99.	17.	61.	468.	81.	17.
MAR	1694.	4612.	0.	1752.	1114.	1008.	716.	687.	91.	15.	54.	485.	75.	15.
APR	1475.	1220.	1079.	866.	726.	632.	322.	319.	42.	121.	16.	531.	37.	121.
MAY	1327.	0.	2552.	647.	793.	636.	191.	191.	27.	278.	5.	647.	22.	278.
JUN	1128.	0.	4498.	803.	995.	796.	679.	196.	21.	490.	2.	803.	19.	490.
JUL	1074.	0.	6120.	965.	1203.	966.	1123.	214.	18.	667.	0.	965.	18.	667.
AUG	1084.	0.	6145.	971.	1209.	962.	1130.	465.	18.	669.	0.	971.	18.	669.
SEP	1150.	0.	3309.	680.	821.	647.	633.	689.	21.	360.	2.	680.	19.	360.
OCT	1364.	1192.	903.	808.	662.	578.	291.	283.	40.	102.	16.	481.	35.	102.
NOV	1505.	3658.	0.	1434.	930.	847.	541.	521.	75.	12.	44.	430.	62.	12.
DEC	1721.	7092.	0.	2448.	1552.	1439.	985.	960.	124.	22.	80.	500.	101.	22.
ANNUAL	16955.	32190.	24605.	16333.	13202.	11503.	8631.	6470.	727.	2783.	381.	7493.	610.	2783.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	534.	3412.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	634.	3972.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 13.5 M3 PANEL= 14.6 M2	3130.	2464.	1684.	636.	335.	1049.	534.	9832.
5	FULL ACES, BIN= 76.4 M3 PANEL= 0.0 M2	3130.	5839.	0.	636.	335.	1049.	534.	11523.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.25	914.	618.05	REF.	REF.	11490.	15962.	27333.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.55	2162.	499.55	118.50	-147.	9287.	14861.	24067.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.78	2468.	435.26	182.79	413.	8091.	14531.	22553.
4	MIN. ACES, BIN= 13.5 M3 PANEL= 14.6 M2	2.37	2432.	326.61	291.44	6273.	6072.	18336.	24355.
5	FULL ACES, BIN= 76.4 M3 PANEL= 0.0 M2	3.17	2432.	244.83	373.22	7964.	4551.	18506.	23018.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.07	889.	371.88	246.17	628.	10400.	15476.	18738.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.61	914.	729.83	-111.78	1084.	16540.	22097.	25231.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.34	960.	328.99	289.06	868.	9042.	14429.	17478.

5.1.3 HVAC Systems Efficiencies and Life-Cycle Costs

System efficiency. The annual efficiency of each system is listed in Table 39 as ACOP. Taken from heat pump terminology, the term signifies the ratio, in consistent units, of total energy services delivered by the system to the total energy consumed during the year. The ratio exceeds unity because ambient heat is pumped from the environment by the heat pump or central air-conditioning unit associated with each of the systems.

A unit of energy delivered to the lot line in the form of fossil fuel is assumed to be equivalent to ϵ units of energy delivered in the form of electricity. Under this assumption,

$$\text{ACOP} = (Q_{HW} + Q_{SH} + Q_{SC})/(\epsilon E_{FOS} + E_{ELE}) , \tag{5}$$

where

Q_{HW} = annual energy delivered for water heating,
Q_{SH} = annual energy delivered for space heating,
Q_{SC} = annual energy removed from house for space cooling,
E_{FOS} = annual fossil fuel energy consumed by the system,
E_{ELE} = annual amount of electricity consumed by the system,
ϵ = equivalency ratio of electricity to fossil fuel (= 1/3).

A perhaps more conventional definition of system efficiency is obtained by expressing annual energy consumption in terms of fossil fuel rather than electrical units. Thus, from Eq. (5), the system efficiency (SEFF) may be written

$$\text{SEFF} = (Q_{HW} + Q_{SH} + Q_{SC})/(E_{FOS} + E_{ELE}/\epsilon) . \tag{6}$$

In this definition of system efficiency, the annual energy services are related to the primary energy content of the fossil fuel before the occurrence of losses from steam-electric conversion and power transmission. Equations (5) and (6) show that ACOP and SEFF are related:

$$\text{SEFF} = \epsilon \times \text{ACOP} . \tag{7}$$

The data of Table 39 are used to illustrate the calculation of the ACOPs of systems 6, 7, and 8 by means of Eq. (5). The annual energy services supplied by the systems are 16,955 MJ for water heating, 32,190 MJ for space heating, and 24,605 MJ for space cooling, or a total of 73,750 MJ. Applying the conversion ratio, 3.6 MJ/kWh, yields a value of 20,486 kWh for the total annual energy services. The annual energy consumption and the ACOP of each of the fossil-fueled space-conditioning systems are given in Table 40.

Life-cycle costs. Table 39 shows two sets of life-cycle costs for each of the eight space-conditioning systems in Knoxville, Tennessee. The first set is based on the actual cost of energy to residential customers in that city; these costs are estimated by escalating the 1980 energy prices of each city according to the projected real increases shown in Table 11. The second set is based on estimated marginal energy costs that are assumed constant

Table 40. Example calculation of annual coefficient of performance for systems 6, 7, and 8

System No.	Gas (therm)[a]	Oil (gal)[b]	Electricity (kWh)[c]	E_{TOT} (kWh)[d]	ACOP[e] ($20{,}486/E_{TOT}$)
6	727	0	2,783	9,885	2.07
7	0	381	7,493	12,704	1.61
8	610	0	2,783	8,742	2.34

[a]0.1×10^6 Btu/therm.
[b]140,000 Btu/gal.
[c]3,413 Btu/kWh.
[d]The equivalency ratio of electricity to fossil fuel, ϵ, is 1/3.
[e]Annual coefficient of performance calculated by Eq. (5).

throughout the country. The marginal energy price represents the charge that would be assessed the customer if users were required to pay costs associated with new generating capacity, new production capacity, and new delivery systems. These asymptotic energy prices are assumed to be constant (in 1980 dollars) because they are based on a relatively abundant fossil fuel, for example, coal.

The first set of life-cycle costs measures the relative economics of the eight space-conditioning systems from the customer's point of view. The system with the lowest of these costs is the one the customer should select if he is financially able to do so and if the system meets his other requirements. The second set of life-cycle costs measures the effectiveness of each system in minimizing total capital investment from the entire nation's perspective. These marginal life-cycle costs, because they include the costs both of new energy production plants and of the space-conditioning systems, spotlight those systems that are beneficial to the nation as a whole.

5.2 Life-Cycle Cost Components in Selected Cities

The breakdown of life-cycle costs into first costs, present value maintenance costs, and present value energy costs is presented in Appendix E for all eight systems of the study and in 115 U.S. cities. Figures 1 through 3 show detailed results of the analysis for three cities representative of warm, moderate, and cold regions of the country. System 8, comprised of a pulse gas furnace, a gas water heater, and a central electric air conditioner, is the preferred system (from the viewpoint of minimum life-cycle costs) in all three locations. Interesting features are as follows:

- Orlando, Florida (Fig. 1) — Except for the ACES, the first costs are nearly the same for all systems and are much lower than for those of HVAC systems in northern cities because the annual requirement for air conditioning greatly exceeds that for space heating.

- Knoxville, Tennessee (Fig. 2) — This city is typical of a broad region of the central United States where the annual heating and cooling requirements are roughly the same; the climate has 3000 to 6000 heating degree-days. Although the full ACES is the most energy efficient, the pulse gas furnace system with electric air conditioning is the economic winner and the system of choice where natural gas services are available.

- Minneapolis, Minnesota (Fig. 3) — Incentives to employ the natural gas system are even greater here than in the Knoxville area because of the greater annual space-heating requirements in this climate. System 8, the pulse gas furnace with electric air conditioner, is clearly the system of choice in the northern regions of the country.

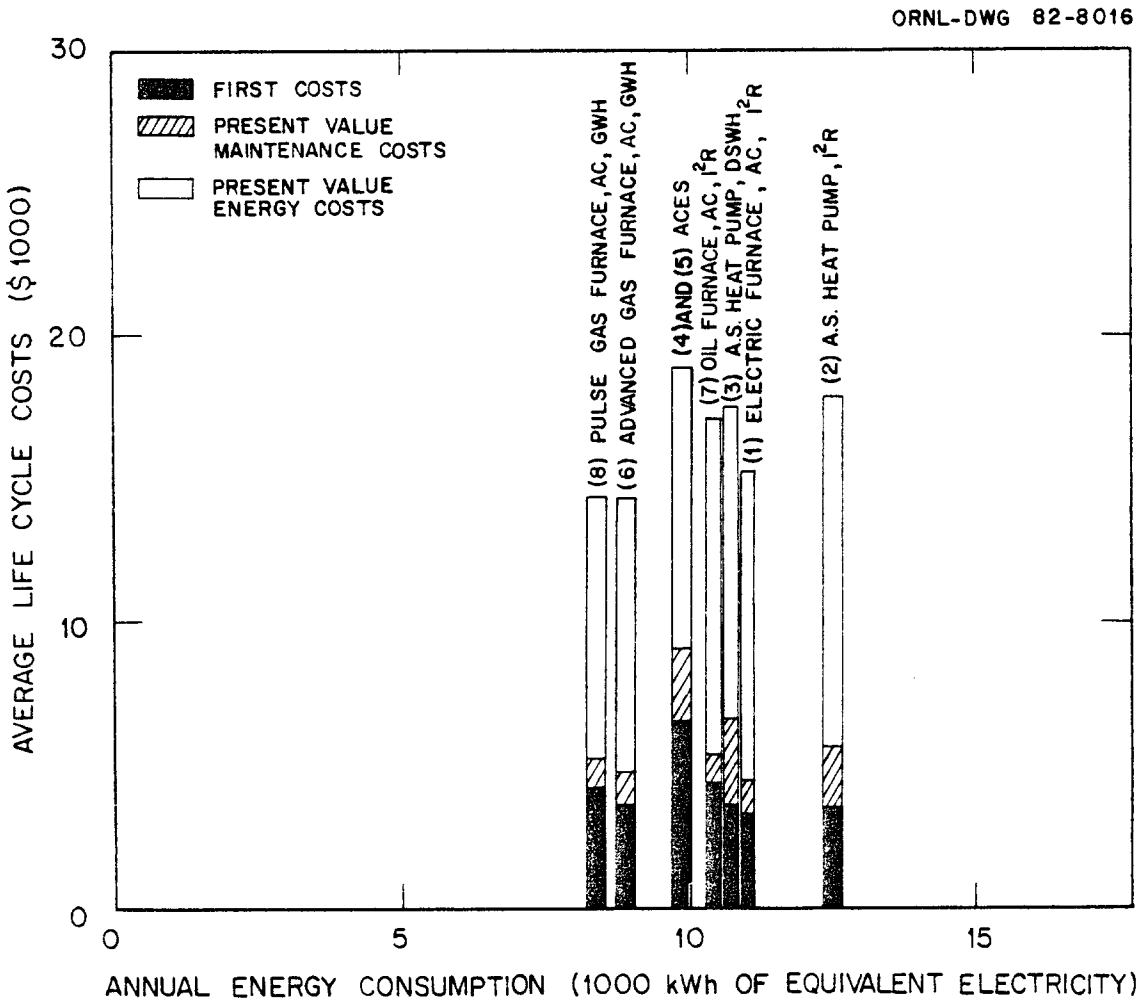

Fig. 1. Life-cycle costs for all systems for Orlando, Florida, 1982, representative of a warm climate. The numbers in parentheses are the system numbers. 3 units of fossil energy = 1 unit of electrical energy. AC: central electric air conditioner; I^2R: electric resistance water heater; A.S.: air source; DSWH: desuperheater water heater; ACES: annual cycle energy system; GWH: gas water heater.

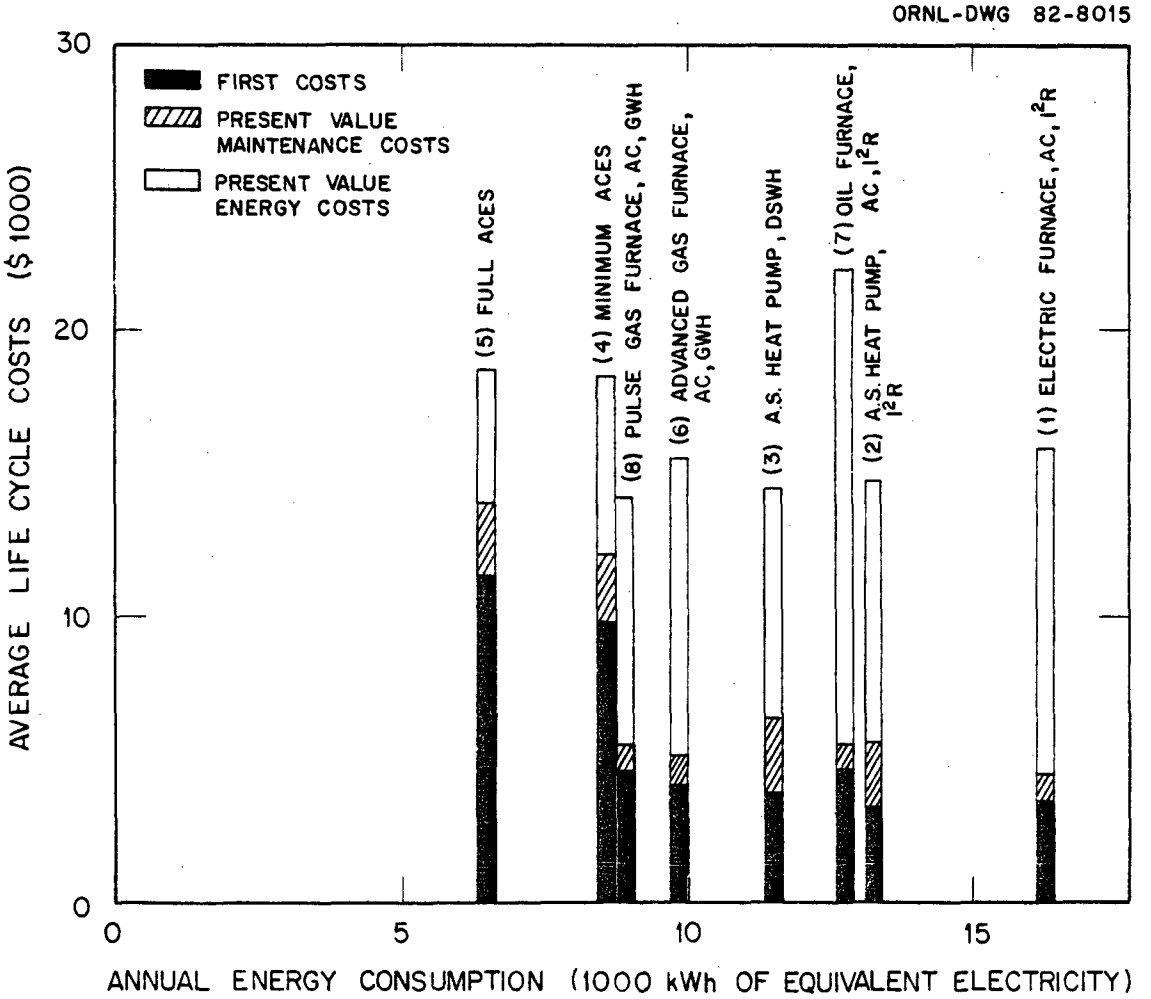

Fig. 2. Life-cycle costs for all systems for Knoxville, Tennessee, 1982, representative of a moderate climate. The numbers in parentheses are the system numbers. 3 units of fossil energy = 1 unit of electrical energy. AC: central electric air conditioner; I^2R: electric resistance water heater; A.S.: air source; DSWH: desuperheater water heater; ACES: annual cycle energy system; GWH: gas water heater.

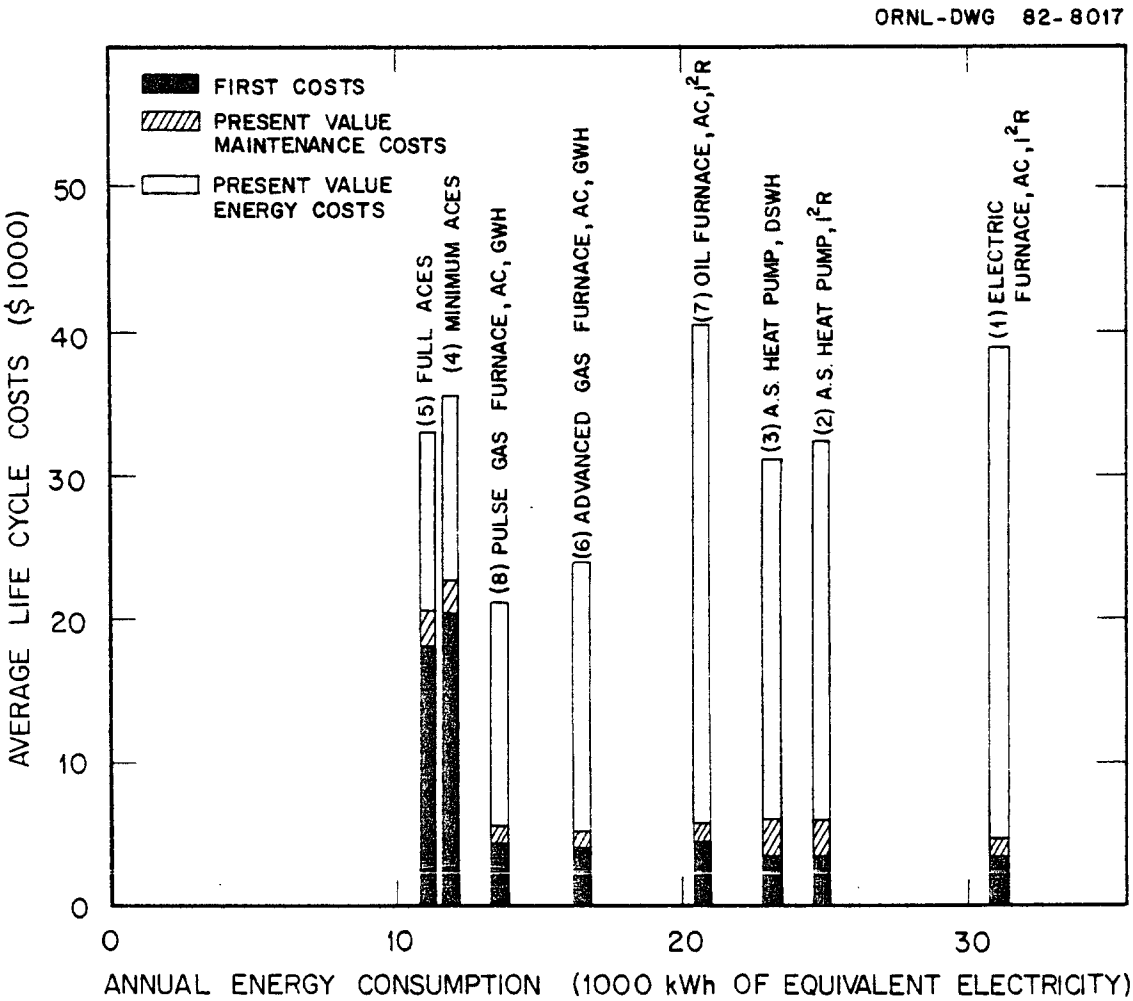

Fig. 3. Life-cycle costs for all systems for Minneapolis, Minnesota, 1982, representative of a cold climate. The numbers in parentheses are the system numbers. 3 units of fossil energy = 1 unit of electrical energy. AC: central electric air conditioner; I^2R: electric resistance water heater; A.S.: air source; DSWH: desuperheater water heater; ACES: annual cycle energy system; GWH: gas water heater.

6. CONCLUSIONS

6.1 National Perspective of Preferred HVAC Systems

The computer output tables of systems evaluations in 115 U.S. cities, presented in Appendix E, show distinct regional patterns in the preferred systems from the standpoints of system efficiency and system economics. These broad patterns are discussed briefly in the following sections. To obtain systems evaluation results for a specific locality, see Appendix C.

6.1.1 Energy Conservation

The full ACES exhibits the highest efficiency of all systems in a broad area spanning the central United States. The ACES yields slightly lower efficiencies, although it is still significantly better than its nearest competitors, in regions north or south of the central region. The ACES is highly efficient in the central region because of a favorable balance between annual heating and cooling needs of the reference houses in such climates. This balance allows a greater degree of interseasonal energy transfer by the system. The ACES performs better than all other systems throughout the country except in the Deep South, where annual cooling needs so greatly exceed annual heating needs that little interseasonal energy transfer is possible.

The pulse gas furnace with a gas water heater and a central electric air conditioner, system 8 of this study, provides a system operating efficiency rivaling that of the ACES in the northern and southern parts of the country. The pulse gas furnace system is also a respectable ACES competitor even in the central regions of the country and will probably be the system of choice in all locations where natural gas services are available at reasonable prices. Furthermore, the system can be improved technologically by extending the pulse combustion concept for use in water heating as well as space heating. Such an improvement would significantly enhance both the performance characteristics and the relative economics of the system.

6.1.2 HVAC System of Economic Choice

The estimated first cost of the ACES is high, more than twice that of a conventional heating and cooling system in most parts of the country. In addition, although the annual operating costs of the ACES are much lower than those of conventional systems, the ACES life-cycle costs still exceed those of all other systems except system 7. (System 7 is comprised of an oil-fired furnace with an electric water heater and a central electric air conditioner.) Consequently, unless the first cost of the ACES can be significantly reduced, which seems unlikely now, the system has scant market prospects in spite of its great potential for energy conservation.

Clearly, the economic winner in this systems comparison study is system 8—comprised of a pulse gas furnace with a gas water heater and a central electric air conditioner. This system exhibits markedly lower life-cycle costs, in most parts of the country, than those of all other systems analyzed. The only exceptions occur in regions where anomalous pockets of low electric power rates exist because of local factors, such as an abundance of hydroelectric capacity. In many parts of the country, system 6, employing an advanced, gas-fired furnace

with a gas water heater and a central electric air conditioner, is a close runner-up to system 8. Depending on the specific gas and power rates that apply, system 6 may be supplanted in the economic ranking by one of the heat pump systems, systems 2 and 3.

Analysis of the heat pump systems shows that the increment in first costs caused by adding a desuperheater is fully justified by the reduction it brings in life-cycle costs. Of the electric systems, system 3 exhibits the lowest life-cycle costs in the northern part of the country. In the South, there is little difference among the life-cycle costs of systems 1, 2, and 3. A somewhat surprising result of the evaluation is the rather close bunching of the life-cycle costs of all systems. Generally speaking, the ACES and oil-furnace systems exhibit high life-cycle costs, and the gas-fired systems exhibit low life-cycle costs. The overall spread in life-cycle costs, however, is less than had been expected, and uncertainties in the calculations may, in some cases, affect the relative rankings of the systems.

6.2 Future Prospects

This study was undertaken to determine whether increasing energy prices are causing changes in the relative life-cycle rankings of new and conventional space-heating and -cooling systems for residences. It was anticipated that the higher energy prices since completion of a earlier systems evaluation study, reported in ref. 1, would improve the competitiveness of such energy-conserving systems as the ACES. Unfortunately, the results of the present study show that this did not occur: costs of equipment and installation have risen even more rapidly than energy costs during the past two years. As a result, it now appears unlikely that systems with high efficiency and high first costs can ever attain a significant share of the market, even if energy prices continue to escalate. A more likely reaction by the residential consumer to excessively high energy prices will be to change his life-style. The practice of centrally heating and cooling an entire single-family residence is likely to be sharply reduced as the average American struggles to cope with the rising costs of energy, home construction, food, and other necessities. Zone control, that is, heating and cooling only a few rooms at selected times, offers an effective way to reduce fuel costs; this method is likely to be used more often in the future.

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APPENDIX A

1980 ENERGY COSTS IN 115 U.S. CITIES

Table A.1. Power cost data for 115 U.S. cities

Location	Electric[a] Jan. 1, 1981 ($1000/kWh)	Gas[b] ($10^6/Btu)	Oil[b] ($/gal)
Alabama			
Birmingham	58.19	3.667	1.17
Montgomery	58.19	3.667	1.17
Arizona			
Tucson	58.67	3.022	1.12
Phoenix	62.97	3.571	1.07
Yuma	63.14	3.478	1.04
Arkansas			
Little Rock	51.48	3.667	1.17
California			
Los Angeles	68.06	3.008	1.13
Merced	50.32	3.477	1.04
Oakland	50.32	3.098	1.12
San Diego	96.21	3.511	1.07
Colorado			
Colorado Springs	34.46	3.022	1.12
Denver	56.68	4.281	1.07
Grand Junction	56.68	3.477	1.04
District of Columbia			
Washington, D.C.	49.34	4.457	1.17
Florida			
Apalachicola	64.09	3.685	1.19
Jacksonville	82.80	3.550	1.17
Orlando	53.01	3.667	1.17
Georgia			
Atlanta	49.43	4.195	1.17
Augusta	49.43	3.685	1.19
Macon	49.43	3.667	1.17
Idaho			
Boise	31.46	3.022	1.12
Idaho Falls	18.00	3.477	1.04
Illinois			
Chicago	56.41	3.953	1.13
E. St. Louis	44.59	3.702	1.06
Urbana	48.08	3.702	1.06
Indiana			
Fort Wayne	40.02	3.697	1.11
Indianapolis	40.07	3.663	1.14
South Bend	40.02	3.697	1.11
Iowa			
Des Moines	54.60	3.697	1.11
Sioux City	60.57	3.697	1.11
Kansas			
Dodge City	52.59	3.702	1.06
Topeka	50.66	3.697	1.11
Kentucky			
Louisville	41.51	3.667	1.17

Table A.1. (continued)

Location	Electric[a] Jan. 1, 1981 ($1000/kWh)	Gas[b] ($10^6/Btu)	Oil[b] ($/gal)
Louisiana			
Lake Charles	47.72	3.667	1.17
New Orleans	45.45	3.550	1.17
Shreveport	35.58	3.667	1.17
Maine			
Portland	62.86	6.319	1.18
Massachusetts			
Falmouth	78.61	6.319	1.18
Michigan			
Battle Creek	54.73	3.702	1.06
Detroit	55.72	4.034	1.13
Sault Ste. Marie	32.72	3.702	1.06
Minnesota			
Duluth	50.81	3.697	1.11
International Falls	49.73	3.702	1.06
Minneapolis	57.97	3.697	1.11
Mississippi			
Biloxi	56.28	3.685	1.19
Columbus	36.90	3.685	1.19
Jackson	63.05	3.667	1.17
Missouri			
Columbia	53.96	3.702	1.06
Kansas City	61.17	3.032	1.13
Springfield	50.40	3.697	1.11
Montana			
Billings	32.16	3.478	1.04
Great Falls	32.16	3.478	1.04
Missoula	32.16	3.478	1.04
Nebraska			
Grand Island	61.11	3.702	1.06
Lincoln	45.14	3.697	1.11
North Platte	38.35	3.702	1.06
Nevada			
Ely	40.41	3.478	1.04
Las Vegas	42.43	3.022	1.12
Winnemucca	60.15	3.478	1.04
New Jersey			
Trenton	76.80	4.657	1.19
New Mexico			
Albuquerque	74.91	3.022	1.12
Roswell	51.51	3.478	1.04
New York			
Albany	46.54	4.657	1.19
Binghamton	49.99	5.319	1.18
Niagara Falls	46.54	6.319	1.18
Syracuse	46.54	4.651	1.19
Westhampton Beach	67.53	6.319	1.18

Table A.1. (continued)

Location	Electric[a] Jan. 1, 1981 ($1000/kWh)	Gas[b] ($10^6/Btu)	Oil[b] ($/gal)
North Carolina			
New Bern	54.40	3.685	1.19
Greensboro	46.11	3.667	1.17
North Dakota			
Bismarck	46.89	3.702	1.06
Grand Forks	43.02	3.702	1.06
Williston	46.89	3.702	1.06
Ohio			
Akron	46.84	3.697	1.11
Columbus	62.41	3.633	1.14
Dayton	62.01	3.697	1.11
Toledo	64.24	3.697	1.11
Oklahoma			
Altus	42.48	3.685	1.19
Oklahoma City	45.65	3.667	1.17
Tulsa	43.63	3.667	1.17
Oregon			
Astoria	34.09	3.478	1.04
Medford	34.09	3.478	1.04
Portland	40.21	3.022	1.12
Pennsylvania			
Middletown	26.10	6.319	1.18
Philadelphia	71.76	5.407	1.15
Pittsburgh	58.82	3.592	1.15
Wilkes-Barre	44.24	6.319	1.18
South Carolina			
Charleston	51.09	3.685	1.19
Greenville	40.05	3.685	1.19
Sumter	50.72	3.685	1.19
South Dakota			
Huron	61.97	3.702	1.06
Rapid City	58.26	3.702	1.06
Tennessee			
Bristol	37.84	3.685	1.19
Knoxville	37.84	3.667	1.17
Memphis	38.79	3.550	1.17
Nashville	36.90	3.550	1.17
Texas			
El Paso	72.48	3.550	1.17
Fort Worth	56.59	3.508	1.17
Houston	59.40	3.893	1.13
San Antonio	46.77	3.550	1.17
Utah			
Salt Lake City	58.26	3.022	1.12
Vermont			
Burlington	39.45	6.319	1.18

Table A1. (continued)

Location	Electric[a] Jan. 1, 1981 ($1000/kWh)	Gas[b] ($10^6/Btu)	Oil[b] ($/gal)
Virginia			
Norfolk	64.32	3.667	1.17
Richmond	64.32	3.667	1.17
Roanoke	47.08	3.667	1.17
Washington			
Moses Lake	18.00	3.478	1.04
Seattle	16.09	5.402	1.13
Spokane	20.02	3.022	1.12
West Virginia			
Charleston	46.82	3.685	1.19
Elkins	47.03	3.685	1.19
Wisconsin			
Green Bay	41.79	3.697	1.11
Madison	41.52	3.697	1.11
Wyoming			
Casper	34.29	3.478	1.04
Cheyenne	26.70	3.478	1.04
Lander	34.29	3.478	1.04
Sheridan	27.22	3.478	1.04

[a]Ref. 18.
[b]Ref. 17.

APPENDIX B

LISTING OF THE MAD COMPUTER PROGRAM AND SAMPLE PROBLEM INPUT DATA

UT-ACES HOUSE--MODEL TWO-FOR ECONOMIC REPORT

1	1						
30.	.083	120.	1.				
80.	80.	80.	80.	80.	80.	80.	80.
80.0	80.0	80.	80.				
8.	1.1	40.0	37.0	37.0	0.8	0.4	
15.	0.85	1.00	0.085	1.29			
.1178	.0812	.00	25.				
4.46	0.41	.80	4.0	6.0	6.0		
0.00	0.00	0.00	2.55	19.0	10.0	2.05	2.40
0.0	0.0	0.0	0.0	0.0	0.0	2.75	2.00
.95	1.0	0.0					
3547.8	3547.8	3547.8	3547.8	3547.8	3547.8	3547.8	3547.8
3547.8	3547.8	3547.8	3547.8				
49.	18.	47.5	4.5	709.	466.	657.	479.5
1155.	.78	.87	20.53	31.	4.0		
.42	1.	1.	70.	78.			
8.0	1.15	16047.9					

ROOF KIT	429.	0.0488	1.0
TYPE 8 WALL	483.	0.0862	1.0
TYPE 2 WALL	1738.5	0.0487	1.0
DOOR	20.	0.25	1.0
WINDOW	166.5	0.580	1.0
ROOF BEDROOM	594.	.0252	.96
ROOF CONSOLE	132.	.0252	.78
FLOOR	1155.	0.040	0.17

```
KNOXVILLE, TENNESSEE                                C        35 49      83 59          980.
        13.        92.     .03784      3.667        1.17


KNOXVILLE,TN                                                                                201
 131. 186. 285. 420. 446. 488. 474. 484. 383. 288. 202. 154.
   9.   8.  11.   8.   8.   7.   6.   6.   6.   6.   7.   6.
    5    9   0.   3.   0.   3.   8.                                                  1     201
   10   14   3.   7.   0.  10.  12.                                                  1     201
   15   19  12.  20.   2.  34.  16.                                                  1     201
   20   24  14.  43.  18.  75.  20.                                                  1     201
   25   29  26.  33.  15.  74.  25.                                                  1     201
   30   34  40.  43.  33. 116.  29.                                                  1     201
   35   39  62.  57.  34. 153.  34.                                                  1     201
   40   44  51.  26.  66. 143.  37.                                                  1     201
   45   49  15.  11.  31.  57.  42.                                                  1     201
   50   54  12.   3.  27.  42.  44.                                                  1     201
   55   59  13.   2.  17.  32.  47.                                                  1     201
   60   64   0.   0.   4.   4.  49.                                                  1     201
   65   69   0.   0.   1.   1.  51.                                                  1     201
   70   74   0.   0.   0.   0.   0.                                                  1     201
    5    9   5.   1.   0.   6.   7.                                                  2     201
   10   14  11.   5.   8.  24.  10.                                                  2     201
   15   19   0.   3.   6.   9.  15.                                                  2     201
   20   24  10.  10.   3.  23.  20.                                                  2     201
   25   29  17.  12.   4.  33.  26.                                                  2     201
   30   34  33.  14.   6.  53.  30.                                                  2     201
   35   39  42.  20.  24.  86.  33.                                                  2     201
   40   44  44.  32.  29. 105.  39.                                                  2     201
   45   49  29.  47.  40. 116.  43.                                                  2     201
   50   54   9.  27.  44.  80.  46.                                                  2     201
   55   59  10.  25.  20.  55.  50.                                                  2     201
   60   64  14.  18.  27.  59.  54.                                                  2     201
   65   69   0.   6.  11.  17.  59.                                                  2     201
   70   74   0.   4.   2.   6.  61.                                                  2     201
   75   79   0.   0.   0.   0.   0.                                                  2     201
   25   29   9.   1.   0.  10.  25.                                                  3     201
   30   34  40.  16.   0.  56.  30.                                                  3     201
   35   39  62.  36.  17. 115.  33.                                                  3     201
   40   44  58.  46.  45. 149.  37.                                                  3     201
   45   49  38.  47.  46. 131.  41.                                                  3     201
   50   54  21.  35.  55. 111.  45.                                                  3     201
   55   59  15.  33.  36.  84.  51.                                                  3     201
   60   64   5.  17.  25.  47.  51.                                                  3     201
   65   69   0.   9.  12.  21.  54.                                                  3     201
   70   74   0.   7.   7.  14.  56.                                                  3     201
   75   79   0.   1.   5.   6.  59.                                                  3     201
   80   84   0.   0.   0.   0.   0.                                                  3     201
   30   34   4.   0.   0.   4.  32.                                                  4     201
   35   39  15.   4.   2.  21.  36.                                                  4     201
   40   44  22.  10.  11.  43.  39.                                                  4     201
   45   49  34.  18.   6.  58.  44.                                                  4     201
   50   54  39.  24.  22.  85.  47.                                                  4     201
   55   59  50.  33.  30. 113.  51.                                                  4     201
   60   64  41.  34.  50. 125.  56.                                                  4     201
   65   69  29.  45.  38. 112.  57.                                                  4     201
   70   74   6.  36.  42.  84.  58.                                                  4     201
   75   79   0.  30.  26.  56.  61.                                                  4     201
   80   84   0.   6.  13.  19.  62.                                                  4     201
   85   89   0.   0.   0.   0.   0.                                                  4     201
   35   39   3.   0.   0.   3.  39.                                                  5     201
   40   44  13.   4.   2.  19.  41.                                                  5     201
```

45	49	0.	6.	14.	20.	45.	5	201
50	54	14.	2.	0.	16.	50.	5	201
55	59	41.	15.	10.	66.	54.	5	201
60	64	85.	29.	31.	145.	60.	5	201
65	69	77.	35.	34.	146.	62.	5	201
70	74	15.	49.	43.	107.	64.	5	201
75	79	0.	63.	54.	117.	66.	5	201
80	84	0.	38.	46.	84.	67.	5	201
85	89	0.	7.	14.	21.	69.	5	201
90	94	0.	0.	0.	0.	0.	5	201
45	49	5.	0.	0.	5.	45.	6	201
50	54	18.	1.	3.	22.	49.	6	201
55	59	16.	10.	9.	35.	52.	6	201
60	64	16.	7.	9.	32.	57.	6	201
65	69	69.	14.	14.	97.	63.	6	201
70	74	106.	32.	46.	184.	67.	6	201
75	79	10.	51.	64.	125.	69.	6	201
80	84	0.	62.	44.	106.	69.	6	201
85	89	0.	54.	41.	95.	71.	6	201
90	94	0.	9.	10.	19.	71.	6	201
95	99	0.	0.	0.	0.	0.	6	201
60	64	2.	0.	0.	2.	62.	7	201
65	69	65.	6.	1.	72.	66.	7	201
70	74	146.	33.	45.	224.	69.	7	201
75	79	33.	62.	67.	162.	71.	7	201
80	84	2.	77.	65.	144.	73.	7	201
85	89	0.	53.	46.	99.	73.	7	201
90	94	0.	17.	23.	40.	73.	7	201
95	99	0.	0.	1.	1.	74.	7	201
100	104	0.	0.	0.	0.	0.	7	201
65	69	73.	5.	2.	80.	67.	8	201
70	74	139.	49.	63.	251.	70.	8	201
75	79	35.	62.	74.	171.	71.	8	201
80	84	1.	68.	53.	122.	72.	8	201
85	89	0.	51.	39.	90.	74.	8	201
90	94	0.	13.	13.	26.	74.	8	201
95	99	0.	0.	4.	4.	73.	8	201
100	104	0.	0.	0.	0.	0.	8	201
45	49	1.	0.	0.	1.	48.	9	201
50	54	16.	1.	0.	17.	51.	9	201
55	59	32.	7.	4.	43.	54.	9	201
60	64	52.	14.	15.	81.	59.	9	201
65	69	88.	34.	45.	167.	63.	9	201
70	74	46.	62.	49.	157.	65.	9	201
75	79	5.	44.	45.	94.	66.	9	201
80	84	0.	55.	40.	95.	67.	9	201
85	89	0.	23.	40.	63.	68.	9	201
90	94	0.	0.	2.	2.	70.	9	201
95	99	0.	0.	0.	0.	0.	9	201
35	39	11.	2.	0.	13.	36.	10	201
40	44	29.	6.	0.	35.	39.	10	201
45	49	42.	12.	9.	63.	44.	10	201
50	54	62.	36.	30.	128.	48.	10	201
55	59	73.	52.	49.	174.	52.	10	201
60	64	20.	35.	46.	101.	54.	10	201
65	69	11.	33.	48.	92.	57.	10	201
70	74	0.	43.	37.	80.	59.	10	201
75	79	0.	28.	24.	52.	61.	10	201
80	84	0.	1.	5.	6.	62.	10	201
85	89	0.	0.	0.	0.	0.	10	201
25	29	12.	2.	0.	14.	27.	11	201
30	34	39.	15.	8.	62.	31.	11	201
35	39	45.	18.	17.	80.	35.	11	201
40	44	46.	31.	24.	101.	39.	11	201
45	49	42.	39.	43.	124.	43.	11	201
50	54	40.	53.	57.	150.	48.	11	201

55	59	5.	35.	48.	88.	50.	11	201
60	64	9.	32.	25.	66.	53.	11	201
65	69	2.	12.	14.	28.	55.	11	201
70	74	0.	3.	4.	7.	58.	11	201
75	79	0.	0.	0.	0.	0.	11	201
15	19	4.	1.	0.	5.	16.	12	201
20	24	37.	9.	4.	50.	21.	12	201
25	29	40.	14.	18.	72.	25.	12	201
30	34	40.	42.	46.	128.	29.	12	201
35	39	53.	51.	47.	151.	34.	12	201
40	44	38.	53.	59.	150.	37.	12	201
45	49	13.	37.	33.	83.	41.	12	201
50	54	6.	13.	21.	40.	47.	12	201
55	59	9.	9.	10.	28.	54.	12	201
60	64	8.	7.	6.	21.	57.	12	201
65	69	0.	7.	4.	11.	59.	12	201
70	74	0.	5.	0.	5.	60.	12	201
75	79	0.	0.	0.	0.	0.	12	201
							0	201

```
C
C     PROGRAM FOR MONTHLY ACES DESIGN--MAD
C
C                    WRITTEN BY
C                    M.L. BALLOU
C                        AND
C                    E.A. NEPHEW
C            OAK RIDGE NATIONAL LABORATORY
C                 OAK RIDGE,TENNESSEE
C
C            MODIFIED BY C.A. SADY  MARCH 5,1981
C                  TO USE JANUARY 1981 COSTS.
C
      COMMON/HPUMP/COPH(76),AUX(12),ENGHP(12),CCOP,HCOP,SCOP
      LOGICAL OPT1,OPT2
      COMMON/DAT/HWT(4),TICE(12),AREA(9),RAB,WAB,RR,WR,HO,SF,GLASS,
     >       PANES,SUP,PSIDES,PDELT,TILT,TSW,TSS,GAL(12),COPCHT,
     >       COPCBR,COPCHW,COPHT,COPIN,COPCW,COPBR,COPHW,EC,EF,EHB,
     >       ECB,EOF,EHW,OPT1,OPT2,COP47,COP17,IPRT
      COMMON/BINS/CITY(10),ZONE,DD(2),ALAT,NINV(12),T(12,40),
     >       H(12,40,2),HBR(12),VAV(12),TAV(12),WB(12,40),
     >       ALONG,ELEV,ELECOS,GASCOS,OILCOS
      COMMON/DIG/TVOL(5),PAREA(5),SYSKW(5),BTEMP(12,5),BLEAK(12,5),
     >       PCOL(12,5),BICE(12,5),IRUN,TBLEAK(12),SILEAK(12),
     >       NOICEM(5),NOICEW(5),NTIME
      COMMON/HOUS/LABEL(50,5),XNS,ARCHG,VOL,VAR(50,5),U(50),DT(50),
     >       HL(50),SM,UA,UFLOOR,DCOOL,DHEAT,BCAP,PAN(12,15)
      COMMON/QLOAD/SOL(12,10),SHG(12),QH(12),QC(12),QW(12),
     >       TITLE(18),SOP(12),MON(12),XNFIL(12),SO(12),TH(12),
     >       TG(12,7),DTH(7),HRSPAN(12),HFLOOR(12),CFLOOR(12)
      COMMON/RICE/ISYS,RATEDC,RATEFL,RATEKW,KWFLAG,YRS,CSTCOL,CSTINS,
     >       CSTCOI,THKSD,THKBTM,THKTP,RATETH,RATEGA,RTMELE,RTMGAS,
     >       RTMOIL
      DIMENSION HEAD(18)
      COMMON/FILE8/POINT(120,9),SAVREC(89),NREC,CASENO
C
C  THE FILE ON UNIT 8 WILL SAVE DATA FROM MAD RUNS TO BE
C  MAPPED LATER.  THE STRUCTURE OF THE FILE IS AS FOLLOWS:
C
C  RECORD 1  LAST RECORD NO. USED, CASE NO. CONTAINED IN SET
C  RECORD 2-31 CITY NAME, FIRST RECORD NO. REPEATED 4 TIMES PER
C              RECORD
C  RECORD 32 POINTER, CITY NAME(8A4), LATITUDE, LONGITUDE,
C            RATIO OF TOTAL COOLING TO SENSIBLE COOLING,
C            RATE OF ELECTRICITY, ISYS,
C            VOLUME OF MIN. ACES BIN,
C            VOLUME OF FULL ACES BIN, FLAG ON VOLUME,
C            PANEL AREA OF MIN. ACES,
C            PANEL AREA OF FULL ACES, FLAG ON PANEL,
C            ANNUAL COP OF 5 SYSTEMS,
C            ANNUAL ENERGY OF 5 SYSTEMS(KWH),
C            SYSTEM COST OF 5 SYSTEMS,
C            TOTAL PRESENT WORTH OF 5 SYSTEMS,
C            SIMPLE PAYBACK PERIOD OF 5 SYSTEMS,
C            SIMPLE  PAYBACK RANK OF 5 SYSTEMS,
C            1ST YEAR FUEL COST OF 5 SYSTEMS,
C            FUEL SAVINGS OF 5 SYSTEMS,
C            AND LIFE CYCLE RANKING OF 5 SYSTEMS
C            ( THE 5 SYSTEMS ARE I2R, HEAT PUMP/I2R,
C            HEAT PUMP/DESUPER, MIN. ACES, AND FULL ACES)
C
C  REST OF THE RECORDS ARE REPEATS OF RECORD 31 ABOVE.
C
```

```
C  JCL FOR GO STEP IS
C  //GO.FT08F001 DD UNIT=SPDA,DSN=T.MLB05929.MADXX,SPACE=(TRK,(20,2)),
C  //  DISP=(NEW,CATLG),DCB=(RECFM=FB,LRECL=680,BLKSIZE=12837)
C                  OR
C  //GO.FT08F001 DD DSN=T.MLB05929.MADXX,DISP=(OLD,KEEP)
C
      DEFINE FILE 8(600,680,E,NREC)
C
C  IFILE8=0 MEANS FILE 8 NOT USED BEFORE
C
      READ(5,450) IFILE8, CASENO
      IF (IFILE8.EQ.0) GO TO 20
C
C  READ IN POINTER TABLE
C
      J1=1
      J2=4
      DO 10 I=2,31
      READ(8'I,500) ((POINT(J,K),K=1,9),J=J1,J2)
      J1=J1+4
      J2=J2+4
10    CONTINUE
C
C  READ LAST RECORD NO. USED AND INITIALIZE NREC
C
      READ(8'1,550) RLAST
      NREC=INT(RLAST)+1
      GO TO 40
C
C  FIRST TIME FILE USED--INITIALIZE POINTER TABLE AND NREC.
C
20    DO 30 J=1,120
      DO 30 K=1,9
      POINT(J,K)=0.
30    CONTINUE
      NREC=32
C
C  READ IN DATA ABOUT HOUSE AND ICE TANK
C
40    CALL DATAIN
      CALL PRTDAT
      NCITY=0
C
C     READ MONTHLY TEMPERATURE, WIND SPEED, AND INSOLATION DATA
C
C     M        = MONTH INDEX
C     I        = BIN INDEX
C     T(M,I)   = TEMPERATURE MIDPOINT OF BIN
C     H(M,I,1) = BIN DAYLIGHT HOURS
C     H(M,I,2) = BIN NIGHT HOURS
C     WB(M,I)  = WET BULB AVERAGE
C     TAV(M)   = AVERAGE OUTDOOR TEMPERATURE (F)
C     VAV(M)   = AVERAGE WIND SPEED (MILES PER HOUR)
C     HBR(M)   = MONTHY INSOLATION
C
C
50    CALL BIN(HEAD,&5000)
C
C  CALCULATE EARTH TEMPERATURE
C  TG(M,1)  = GROUND TEMPERATURE FOR TANK TOP
C  TG(M,2)  = GROUND TEMPERATURE FOR TANK BOTTOM
C  TG(M,3)  = AVERAGE GROUND TEMPERATURE FOR TANK SIDES
C  TG(M,4)  = INLET WATER TEMPERATURE
C  TG(M,5)  = GROUND TEMPERATURE (5 FT)
C
      CALL EARTH(TAV)
```

```
C
C     COMPUTE INSOLATION ON SURFACES
C
        CALL SUNLJ
C
C
C     SOL(M,1) = SOLAR HEAT GAIN THROUGH NORTH WINDOW (BTU/DAY*SQFT)
C     SOL(M,2) = SOLAR HEAT GAIN THROUGH EAST  WINDOW (BTU/DAY*SQFT)
C     SOL(M,3) = SOLAR HEAT GAIN THROUGH SOUTH WINDOW (BTU/DAY-SQFT)
C     SOL(M,4) = SOLAR HEAT GAIN THROUGH WEST  WINDOW (BTU/DAY-SQFT)
C     SOL(M,5) = INCIDENT SOLAR FLUX ON NORTH FACING WALL(BTU/DAY-FT**2)
C     SOL(M,6) = INCIDENT SOLAR FLUX ON EAST FACING WALL (BTU/DAY-FT**2)
C     SOL(M,7) = INCIDENT SOLAR FLUX ON SOUTH FACING WALL(BTU/DAY-FT**2)
C     SOL(M,8) = INCIDENT SOLAR FLUX ON WEST FACING WALL (BTU/DAY-FT**2)
C     SOL(M,9) = INCIDENT SOLAR FLUX ON ROOF (BTU/DAY-FT**2)
C     SOL(M,10) = SOLAR FLUX ON RADIANT/CONVECTOR PANEL  (BTU/DAY-FT**2)
C
C
        DO 80 M=1,12
        SHG(M)= 0.0
        SOP(M)=AREA(9)*SOL(M,9)*RAB/((RR*HO+1.0)*8.0)
        DO 80 J=1,4
        SHG(M)=SHG(M)+AREA(J)*SOL(M,J)*SF/8.0
        SOP(M)=SOP(M)+AREA(J+4)*SOL(M,J+4)*WAB/((WR*HO+1.0)*8.0)
80      CONTINUE
C
C  PANEL CALCULATES SOLAR PANEL HEAT PICKUP
C
        CALL PANEL
C
C  LOADS USES UA OF THE HOUSE TO CALCULATE MONTHLY HEATING,
C  COOLING, AND HOT WATER LOADS.  LOADS ALSO CALCULATES
C  DESIGN DAY HEATING AND COOLING LOADS.
C
        CALL LOADS(&50)
C
C  DIGEST CALCULATES BIN SIZE, PANEL SIZE, AND ENERGY CONSUMPTION
C
        CALL DIGEST(&50)
C
C  ENERGY CALCULATES ENERGY CONSUMPTION OF NON-ACES SYSTEMS
C
        CALL ENERGY
        IF(IPRT.EQ.0) CALL PRTBSC(HEAD)
        IF(IPRT.EQ.1) CALL PRTECO(HEAD)
C
C  WRITE CITY DATA INTO FILE8
C
        NCITY=NCITY+1
        WRITE(8'NREC,300)  (SAVREC(J),J=1,89)
300     FORMAT(F5.0,8A4,21F8.2,59F8.0)
        NWRT=NREC-1
C
C  UPDATE POINTERS
C
        DO 90 J=1,120
        IN=J
        IF(HEAD(1).NE.POINT(J,1)) GO TO 90
        IF(HEAD(2).NE.POINT(J,2)) GO TO 90
        IF(HEAD(3).NE.POINT(J,3)) GO TO 90
        IF(HEAD(4).NE.POINT(J,4)) GO TO 90
        IF(HEAD(5).NE.POINT(J,5)) GO TO 90
        IF(HEAD(6).NE.POINT(J,6)) GO TO 90
        IF(HEAD(7).NE.POINT(J,7)) GO TO 90
        IF(HEAD(8).EQ.POINT(J,8)) GO TO 110
90      CONTINUE
```

```
      DO 100 I=1,8
      POINT(NCITY,I)=HEAD(I)
100   CONTINUE
      POINT(NCITY,9)=FLOAT(NREC-1)
      GO TO 140
C
C  CITY ALREADY IN POINTER TABLE--UPDATE POINTERS IN PREVIOUS RECORDS
C
110   PT1=POINT(IN,9)
120   IP=INT(PT1)
      READ(8'IP,350) PT2
350   FORMAT(F5.0)
C
C  FIND LAST POINTER
C
      IF(PT2.EQ.9999.) GO TO 130
      PT1=PT2
      GO TO 120
C
C  NWRT IS NUMBER OF RECORD JUST WRITTEN
C
130   PT=FLOAT(NWRT)
      READ(8'IP,300) SAVREC
      SAVREC(1)=PT
      WRITE(8'IP,300) SAVREC
      PT=9999.
      READ(8'NWRT,300) SAVREC
      SAVREC(1)=PT
      WRITE(8'NWRT,300) SAVREC
140   CONTINUE
      GO TO 50
C
C  WRITE RECORD 1 AND POINTER TABLE IN RECORD 2-30
C
5000      RLAST=FLOAT(NREC-1)
      WRITE(8'1,400) RLAST,CASENO
400   FORMAT(36F10.0)
      J1=1
      J2=4
      DO 150 I=2,31
      WRITE(8'I,500) ((POINT(J,K),K=1,9),J=J1,J2)
      J1=J1+4
      J2=J2+4
150   CONTINUE
      STOP
450   FORMAT(I10,F10.0)
500   FORMAT(4(8A4,F10.0))
550   FORMAT(F10.0)
      END
      BLOCK DATA
      COMMON/HPUMP/COPH(76),AUX(12),ENGHP(12),CCOP,HCOP,SCOP
      COMMON/QLOAD/SOL(12,10),SHG(12),QH(12),QC(12),QW(12),
     >      TITLE(18),SOP(12),MON(12),XNFIL(12),SO(12),TH(12),
     >      TG(12,7),DTH(7),HRSPAN(12),HFLOOR(12),CFLOOR(12)
      COMMON/ENG/ENG(6,2),EU(6,2,12),NSYS,KSYS(6)
      DATA COPH/3*1.28,5*1.36,5*1.50,5*1.68,5*1.92,5*2.18,5*2.42,
     >          5*2.67,5*2.88,5*3.04,5*3.21,5*3.34,5*3.43,5*3.50,
     >          5*3.56,3*3.60/
      DATA MON/'JAN ','FEB ','MAR ','APR ','MAY ','JUN ','JUL ',
     >         'AUG ','SEP ','OCT ','NOV ','DEC '/
      DATA TH/744.,672.,744.,720.,744.,720.,744.,744.,
     >        720.,744.,720.,744./
      DATA NSYS/3/
      END
      SUBROUTINE AAHP(SIZE,TFOM,TIM,TMP,BH,BC,BW,M)
C
```

```
C   SUBROUTINE AAHP CALCULATES THE ENERGY CONSUMPTION BY AIR-TO-AIR
C     HEAT PUMP SYSTEMS
C
        COMMON/HPUMP/COPH(76),AUX(12),ENGHP(12),CCOP,HCOP,SCOP
        COMMON/ENG/ENG(6,2),EU(6,2,12),NSYS,KSYS(6)
        COMMON/ELOAD/HPEUH(12),HPEUC(12)
      DIMENSION CAP(76)
      DATA CAP/3*10.0,5*10.5,5*12.5,5*14.6,5*17.5,5*21.0,5*24.0,
     1         5*27.5,5*30.5,5*34.0,5*37.0,5*40.5,5*43.5,5*45.7,
     2         5*47.6,3*49.5/
C
      NT = 0.7406*TMP-5.269+21.
      IF (NT.LT.1) NT = 1
      IF (NT.GT.76) NT = 76
      HCOP = (TFOM/2.88)*COPH(NT)
      COPC = (TFOM/2.88)*2.65*0.86
      HPCAP=CAP(NT)*(SIZE/30.5)*(1.0-EXP(-1.2*(TFOM-1.2)))
C
C   PERFORMANCE DEGRADATION FROM FROSTING AND CYCLING
C
      IF (TMP.GT.40.0) GO TO 10
      HPCAP = 0.92 * HPCAP
      HCOP = 0.92 * HCOP
   10 HPMX = HPCAP * TIM
C
C   ENERGY USE BY HEAT PUMP WITH I2R WATER HEATER
C
      HPO = HPMX
      AUXX = BH - HPMX
      IF (AUXX.GT.0.0) GO TO 20
      HPO = BH
      AUXX = 0.0
      HCOP = HCOP * 0.85
   20 DEL = HPO/HCOP + AUXX + BW + BC/CCOP
      HPEUH(M) = HPEUH(M) + HPO/HCOP + AUXX
      ENGHP(M) = ENGHP(M) + HPO/HCOP + BC/CCOP + AUXX
      EU(2,1,M) = EU(2,1,M) + DEL
      AUX(M) = AUX(M) + AUXX
C
C   ENERGY USE BY HEAT PUMP WITH DESUPERHEATER
C
      IF (BH.GT.BC) GO TO 30
C
C   HEAT PUMP IN COOLING MODE
C
      DSH = 0.15 * (BC*(COPC+1.0)/COPC)
      DEL = BC/COPC + DSH/20.0 + (BW-DSH)
      IF (BW.LT.DSH) DEL = BC/COPC + BW/20.0
      GO TO 40
C
C   HEAT PUMP IN HEATING MODE
C
   30 HPO = AMIN1(BH/0.85,HPMX)
      TLD = BH+BW
      IF (HPO.GT.TLD) HPO = TLD
      AUXX = TLD-HPO
      DSH = HPO-BH
      IF (DSH.LT.0.0) DSH = 0.0
      DEL = HPO/HCOP + DSH/20.0 + AUXX
   40 EU(3,1,M) = EU(3,1,M) + DEL
      RETURN
      END
        SUBROUTINE ACECOS
C
C   THIS SUBROUTINE CALCULATES COST OF ACES
C
```

```
      COMMON/HPUMP/COPH(76),AUX(12),ENGHP(12),CCOP,HCOP,SCOP
      LOGICAL OPT1,OPT2
      COMMON/DAT/HWT(4),TICE(12),AREA(9),RAB,WAB,RR,WR,HO,SF,GLASS,
     >       PANES,SUP,PSIDES,PDELT,TILT,TSW,TSS,GAL(12),COPCHT,
     >       COPCBR,COPCHW,COPHT,COPIH,COPCW,COPBR,COPHW,EC,EF,EHB,
     >       ECB,EOF,EHW,OPT1,OPT2,COP47,COP17,IPRT
      COMMON/DIG/TVOL(5),PAREA(5),SYSKW(5),BTEMP(12,5),BLEAK(12,5),
     >       PCOL(12,5),BICE(12,5),IRUN,TBLEAK(12),SILEAK(12),
     >       NOICEH(5),NOICEW(5),NTIME
      COMMON/RICE/ISYS,RATEDC,RATEFL,RATEKW,KWFLAG,YRS,CSTCOL,CSTINS,
     >       CSTCOI,THKSD,THKBTH,THKTP,RATETH,RATEGA,RTHELE,RTHGAS,
     >       RTHOIL
      REAL*4 INSCOS,HECCOS
      COMMON/COSDAT/FANCOS(8),CNTCOS(8),AHPCOS(8),AUXCOS(8),
     >              HWTCOS(8),DUCCOS(8),INSCOS(8),SYSCOS(8),
     >              HECCOS(2),BINCOS(2),PANCOS(2),COILFT(2)
      COMMON/HOUS/LABEL(50,5),XNS,ARCHG,VOL,VAR(50,5),U(50),DT(50),
     >       HL(50),SM,UA,UFLOOR,DCOOL,DHEAT,BCAP,PAN(12,15)
      DIMENSION AHECHP(2,6),DUCTS(2,9),C(11),CBIN(7)
      DATA DUCTS/10000.,514.,
     >           12500.,590.,
     >           26500.,885.,
     >           40000.,1180.,
     >           53500.,1416.,
     >           66500.,1623.,
     >           80000.,1770.,
     >           100000.,1947.,
     >           115000.,2000./
      DATA AHECHP/24500.,2950.,
     >           34000.,3130.,
     >           45000.,3500.,
     >           60000.,4000.,
     >           75000.,4450.,
     >           115000.,5600./
      F(D)=CON-D*D*(ALOG(D/DO)/XKI + ALOG(DO/DI)/XKP)
      DF(D)=-D/XKI-2*D*(ALOG(DO/DI)/XKP+ALOG(D/DO)/XKI)
C_____________________________
C
C  ACES COST
C
C_____________________________
      DO 200 IK=1,2
      IF(IK.EQ.1) K=2
      IF(IK.EQ.2) K=1
      DO 130 J=1,6
      IF(DHEAT.LE.AHECHP(1,J)) GO TO 140
130   CONTINUE
      PRINT 1600, DHEAT
1600  FORMAT('0EXCEEDED CAPACITY ON ACES MECH. PACKAGE IN',
     >       ' SUBROUTINE ACECOS, DHEAT =',F10.0)
C
C  COST OF MECHNICAL PACKAGE
C
140   HECCOS(IK)=AHECHP(2,J)
      DCAP=AHECHP(1,J)
C
C  ADD TO COST IF HIGH EFFICIENCY HEAT PUMP
C
      IF(COPHT.GE.5.0) HECCOS(IK)=HECCOS(IK)+1360.
C
C  ICE STORAGE BIN COST
C  TAKEN FROM R.S. SNOW CONSTRUCTION COST ESTIMATION
C
C  C(1) = LINER MATERIAL AND INSTALLATION
C  C(2) = FLOOR SLAB MATERIAL AND INSTALLATION
C  C(3) = FLOOR INSULATION MATERIAL AND INSTALLATION
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```
C   C(4)  = TOP SLAB MATERIAL AND INSTALLATION
C   C(5)  = TOP INSULATION MATERIAL AND INSTALLATION
C   C(6)  = FOAM FORM WALL (MATERIAL AND INSTALLATION)
C   C(7)  = FOAM FORM SUPPLEMENTAL INSULATION (MAT. + INSTALL.)
C   C(8)  = BAR BLOCK UPGRADE TO FOAM FORM LEVEL
C   C(9)  = FOOTERS, MATERIALS AND INSTALLATION
C   C(10) = EXCAVATION COST
C   C(11) = COIL COSTS
C
C   T=1 DENOTES FREE STANDING BIN CONSTRUCTION
C   T=0 DENOTES INTEGRATED TANK CONSTRUCTION
C
          T=0.
C
C   CBIN(1)  = LINER COST
C   CBIN(2)  = FLOOR COST
C   CBIN(3)  = TOP COST
C   CBIN(4)  = WALLS COST
C   CBIN(5)  = FOOTERS COST
C   CBIN(6)  = EXCAVATION COST
C   CBIN(7)  = COIL COST
          C(1)=.69
          C(2)=1.47
          C(3)=CSTINS*THKBTM
          C(4)=0.0
          C(5)=CSTINS*THKTP
          C(6)=3.73
          C(7)=CSTINS*THKSD
          C(8)=.82
          C(9)=2.36
          C(10)=.1076
          C(11)=CSTCOI
          HT=TICE(1)
          W=SQRT(TVOL(K)/HT)
          ABTM=TVOL(K)/HT
          HT = HT + .5
          CBIN(1)=C(1)*(HT+HT+W)**2
          CBIN(2)=ABTM*(C(2)*T+C(3))
          CBIN(3)=ABTM*(C(4)*T+C(5))
          CBIN(4)=2.*HT*W*((C(6)+C(7))*(T+1.)-(C(7)+C(8))*(T-1.))
          CBIN(5)=2.*W*C(9)*(T+1.)
          CBIN(6)=C(10)*TVOL(K)*T
          CBIN(7)=0.0
          IF(ISYS.NE.1) GO TO 170
C
C   COIL COST
C
          ECAP=OHEAT*(COPH(43)-1)/COPH(43)
          ED=ECAP/TVOL(K)
C
C   BIN VARIABLES FROM INPUT
C
C   TB    TEMPERATURE OF BRINE, F                        NOMINAL - 26.
C   DI    TUBE DIAMETER, INNER, INCHES                   NOMINAL - 0.85
C   DO    TUBE DIAMETER, OUTER, INCHES                   NOMINAL - 1.00
C   XKP   PLASTIC TUBE CONDUCTIVITY, BTU/HR/SQFT/F       NOMINAL - 0.085
C   XKI   ICE THERMAL CONDUCTIVITY, BTU/HR/SQFT/F        NOMINAL - 1.29
C   D     ICE LOG DIAMETER OR LATTICE SPACING, FEET
C
          TB = TICE(8)
          DI = TICE(9)/12.0
          DO = TICE(10)/12.0
          XKP = TICE(11)
          XKI = TICE(12)
C
C   CALCULATE LENGTH OF COIL IN BIN
```

```
C
      CON=(2.0*3.1416*(32.0-TB))/ED
      D1=4./12.
      DO 150 KK=1,100
      D2=D1-F(D1)/DF(D1)
      IF(ABS(D1-D2).LE.0.001) GO TO 160
      D1=D2
150   CONTINUE
160   COILFT(K)=TVOL(K)/(D2*D2)
      CBIN(7)=CSTCOI*COILFT(K) + 100.
170   BINCOS(IK)=CBIN(1)+CBIN(2)+CBIN(3)+CBIN(4)+CBIN(5)+
     >            CBIN(6)+CBIN(7)
C
C  COST OF SOLAR PANEL
C
      PANCOS(IK)=PAREA(K)*CSTCOL
      IF(PAREA(K).GT.0.0) PANCOS(IK)=PANCOS(+IK)+865.+
     >                    PAREA(K)*.7432
C
C  COST OF AUXILIARIES
C
      AUXCOS(3+IK)=320.+240.
      IF(DHEAT.GT.45500.) AUXCOS(3+IK)=AUXCOS(3+IK)+120.
      IF(DHEAT.LE.35000.) AUXCOS(3+IK)=AUXCOS(3+IK)+76.
      IF(DHEAT.GT.35000.0.AND.DHEAT.LE.60000.0) AUXCOS(3+IK)=
     >  AUXCOS(3+IK)+150.
      IF(DHEAT.GT.60000.0.AND.DHEAT.LE.115000.0) AUXCOS(3+IK)=
     >    AUXCOS(3+IK)+235.
C
C  COST OF HOT WATER HEAT-82 GALLONS CAPACITY
C
      HWTCOS(3+IK)=335.
C
C  COST OF DUCTS
C
      DO 180 J=1,9
      IF(DCAP.LE.DUCTS(1,J)) GO TO 185
180   CONTINUE
      PRINT 1200,DCAP
1200  FORMAT('0CAPACITY ON DUCTS EXCEEDED IN SUBROUTINE',
     >       'ACECOS, DCAP=',F10.0)
185   IF(J.EQ.1) DUCCOS(3+IK)=DUCTS(2,J)
      IF(J.EQ.1) GO TO 190
C
C  INTERPOLATE TO FIND COST
C
      DUCCOS(3+IK)=DUCTS(2,J-1)+(DCAP-DUCTS(1,J-1))/
     >       (DUCTS(1,J)-DUCTS(1,J-1))*(DUCTS(2,J)-DUCTS(2,J-1))
C
C  INSTALLATION COST
C
190   INSCOS(3+IK)=170.
      IF(DHEAT.LE.24500.) INSCOS(3+IK)=INSCOS(3+IK)+312.
      IF(DHEAT.GT.24500.0.AND.DHEAT.LE.34500.) INSCOS(3+IK)=
     >  INSCOS(3+IK)+364.
      IF(DHEAT.GT.34500.) INSCOS(3+IK)=INSCOS(3+IK)+468.
      SYSCOS(3+IK)=MECCOS(IK)+BINCOS(IK)+PANCOS(IK)+AUXCOS(3+IK)+
     >             HWTCOS(3+IK)+DUCCOS(3+IK)+INSCOS(3+IK)
200   CONTINUE
      RETURN
      END
      SUBROUTINE BIN(HEAD,*)
      COMMON/BINS/CITY(10),ZONE,DD(2),ALAT,NINV(12),T(12,40),
     >      H(12,40,2),HBR(12),VAV(12),TAV(12),WB(12,40),
     >      ALONG,ELEV,ELECOS,GASCOS,OILCOS
      DIMENSION A(7),TH(12),HEAD(18),HMON(12)
```

```
      DATA HMON/744.,672.,744.,720.,744.,720.,744.,744.,
     >     720.,744.,720.,744./
C
C  THIS SUBROUTINE READS THE BIN WEATHER DATA
C
C
C  ALAT = LATITUDE
C  ALONG = LONGITUDE
C  ELEV = ELEVATION
C
      READ(13,4,END=700) CITY,ZONE,ALAT1,ALAT2,ALONG1,ALONG2,ELEV
      ALAT=ALAT1+ALAT2/60.0
      ALONG=ALONG1+ALONG2/60.0
C
C  READ IN DESIGN DAY INFORMATION
C  DD(1) = DESIGN DAY TEMPERATURE WINTER(F)
C  DD(2) = DESIGN DAY TEMPERATURE SUMMER(F)
C  ELECOS = COST OF ELECTRICITY IN THE CITY
C  GASCOS = COST OF NATURAL GAS
C  OILCOS = COST OF HEATING OIL
C
      READ(13,5) DD,ELECOS,GASCOS,OILCOS
C
C  ADDITIONAL READS (BLANKS IN FILE TO ALLOW FOR MORE FIELDS)
C
     READ (13,5)
     READ (13,5)
     READ (13,5)
C
C  T(M,I)--AVERAGE TEMPERATURE
C  H(M,I,1)--DAY HOURS  H(M,I,2)--NIGHT HOURS
C  HBR(M)--MONTHLY INSOLATION
C  VAV(M)--AVERAGE WIND SPEED (MPH)
C  WB(M,I)--AVERAGE WET BULB
C
      DO 10 M=1,12
      NINV(M)=0
      TAV(M)=0.0
      TH(M)=0.0
      DO 10 I=1,40
      T(M,I)=0.
      WB(M,I)=0.
      DO 10 J=1,2
10    H(M,I,J)=0.
      READ(13,1)  HEAD,NSET
      READ(13,2) HBR,VAV
C
C  CHANGE LANGLEY TO BTU/SQ FT
C
      DO 20 M=1,12
20    HBR(M)=HBR(M)*3.687
C
C  READ IN BIN DATA
C
30    READ(13,3)  (A(J),J=1,7),M,NST
      IF(M.EQ.0) GO TO 40
      NINV(M)=NINV(M)+1
      I=NINV(M)
      T(M,I)=(A(1)+A(2))/2.0
      H(M,I,1)=A(4)
      H(M,I,2)=A(6)-A(4)
      TEST=A(3)+A(4)+A(5)
      IF(TEST.NE.A(6)) GO TO 599
      TAV(M)=TAV(M)+T(M,I)*A(6)
      WB(M,I)=A(7)
      IF (WB(M,I) .GT. T(M,I)-1.) WB(M,I)=T(M,I)-1.
```

```
      TH(M)=TH(M)+A(6)
      GO TO 30
C
C  CALCULATE AVERAGE MONTHLY DRY BULB
C
40    DO 50 M=1,12
      IF(TH(M).NE.HMON(M)) GO TO 599
50    TAV(M)=TAV(M)/TH(M)
C
C  SORT INTO DECREASING ORDER
      DO 100 M=1,12
      N2=NINV(M)-1
      DO 70 K=1,N2
      N1=N2-(K-1)
      DO 60 I=1,N1
      IF(T(M,I).LT.T(M,I+1)) GO TO 60
      SAV=T(M,I)
      T(M,I)=T(M,I+1)
      T(M,I+1)=SAV
      SAV=WB(M,I)
      WB(M,I)=WB(M,I+1)
      WB(M,I+1)=SAV
      DO 60 J=1,2
      SAV=H(M,I,J)
      H(M,I,J)=H(M,I+1,J)
      H(M,I+1,J)=SAV
60    CONTINUE
70    CONTINUE
C
C  INSERT BIN OF ZERO AT BEG AND END OF MONTH
C
      IF(H(M,1,1).EQ.0.0.AND.H(M,1,2).EQ.0.0) GO TO 90
      TOP=T(M,1)-5.
      N=NINV(M)
      DO 80 J=1,N
      I=N-(J-1)
      T(M,I+1)=T(M,I)
      H(M,I+1,1)=H(M,I,1)
      H(M,I+1,2)=H(M,I,2)
      WB(M,I+1)=WB(M,I)
80    CONTINUE
      NINV(M)=NINV(M)+1
      T(M,1)=TOP
      WB(M,1)=TOP-1.
      H(M,1,1)=0.
      H(M,1,2)=0.
90    IF(H(M,NINV(M),1).EQ.0.0.AND.H(M,NINV(M),2).EQ.0.0) GO TO 100
      NINV(M)=NINV(M)+1
      T(M,NINV(M))=T(M,NINV(M)-1)+5.
      WB(M,NINV(M))=T(M,NINV(M))-1.
100   CONTINUE
      RETURN
599   PRINT 600,M,TEST,TH(M),(A(J), J=1,7)
      STOP
700   RETURN1
C  FORMATS
1     FORMAT(18A4,6X,I2)
2     FORMAT(12F5.0)
3     FORMAT(7F5.0,35X,I2,6X,I2)
4     FORMAT(10A4,A4,6X,2F3.0,4X,2F3.0,4X,F10.0)
5     FORMAT(8F10.0)
600   FORMAT('0MISTAKE IN BINS MONTH = ',I5,2F12.6/' ',7F10.2)
      END
      SUBROUTINE COST
C
C  THIS SUBROUTINE CALCULATES COST OF AN I2R SYSTEM, HEAT PUMP
```

```
C   WITH I2R HOT WATER HEATER, AND HEAT PUMP WITH DESUPERHEATER
C   WATER HEATER.
C
        COMMON/HPUMP/COPH(76),AUX(12),ENGHP(12),CCOP,HCOP,SCOP
        LOGICAL OPT1,OPT2
        COMMON/DAT/HWT(4),TICE(12),AREA(9),RAB,WAB,RR,WR,HO,SP,GLASS,
     >        PANES,SUP,PSIDES,PDELT,TILT,TSW,TSS,GAL(12),COPCHT,
     >        COPCBR,COPCHW,COPHT,COPIM,COPCW,COPBR,COPHW,EC,EF,EHB,
     >        ECB,EOP,EHW,OPT1,OPT2,COP47,COP17,IPRT
        COMMON/DIG/TVOL(5),PAREA(5),SYSKW(5),BTEMP(12,5),BLEAK(12,5),
     >        PCOL(12,5),BICE(12,5),IRUN,TBLEAK(12),SILEAK(12),
     >        NOICEH(5),NOICEW(5),NTIME
        COMMON/RICE/ISYS,RATEDC,RATEFL,RATEKW,KWFLAG,YRS,CSTCOL,CSTINS,
     >        CSTCOI,THKSD,THKBTM,THKTP,RATETH,RATEGA,RTMELE,RTMGAS,
     >        RTMOIL
        COMMON/HOUS/LABEL(50,5),XNS,ARCHG,VOL,VAR(50,5),U(50),DT(50),
     >        HL(50),SH,UA,UFLOOR,DCOOL,DHEAT,BCAP,PAN(12,15)
        REAL*4 INSCOS,MECCOS
        COMMON/COSDAT/FANCOS(8),CNTCOS(8),AHPCOS(8),AUXCOS(8),
     >                HWTCOS(8),DUCCOS(8),INSCOS(8),SYSCOS(8),
     >                MECCOS(2),BINCOS(2),PANCOS(2),COILFT(2)
        COMMON/ENG/ENG(6,2),EU(6,2,12),NSYS,KSYS(6)
        DIMENSION FAN(2,6),ELECMP(6),AIRCND(2,8),DUCTS(2,9),HEATP(2,6),
     >          GASFUR(2,3),OILFUR(2,4),PCBFUR(2,3)
C
C   FAN UNIT COST BASED ON SEARS CATALOG-WINTER 80
C
        DATA FAN/35290.,280.,
     >          52697.,310.,
     >          69762.,350.,
     >          84199.,380.,
     >          96793.,400.,
     >          115905.,420./
C
C   ELECTRICAL SERVICE COMPONENTS BASED ON SEARS CATALOG-WINTER 81
C
        DATA ELECMP/76.,93.,145.,234.,234.,234./
C
C   AIR CONDITIONER COST BASED ON SEARS CATALOG-WINTER 80
C
        DATA AIRCND/23000.,1129.,
     >              27500.,1279.,
     >              32000.,1379.,
     >              34000.,1479.,
     >              36500.,1509.,
     >              42000.,1679.,
     >              47000.,1779.,
     >              57000.,1879./
C
C   DUCT SYSTEM COST DEVELOPED FROM R.S. MEANS DATA
C
        DATA DUCTS/10000.,514.,
     >             12500.,590.,
     >             26500.,885.,
     >             40000.,1180.,
     >             53500.,1416.,
     >             66500.,1623.,
     >             80000.,1770.,
     >             100000.,1947.,
     >             115000.,2000./
C
C   HEAT PUMP COST FROM SEARS CATALOG-WINTER 80
C
        DATA HEATP/24500.,1199.,
     >             29000.,1329.,
     >             34500.,1479.,
```

```
     >              40000.,1549.,
     >              48000.,1899.,
     >              58000.,2459./
C
C  CONVENTIONAL GAS FURNACE FROM SEARS CATALOG-WINTER 80
C
        DATA GASFUR/64000.,745.,
     >              84000.,775.,
     >             100000.,815./
C
C  CONVENTIONAL OIL FURNACE COST FROM SEARS CATALOG-WINTER 80
C
        DATA OILFUR/79000.,690.,
     >             -105000.,720.,
     >              131000.,1040.,
     >              158000.,1140./
C
C  PULSED COMBUSTION FURNACE
C
        DATA PCBFUR/37200.,1125.,
     >               55800.,1125.,
     >               74400.,1125./
C
C  AIR CONDITIONING FOR ALL SYSTEMS WITH ELECTRIC
C    AIR CONDITIONER.
C
        DO 40 J=1,8
        IF(DCOOL.LE.AIRCND(1,J)) GO TO 50
40      CONTINUE
        PRINT 1100, DCOOL
1100    FORMAT('0EXCEEDED CAPACITY OF AIR CONDITION UNIT IN SUBROUTINE',
     >          'COST, DCOOL=',F10.0)
50      AIRCON=AIRCND(2,J)
        AIRCAP=AIRCND(1,J)
C
C  COST OF REFRIGERANT LINES FOR ELECTRIC AIR CONDITIONER.
C  BASED ON SEARS CATALOG-WINTER 80
C
        IF(DCOOL.LT.40000.) REFRIG=160.
        IF(DCOOL.GE.40000.0.AND.DCOOL.LE.58000.) REFRIG=200.
        IF(DCOOL.GT.58000.) PRINT 1400, DCOOL
1400    FORMAT('0CAPACITY ON AUXILIARY EXCEEDED, DCOOL=',F10.0)
C
C  INSTALLATION COSTS FOR ALL SYSTEMS
C
        INSTAL=170.
        IF(DCOOL.LE.21700.0) FAC=312.
        IF(DCOOL.GT.21700.0.AND.DCOOL.LE.33500.) FAC=364.
        IF(DCOOL.GT.33500.0.AND.DCOOL.LE.55000.) FAC=468.
        IF(DCOOL.GT.55000.) PRINT 1300, DCOOL
1300    FORMAT('0EXCEEDED CAPACITY ON INSTALLATION IN SUBROUTINE',
     >          'COST, DCOOL=',F10.0)
        INSTAL=INSTAL+FAC
        DO 200 KK=1,NSYS
        KGO=KSYS(KK)
        GO TO (210,220,230,240,250,260),KGO
C_____________________________
C
C  COST OF I2R SYSTEM
C
C_____________________________
210     KSW = 1
        DO 20 J=1,6
        JELE=J
        IF(DHEAT.LE.FAN(1,J)) GO TO 30
20      CONTINUE
```

```
      PRINT 1000,DHEAT
1000  FORMAT('0EXCEEDED CAPACITY OF FAN UNIT IN SUBROUTINE',
     >       'COST, DHEAT=',F10.0)
C
C  COST OF FAN UNIT AND CONTROLS
C
30    FANCOS(KK)=FAN(2,J)
      CNTCOS(KK)=48.
C
C  COST OF AIR CONDITIONING UNIT
C
      AHPCOS(KK)=AIRCON
      DCAP=AIRCAP
C
C  COST OF AUXILIARIES
      AUXCOS(KK)=REFRIG+ELECMP(JELE)
C
C  COST OF HOT WATER HEATER-52 GALLON CAPACITY
C  BASED ON SEARS CATALOG-WINTER 80
C
      HWTCOS(KK)=275.
C
C  COST OF DUCTS
C
      DO 60 J=1,9
      IF(DCAP.LE.DUCTS(1,J)) GO TO 70
60    CONTINUE
      PRINT 1200,DCAP
1200  FORMAT('0CAPACITY ON DUCTS EXCEEDED IN SUBROUTINE',
     >       'COST, DCAP=',F10.0)
70    IF(J.EQ.1) DUCCOS(KK)=DUCTS(2,J)
      IF(J.EQ.1) GO TO 80
C
C  INTERPOLATE TO FIND COST
C
      DUCCOS(KK)=DUCTS(2,J-1)+(DCAP-DUCTS(1,J-1))/
     >       (DUCTS(1,J)-DUCTS(1,J-1))*(DUCTS(2,J)-DUCTS(2,J-1))
C
C  INSTALLATION COST
C  $170 FOR HOT WATER HEATER FROM  R.S.MEANS DATA
C  FAN AND AIR CONDITIONER COST FROM KHASHAB
C
80    INSCOS(KK)=INSTAL
      SYSCOS(KK)=FANCOS(KK)+AHPCOS(KK)+CNTCOS(KK)+AUXCOS(KK)+
     >       HWTCOS(KK)+DUCCOS(KK)+INSCOS(KK)
      GO TO 200
C_____________________________
C
C  HEAT PUMP WITH I2R HOT WATER
C
C_____________________________
220   DO 90 J=1,6
      JELE=J
      IF(DHEAT.LE.FAN(1,J)) GO TO 100
90    CONTINUE
      PRINT 1000, DHEAT
C
C  FAN COST
100   FANCOS(KK)=FAN(2,J)
      DO 110 J=1,6
      IF(DCOOL.LE.HEATP(1,J)) GO TO 120
110   CONTINUE
      PRINT 1500,DCOOL
1500  FORMAT('0CAPACITY EXCEEDED ON HEAT PUMP IN SUBROUTINE',
     >       'COST, DCOOL=',F10.0)
C
```

```
C  HEAT PUMP COST
C
120     AHPCOS(KK)=HEATP(2,J)
        DCAP=HEATP(1,J)
C
C  ADD TO COST IF HIGH EFFICIENCY HEAT PUMP
C
        IF(COP47.GE.3.1.AND.COP47.LE.3.8)
     >          AHPCOS(KK)=AHPCOS(KK)+460.
        IF(COP47.GT.3.8.AND.COP47.LE.4.4)
     >          AHPCOS(KK)=AHPCOS(KK)+945.
        IF(COP47.GT.4.4) AHPCOS(KK)=AHPCOS(KK)+1360.
C
C  CONTROL COSTS
C
        CNTCOS(KK)=45.
        IF(DHEAT.GT.35260.0.AND.DHEAT.LE.69760.)
     >          CNTCOS(KK)=CNTCOS(KK)+32.
        IF(DHEAT.GT.69760.0.AND.DHEAT.LE.115905.)
     >          CNTCOS(KK)=CNTCOS(KK)+53.
C
C  AUXILIARY COSTS
C
        IF(DCOOL.LT.34500.0) AUXCOS(KK)=160.
        IF(DCOOL.GT.34500.0.AND.DCOOL.LE.58000.) AUXCOS(KK)=200.
        AUXCOS(KK)=AUXCOS(KK)+ELECMP(JELE)
C
C  COST OF HOT WATER HEATER-52 GALLON CAPACITY
C
        HWTCOS(KK)=275.
C
C  COST OF DUCTS
C
        DO 130 J=1,9
        IF(DCAP.LE.DUCTS(1,J)) GO TO 140
130     CONTINUE
        PRINT 1200,DCAP
140     IF(J.EQ.1) DUCCOS(KK)=DUCTS(2,J)
        IF(J.EQ.1) GO TO 150
C
C  INTERPOLATE TO FIND COST
C
        DUCCOS(KK)=DUCTS(2,J-1)+(DCAP-DUCTS(1,J-1))/
     >          (DUCTS(1,J)-DUCTS(1,J-1))*(DUCTS(2,J)-DUCTS(2,J-1))
C
C  INSTALLATION COST
C
150     INSCOS(KK)=INSTAL
        SYSCOS(KK)=FANCOS(KK)+AHPCOS(KK)+CNTCOS(KK)+AUXCOS(KK)+
     >              HWTCOS(KK)+DUCCOS(KK)+INSCOS(KK)
        GO TO 200
C-----------------------------
C
C  HEAT PUMP WITH DESUPERHEATER WATER HEATER
C
C-----------------------------
230     DO 95 J=1,6
        JELE=J
        IF(DHEAT.LE.FAN(1,J)) GO TO 105
95      CONTINUE
        PRINT 1000, DHEAT
C
C  FAN COST
105     FANCOS(KK)=FAN(2,J)
        DO 115 J=1,6
        IF(DCOOL.LE.HEATP(1,J)) GO TO 125
```

```
115     CONTINUE
        PRINT 1500,DCOOL
C
C  HEAT PUMP COST
C
125     AHPCOS(KK)=HEATP(2,J)
        DCAP=HEATP(1,J)
C
C  ADD TO COST IF HIGH EFFICIENCY HEAT PUMP
C
        IF(COP47.GE.3.1.AND.COP47.LE.3.8)
     >          AHPCOS(KK)=AHPCOS(KK)+460.
        IF(COP47.GT.3.8.AND.COP47.LE.4.4)
     >          AHPCOS(KK)=AHPCOS(KK)+945.
        IF(COP47.GT.4.4) AHPCOS(KK)=AHPCOS(KK)+1360.
C
C  CONTROL COSTS
C
        CNTCOS(KK)=45.
        IF(DHEAT.GT.35260.0.AND.DHEAT.LE.69760.)
     >          CNTCOS(KK)=CNTCOS(KK)+32.
        IF(DHEAT.GT.69760.0.AND.DHEAT.LE.115905.)
     >          CNTCOS(KK)=CNTCOS(KK)+53.
C
C  AUXILIARY COSTS
C  $400 COST ON DESUPERHEATER PACKAGE BASED ON INDEPENDENT
C  MANUFACTOR SELLING PRICE.
C
        IF(DCOOL.LT.34500.0) AUXCOS(KK)=160.
        IF(DCOOL.GT.34500.0.AND.DCOOL.LE.58000.) AUXCOS(KK)=200.
        AUXCOS(KK)=AUXCOS(KK)+ELECHP(JELE)
        AUXCOS(KK)=AUXCOS(KK)+400.
C
C  COST OF HOT WATER HEATER-82 GALLON CAPACITY
C
        HWTCOS(KK)=335.
C
C  COST OF DUCTS
C
        DO 135 J=1,9
        IF(DCAP.LE.DUCTS(1,J)) GO TO 145
135     CONTINUE
        PRINT 1200,DCAP
145     IF(J.EQ.1) DUCCOS(KK)=DUCTS(2,J)
        IF(J.EQ.1) GO TO 155
C
C  INTERPOLATE TO FIND COST
C
        DUCCOS(KK)=DUCTS(2,J-1)+(DCAP-DUCTS(1,J-1))/
     >          (DUCTS(1,J)-DUCTS(1,J-1))*(DUCTS(2,J)-DUCTS(2,J-1))
C
C  INSTALLATION COST
C  $100 COST ON DESUPERHEATER PACKAGE BASED ON CONTRACTORS ESTIMATE
C
155     INSCOS(KK)=INSTAL+100.
        SYSCOS(KK)=FANCOS(KK)+AHPCOS(KK)+CNTCOS(KK)+AUXCOS(KK)+
     >              HWTCOS(KK)+DUCCOS(KK)+INSCOS(KK)
        GO TO 200
C-----------------------------
C
C  CONVENTIONAL GAS FURNACE SYSTEM
C
C-----------------------------
240     DO 180 J=1,3
        IF(DHEAT*1.5.LE.GASFUR(1,J)) GO TO 190
180     CONTINUE
```

```
      PRINT 1600,DHEAT
1600  FORMAT ('0CAPACITY EXCEEDED ON GAS FURNACE IN',
     >        ' SUBROUTINE COST, DHEAT=',F10.0)
C
C  GAS FURNACE COST
C
190   FANCOS(KK+2) = GASFUR(2,J)
C
C  COST OF AIR CONDITIONING
C
      AHPCOS(KK+2) = AIRCON
      DCAP = AIRCAP
C
C  COST OF CONTROLS
C
      CNTCOS(KK+2) = 26.00
C
C  AUXILIARY COSTS
C    COST OF REFRIGERANT LINES AND COST OF CHIMNEY.
C
      AUXCOS(KK+2) = REFRIG + 140.00
C
C    COST OF ELECTRICAL WIRING
C
      AUXCOS(KK+2) = AUXCOS(KK+2) + ELECMP(1)
C
C  COST OF HOT WATER HEATER-40 GALLON CAPACITY
C
      HWTCOS(KK+2) = 270.
C
C  COST OF DUCTS
C
      DO 310 J=1,9
      IF (DCAP.LE.DUCTS(1,J)) GO TO 320
310   CONTINUE
      PRINT 1200,DCAP
320   IF (J.EQ.1) DUCCOS(KK+2) = DUCTS(2,J)
      IF (J.EQ.1) GO TO 330
C
C  INTERPOLATE TO FIND COST
C
      DUCCOS(KK+2) = DUCTS(2,J-1)+(DCAP-DUCTS(1,J-1))/
     >        (DUCTS(1,J)-DUCTS(1,J-1))*(DUCTS(2,J)-DUCTS(2,J-1))
C
C  INSTALLATION COST PLUS 50.00 GAS HOOKUP CHARGE
C
330   INSCOS(KK+2) =INSTAL + 50.
      SYSCOS(KK+2) =FANCOS(KK+2)+AHPCOS(KK+2)+CNTCOS(KK+2)+
     >  AUXCOS(KK+2)+HWTCOS(KK+2)+DUCCOS(KK+2)+INSCOS(KK+2)
      GO TO 200
C_____________________________
C
C  CONVENTIONAL OIL FURNACE SYSTEM
C
C_____________________________
250   DO 360 J=1,3
      IF(DHEAT*1.5.LE.OILFUR(1,J)) GO TO 370
360   CONTINUE
      PRINT 1700,DHEAT
1700  FORMAT ('0CAPACITY EXCEEDED ON OIL FURNACE IN',
     >        ' SUBROUTINE COST, DHEAT=',F10.0)
C
C  OIL FURNACE COST
C
370   FANCOS(KK+2) = OILFUR(2,J)
C
```

```
C  COST OF AIR CONDITIONING.
C
        AHPCOS(KK+2) = AIRCON
        DCAP = AIRCAP
C
C  COST OF CONTROLS
C
        CNTCOS(KK+2) = 26.00
C
C  AUXILIARY COSTS
C    REFRIGERANT LINES, CHIMNEY, AND TANK.
C
        AUXCOS(KK+2) = REFRIG+240.+156.
C
C    COST OF ELECTRICAL WIRING
C
        AUXCOS(KK+2) = AUXCOS(KK+2) + ELECMP(1)
C
C  COST OF HOT WATER HEATER-52 GALLON CAPACITY
C
        HWTCOS(KK+2) = 275.
C
C  COST OF DUCTS
C
        DO 380 J=1,9
        IF (DCAP.LE.DUCTS(1,J)) GO TO 390
380     CONTINUE
        PRINT 1200,DCAP
390     IF (J.EQ.1) DUCCOS(KK+2) = DUCTS(2,J)
        IF (J.EQ.1) GO TO 400
C
C  INTERPOLATE TO FIND COST
C
        DUCCOS(KK+2) = DUCTS(2,J-1)+(DCAP-DUCTS(1,J-1))/
     >          (DUCTS(1,J)-DUCTS(1,J-1))*(DUCTS(2,J)-DUCTS(2,J-1))
C
C  INSTALLATION COST
C    ADD COST OF CHIMNEY AND TANK INSTALLATION.
C
400     INSCOS(KK+2) = INSTAL + 100. + 200.
C
        SYSCOS(KK+2) =FANCOS(KK+2)+AHPCOS(KK+2)+CNTCOS(KK+2)+
     >    AUXCOS(KK+2)+HWTCOS(KK+2)+DUCCOS(KK+2)+INSCOS(KK+2)
        GO TO 200
C-------------------------------
C
C  PULSED COMBUSTION FURNACE SYSTEM
C
C-------------------------------
260     DO 410 J=1,3
        IF (DHEAT*1.5.LE.PCBFUR(1,J)) GO TO 420
410     CONTINUE
C        PRINT 1800,DHEAT
C1800    FORMAT ('0CAPACITY EXCEEDED ON PULSED COMBUSTION',
C     >          '  FURNACE IN SUBROUTINE COST, DHEAT=',F10.0)
        J=3
C
C  COST OF PULSED COMBUSTION FURNACE.
C
420     FANCOS(KK+2)=PCBFUR(2,J)
C
C  AIR CONDITIONER COST.
C
440     AHPCOS(KK+2) = AIRCON
        DCAP = AIRCAP
C
```

```
C  COST OF CONTROLS
C
        CNTCOS(KK+2) = 26.00
C
C  AUXILIARY COSTS
C    REFRIGERANT LINES AND ELECTRICAL WIRING.
C
        AUXCOS(KK+2) = REFRIG + ELECMP(1)
C
C  COST OF HOT WATER HEATER-40 GALLON CAPACITY
C
        HWTCOS(KK+2) = 270.
C
C  COST OF DUCTS
C
        DO 450 J=1,9
        IF (DCAP.LE.DUCTS(1,J)) GO TO 460
450     CONTINUE
        PRINT 1200,DCAP
460     IF (J.EQ.1) DUCCOS(KK+2) = DUCTS(2,J)
        IF (J.EQ.1) GO TO 470
C
C  INTERPOLATE TO FIND COST
C
        DUCCOS(KK+2) = DUCTS(2,J-1)+(DCAP-DUCTS(1,J-1))/
     >          (DUCTS(1,J)-DUCTS(1,J-1))*(DUCTS(2,J)-DUCTS(2,J-1))
C
C  INSTALLATION COST
C    ADD GAS HOOKUP - 50.00.
C
470     INSCOS(KK+2) = INSTAL + 50.00
        SYSCOS(KK+2) =FANCOS(KK+2)+AHPCOS(KK+2)+CNTCOS(KK+2)+
     >    AUXCOS(KK+2)+HWTCOS(KK+2)+DUCCOS(KK+2)+INSCOS(KK+2)
200     CONTINUE
        RETURN
        END
        SUBROUTINE DATAIN
        LOGICAL OPT1,OPT2
        COMMON/DAT/HWT(4),TICE(12),AREA(9),RAB,WAB,RR,WR,HO,SF,GLASS,
     >        PANES,SUP,PSIDES,PDELT,TILT,TSW,TSS,GAL(12),COPCHT,
     >        COPCBR,COPCHW,COPHT,COPIM,COPCW,COPBR,COPHW,EC,EF,EHB,
     >        ECB,EOF,EHW,OPT1,OPT2,COP47,COP17,IPRT
        COMMON/BINS/CITY(10),ZONE,DD(2),ALAT,NINV(12),T(12,40),
     >        H(12,40,2),HBR(12),VAV(12),TAV(12),WB(12,40),
     >        ALONG,ELEV,ELECOS,GASCOS,OILCOS
        COMMON/HOUS/LABEL(50,5),XNS,ARCHG,VOL,VAR(50,5),U(50),DT(50),
     >        HL(50),SM,UA,UFLOOR,DCOOL,DHEAT,BCAP,PAN(12,15)
        COMMON/QLOAD/SOL(12,10),SHG(12),QH(12),QC(12),QW(12),
     >        TITLE(18),SOP(12),MON(12),XNFIL(12),SO(12),TH(12),
     >        TG(12,7),DTH(7),HRSPAN(12),HFLOOR(12),CFLOOR(12)
        COMMON/RICE/ISYS,RATEDC,RATEFL,RATEKW,KWFLAG,YRS,CSTCOL,CSTINS,
     >        CSTCOI,THKSD,THKBTM,THKTP,RATETH,RATEGA,RTMELE,RTMGAS,
     >        RTMOIL
        COMMON/ENG/ENG(6,2),EU(6,2,12),NSYS,KSYS(6)
C
C  INPUT DATA
C
C     DD(1) = DESIGN DAY TEMPERATURE WINTER  (F)
C     DD(2) = DESIGN DAY TEMPERATURE SUMMER  (F)
C     DHEAT = DESIGN DAY HEAT LOSS WINTER  (BTUH/HR)
C     SUP = SUPPRESSION FACTOR FOR UA
C     PSIDES = NUMBER OF SIDES PANEL FOR CONVECTION
C     PDELT = SOLAR PENEL EXCHANGER DELTA TEMPERATURE (F)
C     TSW = HOUSE TEMPERATURE SETTING WINTER (F)
C     TSS = HOUSE TEMPERATURE SETTING SUMMER (F)
C     AREA(1) = NORTH FACING WINDOW AREA (FT**2)
```

```
C     AREA(2) = EAST FACING WINDOW AREA (FT**2)
C     AREA(3) = SOUTH FACING WINDOW AREA (FT**2)
C     AREA(4) = WEST FACING WINDOW AREA (FT**2)
C     AREA(5) = NORTH FACING WALL AREA (FT**2)
C     AREA(6) = EAST FACING WALL AREA (FT**2)
C     AREA(7) = SOUTH FACING WALL AREA (FT**2)
C     AREA(8) = WEST FACING WALL AREA (FT**2)
C     AREA(9) = EQUIVALENT FLAT ROOF AREA (FT**2)
C     SF = WINDOW SHADING FACTOR (CURTAINS, BLINDS, ETC.)
C     WAB = WALL SURFACE ABSORPTANCE
C     RAB = ROOF SURFACE ABSORPTANCE
C     TICE(1) = ICE STORAGE TANK HEIGHT (FT)
C     TICE(2) = DEPTH BELOW GROUND SURFACE (FT)
C     TICE(3) = TES TANK TOP R-VALUE
C     TICE(4) = TES TANK SIDES R-VALUE
C     TICE(5) = TES TANK BOTTOM R-VALUE
C     TICE(6) = ICE PACKING FRACTION FOR BRINE CHILLER
C     TICE(7) = ICE PACKING FRACTION FOR ICE MAKER
C     TICE(8) = TEMPERATURE OF BRINE
C     TICE(9) = DIAMETER OF PLASTIC TUBE, INNER, INCHES
C     TICE(10) = DIAMETER OF PLASTIC TUBE, OUTER, INCHES
C     TICE(11) = THERMAL CONDUCTIVITY OF PLASTIC TUBE
C     TICE(12) = THERMAL CONDUCTIVITY OF ICE
C     GLASS = GLASS TYPE
C     PANES = NO. OF PANES (SINGLE OR DOUBLE GLAZING)
C     HO = OUTDOOR FILM COEFFICIENT
C     RR = ROOF THERMAL RESISTANCE (FOR INSOLATION CALC.)
C     WR = WALL THERMAL RESISTANCE (FOR INSOLATION CALC.)
C     HWT(1) = HOT WATER TANK AREA (FT**2)
C     HWT(2) = HOT WATER TANK U(BTU/HR*FT**2-F)
C     HWT(3) = HOT WATER STORAGE TEMPERATURE (F)
C     HWT(4) = HOT WATER DELIVERY EFFICIENCY
C     IPRT = 0 GIVES BASIC OUTPUT
C     IPRT = 1 GIVES ECONOMIC OUTPUT
C     ISYS = 1 FOR BRINE CHILLER SYSTEM
C     ISYS = 2 FOR ICE MAKER SYSTEM
C     KSYS = WHICH SYSTEMS TO MODEL
C              IF LEFT BLANK, WILL MODEL 2 ACES, HEAT PUMP WITH DESUPER
C                WATER HEATER, HEAT PUMP WITH ELECTRIC WATER HEATER, AND
C                ALL ELECTRIC SYSTEM
C            = 1 ELECTRIC HEAT, A/C, AND WATER HEATER
C            = 2 HEAT PUMP WITH ELECTRIC WATER HEATER
C            = 3 HEAT PUMP WITH DESUPER WATER HEATER
C            = 4 GAS HEAT AND WATER HEATER AND ELECTPIC A/C
C            = 5 OIL HEAT AND ELECTRIC WATER HEATER AND A/C
C            = 6 PULSED COMBUSTION HEAT AND CONVENTIONAL GAS
C                  WATER HEATER AND ELECTRIC A/C
C     RATED = DISCOUNT RATE
C     RATEFL = ESCALATION RATE OF ELEC.
C     RATEKW = RATE PER KILOWATT-HR OF ELEC.(INPUT 0
C              TO PICK UP RATES FOR EACH CITY)

C     YRS = LIFETIME OF THE SYSTEM (YRS)
C     CSTCOL = UNIT COST OF COLLECTOR
C     CSTINS = UNIT COST OF INSULATION
C     CSTCOI = UNIT COST OF COIL
C     THKSD = SIDE INSULATION THICKNESS (IN)
C     THBTM = BOTTOM INSULATION THICKNESS (IN)
C     THKTP = TOP INSULATION THICKNESS (IN)
C     COPHT = ACES HEATING COP AT 32 F TANK
C     COPIM = ACES COOLING COP IN ICE MELT PHASE
C     COPCW = ACES COOLING COP IN CHILLED WATER PHASE
C     COPHW = ACES COP FOR HOT WATER ONLY
C     COPCHT = ACES COMPRESSOR COP HEATING PHASE
C     COPCBR = ACES COMPRESSOR COP COOLING PHASE
C     COPCHW = ACES COPRESSOR COP HOT WATER PHASE
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C       COPBR = ACES COP FOR REMOVAL OF BIN HEAT AT NIGHT
C       EC = ACES HEAT PUMP COMPRESSOR MOTOR (WATTS)
C       EF = ACES INDOOR FAN COIL MOTOR (WATTS)
C       EHB = ACES HOT BRINE PUMP MOTOR (WATTS)
C       ECB = ACES COLD BRINE PUMP MOTOR (WATTS)
C       EOF = ACES OUTDOOR FAN MOTOR (WATTS)
C       EHW = HOT WATER CIRCULATING PUMP (WATTS)
C       COP47 = COP FOR HEAT PUMP AT 47F
C       COP17 = COP FOR HEAT PUMP AT 17F
C
        READ(5,190) TITLE
190     FORMAT(18A4)
        READ(5,180) IPRT,ISYS
180     FORMAT(5I10)
        NSYS = 6
        DO 15 K=1,6
        KSYS(K) = K
15      CONTINUE
C
C  READ HOT WATER TANK DATA
C
        READ(5,200) HWT
200     FORMAT(8F10.0)
        READ(5,200) GAL
C
C  READ ICE TANK DATA
C
        READ(5,200) (TICE(I),I=1,7)
        READ(5,200) (TICE(I),I=8,12)
C
C  READ ECONOMIC DATA
C
        READ(5,200) RATEDC,RATEFL,RATEKW,YRS
        IF(RATEKW.EQ.0.0) KWFLAG=0
        IF(RATEKW.NE.0.0) KWFLAG=1
        READ(5,200) CSTCOL,CSTINS,CSTCOI,THKSD,THKBTM,THKTP
C
C  READ ACES COPS AND PUMP ENERGIES AND
C    COPS FOR HEAT PUMP
C
        READ(5,200) COPCHT,COPCBR,COPCHW,COPHT,COPIM,COPCW,COPBR,COPHW
        READ(5,200) EC,EF,EHB,ECB,EOF,EHW,COP47,COP17
        OPT1=.FALSE.
        IF(COPHT.NE.0.0.AND.COPIM.NE.0.0) OPT1=.TRUE.
        OPT2=.FALSE.
        IF(EC.NE.0.0.AND.EF.NE.0.0.AND.EHB.NE.0.0.AND.ECB.NE.0.0)
     >     OPT2=.TRUE.
        EC=EC*3412.
        EF=EF*3412.
        EHB=EHB*3412.
        ECB=ECB*3412.
        EOF=EOF*3412.
        EHW=EHW*3412.
C
C  READ SUPPRESS FACTOR, NUMBER OF PANEL SIDES, AND PANEL EXCHANGER
C   DELTA T.
C
        READ(5,200) SUP,PSIDES,PDELT
C
C  READ INTERNAL SOURCES
C
        READ(5,200) SO
C
C  READ DATA ABOUT HOUSE CONSTRUCTION
C
        READ(5,200) (AREA(I),I=1,8)
```

```
      READ(5,200) AREA(9),WAB,RAB,WR,RR,HO
      READ(5,200) SF,GLASS,PANES,TSW,TSS
      READ(5,200) XNS,ARCHG,VOL
      NS=XNS
      DO 10 J=1,NS
      READ(5,220) (LABEL(J,I),I=1,5),(VAR(J,I),I=1,5)
220   FORMAT(5A4,5F10.2)
10    CONTINUE
C
C  CALCULATE HEAT LOSS (BTU/HR) BASED ON 50 DEGREE TEMPERATURE DIFFERENCE
C
      SM=0.0
      DO 40 J=1,NS
      JAY=J
      UR=0.0
      DO 20 K=2,4
      IF(VAR(J,K).NE.0.0) UR=UR+1./VAR(J,K)
20    CONTINUE
      U(J)=1./UR
      IF(JAY.EQ.NS) GO TO 30
      DT(J)=VAR(J,5)*50.
      HL(J)=U(J)*VAR(J,1)*DT(J)
      SM=SM+HL(J)
30    IF(JAY.EQ.NS) UFLOOR=U(J)*VAR(J,1)
40    CONTINUE
      RETURN
      END
      SUBROUTINE DIGEST(*)
      DIMENSION VOLM(2),ENSUP(5),COPFAC(76)
      COMMON/EDIG/ACESEU(12,2)
      COMMON/HPUMP/COPH(76),AUX(12),ENGHP(12),CCOP,HCOP,SCOP
      LOGICAL OPT1,OPT2
      COMMON/DAT/HWT(4),TICE(12),AREA(9),RAB,WAB,RR,WR,HO,SF,GLASS,
     >       PANES,SUP,PSIDES,PDELT,TILT,TSW,TSS,GAL(12),COPCHT,
     >       COPCBR,COPCHW,COPHT,COPIM,COPCW,COPBR,COPHW,EC,EF,EHB,
     >       ECB,EOF,EHW,OPT1,OPT2,COP47,COP17,IPRT
      COMMON/BINS/CITY(10),ZONE,DD(2),ALAT,NINV(12),T(12,40),
     >       H(12,40,2),HBR(12),VAV(12),TAV(12),WB(12,40),
     >       ALONG,ELEV,ELECOS,GASCOS,OILCOS
      COMMON/DIG/TVOL(5),PAREA(5),SYSKW(5),BTEMP(12,5),BLEAK(12,5),
     >       PCOL(12,5),BICE(12,5),IRUN,TBLEAK(12),SILEAK(12),
     >       NOICEM(5),NOICEW(5),NTIME
      COMMON/HOUS/LABEL(50,5),XNS,ARCHG,VOL,VAR(50,5),U(50),DT(50),
     >       HL(50),SM,UA,UFLOOR,DCOOL,DHEAT,BCAP,PAN(12,15)
      COMMON/QLOAD/SOL(12,10),SHG(12),QH(12),QC(12),QW(12),
     >       TITLE(18),SOP(12),HON(12),XNFIL(12),SO(12),TH(12),
     >       TG(12,7),DTH(7),HRSPAN(12),HFLOOR(12),CFLOOR(12)
      COMMON/RICE/ISYS,RATEDC,RATEFL,RATEKW,KWFLAG,YRS,CSTCOL,CSTINS,
     >       CSTCOI,THKSD,THKBTM,THKTP,RATETH,RATEGA,RTMELE,RTMGAS,
     >       RTMOIL
C
C  THIS SUBROUTINE CALCULATES BIN SIZE, PANEL AREA, AND
C  ENERGY CONSUMPTION FOR ACES
C
C  TCAP = LATENT AND SENSIBLE ENERGY CAPACITY OF BIN
C  QBIN = INSTANTOUS ENERGY CONTENT OF BIN
C  QLK = BIN ENERGY LEAKAGE
C  BIN = CHANGE IN ENERGY CONTENT IN ONE TIME INCREMENT
C
C  SYSKW = TOTAL ACES ENERGY IN BTU
C  ENSUP = SUPPLEMENTAL COOLING ENERGY IN BTU
C  PAREA = PANEL AREA
C  TVOL = BIN VOLUME
C  ACESEU = MONTHLY ACES ENERGY IN BTU
C  BTEMP = MONTHLY AVERAGE BIN TEMPERATURE
C  BLEAK = MONTHLY BIN LEAKAGE IN BTU
```

```
C   PCOL = MONTHLY PANEL COLLECTION IN BTU
C
          RT= TICE(3)
          RS= TICE(4)
          RB= TICE(5)
          HT= TICE(1)
C
C   ISYS=1 MEANS BRINE CHILLER    ISYS=2 MEANS ICE MAKER
C
          IF(ISYS.EQ.1) PF= TICE(6)
          IF(ISYS.EQ.2) PF=TICE(7)
          TMX = 45.0
          ALPCW=1.0871
          ALPHW=0.663
          IF(OPT1) GO TO 20
          IF(OPT2) GO TO 10
C
C   CALCULATE EC,EF,EHB,ECB
C
          EC=0.3333*DHEAT
          EF=0.06*DHEAT
          ECB=0.018*DHEAT
          EHB=0.025*DHEAT
          EOF=0.0436*DHEAT
          EHW=0.01*DHEAT
          ALPCW=(0.754*DHEAT+0.25*ECB)/(0.754*DHEAT-EF)
          ALPHW=(COPCHW*EC-0.25*ECB)/(EC*(1.+COPCHW))
C
C   CALCULATE COPS FROM MOTOR ENERGIES
C
10        COPHT=((1.+COPCHT)*EC+EF+EHB+0.75*ECB)/(EC+EF+EHB+ECB)
          COPIM=(1.051*DHEAT-EF)/(EF+ECB)
          COPCW=(0.754*DHEAT-EF)/(EF+ECB)
          COPHW=EC*(1.+COPCHW)/(EC+ECB+EHW)
          COPBR=(COPCBR*EC-0.25*ECB)/(EC+ECB+EHB+EOF)
C
C   CALCULATE ACES COP ADJUSTMENT FACTOR FROM COPHT
C
20        J=32.0+11.5
          ACOPF=COPHT/COPH(J)
          DO 30 J=1,76
          COPFAC(J)=COPH(J)*ACOPF
30        CONTINUE
C
C   VMIN = VOLUME OF ICE FORMED IN 2 WEEKS IN JAN.
C
          VMIN= (QH(1)+QW(1))*.5*(COPFAC(43)-1.)/
     >          COPFAC(43)/(57.0*PF*144.)
C
          IRUN=0
          NTIME=4
C
C       ------------------------------------------------------------------
C       VOLM(1)= NEEDED ICE VOLUME,  VOLM(2)= FORMABLE ICE VOLUME
C       ------------------------------------------------------------------
C
C
          DO 100 J=1,2
          VOLM(J)=1.0
          DO 90 ITER=1,500
          VTES=VOLM(J)
          TP=VTES/HT
          SD=4.0*SQRT(VTES*HT)
          TEM= 32.0
          TCAP= 57.0*PF*VTES*(144.0+TMX-32.0)+(1.-PF)*VTES*62.4*(TMX-32.)
          TCAPL=57.0*PF*VTES*144.0
```

```
      QBIN=TCAP
      DO 40 I=1,12
      M=I
      IF(J.EQ.2) M=8-I
      IF(M.LE.0) M=M+12
      DO 40 JJ=1,NTIME
      NT= TEM+11.5
      TCF= (TG(M,1)-TEM)/RT
      BCF= (TG(M,2)-TEM)/RB
      SCF= (TG(M,3)-TEM)/RS
      QLK= (TP*(TCF+BCF)+SD*SCF)*TH(M)
      BIN= QLK+(QH(M)+QW(M))*(1.-COPFAC(NT))/COPFAC(NT)+QC(M)*
     >     (COPCW+1.)/COPCW
      BIN=BIN/NTIME
      IF(J.EQ.2) BIN=-BIN
      IF(BIN.LE.0.0) GO TO 40
      QBIN= QBIN-BIN
      TEM=32.0+(QBIN-TCAPL)/(TCAP-TCAPL)*(TMX-32.0)
      IF(QBIN.LE.TCAPL) TEM=32.0
      IF(TEM.GT.45.0) TEM= 45.0
      IF(TEM.LT.32.0) TEM= 32.0
40    CONTINUE
C  FIRST ITERATION
      IF(VTES.GT.1.0) GO TO 50
      VOLM(J)=VOLM(J)+100.
      GO TO 90
C  CONTINUE TO MAKE VOLUME LARGER IF QBIN IMPROVING
50    IF(QBIN.GT.0.0) GO TO 60
      VOLM(J)=VOLM(J)+100.
      GO TO 90
C  CHANGE IN SIGN OF QBIN-USE BISECTION TO FIND ROOT
60    VL=VTES-100
      VR=VTES
70    VTES=(VL+VR)*0.5
      VOLM(J)=VTES
      TP=VTES/HT
      SD=4.0*SQRT(VTES*HT)
      TEM= 32.0
      TCAP= 57.0*PF*VTES*(144.0+TMX-32.0)+(1.-PF)*VTES*62.4*(TMX-32.)
      TCAPL=57.0*PF*144.0*VTES
      QBIN=TCAP
      DO 80 I=1,12
      M=I
      IF(J.EQ.2) M=8-I
      IF(M.LE.0) M=M+12
      DO 80 JJ=1,NTIME
      NT= TEM+11.5
      TCF= (TG(M,1)-TEM)/RT
      BCF= (TG(M,2)-TEM)/RB
      SCF= (TG(M,3)-TEM)/RS
      QLK= (TP*(TCF+BCF)+SD*SCF)*TH(M)
      BIN= QLK+(QH(M)+QW(M))*(1.-COPFAC(NT))/COPFAC(NT)+QC(M)*
     >     (COPCW+1.)/COPCW
      BIN=BIN/NTIME
      IF(J.EQ.2) BIN=-BIN
      IF(BIN.LE.0.0) GO TO 80
      QBIN= QBIN-BIN
      TEM=32.0+(QBIN-TCAPL)/(TCAP-TCAPL)*(TMX-32.0)
      IF(QBIN.LE.TCAPL) TEM=32.0
      IF(TEM.GT.45.0) TEM= 45.0
      IF(TEM.LT.32.0) TEM= 32.0
80    CONTINUE
      IF(VTES-VL.LE.VTES*.0001) GO TO 100
      IF(QBIN.LE.0.0) VL=VTES
      IF(QBIN.GT.0.0) VR=VTES
      GO TO 70
```

```
90      CONTINUE
100     CONTINUE
        VLM= VOLM(2)
        IF(VOLM(1).LT.VOLM(2)) VLM= VOLM(1)
C
C     ------------------------------------------------------------------
C     SOLAR PANEL OPERATION BEGINS AT MONTH  (MM+1)
C     ------------------------------------------------------------------
C
110     TP= VLM/HT
        SD= 4.0*SQRT(VLM*HT)
        TCAP= 57.0*PF*VLM*(144.+TMX-32.)+(1.-PF)*VLM*62.4*(TMX-32.)
        TCAPL=57.0*PF*144.0*VLM
        NTMX= TMX+11.5
C
        MM=0
        DO 120 M=1,12
        TCF= (TG(M,1)-TMX )/RT
        BCF= (TG(M,2)-TMX )/RB
        SCF= (TG(M,3)-TMX )/RS
        QLK= (TP*(TCF+BCF)+SD*SCF)*TH(M)
        BIN= QLK+(QH(M)+QW(M))*(1.-COPFAC(NTMX))/COPFAC(NTMX)+QC(M)*
     >       (COPCW+1.)/COPCW
        IF(BIN.GT.0.0) MM=M
120     CONTINUE
C
C     ------------------------------------------------------------------
C     SIZE SOLAR PANEL AND COMPUTE ENERGY CONSUMPTION
C     ------------------------------------------------------------------
C
        ARE= 0.0
        IRUN=IRUN+1
        NTIME=4
C
        DO 150 ITER=1,100
        ETOT= 0.0
        ESUP= 0.0
        TEM= TMX
        QBIN=TCAP
        QMIN=TCAP
        FULPAN=0.0
        NOICEM(IRUN) = -1
        NOICEW(IRUN) = 0
C
        DO 140 I=1,12
        M= MM+I
        IF(M.GT. 12) M=M- 12
        STEMP(M,IRUN)=0.0
        BLEAK(M,IRUN)=0.0
        PCOL(M,IRUN)=0.0
        BICE(M,IRUN)=0.0
        ACESEU(M,IRUN)=0.0
        DO 140 JJ=1,NTIME
        NT= TEM+11.5
        MT=TEM-30.5
        TCF= (TG(M,1)-TEM)/RT
        BCF= (TG(M,2)-TEM)/RB
        SCF= (TG(M,3)-TEM)/RS
        QLK= (TP*(TCF+BCF)+SD*SCF)*TH(M)/NTIME
        BIN = QLK+(QH(M)+QW(M))/NTIME*(1.-COPFAC(NT))/COPFAC(NT)+
     >        QC(M)/NTIME*(COPCW+1.)/COPCW
        CMX= ARE*PAN(M,MT)/NTIME
        COL=0.0
        IF(BIN.LT.0.0) COL=AMIN1(CMX,-BIN)
        IF(COL.EQ.CMX) FULPAN=FULPAN+PAN(M,MT)/NTIME
        QBIN= QBIN+BIN+COL
```

```
      IF(QBIN.LT.QMIN) QMIN=QBIN
      ECOL=0.0
      IF(CMX.NE.0.0)  ECOL=COL/CMX*(HRSPAN(M)/NTIME*.021*
     >                (AMAX1(DCOOL,DHEAT)))
      IF(QW(M).LT.QH(M)) ENERGY= (QH(M)+QW(M))/(NTIME*COPFAC(NT))+
     >                          QC(M)/(NTIME*COPIM)+ECOL
      IF(QW(M).GE.QH(M)) ENERGY=QH(M)/(NTIME*COPFAC(NT))+
     >              QW(M)/(NTIME*COPHW)+ QC(M)/(NTIME*COPIM)+ECOL
      IF(QBIN.LT.TCAP.OR.QC(M).LE.0.0)  GO TO 130
C
C  SUPPLEMENTAL COOLING MODE
C
      QBIN=TCAP
      IF(1.EQ.0) QC(M)=1.0
C  THE ABOVE STATEMENT KEEPS OPTIMIZING COMPILER FROM CALCULATING
C  TERMK TOO SOON AND GETTING DIVIDE BY ZERO
      TERMK=ALPCW+QLK/(QC(M)/NTIME)-ALPHW*((QH(M)+QW(M))/QC(M))
      COPSC=(COPCW**(-1)+TERMK*COPBR**(-1))**(-1)
      ENERGY=QH(M)/(NTIME*COPFAC(NT))+QW(M)/(NTIME*COPHW)+
     >       ECOL+QC(M)/(NTIME*COPSC)
      ESUP= ESUP+QC(M)/(NTIME*COPSC)
130   ETOT= ETOT+ENERGY
      ACESEU(M,IRUN)=ACESEU(M,IRUN)+ENERGY
      BTEMP(M,IRUN)= TEM/NTIME+BTEMP(M,IRUN)
      BLEAK(M,IRUN)= QLK+BLEAK(M,IRUN)
      PCOL(M,IRUN)= COL+PCOL(M,IRUN)
      IF(QBIN.GT.TCAPL) BICE(M,IRUN)=0.0
      IF(QBIN.LE.TCAPL) BICE(M,IRUN)=(TCAPL-QBIN)/(144.0*57.0)
      IF (NOICEM(IRUN).LT.0.AND.BICE(M,IRUN).GT.0.0) NOICEM(IRUN)=0
      IF (NOICEM(IRUN).EQ.0.AND.BICE(M,IRUN).EQ.0.0) NOICEW(IRUN) =JJ
      IF (NOICEM(IRUN).EQ.0.AND.BICE(M,IRUN).EQ.0.0) NOICEM(IRUN) =M
      TEM=32.0+(QBIN-TCAPL)/(TCAP-TCAPL)*(TMX-32.0)
      IF(QBIN.LE.TCAPL) TEM=32.0
      IF(TEM.GT.45.) TEM=45.
      IF(TEM.LT.32.) TEM=32.
140   CONTINUE
C
      IF(ABS(QMIN/TCAP).LT.0.0001) GO TO 160
      IF(VLM.EQ.VOLM(2)) GO TO 160
      IF(FULPAN.EQ.0.0) GO TO 180
      ARE=ARE-QMIN/FULPAN
150   CONTINUE
C
160   SYSKW(IRUN)= ETOT
      ENSUP(IRUN)= ESUP
      PAREA(IRUN)= ARE
      IF(PAREA(IRUN).LT.10.0) PAREA(IRUN)=0.0
      TVOL(IRUN)=VLM
C  CALCULATE HEAT LEAKAGE COEFFICIENTS AT 32 DEG TANK TEMP
      DO 170 M=1,12
      SILEAK(M)=((TG(M,3)-32.0)/RS)*TH(M)
      TBLEAK(M)=((TG(M,1)-32.0)/RT+(TG(M,2)-32.0)/RB)*TH(M)
      SILEAK(M)=SILEAK(M)/1000.
      TBLEAK(M)=TBLEAK(M)/1000.
170   CONTINUE
      IF(IRUN .EQ. 1) VLM =VMIN
      IF(IRUN .EQ. 2) GO TO 190
      GO TO 110
180   PRINT 310, CITY
310   FORMAT('1',10A4,'FULL PANEL = 0')
      RETURN1
190     RETURN
      END
      SUBROUTINE EARTH(T)
C
C  PROGRAM TO CALCULATE EARTH TEMPERATURE FROM AIR TEMPERATURE
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C  ADAPTED FROM 'EARTH TEMPERATURE AND THERMAL DIFFUSIVITY AT SELECTED
C  STATIONS IN THE UNITED STATES' BY T. KUSUDA AND P.R.ACHENBACH
C
      LOGICAL OPT1,OPT2
      COMMON/DAT/HWT(4),TICE(12),AREA(9),RAB,WAB,RR,WR,HO,SF,GLASS,
     >       PANES,SUP,PSIDES,PDELT,TILT,TSW,TSS,GAL(12),COPCHT,
     >       COPCBR,COPCHW,COPHT,COPIN,COPCW,COPBR,COPHW,EC,EF,EHB,
     >       ECB,EOF,EHW,OPT1,OPT2,COP47,COP17,IPRT
      COMMON/QLOAD/SOL(12,10),SHG(12),QH(12),QC(12),QW(12),
     >       TITLE(18),SOP(12),HON(12),XNFIL(12),SO(12),TH(12),
     >       TG(12,7),DTH(7),HRSPAN(12),HFLOOR(12),CFLOOR(12)
      COMMON/LEAST/A,B,P
      COMMON/EQU/DT
      DIMENSION T(12),HHR(12)
      DATA HHR/744,672,744,720,744,720,744,744,720,744,720,744/
      PI=3.141593
      D=0.025
C
C  LEAST SQUARE ANALYSIS FOR A,B,P
C
      CALL LSS(T)
      DT=SQRT(PI/(D*8766.))
C
C  SELECT A DEPTH FOR INLET WATER SO THAT GROUND TEMPERATURE
C  IS 36 OR ABOVE.
C
      X=1.0
10    THR=0.0
      X=X+.5
      IF(X.GT.40.0) GO TO 70
      DO 20 K=1,12
      THR=THR+HHR(K)
      TG(K,4)=ET(THR,X)
      IF(TG(K,4).LT.36.0) GO TO 10
20    CONTINUE
      DTH(4)=X
      NDTH=5
      DTH(1)=TICE(2)
      DTH(2)=TICE(2)+TICE(1)
      DTH(3)=TICE(2)+TICE(1)/2.0
      DTH(5)=5.0
C
C  CALCULATE EARTH TEMPERATURES AT DESIRED DEPTHS
C
      DO 60 I=1,NDTH
      THR=0.0
      DO 50 K=1,12
      THR=THR+HHR(K)
      TG(K,I)=ET(THR,DTH(I))
50    CONTINUE
60    CONTINUE
      RETURN
70    PRINT 100
100   FORMAT('0FAILED TO FIND DEPTH FOR INLET',
     >       ' WATER IN SUBROUTINE EARTH')
      STOP
      END
      SUBROUTINE ENERGY
      LOGICAL OPT1,OPT2
      COMMON/DAT/HWT(4),TICE(12),AREA(9),RAB,WAB,RR,WR,HO,SF,GLASS,
     >       PANES,SUP,PSIDES,PDELT,TILT,TSW,TSS,GAL(12),COPCHT,
     >       COPCBR,COPCHW,COPHT,COPIN,COPCW,COPBR,COPHW,EC,EF,EHB,
     >       ECB,EOF,EHW,OPT1,OPT2,COP47,COP17,IPRT
      COMMON/FRACS/ANHEAT,ANCOOL,ANWATR,ANLATN,RATIO
      COMMON/HPUMP/COPH(76),AUX(12),ENGHP(12),CCOP,HCOP,SCOP
      COMMON/HOUS/LABEL(50,5),XNS,ARCHG,VOL,VAR(50,5),U(50),DT(50),
```

```
     >          HL(50),SH,UA,UFLOOR,DCOOL,DHEAT,BCAP,PAN(12,15)
        COMMON/ENG/ENG(6,2),EU(6,2,12),NSYS,KSYS(6)
        COMMON/QLOAD/SOL(12,10),SHG(12),QH(12),QC(12),QW(12),
     >          TITLE(18),SOP(12),NON(12),XNFIL(12),SO(12),TH(12),
     >          TG(12,7),DTH(7),HRSPAN(12),HFLOOR(12),CFLOOR(12)
        COMMON/ELOAD/HPEUH(12),HPEUC(12)
        DIMENSION HPEUW(12)
        DIMENSION PCBFUR(3),ACSEER(2,8)
        DIMENSION EFGHW(2,7)
C
C   CAPACITIES OF FURNACE
C     PULSED COMBUSTION
        DATA PCBFUR/55000.,76000.,120000./
C
C   EFFICIENCY OF GAS HOT WATER HEATER BASED ON GAL USED PER DAY.
C
        DATA EFGHW/20.,32.5,
     >             30.,40.0,
     >             40.,47.0,
     >             50.,50.5,
     >             64.,54.0,
     >             80.,57.0,
     >             90.,59.0/
C
C   SEASONAL ENERGY EFFICIENCY RATIOS FOR AIR CONDITIONERS
C   BASED ON SEARS CATALOG - WINTER 80
C
        DATA ACSEER/23000.,9.8,
     >              27500.,9.9,
     >              32000.,9.6,
     >              34000.,9.6,
     >              36500.,9.3,
     >              42000.,10.3,
     >              47000.,9.8,
     >              57000.,9.2/
C
C   THIS SUBROUTINE CALCULATES THE ENERGY USED IN A NON-ACES SYSTEM
C
C   ENG(I,J)=YEARLY ENERGY OF TYPE J USED BY SYSTEM I
C   EU(I,J,M)=ENERGY USED BY SYSTEM I OF TYPE J IN MONTH M
C
        DO 10 I=1,NSYS
        DO 10 J=1,2
10      ENG(I,J) = 0E0
        DO 15 I=1,NSYS
        DO 15 M=1,12
15      EU(I,2,M) = 0E0
C
C   FIND SEER FOR AIR CONDITIONER
C
        DO 25 J=1,8
        IF (DCOOL.LE.ACSEER(1,J)) GO TO 35
25      CONTINUE
        J = 8
35      CCOPAC = ACSEER(2,J)/3.412
        CCOPAC = 2.55
        KSW = 0
        DO 100 KK=1,NSYS
        KGO = KSYS(KK)
        GO TO (130,120,110,140,150,160),KGO
C   HEAT PUMP WITH DESUPERHEATER WATER HEATER
C
C   ENERGY USE CALCULATION DONE IN AAHP SUBROUTINE
C
110     DO 50 M=1,12
        ENG(3,1)=ENG(3,1)+EU(3,1,M)
```

```
50      CONTINUE
        GO TO 100
C
C  HEAT PUMP WITH I2R HOT WATER HEATER
C    ENERGY USE CALCULATION ALREADY DONE IN SUBROUTINE AAHP.
C
120     DO 60 M=1,12
        ENG(2,1)=ENG(2,1)+EU(2,1,M)
60      CONTINUE
        GO TO 100
C
C  ELECTRIC HEAT WITH AIR CONDITIONER
C
130     DO 70 M=1,12
        EU(1,1,M)=QH(M)+QC(M)/CCOPAC+QW(M)
        ENG(1,1)=ENG(1,1)+EU(1,1,M)
70      CONTINUE
        GO TO 100
C
C  GAS FURNACE AND WATER HEATER WITH ELECTRIC A/C
C
140     DO 210 M=1,12
C
C  ENERGY USED BY FAN
C
        EFAN = .0114*QH(M)
C
C  FIND EFFICIENCY FACTOR FOR GAS HOT WATER HEATER
C
293     DO 295 J=1,7
        IF (GAL(M).LE.EFGHW(1,J)) GO TO 298
295     CONTINUE
        J=7
        PRINT 1000,GAL(M)
298     IF (J.EQ.1) EFGH2O=EFGHW(2,J)
        IF (J.NE.1) EFGH2O = EFGHW(2,J-1)+(GAL(M)-EFGHW(1,J-1))/
     >            (EFGHW(1,J)-EFGHW(1,J-1))*(EFGHW(2,J)-EFGHW(2,J-1))
        EFGH2O = EFGH2O/1E2
C
C  CALCULATE ELECTRIC ENERGY USED BY SYSTEM
C
        EU(4,2,M)=EFAN + QC(M)/CCOPAC
        ENG(4,2)=EU(4,2,M) + ENG(4,2)
C
C  CALCULATE GAS ENERGY USED BY SYSTEM
C
        EU(4,1,M) = QW(M)/EFGH2O + EU(4,1,M)
        ENG(4,1) = ENG(4,1) + EU(4,1,M)
210     CONTINUE
        GO TO 100
C
C  OIL FURNACE WITH ELECTRIC WATER HEATER AND A/C
C
150     DO 240 M=1,12
C
C  ENERGY USED BY FAN
C
        EFAN = .0114*QH(M)
C
C  ELECTRIC ENERGY USED
C
320     EU(5,2,M) = EFAN + QC(M)/CCOPAC + QW(M)
        ENG(5,2) = ENG(5,2) + EU(5,2,M)
C
C  OIL ENERGY USED
C
```

```
      ENG(5,1) = ENG(5,1) + EU(5,1,M)
240   CONTINUE
      GO TO 100
C
C  PULSED COMBUSTION FURNACE WITH CONVENTIONAL GAS WATER HEATING
C     AND WITH ELECTRIC A/C
C
160   DO 250 K=1,3
      IF (DHEAT*1.5E0.LT.PCBFUR(K)) GO TO 260
250   CONTINUE
260   CAPPCB = PCBFUR(K)
      EFPCB = .93E0
      DO 270 M=1,12
C
C  ENERGY USED BY FAN
C
      EFAN = .0114*QH(M)
      HRSOP = QH(M)/CAPPCB
C
C  FIND EFFICIENCY FACTOR FOR GAS HOT WATER HEATER
C
      DO 265 J=1,7
      IF (GAL(M).LE.EFGHW(1,J)) GO TO 268
265   CONTINUE
      J=7
      PRINT 1000,GAL(M)
268   IF (J.EQ.1) EFGH2O=EFGHW(2,J)
      IF (J.NE.1) EFGH2O = EFGHW(2,J-1)+(GAL(M)-EFGHW(1,J-1))/
     >            (EFGHW(1,J)-EFGHW(1,J-1))*(EFGHW(2,J)-EFGHW(2,J-1))
      EFGH2O = EFGH2O/1E2
C
C  ELECTRIC ENERGY USED
C
      EU(6,2,M) = EFAN + QC(M)/CCOPAC
      ENG(6,2) = ENG(6,2) + EU(6,2,M)
C
C  GAS ENERGY USED
C
      EU(6,1,M) = QW(M)/EFGH2O
      IF (QH(M).GE.5E-20)
     >    EU(6,1,M) = EU(6,1,M) + QH(M)/EFPCB
      ENG(6,1) = ENG(6,1) + EU(6,1,M)
270   CONTINUE
100   CONTINUE
1000  FORMAT ('0EXCEEDED UPPER BOUND FOR GAS HOT WATER',
     > ' EFFICIENCY CURVE IN SUBROUTINE ENERGY, GAL(M) =',F10.2)
      RETURN
      END
       SUBROUTINE LOADS(*)
      COMMON/ENG/ENG(6,2),EU(6,2,12),NSYS,KSYS(6)
      COMMON/ELOAD/HPEUH(12),HPEUC(12)
      COMMON/HPUMP/COPH(76),AUX(12),ENGHP(12),CCOP,HCOP,SCOP
      COMMON/FRACS/ANHEAT,ANCOOL,ANWATR,ANLATN,RATIO
      LOGICAL OPT1,OPT2
      COMMON/DAT/HWT(4),TICE(12),AREA(9),RAB,WAB,RR,WR,HO,SF,GLASS,
     >       PANES,SUP,PSIDES,PDELT,TILT,TSW,TSS,GAL(12),COPCHT,
     >       COPCBR,COPCHW,COPHT,COPIM,COPCW,COPBR,COPHW,EC,EF,EHB,
     >       ECB,EOF,EHW,OPT1,OPT2,COP47,COP17,IPRT
      COMMON/BINS/CITY(10),ZONE,DD(2),ALAT,NINV(12),T(12,40),
     >       H(12,40,2),HBR(12),VAV(12),TAV(12),WB(12,40),
     >       ALONG,ELEV,ELECOS,GASCOS,OILCOS
      COMMON/DIG/TVOL(5),PAREA(5),SYSKW(5),BTEMP(12,5),BLEAK(12,5),
     >       PCOL(12,5),BICE(12,5),IRUN,TBLEAK(12),SILEAK(12),
     >       NOICEM(5),NOICEW(5),NTIME
      COMMON/HOUS/LABEL(50,5),KNS,ARCHG,VOL,VAR(50,5),U(50),DT(50),
     >       HL(50),SM,UA,UFLOOR,DCOOL,DHEAT,BCAP,PAN(12,15)
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      COMMON/QLOAD/SOL(12,10),SHG(12),QH(12),QC(12),QW(12),
     >        TITLE(18),SOP(12),MON(12),XNFIL(12),SO(12),TH(12),
     >        TG(12,7),DTH(7),HRSPAN(12),HFLOOR(12),CFLOOR(12)
      DIMENSION GASFUR(3),OILFUR(4),EFG(2,8),EFO(2,13)
      DIMENSION QBINH(2),QBINC(2)
C
C  CAPACITIES OF FURNACES
C    GAS
      DATA GASFUR/64000.,84000.,100000./
C    OIL
      DATA OILFUR/79000.,105000.,131000.,158000./
C
C  EFFICIENCY CURVES BASED ON PERCENT ON TIME
C    GAS FURNACE
      DATA EFG/0.0,55.,
     >          2.0,59.,
     >          5.0,65.,
     >         10.0,68.,
     >         15.0,70.,
     >         20.0,72.,
     >         50.0,74.5,
     >        100.0,80./
C    OIL FURNACE
      DATA EFO/1.0,30.,
     >        5.0,50.,
     >        6.0,55.,
     >        7.5,58.,
     >       10.0,60.,
     >       15.0,61.,
     >       20.0,62.,
     >       50.0,64.,
     >       85.0,67.,
     >       91.0,67.5,
     >       94.0,69.,
     >       97.0,72.,
     >      100.0,75./
C
C  THIS SUBROUTINE CALCULATES MONTHLY HOT WATER, HEATING,
C  AND COOLING LOADS USING BIN WEATHER DATA.
C
C
C
C
C     C1 = (3 PEOPLE * 200 BTU/PERSON/HR / 1094 BTU/# OF WATER) * 0.5
C     C2 = (3 PEOPLE * 200 BTU/PERSON/HR / 1094 BTU/# OF WATER) * 0.75
C     WD = DESIGN HUMIDITY RATIO
C     WI = INDOOR HUMIDITY RATIO
C     WO = OUTDOOR HUMIDITY RATIO
C     XNFIL = MONTHLY INFILTRATION
C     QH = MONTHLY HEATING LOAD
C     QC = MONTHLY COOLING LOAD
C     QW = MONTHLY HOT WATER LOAD
C     ANHEAT = ANNUAL HEATING LOAD
C     ANCOOL = ANNUAL COOLING LOAD
C     ANLATN = ANNUAL LATENT COOLING LOAD
C     ANWATR = ANNUAL HOT WATER LOAD
C     ANPWHR = ANNUAL POWER FOR AIR TO AIR HEAT PUMP
C     CCOP = ANNUAL COOLING COP FOR AIR TO AIR HEAT PUMP
C     HCOP = ANNUAL HEATING COP FOR AIR TO AIR HEAT PUMP
C     SCOP = ANNUAL COP FOR AIR TO AIR HEAT PUMP
C     CCOPAC = ANNUAL CCOP FOR ELECTRIC AIR CONDITIONER
C
C     DD(1) = DESIGN DAY TEMPERATURE, WINTER
C     DD(2) = DESIGN DAY TEMPERATURE, SUMMER
C     DHEAT = DESIGN DAY HEATING LOAD
C     DCOOL = DESIGN DAY COOLING LOAD
```

```
C       SUP = SUPPRESSION FACTOR
C       TSS = HOUSE TEMPERATURE SETTING,SUMMER
C       TSW = HOUSE TEMPERATURE SETTING, WINTER
C       UFLOOR = UA (FLOOR)
C       UA = UA (WALLS,WINDOWS,DOORS AND CEILINGS)
C       BCAP = BLOWER CAPACITY (CFM)
C       ARCHG = NUMBER OF AIR CHANGES PER HOUR
C       VOL = NUMBER OF CUBIC FEET PER AIR CHANGE
C       HPEUH(M) = HEAT PUMP ENERGY FOR HEATING AND AUXILIARY ENERGY
C       HPEUC(M) = HEAT PUMP ENERGY FOR COOLING
C       AUX(M) = AUXILIARY ENERGY FOR HEATING
C
C
          C1=(3.*200./1094.)*0.5+5./24.
          C2=(3.*200./1094.)*0.75+5./24.
          PB=29.92
          C=ARCHG*VOL/.695
          CALL PSY1(TSS,66.,PB,WD,V)
C
C
C
          CONST=(1.08*ARCHG*VOL)/(.695*60.)
C
C
C   CALCULATE UA AND DESIGN DAY LOADS
C
          UA=(SM/50.)*SUP
          WINF=CONST*(.15+.013*15.0+.005*(TSW-DD(1)))
          SINF=CONST*(.15+.013*7.5+.005*(DD(2)-TSS))
          DHEAT=(UA+WINF)*(TSW-DD(1))+UFLOOR*(TSW-TG(1,5))
          DCOOL=(UA+SINF)*(DD(2)-TSS)-UFLOOR*(TSS-TG(8,5))+SOP(8)+
     >          SHG(8)+SO(8)
          DCOOL=1.3*DCOOL
C
C   FIND GAS FURNACE CAPACITY
C
          DO 2 K=1,3
          IF (DHEAT*1.5.LT.GASFUR(K)) GO TO 4
2         CONTINUE
          K = 3
4         CAPGAS=GASFUR(K)
C
C   FIND OIL FURNACE CAPACITY
C
          DO 6 K=1,3
          IF (DHEAT*1.5E0.LT.OILFUR(K)) GO TO 8
6         CONTINUE
          K = 3
8         CAPOIL = OILFUR(K)
C
C   ESTIMATE REQUIRED BLOWER CAPACITY                          (CFM)
C
          CAPH= DHEAT/(1.08*(95.0-TSW))
          CAPC= DCOOL/(1.08*(TSS-50.0))
          IF(CAPC.GT.CAPH) CAPH=CAPC
          M= (CAPH+25.0)/50.0
          BCAP= 50*M
C
C   ADJUST COOLING COP TO MODEL HEAT PUMP SPECIFIED BY USER
C   WITH 14% CYCLING LOSS AS CONSTANT.
C   2.88 IS COP IN ARRAY COPH AT 32 DEGREES.
C
C
          COPBAR=(COP17+COP47)/2.
          CCOP=2.65*.86*COPBAR/2.88
          ANPWHP=0.0
```

```
      ANWATR=0.0
      ANHEAT=0.0
      ANCOOL=0.0
      ANLATN=0.0
      DO 100 M=1,12
C
C     HWT(1) = HOT WATER TANK SURFACE AREA
C     HWT(2) = U-VALUE OF HOT WATER TANK INSULATION
C     HWT(3) = HOT WATER STORAGE TEMPERATURE
C
      CON=231.*62.4/(24.*1728.)
      QS=HWT(1)*HWT(2)*(HWT(3)-70.0)
      RATE=(GAL(M)*((HWT(3)-TG(M,4))*CON)+QS)/HWT(4)
C
C  CALCULATE MONTHLY INFILTRATION COEFFICIENT   (BTUH/F)
C
      XNFIL(M)= CONST*(.15+.013*VAV(M)+.005*ABS(TAV(M)-TSW))
      IF(XNFIL(M).EQ.0.0) GO TO 10
      TGRND= TG(M,5)
      HFLOOR(M)= UFLOOR*((TGRND+TSW)/2.0-TSW)
      CFLOOR(M)= UFLOOR*((TGRND+TSS)/2.0-TSS)
10    UAT= UA+XNFIL(M)
C
C  CALCULATE BALANCE TEMPERATURES
C
      TBALHD=TSW-(SOP(M)+SHG(M)+SO(M)+HFLOOR(M))/UAT
      TBALHN=TSW-(SO(M)+HFLOOR(M))/UAT
      TBALCD=TSS-(SOP(M)+SHG(M)+SO(M)+CFLOOR(M))/UAT
      TBALCN=TSS-(SO(M)+CFLOOR(M))/UAT
      IF(TBALCD.LT.65.) TBALCD=65.0
      IF(TBALCN.LT.65.) TBALCN=65.0
C
      AIRFLO=C*(.15+.013*VAV(M)+.005*ABS(TAV(M)-TSS))
      AUX(M)=0.0
      HPEUH(M)=0.0
      HPEUC(M)=0.0
      ENGHP(M)=0.0
      QH(M)=0.0
      QC(M)=0.0
      QW(M)=0.0
      SLATD=0.0
      SLATN=0.0
      SIZE=6000.*INT((DCOOL+6000.)/6000.)
      IEND=NINV(M)
      DO 15 J=1,6
15    EU(J,1,M) = 0.0
      DO 80 I=1,IEND
      CALL PSY1(T(M,I),WB(M,I),PB,WO,V)
      AIRFLW=AIRFLO/V
      SATVH=.444*T(M,I)+1061.
      TIME = H(M,I,1) + H(M,I,2)
      BW = RATE*TIME
C
C  CALCULATE HEATING LOAD FOR EACH TEMPERATURE BIN
C
      DO 20 J=1,2
      QBINH(J)=0.0
      QBINC(J)=0.0
20    CONTINUE
      IF(T(M,I).GT.TBALHD) GO TO 30
      QBINH(1)=(UAT*(TSW-T(M,I))-(SOP(M)+SHG(M)+SO(M)+HFLOOR(M)))
     >          *H(M,I,1)
30    IF(T(M,I).GT.TBALHN) GO TO 40
      QBINH(2)=(UAT*(TSW-T(M,I))-(SO(M)+HFLOOR(M)))*H(M,I,2)
C
C  CALCULATE COOLING LOADS AND LATENT COOLING LOAD
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```
C  OF EACH TEMPERATURE BIN
C
40      IF(T(M,I).LT.TBALCD) GO TO 50
        QBINC(1)=(UAT*(T(M,I)-TSS)+SOP(M)+SHG(M)+SO(M)+CFLOOR(M))
     >          *H(M,I,1)
        WI=WO+C1/AIRFLW
        IF (WI .LE. WD) GO TO 50
        WLBHD=(WI-WD)*AIRFLW
        SLATD=SLATD+WLBHD*H(M,I,1)*SATVH
        QBINC(1)=QBINC(1)+WLBHD*H(M,I,1)*SATVH
50      IF(T(M,I).LT.TBALCN) GO TO 60
        QBINC(2)=(UAT*(T(M,I)-TSS)+SO(M)+CFLOOR(M))*H(M,I,2)
        WI=WO+C2/AIRFLW
        IF (WI .LE. WD) GO TO 60
        WLBHN=(WI-WD)*AIRFLW
        SLATN=SLATN+WLBHN*H(M,I,2)*SATVH
        QBINC(2)=QBINC(2)+WLBHN*H(M,I,2)*SATVH
60      BH=QBINH(1)+QBINH(2)
        QH(M)=QH(M)+BH
        DO 62 J=1,2
        IF (QBINH(J).LT.5E-20) GO TO 62
        PCT=QBINH(J)/(CAPGAS*H(M,I,J))*1E2
        DO 64 JK=1,8
        IF (PCT.LE.EFG(1,JK)) GO TO 66
64      CONTINUE
66      EFGAS = EFG(2,JK-1)+(PCT-EFG(1,JK-1))/
     >                (EFG(1,JK)-EFG(1,JK-1))*(EFG(2,JK)-EFG(2,JK-1))
        EFGAS = EFGAS/1E2
        EU(4,1,M) = EU(4,1,M) + QBINH(J)/EFGAS
        PCT = QBINH(J)/(CAPOIL*H(M,I,J))*1E2
        DO 67 JK=1,13
        IF (PCT.LE.EFO(1,JK)) GO TO 68
67      CONTINUE
68      EFOIL = EFO(2,JK-1)+(PCT-EFO(1,JK-1))/
     >                (EFO(1,JK)-EFO(1,JK-1))*(EFO(2,JK)-EFO(2,JK-1))
        EFOIL = EFOIL/1E2
        EU(5,1,M) = EU(5,1,M) + QBINH(J)/EFOIL
62      CONTINUE
C       PRINT 600, M,QH(M),QBINH
600     FORMAT('0',I5,3F15.2)
        BC = QBINC(1)+QBINC(2)
        QC(M)=QC(M)+BC
C
C  CALCULATE AIR TO AIR HEAT PUMP ENERGY NEEDED
C
        CALL AAHP(SIZE,COPBAR,TIME,T(M,I),BH,BC,BW,M)
80      CONTINUE
C
C  ZERO SMALL LOADS
C
        IF(QC(M).EQ.0.0) GO TO 90
        IF(QH(M)/QC(M).LE.0.2) QH(M)=0.0
        IF(QH(M).EQ.0.0) GO TO 90
        IF(QC(M)/QH(M).LE.0.2) QC(M)=0.0
C
C  MONTHLY HOT WATER LOAD
C
90      QW(M) = RATE*TH(M)
C
        IF (M .EQ. 8) DLT=SLATD+SLATN
C
C  ANNUAL SUMS
C
        ANPWHP=ANPWHP+ENGHP(M)
        ANHEAT=ANHEAT+QH(M)
        ANCOCL=ANCOOL+QC(M)
```

```
      ANWATR=ANWATR+QW(M)
      ANLATN=ANLATN+SLATD+SLATN
100   CONTINUE
      IF(ANHEAT.EQ.0.0) GO TO 110
      HCOP=ANHEAT/(ANPWHP-ANCOOL/CCOP)
      SCOP=(ANHEAT+ANCOOL+ANWATR)/(ANPWHP+ANWATR)
C  CORRECT DCOOL TO ACCOUNT FOR ACTUAL LATENT COOLING NEEDS
      IF(QC(8).NE.0.0) DCOOL=QC(8)*DCOOL/(1.3*(QC(8)-DLT))
      RATIO=ANCOOL/(ANCOOL-ANLATN)
      RETURN
110   PRINT 500, CITY
500   FORMAT('1',10A4,'  HEATING LOADS ARE ZERO')
      RETURN1
      END
      SUBROUTINE LSS(T)
C
C  SUBROUTINE TO DO LEAST SQUARE FIT ON T TO GET A,B,P
C  THIS IS USED IN COMBINATION WITH SUBROUTINE EARTH
C
      COMMON/LEAST/A,B,P
      DIMENSION T(12)
      PI=3.141593
      TERM1=0.0
      SUM=0.0
      TERM2=0.0
      DO 20 K=1,12
      SUM =SUM+T(K)
      WTH=PI*(K)/6.
      TERM1=T(K)*COS(WTH)+TERM1
      TERM2=T(K)*SIN(WTH)+TERM2
20    CONTINUE
      A=SUM/12.
      B=-2/12.*SQRT(TERM1*TERM1+TERM2*TERM2)
      ARG=TERM2/TERM1
      P=ATAN(ARG)
      RETURN
      END
      SUBROUTINE PANEL
      LOGICAL OPT1,OPT2
      COMMON/DAT/HWT(4),TICE(12),AREA(9),RAB,WAB,RR,WR,HO,SF,GLASS,
     >       PANES,SUP,PSIDES,PDELT,TILT,TSW,TSS,GAL(12),COPCHT,
     >       COPCBR,COPCHW,COPHT,COPIM,COPCW,COPBR,COPHW,EC,EF,EHB,
     >       ECB,EOF,EHW,OPT1,OPT2,COP47,COP17,IPRT
      COMMON/BINS/CITY(10),ZONE,DD(2),ALAT,NINV(12),T(12,40),
     >       H(12,40,2),HBR(12),VAV(12),TAV(12),WB(12,40),
     >       ALONG,ELEV,ELECOS,GASCOS,OILCOS
      COMMON/QLOAD/SOL(12,10),SHG(12),QH(12),QC(12),QW(12),
     >       TITLE(18),SOP(12),MON(12),XNFIL(12),SO(12),TH(12),
     >       TG(12,7),DTH(7),HRSPAN(12),HFLOOR(12),CFLOOR(12)
      COMMON/HOUS/LABEL(50,5),XNS,ARCHG,VOL,VAR(50,5),U(50),DT(50),
     >       HL(50),SM,UA,UFLOOR,DCOOL,DHEAT,BCAP,PAN(12,15)
C
C  THIS SUBROUTINE CALCULATES SOLAR PANEL HEAT PICKUP
C
C  PDELT = PANEL DELTA TEMPERATURE
C  PSIDES = NUMBER OF PANEL SIDES CONVECTIVE
C  VAV(M)  = WIND SPEED FOR MONTH M
C  T(M,I)  = TEMPERATURE FOR MONTH M AND BIN I
C  H(M,I,1) = BIN DAYLIGHT HOURS
C  H(M,I,2) = BIN NIGHT HOURS
C
      DO 100 NT=1,15
      DO 100 M=1,12
      PAN(M,NT)=0.
      TNXT=NT+31+PDELT
      UU = 0.912+0.409*VAV(M)
```

```
      FR= 0.941-0.028*UU
      HRSPAN(M)=0.0
      DO 100 I=1,40
      IF(T(M,I).LT.32.0) GO TO 100
    DY= FR*(.93*SOL(M,10)/8.0+PSIDES*UU*(T(M,I)-TNXT)-15.0)*H(M,I,1)
      IF(DY.LT.0.0) DY=0.0
      IF(DY.GT.0.0) HRSPAN(M)=HRSPAN(M)+H(M,I,1)
      DK= FR*(PSIDES*UU*(T(M,I)-TNXT)-15.0)*H(M,I,2)
      IF(DK.LT.0.0) DK=0.0
      IF(DK.GT.0.0) HRSPAN(M)=HRSPAN(M)+H(M,I,2)
      PAN(M,NT)= PAN(M,NT)+DY+DK
100   CONTINUE
C
      RETURN
      END
      SUBROUTINE PRTDAT
C
C  OUTPUTS INPUT DATA
C
      LOGICAL OPT1,OPT2
      COMMON/DAT/HWT(4),TICE(12),AREA(9),RAB,WAB,RR,WR,HO,SF,GLASS,
     >       PANES,SUP,PSIDES,PDELT,TILT,TSW,TSS,GAL(12),COPCHT,
     >       COPCBR,COPCHW,COPHT,COPIN,COPCW,COPBR,COPHW,EC,EF,EHB,
     >       ECB,EOF,EHW,OPT1,OPT2,COP47,COP17,IPRT
      COMMON/HOUS/LABEL(50,5),XNS,ARCHG,VOL,VAR(50,5),U(50),DT(50),
     >       HL(50),SM,UA,UFLOOR,DCOOL,DHEAT,BCAP,PAN(12,15)
      COMMON/QLOAD/SOL(12,10),SHG(12),QH(12),QC(12),QW(12),
     >       TITLE(18),SOP(12),MON(12),XNFIL(12),SO(12),TH(12),
     >       TG(12,7),DTH(7),HRSPAN(12),HFLOOR(12),CFLOOR(12)
      COMMON/RICE/ISYS,RATEDC,RATEFL,RATEKW,KWFLAG,YRS,CSTCOL,CSTINS,
     >       CSTCOI,THKSD,THKBTM,THKTP,RATETH,RATEGA,RTMELE,RTMGAS,
     >       RTMOIL
C  WATER TANK AND ICE TANK AND ECONOMIC DATA
C
      PRINT 300, TITLE
      IF(ISYS.EQ.1) PRINT 310
      IF(ISYS.EQ.2) PRINT 320
      PRINT 330,HWT(1),TICE(1),RATEDC,HWT(2),TICE(2),RATEKW,HWT(3),
     >          TICE(3),RATEFL,HWT(4),TICE(4),YRS,TICE(5),CSTCOL,
     >          TICE(6),TICE(7),CSTINS,TICE(8),CSTCOI,TICE(10),TICE(9)
C
C  COPS AND PUMP ENERGIES
C
      PRINT 340, COPCHT,COP47,TICE(11),COPCBR,COP17,COPCHW,COPHT,
     >           COPIN,COPCW,COPBR,COPHW,EC,EF,EHB,ECB,EOF,EHW
C
C  INTERNAL SOURCES
C
      PRINT 350, MON,SO
C
C  DESCRIPTION OF HOUSE
C
      PRINT 360, (AREA(I),I=1,9),WAB,HO,RAB,GLASS,WR,
     >           PANES,RR,SF,SUP
      PRINT 370, TSW,TSS,VOL,ARCHG
      PRINT 380, PSIDES,PDELT
C
C  PRINT SURFACES OF THE HOUSE
C
      NS=XNS
      IF(NS.EQ.0) GO TO 80
      PRINT 390
      NS1=NS-1
      DO 40 J=1,NS1
      PRINT 400, (LABEL(J,I),I=1,5),(VAR(J,I),I=1,4),U(J),DT(J),
     >           HL(J)
```

```
40      CONTINUE
        PRINT 410, SM
        PRINT 420, (LABEL(NS,I),I=1,5),(VAR(NS,I),I=1,4),U(NS)
        PRINT 430, UFLOOR
80      RETURN
300     FORMAT(1H1,18A4)
310     FORMAT('0HOT WATER TANK',T50,'ICE TANK',T95,'IN-BIN HEAT PUMP'/)
320     FORMAT('0HOT WATER TANK',T50,'ICE TANK',T95,
     >          'ICE MAKER HEAT PUMP'/)
330     FORMAT('0WATER TANK SURFACE AREA(FT**2)',T35,F10.3,T50,
     >          'ICE BIN HEIGHT(FT)',T80,F10.3,
     >          T95,'DISCOUNT RATE',T120,F10.4/
     >         ' WATER TANK U(BTU/HR*FT**2)',T35,F10.3,T50,
     >         'DEPTH BELOW SURFACE(FT)',
     >         T80,F10.3,T95,'RATE PER KILOWATT-HR',T120,F10.3/
     >         ' WATER STORAGE TEMP (F)',T35,F10.3,T50,
     >         'ICE BIN TOP R VALUE',T80,
     >         F10.3,T95,'ESCALATION RATE ELEC.',T120,F10.3/
     >         ' WATER DELIVERY EFFICIENCY',T35,F10.3,
     >         T50,'ICE BIN SIDE R VALUE',T80,
     >         F10.3,T95,'LIFETIME (YRS)',T120,F10.3/
     >         1X,T50,'ICE BIN BOT R VALUE',T80,F10.3,
     >         T95,'PANEL COST($/SQFT)',T120,F10.2,/
     >         1X,T50,'ICE PACKING FRACTION',T80,F7.3,F7.3,T95,
     >         'INSULATION COST($/SQFT)',T120,F10.3/
     >         1X,T50,'BRINE TEMPERATURE',T83,F6.2,'F',
     >         T95,'COIL COST($/FT)',T120,F10.3/
     >         1X,T95,'COIL OD(INCHES)',T120,F10.3,/
     >         1X,T95,'COIL ID(INCHES)',T120,F10.3)
340     FORMAT(' COMPRESSOR COP CC(H)',T35,F10.3,T50,
     >         'HEAT PUMP COP 47F',T80,F10.3,
     >         T95,'COIL CONDUCTIVITY',T120,F10.3/
     >         ' COMPRESSOR COP CC(BR)',T35,F10.3,T50,
     >         'HEAT PUMP COP 17F',T80,F10.3/
     >         ' COMPRESSOR COP CC(HW)',T35,F10.3,/
     >         ' ACES HEATING COP(H)',T35,F10.3/
     >         ' ACES COOLING COP (IM)',T35,F10.3/
     >         ' ACES COOLING COP(CW)',T35,F10.3/
     >         ' ACES COP FOR NIGHT HEAT REMOVAL(H)',T36,F9.3/
     >         ' ACES HOT WATER COP(HW)',T35,F10.3/
     >         ' ACES COMPRESSOR MOTOR (BTUH)',T35,F10.3/
     >         ' ACES INDOOR FAN COIL MOTOR (BTUH)',T35,F10.3/
     >         ' ACES HOT BRINE PUMP MOTOR(BTUH)',T35,F10.3/
     >         ' ACES COLD BRINE PUMP MOTOR(BTUH)',T35,F10.3/
     >         ' ACES OUTDOOR FAN MOTOR(BTUH)',T35,F10.3/
     >        ' ACES HOT WATER PUMP(BTUH)',T35,F10.3/)
350     FORMAT('0',T23,A4,11(5X,A4)/' INTERNAL SOURCES',12F9.0//)
360     FORMAT('0DESCRIPTION OF HOUSE'/' ',T30,6X,'N',9X,'E',9X,
     >         'S',9X,'W'/
     >         ' OVERALL WINDOW AREA',T30,4F10.1/
     >         ' OVERALL WALL AREA',T30,4F10.1/
     >         ' ROOF AREA',T20,F10.3,T50,'WALL ABSORPTANCE',T80,F10.3/
     >         ' OUTDOOR FILM COEFF',T20,F10.3,T50,'ROOF ABSORPTANCE',
     >         T80,F10.3/
     >         ' GLASS TYPE',T20,F10.3,T50,'WALL THERMAL RESISTANCE',
     >         T80,F10.3/
     >         ' NO OF PANES',T20,F10.3,T50,'ROOF THERMAL RESISTANCE',
     >         T80,F10.3/
     >         ' WINDOW SHADING FACTOR',T20,F10.2,T50,
     >         'U ADJUSTMENT FACTOR',T80,F10.2//)
370     FORMAT(' THERMOSTAT SETTING WINTER',F10.0/
     >         ' THERMOSTAT SETTING SUMMER',F10.0/
     >         ' HOUSE VOLUME (FT**3)',6X,F10.2/
     >         ' AIR CHANGES PER HOUR',6X,F10.2/)
380     FORMAT('0SOLAR PANEL:  SIDES(CONVECTION)',3X,F10.0,5X,
     >         'EXCHANGER DELTA T (F)',F10.0/)
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390     FORMAT(' BUILDING HEAT',9X,'AREA     H-INSIDE    U(SLAB)',
     >        ' H-OUTSIDE',2X,'UTOTAL)    DELTA T  HEAT LOSS'/
     >        ' TRANSFER SURFACES     (SQFT)',
     >        '  **********(BTU/HR/SQFT/DEG-F)**********   (DEG-F)',2X,
     >        '(BTU/HR)'/2H0 )
400     FORMAT(' ',5A4,F8.2,2X,4(F8.5,2X),F8.2,F10.2)
410     FORMAT(3X/74X,'SUM =',F10.2)
420     FORMAT('0',5A4,F8.2,2X,4(F8.5,2X))
430     FORMAT('0  UA(FLOOR)   ',F10.2)
        END
        SUBROUTINE PRTBSC(HEAD)
C
C  PRINTS THE SUMMARY PAGE FOR EACH CITY
C
        COMMON/ENG/ENG(6,2),EU(6,2,12),NSYS,KSYS(6)
        COMMON/PWFDAT/ANZCOS(8),FFCOS(8),FFSAV(8),FICOST(8),
     >          FUELPW(8),TOTPW(8),TOTPWH(8),ANTOT(14)
        REAL*4 INSCOS,HECCOS
        COMMON/COSDAT/FANCOS(8),CNTCOS(8),AHPCOS(8),AUXCOS(8),
     >                HWTCOS(8),DUCCOS(8),INSCOS(8),SYSCOS(8),
     >                HECCOS(2),HINCOS(2),PANCOS(2),COILFT(2)
        COMMON/EDIG/ACESEU(12,2)
        COMMON/ELOAD/HPEUH(12),HPEUC(12)
        COMMON/HPUMP/COPH(76),AUX(12),ENGHP(12),CCOP,HCOP,SCOP
        COMMON/FRACS/ANHEAT,ANCOOL,ANWATR,ANLATN,RATIO
        LOGICAL OPT1,OPT2
        COMMON/DAT/HWT(4),TICE(12),AREA(9),RAB,WAB,RR,WR,HO,SF,GLASS,
     >        PANES,SUP,PSIDES,PDELT,TILT,TSW,TSS,GAL(12),COPCHT,
     >        COPCBR,COPCHW,COPHT,COPIN,COPCW,COPBR,COPHW,EC,EF,EHB,
     >        ECB,EOF,EHW,OPT1,OPT2,COP47,COP17,IPRT
        COMMON/BINS/CITY(10),ZONE,DD(2),ALAT,NINV(12),T(12,40),
     >        H(12,40,2),HBR(12),VAV(12),TAV(12),WB(12,40),
     >        ALONG,ELEV,ELECOS,GASCOS,OILCOS
        COMMON/DIG/TVOL(5),PAREA(5),SYSKW(5),BTEMP(12,5),BLEAK(12,5),
     >        PCOL(12,5),BICE(12,5),IRUN,TBLEAK(12),SILEAK(12),
     >        NOICEM(5),NOICEW(5),NTIME
        COMMON/HOUS/LABEL(50,5),XNS,ARCHG,VOL,VAR(50,5),U(50),DT(50),
     >        HL(50),SH,UA,UFLOOR,DCOOL,DHEAT,BCAP,PAN(12,15)
        COMMON/QLOAD/SOL(12,10),SHG(12),QH(12),QC(12),QW(12),
     >        TITLE(18),SOP(12),HON(12),XWFIL(12),SO(12),TH(12),
     >        TG(12,7),DTH(7),HRSPAN(12),HFLOOR(12),CFLOOR(12)
        COMMON/RICE/ISYS,RATEDC,RATEFL,RATEKW,KWFLAG,YRS,CSTCOL,CSTINS,
     >        CSTCOI,THKSD,THKBTM,THKTP,RATETH,RATEGA,RTMELE,RTMGAS,
     >        RTMOIL
        COMMON/FILE8/POINT(120,9),SAVREC(89),NREC,CASENO
        DIMENSION ANNUAL(3,5),TOTAL(7),PCOEF(12),HEAD(18),QHMM(12),
     >          QWMM(12),QCMM(12),TYPE(6)
        DATA TYPE/'BRIN','E CH','ILL ','ICE ','MAKE','R   '/
C
        DO 10 L=1,3
        DO 10 J=1,IRUN
        ANNUAL(L,J)=0.0
10      CONTINUE
        IF(KWFLAG.EQ.0) RATEKW=ELECOS
        ALAT=ALAT*180./3.1415927
        WRITE(6,300) (CITY(I),I=1,9),ALAT,ELEV,RATEKW,TITLE
300     FORMAT('1',9A4,1X,'LATITUDE  =',F8.2,2X,
     >        'ELEVATION=',F8.0,2X,'ELEC.COST=',F7.4/1X,18A4)
C
C  PRINT TEMPERATURE SETTINGS AND DESIGN DAY INFORMATION
C
        PANNHR=DHEAT/150.
        WRITE(6,310) TSW,DD(1),DHEAT,BCAP,RATIO,COPHT,COPIN,TSS,DD(2),
     >                DCOOL,PANNHR,COPHW,COPCW,COPBR
310     FORMAT(' TSETW(F)=',F8.0,2X,'TDDW(F)=',F8.0,2X,'DDHL(BTUH)=',
     >        F8.0,2X,'BCAP(CPM)=',F8.0,2X,'COOL(T/S)=',F7.4,2X,
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     >          'COPHT=',F7.2,2X,'COPIH=',F7.2/
     >          ' TSETS(F)=',F8.0,2X,'TDDS(F)=',F8.0,2X,'DDCL(BTUH)=',
     >          F8.0,2X,'PAN (MHR)=',F8.0,2X,
     >          'COPHW=',4X,F7.2,2X,'COPCW=',F7.2,2X,
     >          'COPBR=',F7.2)
        WRITE(6,320) MON
320     FORMAT('0CLIMATIC PARAMETERS:',T31,12(2X,A4,2X),1X,'ANNUAL'/)
C
C  WRITE CLIMATIC PARAMETERS AND BUILDING LOADS
C
        DO 20 K=1,7
        TOTAL(K)=0.0
20      CONTINUE
        DO 30 M=1,12
        TOTAL(1)=TOTAL(1)+VAV(M)
        TOTAL(2)=TOTAL(2)+TAV(M)
30      CONTINUE
        TOTAL(1)=TOTAL(1)/12.0
        TOTAL(2)=TOTAL(2)/12.0
        DO 40 JK=1,12
        IT=32.-30.5
        PCOEF(JK)=PAN(JK,IT)/1000.
40      CONTINUE
        WRITE(6,330) VAV,TOTAL(1),TAV,TOTAL(2),
     >               (DTH(I),(TG(M,I),M=1,12),I=1,4),TBLEAK,SILEAK,
     >               XNFIL,PCOEF
330     FORMAT('0AVERAGE WIND SPEED      (MPH)',13F8.2,/,
     >          ' AVERAGE OUTDOOR AIR TEMP (F)',13F8.2,/,
     >          ' TEMP AT BIN TOP  (',F4.0,')  (F)',12F8.2,/,
     >          ' TEMP AT BIN BOT  (',F4.0,')  (F)',12F8.2,/,
     >          ' TEMP AT BIN SIDE (',F4.0,')  (F)',12F8.2,/,
     >          ' WATER INLET TEMP (',F4.0,')  (F)',12F8.2,/,
     >          ' BIN TOP-BOT LK32F(MBTU/SQFT)',12F8.3,/,
     >          ' BIN SIDE LEAK 32F(MBTU/SQFT)',12F8.3,/,
     >          ' INFILTRATION COEFF. (BTUH/F)',12F8.2/,
     >          ' PANEL HEAT COEF 32F(MBTU/SQ)',12F8.2)
C
C  WRITE PANEL HEAT PICKUP COEFFICENT TO UNIT 10
C
        IF(ISYS.EQ.1) WRITE(10,340) HEAD
340     FORMAT(18A4)
        IF(ISYS.EQ.1) WRITE(10,350) PCOEF
350     FORMAT(12F6.2)
        DO 50 M=1,12
        TOTAL(5)=TOTAL(5)+QH(M)
        TOTAL(6)=TOTAL(6)+QW(M)
        TOTAL(7)=TOTAL(7)+QC(M)
        QHMM(M)=QH(M)/1.0E6
        QWMM(M)=QW(M)/1.0E6
        QCMM(M)=QC(M)/1.0E6
50      CONTINUE
        DO 60 JK=5,7
        TOTAL(JK)=TOTAL(JK)/1.0E6
60      CONTINUE
        WRITE(6,360) QHMM,TOTAL(5),QWMM,
     >  TOTAL(6),QCMM,TOTAL(7)
360     FORMAT('0BUILDING LOADS:'/,
     >          '0SPACE HEAT            (MMBTU)',13F8.2/,
     >          ' WATER HEAT            (MMBTU)',13F8.2/,
     >          ' SPACE COOL            (MMBTU)',13F8.2)
C
C  ECONOMIC CALCULATIONS
C
C  PRESENT WORTH FACTORS
C
        DC=1+RATEDC
```

```
      FL=1.+RATEFL
      PWF=FL/(RATEDC-RATEFL)*(1.-(FL/DC)**YRS)
      IF(RATEDC.EQ.RATEFL) PWF=YRS
      PWF=18.59
      PWFG=31.67
      PWFO=25.25
      PWFME=16.48
      PWFMG=16.48
      PWFMO=16.48
      DO 62 M=4,8
      ANTOT(M)=0.0
62    CONTINUE
      DO 65 M=1,12
      ANTOT(4)=ANTOT(4)+EU(1,1,M)/3412.
      ANTOT(5)=ANTOT(5)+EU(2,1,M)/3412.
      ANTOT(6)=ANTOT(6)+EU(3,1,M)/3412.
      ANTOT(8)=ANTOT(8)+ACESEU(M,1)/3412.
      ANTOT(7)=ANTOT(7)+ACESEU(M,2)/3412.
65    CONTINUE
      CALL COST
      CALL ACECOS
      CALL PWFCOS(PWF,PWFG,PWFO,PWFME,PWFMG,PWFMO)
      TENGHP=0.0
      TOTAUX=0.0
      DO 70 M=1,12
      AUX(M)=AUX(M)/3412.
      ENGHP(M)=ENGHP(M)/3412.
      TOTAUX=TOTAUX+AUX(M)
      TENGHP=ENGHP(M)+TENGHP
70    CONTINUE
C
C  PRINT AIR TO AIR HEAT PUMP COST AND PERFORMANCE
C
      WRITE(6,370) ENGHP,TENGHP,AUX,TOTAUX,SYSCOS(2),CCOP,FUELPW(2),
     >             HCOP,ANZCOS(2),SCOP,TOTPW(2)
370   FORMAT('0HEAT PUMP COST AND PERFORMANCE:',/,
     >       '0HEAT PUMP ENERGY USE    (KWH)',12F8.2,F8.0,/,
     >       ' STRIP HEAT              (KWH)',12F8.2,F8.0,/,
     >       ' SYSTEM COSTS          ',F8.2,5X,'COOLING COP ',F8.2,/,
     >       ' FUEL PRESENT WORTH    ',F8.2,5X,'HEATING COP ',F8.2,/,
     >       ' MAINT. PRESENT WORTH ',F8.2,5X,'ANNUAL  COP ',F8.2/
     >      ' ',T92,'PRESENT WORTH = ',F8.2)
      IS=ISYS*ISYS
      IE=IS+2
      WRITE(6,380) (TYPE(I),I=IS,IE)
380   FORMAT('0ACES DESIGN, COST, AND PERFORMANCE:',2X,3A4)
      DO 100 J=1,IRUN
      IF(J.EQ.1) K=2
      IF(J.EQ.2) K=1
      DO 80 M=1,12
      BLEAK(M,J)=BLEAK(M,J)/1.0E3
      PCOL(M,J)=PCOL(M,J)/1.0E3
      ANNUAL(1,J)=ANNUAL(1,J)+BLEAK(M,J)
      ANNUAL(2,J)=ANNUAL(2,J)+PCOL(M,J)
80    CONTINUE
      YCOP=(TOTAL(5)+TOTAL(6)+TOTAL(7))*1.0E6/SYSKW(J)
      COEF=TOTPW(2)/TOTPW(3+K)
      SYSKW(J)=SYSKW(J)/3412.
      AUXHWT=AUXCOS(3+K)+HWTCOS(3+K)
C
C  CALCULATE PANEL HEAT PICKUP COEFF
C
      DO 90 M=1,12
      MT=BTEMP(M,J)-30.5
      PCOEF(M)=PAN(M,MT)/1000.
90    CONTINUE
```

```
C
C  PRINT ACES DESIGN PARAMETERS
C
      WRITE(6,390)  (BLEAK(M,J),M=1,12),ANNUAL(1,J),
     >              (PCOL(M,J),M=1,12),ANNUAL(2,J),
     >              (PCOEF(M),M=1,12),(BTEMP(M,J),M=1,12),
     >              (BICE(M,J),M=1,12),TVOL(J),AUXHWT,INSCOS(3+K),
     >              ANZCOS(3+K),PAREA(J),PANCOS(K),DUCCOS(3+K),
     >              TOTPW(K+3),COILFT(J),MECCOS(K),SYSCOS(3+K),
     >              NOICEM(J),NOICEW(J),NTIME,
     >              SYSKW(J),BINCOS(K),FUELPW(3+K),COEF,YCOP
390   FORMAT('0BIN HEAT LEAKAGE      (MBTU) ',13F8.1,/,
     >       ' PANEL HEAT COLLECTION(MBTU) ',13F8.1,/,
     >       ' PANEL HEAT COEFF.(MBTU/SQFT)',12F8.2/,
     >       ' BIN ICE/WATER TEMPERATURE(F)',12F8.2,/,
     >       ' ICE INVENTORY          (FT**3)',12F8.2,/,
     >       ' BIN VOLUME (FT**3) = ',F8.2,5X,'AUX. COST  = ',F8.2,5X,
     >       'INSTALLATION COST= ',F8.2,5X,'MAINT. P.WORTH= ',F8.2,/,
     >       ' PANEL AREA (FT**2) = ',F8.2,5X,'PANEL COST = ',F8.2,5X,
     >       'DUCTS COST        = ',F8.2,5X,'PRESENT WORTH = ',F8.2,/
     >       ' COIL LENGTH    (FT) = ',F8.2,5X,'MECH COST  = ',F8.2,5X,
     >       'SYSTEM COST       = ',F8.2,
     >       5X,'DATE ICE MELTED',I3,',',I2,'/',I2,/
     >       ' ENERGY USE    (KWH) = ',F8.2,5X,'BIN COST   = ',F8.2,5X,
     >       'FUEL PRESENT WORTH ',F8.2,5X,'ECON COEFF.   = ',F8.2/
     >       ' ANNUAL COP          =',F8.2)
100   CONTINUE
      SAVREC(1)=9999.
      DO 110 K=1,8
      J=K+1
      SAVREC(J)=HEAD(K)
110   CONTINUE
      SAVREC(10)=ALAT
      SAVREC(11)=ALONG
      SAVREC(12)=RATIO
      RETURN
      END
      SUBROUTINE PRTECO(HEAD)
C
C  PRINTS A SUMMARY PAGE FOR EACH CITY
C
      COMMON/PWFDAT/ANZCOS(8),FFCOS(8),FFSAV(8),FICOST(8),
     >       FUELPW(8),TOTPW(8),TOTPWH(8),ANTOT(14)
      REAL*4 INSCOS,MECCOS
      COMMON/COSDAT/PANCOS(8),CNTCOS(8),AHPCOS(8),AUXCOS(8),
     >              HWTCOS(8),DUCCOS(8),INSCOS(8),SYSCOS(8),
     >              MECCOS(2),BINCOS(2),PANCOS(2),COILFT(2)
      COMMON/DIG/TVOL(5),PAREA(5),SYSKW(5),BTEMP(12,5),BLEAK(12,5),
     >      PCOL(12,5),BICE(12,5),IRUN,TBLEAK(12),SILEAK(12),
     >      NOICEM(5),NOICEW(5),NTIME
      LOGICAL OPT1,OPT2
      COMMON/DAT/HWT(4),TICE(12),AREA(9),RAB,WAB,RR,WR,HO,SF,GLASS,
     >      PANES,SUP,PSIDES,PDELT,TILT,TSW,TSS,GAL(12),COPCHT,
     >      COPCBR,COPCHW,COPHT,COPIM,COPCW,COPBR,COPHW,EC,EF,EHB,
     >      ECB,EOF,EHW,OPT1,OPT2,COP47,COP17,IPRT
      COMMON/HOUS/LABEL(50,5),XNS,ARCHG,VOL,VAR(50,5),U(50),DT(50),
     >      HL(50),SM,UA,UFLOOR,DCOOL,DHEAT,BCAP,PAN(12,15)
      COMMON/FRACS/ANHEAT,ANCOOL,ANWATR,ANLATN,RATIO
      COMMON/EDIG/ACESEU(12,2)
      COMMON/ENG/ENG(6,2),EU(6,2,12),NSYS,KSYS(6)
      COMMON/ELOAD/HPEUH(12),HPEUC(12)
      COMMON/BINS/CITY(10),ZONE,DD(2),ALAT,NINV(12),T(12,40),
     >      H(12,40,2),HBR(12),VAV(12),TAV(12),WB(12,40),
     >      ALONG,ELEV,ELECOS,GASCOS,OILCOS
      COMMON/RICE/ISYS,RATEDC,RATEFL,RATEKW,KWFLAG,YRS,CSTCOL,CSTINS,
     >      CSTCOI,THKSD,THKBTM,THKTP,RATETH,RATEGA,RTHELE,RTHGAS,
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```
C   PRESENT WORTH FACTOR
C
        DC=1.+RATEDC
        FL=1.+RATEFL
C       PWF=FL/(RATEDC-RATEFL)*(1.-(FL/DC)**YRS)
C       IF(RATEDC.EQ.RATEFL) PWF=YRS
        PWF = 18.59
        PWFG = 31.67
        PWFO = 25.25
        PWFME=16.48
        PWFMG=16.48
        PWFMO=16.48
C
C   ANNUAL TOTALS AND CONVERT TO METRIC
C
        DO 10 M=1,14
10      ANTOT(M) = 0.0
        DO 30 M=1,12
        QW(M)=QW(M)*1.055/1000.
        QH(M)=QH(M)*1.055/1000.
        QC(M)=QC(M)*1.055/1000.
        DO 20 K=1,6
      IF (KSYS(K).GE.1.AND.KSYS(K).LE.3) EU(K,1,M) = EU(K,1,M)/3412.
        IF (KSYS(K).GE.4.AND.KSYS(K).LE.6)
     >      EU(K,2,M) = EU(K,2,M)/3412.
        IF (KSYS(K).EQ.4.OR.KSYS(K).EQ.6)
     >      EU(K,1,M) = EU(K,1,M)/1E5
        IF (KSYS(K).EQ.5) EU(K,1,M)=EU(K,1,M)/1.4E5
20      CONTINUE
        ACESEU(M,1)=ACESEU(M,1)/3412.
        ACESEU(M,2)=ACESEU(M,2)/3412.
30      CONTINUE
        DO 40 M=1,12
        ANTOT(1)=ANTOT(1)+QW(M)
        ANTOT(2)=ANTOT(2)+QH(M)
        ANTOT(3)=ANTOT(3)+QC(M)
        ANTOT(4)=ANTOT(4) + EU(1,1,M)
        ANTOT(5)=ANTOT(5)+EU(2,1,M)
        ANTOT(6)=ANTOT(6)+EU(3,1,M)
        ANTOT(7)=ANTOT(7)+ACESEU(M,2)
        ANTOT(8)=ANTOT(8)+ACESEU(M,1)
        ANTOT(9)=ANTOT(9)+EU(4,1,M)
        ANTOT(10)=ANTOT(10)+EU(4,2,M)
        ANTOT(11)=ANTOT(11)+EU(5,1,M)
        ANTOT(12)=ANTOT(12)+EU(5,2,M)
        ANTOT(13)=ANTOT(13)+EU(6,1,M)
        ANTOT(14)=ANTOT(14)+EU(6,2,M)
40      CONTINUE
        DHEAT=DHEAT*.29307
        DCOOL=DCOOL*.29307
        DO 50 I=1,2
        BVOL(I)=TVOL(I)*.0283
        PANARE(I)=PAREA(I)*.0929
        IF(PANARE(I).GT.84.) XMAK(I)=STAR
        IF(PANARE(I).LE.84.) XMAK(I)=BLANK
        NOTE=0
        IF(PANARE(I).GT.84) NOTE=1
50      CONTINUE
C
C   CALCULATE ANNUAL COPS
C
        ANCOP(1)=1000.*(ANTOT(1)+ANTOT(2)+ANTOT(3))/(ANTOT(4)*1.055*
     >              3412.)
        ANCOP(2)=1000.*(ANTOT(1)+ANTOT(2)+ANTOT(3))/(ANTOT(5)*1.055*
     >             3412.)
        ANCOP(3)=1000.*(ANTOT(1)+ANTOT(2)+ANTOT(3))/(ANTOT(6)*1.055*
```

```
     >            3412.)
        ANCOP(4)=1000.*(ANTOT(1)+ANTOT(2)+ANTOT(3))/(ANTOT(7)*1.055*
     >            3412.)
        ANCOP(5)=1000.*(ANTOT(1)+ANTOT(2)+ANTOT(3))/(ANTOT(8)*1.055*
     >            3412.)
C
C   FOR FUEL FIRED SYSTEMS
        ANCOP(6)=1000.*(ANTOT(1)+ANTOT(2)+ANTOT(3))/1.055/
     >              (ANTOT(9)*1E5/3.0+ANTOT(10)*3412.)
        ANCOP(7)=1000.*(ANTOT(1)+ANTOT(2)+ANTOT(3))/1.055/
     >             (ANTOT(11)*1.4E5/3.0+ANTOT(12)*3412.)
        ANCOP(8)=1000.*(ANTOT(1)+ANTOT(2)+ANTOT(3))/1.055/
     >              (ANTOT(13)*1E5/3.0+ANTOT(14)*3412.)
C
C   PRINT TABLE
C
        PRINT 1000, (CITY(J),J=1,8),RATEKW,RTMELE,PWF,PWFME,DHEAT,
     >  RATETH,RTMGAS,PWFG,PWFMG,IDD1,IDD2,DCOOL,RATEGA,RTMOIL,
     >  PWFO,PWFMO,RATIO
C
C   DESIGN AND PERFORMANCE
C
C
        PRINT 2010
        KX=3
        DO 80 K=4,6
        DO 80 L=1,5
        KX=KX+1
        FMT1(KX) = FORM1(L,KSYS(K)-3)
        FMT2(KX) = FORM2(L,KSYS(K)-3)
        FMT3(KX) = FORM3(L,KSYS(K)-3)
        FMT4(KX) = FORM4(L,KSYS(K)-3)
80      CONTINUE
        FMT1(18) = FMT
        FMT2(18) = FMT
        FMT3(18) = FMT
        FMT4(18) = FMT
        PRINT FMT1
        PRINT 2014
        PRINT FMT2
        PRINT 2016
        PRINT FMT3
        PRINT 2018
        PRINT FMT4
        PRINT 1030
        DO 90 M=1,12
        PRINT 2020, MON(M),QW(M),QH(M),QC(M),
     >        (EU(I,1,M),I=1,3),ACESEU(M,2),ACESEU(M,1),
     >        ((EU(I,J,M),J=1,2),I=4,6)
        IF (M.EQ.3.OR.M.EQ.6.OR.M.EQ.9.OR.M.EQ.12) PRINT 1030
90      CONTINUE
        PRINT 1040, ANTOT
C
C   CHECK IF FULL ACES IS A VALID DESIGN (BIGGER THAN MIN. ACES)
C
C   IF NOT-SET FULL ACES TO MIN. ACES DESIGN
C
        IF(BVOL(1).GE.BVOL(2)) GO TO 210
        BVOL(1)=BVOL(2)
        PANARE(1)=PANARE(2)
        XMAK(1)=XMAK(2)
        MECCOS(2)=MECCOS(1)
        BINCOS(2)=BINCOS(1)
        PANCOS(2)=PANCOS(1)
        AUXCOS(5)=AUXCOS(4)
        HWTCOS(5)=HWTCOS(4)
```

```
     >          RTMOIL
      COMMON/QLOAD/SOL(12,10),SHG(12),QH(12),QC(12),QW(12),
     >          TITLE(18),SOP(12),MON(12),XNFIL(12),SO(12),TH(12),
     >          TG(12,7),DTH(7),HRSPAN(12),HFLOOR(12),CFLOOR(12)
      COMMON/FILE8/POINT(120,9),SAVREC(89),NREC,CASENO
      DIMENSION HLOSS(12),BVOL(2),PANARE(2),TYPE(2),
     >              ANCOP(8),SKIND(2,2),XMAK(2),HEAD(18)
      DIMENSION FMT1(19),FMT2(19),FMT3(19),FMT4(19),
     >              FORM1(5,3),FORM2(5,3),FORM3(5,3),FORM4(5,3)
      DATA FMT1(1)/4H('+'/,FMT1(2)/4H,T83/,
     >        FMT1(3)/4H,    /,FMT1(19)/4H)    /,
     >        FMT2(1)/4H('+'/,FMT2(2)/4H,T83/,
     >        FMT2(3)/4H,    /,FMT2(19)/4H)    /,
     >        FMT3(1)/4H('+'/,FMT3(2)/4H,T83/,
     >        FMT3(3)/4H,    /,FMT3(19)/4H)    /,
     >        FMT4(1)/4H('+'/,FMT4(2)/4H,T83/,
     >        FMT4(3)/4H,    /,FMT4(19)/4H)    /,
     >        FMT/4H |' /
      DATA FORM1/4H'    ,4H    (,4H6)   ,4H     ,4H|', ,
     >              4H'    ,4H    (,4H7)   ,4H     ,4H|', ,
     >              4H'    ,4H    (,4H8)   ,4H     ,4H|', /
      DATA FORM2/4H'  G,4HAS F,4HURNA,4HCE  ,4H|', ,
     >              4H'  O,4HIL F,4HURNA,4HCE  ,4H|', ,
     >              4H'PUL,4HSE G,4HAS F,4HURN.,4H|', /
      DATA FORM3/4H'  G,4HAS  ,4H| EL,4HEC. ,4H|', ,
     >              4H'  O,4HIL  ,4H| EL,4HEC. ,4H|', ,
     >              4H'  G,4HAS  ,4H| EL,4HEC. ,4H|', /
      DATA FORM4/4H'THE,4HRMS ,4H|  K,4HWH  ,4H|', ,
     >              4H'  G,4HAL  ,4H|  K,4HWH  ,4H|', ,
     >              4H'THE,4HRMS ,4H|  K,4HWH  ,4H|', /
      DIMENSION DESC(10,6)
      DATA DESC/4HEL. ,4HFURN,4HACE ,4HAND ,4HWATE,4HR HE,
     >             4HATER,4H, CE,4HNTRA,4HL AC,
     >             4HHEAT,4H PUM,4HP WI,4HTH E,4HLEC.,4H RES,
     >             4H. WA,4HTER ,4HHEAT,4HER  ,
     >             4HHEAT,4H PUM,4HP, D,4HESUP,4HERHE,4HATER,
     >             4H WAT,4HER H,4HEATE,4HR   ,
     >             4HGAS ,4HFURN,4HACE,,4H GAS,4H HOT,4H WAT,
     >             4HER, ,4HCENT,4HRAL ,4HAC  ,
     >             4HOIL ,4HFURN,4HACE,,4H EL.,4H HOT,4H WAT,
     >             4HER, ,4HCENT,4HRAL ,4HAC  ,
     >             4HPULS,4HE GA,4HS FU,4HPNAC,4HE, G,4HAS H,
     >             4HW, C,4HENTR,4HAL A,4HC   /
      DATA SKIND/'BR.C','ICE ','HILL','MAKE'/
      DATA BLANK/'    '/,STAR/'*   '/
      TYPE(1)=SKIND(ISYS,1)
      TYPE(2)=SKIND(ISYS,2)
C
C  IF KWFLAG=0 USE POWER COST OF PARTICULAR CITY
C
      IF(KWFLAG.EQ.0) RATEKW=ELECOS
      RATEGA=OILCOS
      RATETH=GASCOS/10.0
      RTMELE=0.0850
      RTMGAS=0.8150
      RTMOIL=1.4600
C
C  CALCULATE COST OF SYSTEMS
C
      CALL ACECOS
      CALL COST
C
C  TEMPERATURES CONVERTED TO METRIC
      IDD1=(DD(1)-32.)/1.8+0.5
      IDD2=(DD(2)-32.)/1.8+0.5
C
```

```
      DUCCOS(5)=DUCCOS(4)
      INSCOS(5)=INSCOS(4)
      SYSCOS(5)=SYSCOS(4)
      ANTOT(8)=ANTOT(7)
      GO TO 100
100   CONTINUE
C
C  SYSTEM COST
C
210   PRINT 1050
      DO 215 J=1,3
      PRINT 2060,J,(DESC(I,KSYS(J)),I=1,10)
      PRINT 1070, FANCOS(J),AHPCOS(J),CNTCOS(J),AUXCOS(J),
     >        HWTCOS(J),DUCCOS(J),INSCOS(J),SYSCOS(J),BLANK
215   CONTINUE
      PRINT 1030
      PRINT 1100, BVOL(2),PANARE(2),XMAK(2)
      PRINT 1070, MECCOS(1),BINCOS(1),PANCOS(1),AUXCOS(4),HWTCOS(4),
     >            DUCCOS(4),INSCOS(4),SYSCOS(4),XMAK(2)
      PRINT 1110, BVOL(1),PANARE(1),XMAK(1)
      PRINT 1070, MECCOS(2),BINCOS(2),PANCOS(2),AUXCOS(5),HWTCOS(5),
     >            DUCCOS(5),INSCOS(5),SYSCOS(5),XMAK(1)
      PRINT 1030
      PRINT 2050
      DO 217 J=4,6
      JJ=J+2
      PRINT 2060,JJ,(DESC(I,KSYS(J)),I=1,10)
      PRINT 1070, FANCOS(JJ),AHPCOS(JJ),CNTCOS(JJ),AUXCOS(JJ),
     >        HWTCOS(JJ),DUCCOS(JJ),INSCOS(JJ),SYSCOS(JJ),BLANK
217   CONTINUE
      PRINT 1030
C
C  COMPARATIVE OWNING COST
C
218   CALL PWFCOS(PWF,PWFG,PWFO,PWFME,PWFMG,PWFMO)
      PRINT 1120
      DO 225 J=1,3
      PRINT 2060,J,(DESC(I,KSYS(J)),I=1,10)
      IF (J.EQ.1)
     >  PRINT 1170, ANCOP(1),ANZCOS(1),FFCOS(1),FUELPW(1),TOTPW(1),
     >            TOTPWM(1)
      IF (J.NE.1)
     >  PRINT 1140, ANCOP(J),ANZCOS(J),FFCOS(J),FFSAV(J),
     >            FICOST(J),FUELPW(J),TOTPW(J),BLANK,TOTPWM(J)
225   CONTINUE
      PRINT 1150, BVOL(2),PANARE(2)
      PRINT 1140, ANCOP(4),ANZCOS(4),FFCOS(4),FFSAV(4),FICOST(4),
     >            FUELPW(4),TOTPW(4),XMAK(2),TOTPWM(4)
      PRINT 1160, BVOL(1),PANARE(1)
      PRINT 1140, ANCOP(5),ANZCOS(5),FFCOS(5),FFSAV(5),FICOST(5),
     >            FUELPW(5),TOTPW(5),XMAK(2),TOTPWM(5)
      DO 228 J=4,6
      JJ=J+2
      PRINT 2060, JJ,(DESC(I,KSYS(J)),I=1,10)
      PRINT 1140, ANCOP(JJ),ANZCOS(JJ),FFCOS(JJ),FFSAV(JJ),
     >            FICOST(JJ),FUELPW(JJ),TOTPW(JJ),BLANK,TOTPWM(JJ)
228   CONTINUE
      PRINT 1030
      IF(NOTE.EQ.1) PRINT 1180
C
C  SAVE DATA TO WRITE ON UNIT 8 FOR LATER MAP WORK.
C
      SAVREC(1)=9999.
      DO 220 K=1,8
      J=K+1
      SAVREC(J)=HEAD(K)
```

```
220     CONTINUE
        ALAT=ALAT*180./3.145927
        SAVREC(10)=ALAT
        SAVREC(11)=ALONG
        SAVREC(12)=RATIO
        SAVREC(13)=RATEKW
        SAVREC(14) = RATETH
        SAVREC(15) = RATEGA
        SAVREC(16)=FLOAT(ISYS)
        SAVREC(17)=BVOL(2)
        SAVREC(18)=BVOL(1)
        SAVREC(19)=1111.
        SAVREC(20)=PANARE(2)
        SAVREC(21)=PANARE(1)
        SAVREC(22)=1111.
        IF(XMAK(2).EQ.STAR) SAVREC(19)=9999.
        IF(XMAK(1).EQ.STAR) SAVREC(22)=9999.
        DO 230 K=1,8
        SAVREC(22+K)=ANCOP(K)
        SAVREC(30+K)=SYSCOS(K)
        SAVREC(38+K)=TOTPW(K)
        SAVREC(48+K)=FICOST(K)
        SAVREC(54+K)=FFCOS(K)
        SAVREC(62+K)=FFSAV(K)
        SAVREC(70+K)=TOTPW(K)
230     CONTINUE
        DO 235 K=1,11
        SAVREC(78+K)=ANTOT(3+K)
235     CONTINUE
        RETURN
C
C  FORMAT STATEMENTS
C
1000    FORMAT(1H1//'0',T49,8A4,/
     >       '0     167 SQ M HOME, WELL INSULATED',T46,
     >       'EL. ($/KWHR) =',F7.4,',',F7.4,4X,
     >       'PWF =',F6.2,',',F6.2,T101,
     >       'DESIGN WEATHER: WINTER  SUMMER',/,5X,
     >       'DESIGN HEATING LOAD (WATTS) =',F7.0,T46,
     >       'GAS ($/THERM)=',F7.4,',',F7.4,4X,
     >       'PWF =',F6.2,',',F6.2,T101,
     >       'OUTDOOR TEMP. =',I5,' C',I6,' C',/,5X,
     >       'DESIGN COOLING LOAD (WATTS) =',F7.0,T46,
     >       'OIL ($/GAL.) =',F7.4,',',F7.4,4X,
     >       'PWF =',F6.2,',',F6.2,T101,
     >       'TOTAL/SENSIBLE COOLING =',F6.2)
1030    FORMAT('+',3X,127('_'))
1040    FORMAT('     | ANNUAL|',3(F8.0,'|'),3(F7.0,'|'),
     >       2(F8.0,'|'),5(F7.0,'|'),F7.0,' |',/'+',3X,127('_'))
1050    FORMAT('0',T50,'SYSTEMS FIRST COSTS'/'+',3X,127('_')/
     >       '     |     |',T51
     >       ,'|',T76,'COMPONENTS COSTS, $',T121,'|',
     >       ' TOTAL    ',T131,'|'/'+',T51,71('_')/
     >       4X,'| NO.|  CONVENTIONAL ELECTRIC SYSTEMS',
     >       T51,'|FAN UNIT |',
     >        'A/C, H.P.| CONTROL |AUXILIARY|W. HEATER|  DUCTS  |',
     >        ' INSTALN.| COST, $ |'/'+',3X,127('_'))
1070    FORMAT('+',T51,'|',7(F8.0,' |'),F8.0,A1,'|')
1100    FORMAT('     |     |  ANNUAL CYCLE ENERGY SYSTEMS (ACES)',
     >       T51,'| MECH. P.| ICE BIN |',
     >      '  PANEL  |AUXILIARY|W. HEATER|  DUCTS  | INSTALN.|',
     >       ' TOTAL, $|'/'+',3X,127('_')/
     >      '     |  4 |MIN. ACES, BIN=',F5.1,' M3 PANEL=',F5.1,' M2',A1)
1110    FORMAT('     |  5 |FULL ACES, BIN=',F5.1,' M3 PANEL=',F5.1,
     >        ' M2',A1)
1120    FORMAT(/'0',T50,'SYSTEM COMPARISONS'/'+',3X,127('_')/
```

```
     >          4X,'|     |',T51,'| SYSTEM  |  MAINT. |1ST YEAR |1ST ',
     >         'YEAR | INCREM. | ENERGY  |',T131,'|'/
     >         4X,'|     |   NEW CONSTRUCTION ALTERNATIVES',T51,
     >        '| EFFIC.  | PRESENT | ENERGY  | ENERGY  |  FIRST  |',
     >         ' PRESENT |  LIFE CYCLE COST  |'/
     >         '+',T111,21('_'),/,
     >         4X,'|     |',T51,'| (ACOP)  |  WORTH  |  COST   | SAV',
     >         'ING  |  COST   | WORTH   | AVERAGE |MARGINAL |'/
     >         '     | NO.|',T51,'|',T61,4('|     $     '),
     >         T101,'|',2(4X,'$',4X,'|'),4X,'$',T131,
     >         '|',/'+',3X,127('_'))
1140    FORMAT('+',T51,'|',F8.2,' |',F8.0,' |',2(F8.2,' |'),
     >         F8.0,' |',F8.0,' |',F8.0,A1,'|',F8.0,' |')
1150    FORMAT('     |  4 |MIN. ACES, BIN=',F5.1,' M3 PANEL=',F5.1,
     >              ' M2',T51,'|')
1160    FORMAT('     |  5 |FULL ACES, BIN=',F5.1,' M3 PANEL=',F5.1,
     >              ' M2',T51,'|')
1170    FORMAT('+',T51,'|',F8.2,' |',F8.0,' |',F8.2,' |',
     >         2('  REF.    |'),2(F8.0,' |'),F8.0,' |')
1180    FORMAT('0*UNGLAZED PANEL EXCEEDS A PRACTICAL SIZE, AN',
     >          ' ALTERNATIVE SUPPLEMENTARY HEAT SOURCE SHOULD BE USED',
     >          ' IN THIS DESIGN.')
2010    FORMAT(/'0',T50,'DESIGN AND PERFORMANCE'/'+',4X,126('_')/
     >         '     |',7X,'|',6X,'BUILDING LOADS',6X,
     >         '|',T73,'  SYSTEM ENERGY CONSUMPTION',T131,'|'/
     >         '+',T13,119('_')/
     >        4X,'|',7X,'|  WATER |  SPACE |  SPACE |  (1)  |  (2)  ',
     >         '|  (3)  |  (4)   |  (5)   |')
2014  FORMAT(4X,'| MONTH |  HEAT  |  HEAT  |  COOL  | ELEC. |  HEAT',
     >          ' |  HP   |  MIN.  |  FULL  |')
2016  FORMAT('+',T82,50('_'),/,
     >       4X,'|',7X,'|',T22,'|',T31,'|',T40,'|  RES. |  PUMP |',
     >          '  DS   |  ACES  |  ACES  |')
2018  FORMAT(4X,'|',7X,'|   MJ   |   MJ   |   MJ   |  KWH  |',
     >          '  KWH  |  KWH   |  KWH   |  KWH   |')
2020    FORMAT(4X,'|',2X,A4,' |',3(F8.0,'|'),3(F7.0,'|'),2(F8.0,'|'),
     >         5(F7.0,'|'),F7.0,' |')
2040    FORMAT('     | ANNUAL|',2(F7.2,' |'),F8.2,' |',A4,4X,' |',
     >          3(F8.0,' |'),5(F7.0,'|'),F7.0,'  |',/'+',3X,127('_')/
     >         '     | ANNUAL COP',T81,'|',2(2X,F7.2,6X,'|'),
     >         2X,F7.2,6X,'  |',
     >         /'+',3X,127('_'))
2050    FORMAT(4X,'|     |  FOSSIL FUEL FIRED  SYSTEMS',T51,
     >            '| FURNACE |',
     >          '   A/C   | CONTROL |AUXILIARY|W. HEATER|  DUCTS  |',
     >         ' INSTALN.| TOTAL, $|'/'+',3X,127('_'))
2060    FORMAT ('     |  ',I1,' |',10A4)
        END
        SUBROUTINE PSY1 (DB,WB,PB,W,V)
C
C     ****************************************************************
C
C  THIS SUBROUTINE WAS TAKEN FROM NBSLD BY T. KUSUDA.
C  IT GENERATES DEWPOINT TEMPERATURE,VAPOR PRESSURE, HUMIDITY RATIO,
C  ENTHALPHY, SPECIFIC VOLUME, AND RELATIVE HUMIDITY.
C
        PVP=PVSF(WB)
        IF (DB.LE.WB) GO TO 30
        WSTAR=0.622*PVP/(PB-PVP)
        IF (WB.GT.32.0) GO TO 40
        PV=PVP-5.704E-4*PB*(DB-WB)/1.8
        GO TO 50
C
30      PV=PVP
        GO TO 50
C
```

```
40      CDB=(DB-32.)/1.8
        CWB=(WB-32.)/1.8
        HL=597.31+0.4409*CDB-CWB
        CH=0.2402+0.4409*WSTAR
        EX=(WSTAR-CH*(CDB-CWB)/HL)/0.622
        PV=PB*EX/(1.+EX)
50      W=0.622*PV/(PB-PV)
        V=0.754*(DB+459.7)*(1+7000*W/4360)/PB
        H=0.24*DB+(1061+0.444*DB)*W
        IF (PV.LE.0) RETURN
        IF (DB.NE.WB) GO TO 60
        DP=DB
        RH=1.
        RETURN
C
60      CONTINUE
C      DP=DPF(PV)
        RH=PV/PVSF(DB)
        RETURN
C
        END
        SUBROUTINE PWFCOS(PWF,PWFG,PWFO,PWFME,PWFNG,PWFMO)
C
C  THIS SUBROUTINE CALCULATES PRESENT WORTH AND LIFE CYCLE RANKING
C  OF THE SYSTEMS
C
        COMMON/ENG/ENG(6,2),EU(6,2,12),NSYS,KSYS(6)
        REAL*4 INSCOS,MECCOS
        COMMON/COSDAT/FANCOS(8),CNTCOS(8),AHPCOS(8),AUXCOS(8),
     >                HWTCOS(8),DUCCOS(8),INSCOS(8),SYSCOS(8),
     >                MECCOS(2),MINCOS(2),PANCOS(2),COILFT(2)
        COMMON/PWFDAT/ANZCOS(8),FFCOS(8),FFSAV(8),FICOST(8),
     >       FUELPW(8),TOTPW(8),TOTPWM(8),ANTOT(14)
        COMMON/RICE/ISYS,RATEDC,RATEFL,RATEKW,KWFLAG,YRS,CSTCOL,CSTINS,
     >       CSTCOI,THKSD,THKBTM,THKTP,RATETH,RATEGA,RTHELE,RTHGAS,
     >       RTHOIL
        DIMENSION DUM(8),FFCOS2(3),ANCOST(8),FFCOSM(8),FFCSM2(3)
        DATA ANCOST/914.,2162.,2468.,0.0,0.0,
     >              889.,914.,960./
C
C  ANNUALIZED MAINTENANCE COSTS
C
C  USING ALL ELECTRIC SYSTEM AS REFERENCE SYSTEM
C
        FFCREF = ANTOT(4) * RATEKW
        SYSREF = SYSCOS(1)
        DO 5 K=1,NSYS
        IF (KSYS(K).EQ.1) GO TO 8
5       CONTINUE
        SYSREF = SYSCOS(NSYS+1)
        GO TO 9
8       SYSREF = SYSCOS(K)
9       CONTINUE
C
        DO 10 K=1,6
        KK = K
        IF (K.GT.3) KK=K+2
10      ANZCOS(KK) = ANCOST(KK)
C
C  FOR ACES SYSTEMS
        ANZCOS(4)=2432.00
        ANZCOS(5)=2432.00
C
C  1ST YEAR FUEL COST (AVERAGE & MARGINAL)
C
        DO 20 K=1,5
```

```
      FFCOS(K)=ANTOT(3+K)*RATEKW
      FFCOSM(K)=ANTOT(3+K)*RTMELE
20    CONTINUE
C
C     FOR FUEL FIRED SYSTEMS - 3 PER STUDY
C
C  COST FOR FOSSIL FUEL
C    GAS
      FFCOS(6)  = ANTOT(10)*RATEKW
      FFCOSM(6)  = ANTOT(10)*RTMELE
      FFCOS2(1)  = ANTOT(9)*RATETH
      FFCSM2(1)  = ANTOT(9)*RTMGAS
C    OIL
      FFCOS(7)  = ANTOT(12)*RATEKW
      FFCOSM(7)  = ANTOT(12)*RTMELE
      FFCOS2(2)  = ANTOT(11)*RATEGA
      FFCSM2(2)  = ANTOT(11)*RTMOIL
C    GAS FURNACE
      FFCOS(8)  = ANTOT(14)*RATEKW
      FFCOSM(8)  = ANTOT(14)*RTMELE
      FFCOS2(3)  = ANTOT(13)*RATETH
      FFCSM2(3)  = ANTOT(13)*RTMGAS
25    KEND = 8
C
C  FUEL PRESENT WORTH (AVERAGE AND MARGINAL)
C
      DO 70 K=1,KEND
      FUELPW(K)=FFCOS(K)*PWF
      TOTPWM(K)  = FFCOSM(K)*PWFME
70    CONTINUE
      FUELPW(6)  = FUELPW(6)  + FFCOS2(1)*PWFG
      TOTPWM(6)  = TOTPWM(6)  + FFCSM2(1)*PWFMG
      FFCOS(6)  = FFCOS(6)  + FFCOS2(1)
      FUELPW(7)  = FUELPW(7)  + FFCOS2(2)*PWFO
      TOTPWM(7)  = TOTPWM(7)  + FFCSM2(2)*PWFMO
      FFCOS(7)  = FFCOS(7)  + FFCOS2(2)
      FUELPW(8)  = FUELPW(8)  + FFCOS2(3)*PWFG
      TOTPWM(8)  = TOTPWM(8)  + FFCSM2(3)*PWFMG
      FFCOS(8)  = FFCOS(8)  + FFCOS2(3)
C
C  1ST YEAR FUEL SAVINGS
C
      DO 30 K=1,KEND
      FFSAV(K)=FFCREF-FFCOS(K)
30    CONTINUE
C
C  INCREMENTAL FIRST COSTS
C
      DO 40 K=1,KEND
      FICOST(K)  = SYSCOS(K)-SYSCOS(1)
40    CONTINUE
C
C
C  TOTAL PRESENT WORTH
C
      DO 80 K=1,KEND
      TOTPW(K)=FUELPW(K)+SYSCOS(K)+ANZCOS(K)
80    CONTINUE
C
C  MARGINAL LIFE CYCLE COST
C
      DO 90 K=1,KEND
      TOTPWM(K)  = TOTPWM(K)  + SYSCOS(K)  + ANZCOS(K)
90    CONTINUE
      RETURN
      END
```

```
      FUNCTION ET(TH,X)
C
C  TH IS THE SUM OF DAYS SINCE JANUARY AND X IS THE DEPTH IN FEET.
C  THIS FUNCTION IS USED IN COMBINATION WITH SUBROUTINE EARTH.
C
      COMMON/EQU/DT
      COMMON/LEAST/A,B,P
      PI=3.141593
      E1=EXP(-1*DT*X)
      ARG=2.*PI*(TH/8766.)-DT*X-P
      ET=A-ABS(B)*E1*COS(ARG)
      RETURN
      END
      FUNCTION PVSF (X)
C
C     ******************************************************************
C
C  THIS FUNCTION WAS TAKEN FROM NBSLD BY T.KUSUDA
C
C  IT GIVES THE PARTIAL PRESSURE OF WATER VAPOR IN MOISTURE
C   SATURATED AIR, IN HG.
C
      DIMENSION A(6),B(4),P(4)
      DATA A/-7.90298,5.02808,-1.3816E-7,11.344,8.1328E-3,-3.49149/
      DATA B/-9.09718,-3.56654,0.876793,0.0060273/
      T=(X+459.688)/1.8
      IF (T.LT.273.16) GO TO 10
      Z=373.16/T
      P(1)=A(1)*(Z-1.0)
      P(2)=A(2)*ALOG10(Z)
      Z1=A(4)*(1.0-1.0/Z)
      P(3)=A(3)*(10.0**Z1-1.0)
      Z1=A(6)*(Z-1.0)
      P(4)=A(5)*(10.0**Z1-1.0)
      GO TO 20
C
10    Z=273.16/T
      P(1)=B(1)*(Z-1.0)
      P(2)=B(2)*ALOG10(Z)
      P(3)=B(3)*(1.0-1.0/Z)
      P(4)=ALOG10(B(4))
20    SUM=0
      DO 30 I=1,4
30    SUM=SUM+P(I)
      PVSF=29.921*10.0**SUM
      RETURN
C
      END
      SUBROUTINE GLAZE(IGLASS,T,A,TD,AO,AI)
C
C  THIS SUBROUTINE IS CALLED BY TRNSMT
C
      DIMENSION T(6),A(6),TD(6),AO(6),AI(6),A1(48),T2(48),AO3(48),
     >          AI4(48),T5(48)
      DATA A1/0.01154,0.77674,-3.94657,8.57881,-8.38135,3.01188,0.01636,
     11.40783,-6.79030,14.37378,-13.83357,4.92439,0.01837,1.92497,
     2-8.89134,18.40197,-17.48648,6.17544,0.01902,2.35417,-10.47151,
     321.24322,-19.95978,6.99964,0.01712,3.50839,-13.86390,26.34330,
     4-23.84846,8.17372,0.01406,4.15958,-15.06279,27.18492,-23.88518,
     58.03650,0.01153,4.55946,-15.43294,26.70568,-22.87993,7.57795,
     60.00962,4.81911,-15.47137,25.86516,-21.69106,7.08714/
      DATA T2/-0.00885,2.71235,-0.62062,-7.07329,9.75995,-3.89922,
     1-0.01114,2.39371,0.42978,-8.98262,11.51798,-4.52064,-0.01200,
     22.13036,1.13833,-10.07925,12.44161,-4.83285,-0.01218,1.90950,
     31.61391,-10.64872,12.83698,-4.95199,-0.01056,1.29711,2.28615,
     4-10.37132,11.95884,-4.54880,-0.00835,0.92766,2.15721,-8.71429,
```

```
      59.87152,-3.73328,-0.00646,0.68256,1.82449,-6.95325,7.80647,
      6-2.94454,-0.00496,0.51403,1.47607,-5.41985,6.05546,-2.28162/
         DATA AO3/0.01407,1.06226,-5.59131,12.15034,-11.78092,4.20070,
      10.01819,1.86277,-9.24831,19.49443,-18.56094,6.53940,0.01905,
      22.47900,-11.74226,24.14037,-22.64299,7.89954,0.01862,2.96400,
      3-13.48701,27.13020,-25.11877,8.68895,0.01423,4.14384,-16.66709,
      431.30484,-27.81955,9.36959,0.01056,4.71447,-17.33454,30.91781,
      5-26.63898,8.79495,0.00819,5.01768,-17.21228,29.46388,-24.76915,
      68.05040,0.00670,5.18781,-16.84820,27.90292,-22.99619,7.38140/
         DATA AI4/0.00228,0.34559,-1.19908,2.22366,-2.05287,0.72376,
      10.00123,0.29788,-0.92256,1.58171,-1.40040,0.48316,0.00067,
      20.26017,-0.72713,1.14950,-0.97138,0.32705,0.00035,0.22974,
      3-0.58381,0.84626,-0.67666,0.22102,-0.00009,0.15049,-0.27590,
      40.25618,-0.12919,0.02859,-0.00016,0.10579,-0.15035,0.06487,
      50.02759,-0.02317,-0.00015,0.07717,-0.09059,0.00050,0.06711,
      6-0.03394,-0.00012,0.05746,-0.05878,-0.01855,0.06837,-0.03191/
         DATA T5/-0.00401,0.74050,7.20350,-20.11763,19.68824,-6.74585,
      1-0.00438,0.57818,7.42065,-20.26848,19.79706,-6.79619,-0.00428,
      20.45797,7.41367,-19.92004,19.40969,-6.66603,-0.00401,0.36698,
      37.27324,-19.29364,18.75408,-6.43968,-0.00279,0.16468,6.17715,
      4-15.84811,15.28302,-5.23666,-0.00192,0.08180,4.94753,-12.43481,
      511.92495,-4.07787,-0.00136,0.04419,3.87529,-9.59069,9.16022,
      6-3.12776,-0.00098,0.02576,3.00400,-7.33834,6.98747,-2.38328/
         L=IGLASS*6
         K=L-5
         DO 100 M=1,6
         N=M-1
         A(M)=A1(K+N)
         T(M)=T2(K+N)
         AO(M)=AO3(K+N)
         AI(M)=AI4(K+N)
         TD(M)=T5(K+N)
100      CONTINUE
         RETURN
         END
         SUBROUTINE SUNLJ
C
C     LIU-JORDAN SUN DATA TABLE GENERATOR
C
C  HOO     = DAILY TOTAL EXTRATERRESTRIAL RADIATION ON A HORIZONTAL
C            SURFACE FOR A GIVEN LATITUDE AND DECLINATION ANGLE
C  ALAT    = LATITUDE
C  DEC     = SOLAR DECLINATION ANGLE, RADIANS
C  HALF    = SUNRISE HOUR ANGLE, RADIANS
C  RDV     = RATIO OF AVERAGE INTENSITY OF DIFFUSE RADIATION TO
C            DAILY DIFFUSE RADIATION
C  RTV     = RATIO OF AVERAGE INTENSITY OF TOTAL RADIATION TO
C            DAILY TOTAL RADIATION
C  TLTCOS  = COS OF INCIDENT ANGLE OF TILTED SOLAR PANEL
C  THCOS   = COS OF INCIDENT ANGLE ON HORIZONTAL SURFACE
C  SCOSV   = COS OF INCIDENT ANGLE ON SOUTH WALL
C  SWCOSV  = COS OF INCIDENT ANGLE ON EAST OR WEST WALL
C
         DIMENSION ANG(12),RTV(7),RDV(7),GHOUR(18),GRT(7,18),RO(12)
C
         LOGICAL OPT1,OPT2
         COMMON/DAT/HWT(4),TICE(12),AREA(9),RAB,WAB,RR,WR,HO,SF,GLASS,
     >         PANES,SUP,PSIDES,PDELT,TILT,TSW,TSS,GAL(12),COPCHT,
     >         COPCBR,COPCHW,COPHT,COPIH,COPCW,COPBR,COPHW,EC,EF,EHB,
     >         ECB,EOF,EHW,OPT1,OPT2,COP47,COP17,IPRT
         COMMON/BINS/CITY(10),ZONE,DD(2),ALAT,NINV(12),T(12,40),
     >         H(12,40,2),HBR(12),VAV(12),TAV(12),WB(12,40),
     >         ALONG,ELEV,ELECOS,GASCOS,OILCOS
         COMMON/QLOAD/SOL(12,10),SHG(12),QH(12),QC(12),QW(12),
     >         TITLE(18),SOP(12),MON(12),XNFIL(12),SO(12),TH(12),
     >         TG(12,7),DTH(7),HRSPAN(12),HFLOOR(12),CFLOOR(12)
```

```
      DATA GHOUR/8.0,8.5,9.0,9.5,10.0,10.5,11.0,11.5,12.0,12.5,13.0,
     >          13.5,14.0,14.5,15.0,15.5,16.0,16.25/
      DATA GRT/
     1   0.197  ,  0.164  ,  0.103  ,  0.034  ,  0.0    ,  0.0    ,0.0
     2,  0.188  ,  0.160  ,  0.105  ,  0.044  ,  0.0    ,  0.0    ,0.0
     3,  0.180  ,  0.155  ,  0.108  ,  0.052  ,  0.0    ,  0.0    ,0.0
     4,  0.171  ,  0.150  ,  0.109  ,  0.059  ,  0.011  ,  0.0    ,0.0
     5,  0.165  ,  0.145  ,  0.110  ,  0.065  ,  0.020  ,  0.0    ,0.0
     6,  0.158  ,  0.140  ,  0.109  ,  0.068  ,  0.026  ,  0.002  ,0.0
     7,  0.152  ,  0.135  ,  0.108  ,  0.072  ,  0.032  ,  0.005  ,0.0
     8,  0.147  ,  0.131  ,  0.106  ,  0.074  ,  0.036  ,  0.007  ,0.0
     9,  0.142  ,  0.128  ,  0.105  ,  0.076  ,  0.040  ,  0.011  ,0.0
     1,  0.137  ,  0.124  ,  0.103  ,  0.077  ,  0.045  ,  0.015  ,0.0
     2,  0.133  ,  0.121  ,  0.101  ,  0.078  ,  0.048  ,  0.019,0.003
     3,  0.128  ,  0.118  ,  0.100  ,  0.078  ,  0.050  ,  0.022,0.005
     4,  0.124  ,  0.114  ,  0.099  ,  0.078  ,  0.052  ,  0.026,0.008
     5,  0.120  ,  0.111  ,  0.097  ,  0.078  ,  0.054  ,  0.029,0.010
     6,  0.117  ,  0.109  ,  0.096  ,  0.078  ,  0.055  ,  0.032,0.013
     7,  0.112  ,  0.105  ,  0.095  ,  0.077  ,  0.057  ,  0.035,0.015
     8,  0.109  ,  0.103  ,  0.093  ,  0.077  ,  0.058  ,  0.038,0.018
     9,  0.107  ,  0.101  ,  0.092  ,  0.077  ,  0.058  ,  0.039,.019/
      DATA RO/1.0315,1.0235,1.0103,0.9913,0.9757,0.9680,0.9680,0.9757,
     >          0.9898,1.0087,1.0238,1.0318/
      DATA ANG/-21.25,-12.92,-2.42,9.5,18.68,23.28,21.65,14.28,3.32,
     >         -8.25,-18.3,-23.23/
C
      PI=3.1415927
      IGLASS=GLASS
      ITYPE=PANES
      TILT=(ALAT+20.0)*PI/180.0
      ALAT=ALAT*PI/180.0
C
C
      DO 1000 M=1,12
      DO 10 K=1,10
      SOL(M,K)=0.0
10    CONTINUE
      HBAR=HBR(M)
      DEC=ANG(M)*PI/180.0
C
      AB=-TAN(ALAT)*TAN(DEC)
      HALF=ARCOS(AB)
      HOO=24.0*442.0*RO(M)/PI
      HOO=(COS(ALAT)*COS(DEC)*SIN(HALF)+HALF*SIN(ALAT)*SIN(DEC))*HOO
      HOUR=24.0*HALF/PI
      IF(HOUR.LT.8.0.OR.HOUR.GE.16.25) PRINT 500
500   FORMAT('1 IN SUBROUTINE SUNLJ, THE HOUR OF SUNRISE',
     >        ' OR SUNSET EXCEEDS THE LIMITS OF PROGRAM BECAUSE'/
     >        '  THE LATITUDE IS GREATER THAN 49.  THE HOUR IS'
     >        ' BEING RESET.')
      IF(HOUR.LT.8.0) HOUR=8.0
      IF(HOUR.GE.16.25) HOUR=16.2
C
      SUM1=0.0
      SUM2=0.0
      DO 20 I=1,18
      I2=I
      I1=I-1
      IF(GHOUR(I).GT.HOUR) GO TO 30
20    CONTINUE
C
30    DO 40 J=1,7
      W=(2*J-1)*PI/24.0
      IF(W.GT.0.95*HALF) GO TO 50
      JAY=J
      X=(GHOUR(I2)-HOUR)/(GHOUR(I2)-GHOUR(I1))
```

```
      RTV(J)=GRT(J,I2)-(GRT(J,I2)-GRT(J,I1))*X
      RDV(J)=(PI/24.)*(COS(W)-COS(HALF))/(SIN(HALF)-HALF*COS(HALF))
      IF (RDV(J) .LT. 0.0)  RDV(J)=0.0
      SUM1=SUM1+RTV(J)
      SUM2=SUM2+RDV(J)
40    CONTINUE
C
50    DO 60 J=1,JAY
      RTV(J)=0.5*RTV(J)/SUM1
      IF(RTV(J).LT.0.0) RTV(J)=0.0
      RDV(J)=0.5*RDV(J)/SUM2
60    CONTINUE
C
      AKBAR=HBAR/HOO
      IF(AKBAR.GT.0.75) DH=0.167
      IF(AKBAR.GT.0.75) GO TO 70
      DH=.41717143-1.2034286*AKBAR
      IF(DH.LT.0.0) DH=0.0
      DH=DH+.78842857-.82857143*AKBAR
      IF(DH.GT.1.0) DH=1.0
C
70    RHO=0.2
      DO 200 J=1,JAY
      W=(2*J-1)*PI/24.0
      THCOS=COS(ALAT)*COS(DEC)*COS(W)+SIN(ALAT)*SIN(DEC)
      BETA=ARSIN(THCOS)
      PHISIN=COS(DEC)*SIN(W)/COS(BETA)
      PHI=ARSIN(PHISIN)
      TEST=COS(W)-TAN(DEC)/TAN(ALAT)
      IF(TEST.LE.0.0) PHI=PI-PHI
      SCOSV=0.0
      IF(PHI.LE.1.57079) SCOSV=COS(BETA)*COS(PHI)
      GAM=ABS(PHI-1.570796)
      EWCOSV=COS(BETA)*COS(GAM)
      TLTCOS=COS(ALAT-TILT)*COS(DEC)*COS(W)+SIN(ALAT-TILT)*SIN(DEC)
      IF(TLTCOS.LT.0.0)  TLTCOS=0.0
C
      TERM=RTV(J)-RDV(J)*DH
      IF(DH.GT.0.98.OR.TERM.LT.0.0) TERM=0.0
C
C  CALCULATE THE HOURLY DIRECT, DIFFUSE, REFLECTIVE, AND TOTAL
C   RADIATION ON SURFACES
C
      EDIR=(EWCOSV/THCOS)*HBAR*TERM
      EDIF=HBAR*RDV(J)*DH/2.0
      EREF=HBAR*RTV(J)*RHO/2.0
      EDRF=EDIF+EREF
      SDIR=(SCOSV/THCOS)*HBAR*TERM
      HDIR=HBAR*TERM
      HDRF=HBAR*(RDV(J)*DH)
      PDIR=(TLTCOS/THCOS)*HBAR*TERM
      PDIF=HBAR*RDV(J)*DH*(1.0+COS(TILT))/2.0
      PREF=HBAR*RTV(J)*RHO*(1.0-COS(TILT))/2.0
      SOL(M,10)=SOL(M,10)+2.0*(PDIR+PDIF+PREF)
      SOL(M,9)=SOL(M,9)+2.0*(HDIR+HDRF)
      SOL(M,5)=SOL(M,5)+2.0*EDRF
      SOL(M,6)=SOL(M,6)+EDIR+2.0*EDRF
      SOL(M,7)=SOL(M,7)+2.0*(SDIR+EDRF)
      CALL TRNSMT(SCOSV,IGLASS,ITYPE,TDR,TDF)
      SOL(M,1)=SOL(M,1)+2.0*EDRF*TDF
      SOL(M,3)=SOL(M,3)+2.0*(TDR*SDIR+TDF*EDRF)
      CALL TRNSMT (EWCOSV,IGLASS,ITYPE,TDR,TDF)
      SOL(M,2)=SOL(M,2)+TDR*EDIR+TDF*EDRF*2.0
200   CONTINUE
C
C
```

```
      SOL(N,4)=SOL(N,2)
      SOL(N,8)=SOL(N,6)
1000  CONTINUE
C
      RETURN
      END
      SUBROUTINE TRNSMT(X,IGLASS,ITYPE,TDR,TDF)
      DIMENSION D(4),T(6),A(6),TD(6),AO(6),AI(6),C(10)
      REAL NO,NI
C     ITYPE=NUMBER OF PANES,1-SINGLE GLAZING AND 2-DOUBLE GLAZING
C     IGLASS IS AN INTEGER FROM 1 TO 8 WHICH REPRESENTS ONE TYPE OF
C     GLASS GIVEN IN TABLE A-7, PAGE 28A OF NBSLD HANDBOOK.
C     1--- K*L=0.05 (1/8 IN SHEET)
C     2--- K*L=0.10
C     3--- K*L=0.1  (1/4 IN REG. PLATE)
C     4--- K*L=0.20
C     5--- K*L=0.40
C     6--- K*L=0.60
C     7--- K*L=0.80 (K/% TRANS. H.A. PLATE)
C     8--- K*L=1.0
C     D(1)=TDR FOR SINGLE GLAZING
C     D(2)=TDF FOR SINGLE GLAZING
C     D(3)=TDR FOR DOUBLE GLAZING
C     D(4)=TDF FOR DOUBLE GLAZING
C
C     C(1)=TRANSMISSIVITY OF A SINGLE PANE FOR DIRECT RADIATION
C     C(2)=TRANSMISSIVITY OF A SINGLE PANE FOR DIFFUSE RADIATION
C     C(3)=ABSORPTIVITY OF A SINGLE PANE FOR DIRECT RADIATION
C     C(4)=ABSORPTIVITY OF A SINGLE PANE FOR DIFFUSE RADIATION
C     C(5)=TRANSMISSIVITY OF A DOUBLE PANE FOR DIRECT RADIATION
C     C(6)=TRANSMISSIVITY OF A DOUBLE PANE FOR DIFFUSE RADIATION
C     C(7)=ABSORPTIVITY OF INNER PANE FOR DIRECT RADIATION
C     C(8)=ABSORPTIVITY OF OUTER PANE FOR DIRECT RADIATION
C     C(9)=ABSORPTIVITY OF INNER PANE FOR DIFFUSE RADIATION
C     C(10)=ABSORPTIVITY OF OUTER PANE FOR DIFFUSE RADIATION
C
C     RI,RO,RA=THERMAL RESISTANCE(INSIDE,OUTSIDE,AND AIRSPACE)
      RI=0.70
      RO=0.25
      RA=1.0
      CALL GLAZE(IGLASS,T,A,TD,AO,AI)
      DO 10 K=1,10
10    C(K)=0.0
      DO 100 J=2,6
      ETA=X**(J-1)
      C(1)=C(1)+T(J)*ETA
      C(2)=C(2)+T(J)/(J+1)
      C(3)=C(3)+A(J)*ETA
      C(4)=C(4)+A(J)/(J+1)
      C(5)=C(5)+TD(J)*ETA
      C(6)=C(6)+TD(J)/(J+1)
      C(7)=C(7)+AI(J)*ETA
      C(8)=C(8)+AO(J)*ETA
      C(9)=C(9)+AI(J)/(J+1)
      C(10)=C(10)+AO(J)/(J+1)
100   CONTINUE
      C(1)=C(1)+T(1)
      C(2)=(C(2)+T(1)/2.0)*2.0
      C(3)=C(3)+A(1)
      C(4)=(C(4)+A(1)/2.0)*2.0
      C(5)=C(5)+TD(1)
      C(6)=(C(6)+TD(1)/2.0)*2.0
      C(7)=C(7)+AI(1)
      C(8)=C(8)+AO(1)
      C(9)=(C(9)+AI(1)/2.0)*2.0
      C(10)=(C(10)+AO(1)/2.0)*2.0
```

```
C
C       DOUBLE-GLAZING
          NI=(RO+RA)/(RO+RA+RI)
          NO=RO/(RO+RI+RA)
          D(3)=C(5)+NO*C(8)+NI*C(7)
          D(4)=C(6)+NO*C(10)+NI*C(9)
C
C       SINGLE-GLAZING
          NO=RO/(RO+RI)
          D(1)=C(1)+NO*C(3)
          D(2)=C(2)+NO*C(4)
          IF(ITYPE.EQ.2)GOTO 200
          TDR=D(1)
          TDF=D(2)
          GOTO 300
200       TDR=D(3)
          TDF=D(4)
300       CONTINUE
          RETURN
          END
```

APPENDIX C

CALCULATED SEASONAL PERFORMANCE FACTORS AND ENERGY CONSUMPTION FOR AIR-TO-AIR HEAT PUMPS IN 115 U.S. CITIES

Table C.1. Calculated peformance and energy consumptions for air-to-air heat pumps

Location	SPFH[a]	Heating[b]			Cooling[c]
		Primary	Auxiliary	Total	
Alabama					
Birmingham	1.817	3,328	213	3,541	4,984
Montgomery	1.880	2,498	70	2,568	5,979
Arizona					
Tucson	2.057	1,777	0	1,777	6,743
Phoenix	2.005	1,529	0	1,529	8,178
Yuma	2.096	1,004	0	1,004	9,087
Arkansas					
Little Rock	1.837	3,774	56	3,830	5,295
California					
Los Angeles	2.197	1,171	0	1,171	2,754
Merced	1.998	2,805	0	2,805	7,182
Oakland	2.193	2,461	0	2,461	1,425
San Diego	2.085	1,035	0	1,035	2,169
Colorado					
Colorado Springs	1.618	7,621	3,141	10,762	2,107
Denver	1.614	7,465	3,114	10,579	2,112
Grand Junction	1.755	7,067	898	7,965	3,150
District of Columbia					
Washington	1.788	5,788	978	6,766	3,282
Florida					
Apalachicola	1.928	1,282	0	1,282	7,600
Jacksonville	1.962	1,309	0	1,309	7,523
Orlando	1.905	675	0	675	7,987
Georgia					
Atlanta	1.820	4,093	376	4,469	4,078
Augusta	1.851	2,999	104	3,103	5,432
Macon	1.898	2,534	55	2,589	5,699
Idaho					
Boise	1.765	8,055	854	8,909	2,314
Idaho Falls	1.543	9,417	5,033	14,450	1,688
Illinois					
Chicago	1.581	8,413	3,878	12,291	2,148
E. St. Louis	1.671	5,125	1,973	8,098	3,771
Urbana	1.552	7,701	4,248	11,949	2,875
Indiana					
Fort Wayne	1.638	7,793	2,939	10,732	2,601
Indianapolis	1.654	7,130	2,335	9,465	2,960
South Bend	1.603	8,046	3,549	11,595	2,417
Iowa					
Des Moines	1.501	7,870	5,298	13,168	2,732
Sioux City	1.465	7,999	6,014	14,013	2,920
Kansas					
Dodge City	1.677	7,009	1,389	8,398	3,561
Topeka	1.636	1,977			
Kentucky					
Louisville	1.768	5,433	940	6,373	4,004

Table C.1. (continued)

Location	SPFH[a]	Heating[b]			Cooling[c]
		Primary	Auxiliary	Total	
Louisiana					
Lake Charles	1.901	1,648	0	1,648	7,310
New Orleans	1.891	1,375	0	1,375	7,182
Shreveport	1.882	2,926	60	2,986	6,044
Maine					
Portland	1.573	8,579	4,339	12,918	1,443
Massachusetts					
Falmouth	1.645	6,660	3,477	10,137	1,535
Michigan					
Battle Creek	1.614	8,347	3,322	11,669	2,073
Detroit	1.582	8,417	4,117	12,534	2,097
Sault Ste. Marie	1.363	8,371	12,130	20,501	1,013
Minnesota					
Duluth	1.292	8,474	15,905	24,379	953
International Falls	1.245	8,379	17,704	26,083	999
Minneapolis	1.400	8,751	8,319	17,070	2,074
Mississippi					
Biloxi	1.877	1,758	0	1,758	7,344
Columbus	1.869	3,493	292	3,785	5,554
Jackson	1.879	2,806	95	2,901	5,833
Missouri					
Columbia	1.666	6,167	2,023	8,190	3,690
Kansas City	1.710	6,366	1,179	7,545	4,044
Springfield	1.676	6,002	1,908	7,910	3,823
Montana					
Billings	1.543	8,230	4,508	12,738	1,996
Great Falls	1.455	8,780	6,919	15,699	1,676
Missoula	1.647	9,232	3,447	12,679	1,504
Nebraska					
Grand Island	1.548	8,852	3,618	12,470	2,874
Lincoln	1.495	7,537	5,042	12,579	2,856
North Platte	1.512	8,046	4,906	12,952	2,522
Nevada					
Ely	1.530	9,178	5,435	14,613	2,011
Las Vegas	1.850	2,899	0	2,899	6,870
Winnemucca	1.651	8,343	1,876	10,219	2,727
New Jersey					
Trenton	1.741	6,618	1,461	8,079	2,666
New Mexico					
Albuquerque	1.839	5,303	251	5,554	3,555
Roswell	1.775	4,475	220	4,695	4,519
New York					
Albany	1.478	6,927	6,267	13,194	1,827
Binghamton	1.462	7,397	7,688	15,085	1,413
Niagara Falls	1.504	7,244	6,729	13,973	1,793
Syracuse	1.567	8,232	4,062	12,294	1,901
Westhampton Beach	1.692	5,963	2,618	8,581	1,954

Table C.1. (continued)

Location	SPFH[a]	Heating[b]			Cooling[c]
		Primary	Auxiliary	Total	
North Carolina					
New Bern	1.904	2,823	54	2,877	5,767
Greensboro	1.797	4,524	427	4,951	3,725
North Dakota					
Bismarck	1.324	9,314	11,592	20,906	1,908
Grand Forks	1.266	9,617	15,085	24,702	1,651
Williston	1.369	8,840	9,061	17,901	1,854
Ohio					
Akron	1.622	8,018	3,112	11,130	2,018
Columbus	1.745	6,831	1,423	8,254	2,677
Dayton	1.677	6,611	2,150	8,761	3,140
Toledo	1.563	8,217	4,241	12,458	2,359
Oklahoma					
Altus	1.757	4,786	304	5,090	5,253
Oklahoma City	1.753	5,166	579	5,745	4,893
Tulsa	1.747	4,979	509	5,488	5,069
Oregon					
Astoria	1.950	4,793	1,123	5,916	358
Medford	1.896	6,035	50	6,085	2,355
Portland	1.968	5,440	140	5,580	1,366
Pennsylvania					
Middletown	1.714	6,955	1,837	8,792	2,710
Philadelphia	1.767	6,568	1,332	7,900	2,578
Pittsburgh	1.528	6,550	4,906	11,456	1,991
Wilkes-Barre	1.576	6,578	4,043	10,621	1,926
South Carolina					
Charleston	1.881	2,720	58	2,778	5,737
Greenville	1.861	3,746	188	3,934	4,002
Sumter	1.905	2,809	58	2,867	5,151
South Dakota					
Huron	1.364	8,979	9,408	18,387	2,418
Rapid City	1.500	8,012	5,400	13,412	2,171
Tennessee					
Bristol	1.790	4,915	627	5,542	3,227
Knoxville	1.842	4,435	419	4,854	3,637
Memphis	1.820	4,143	393	4,536	5,155
Nashville	1.744	4,730	846	5,576	4,090
Texas					
El Paso	1.887	3,239	84	3,323	5,137
Fort Worth	1.854	3,150	84	3,234	6,650
Houston	1.884	1,627	0	1,627	8,046
San Antonio	2.002	1,269	0	1,269	8,062
Utah					
Salt Lake City	1.725	7,408	1,697	9,105	2,376
Vermont					
Burlington	1.450	9,022	7,245	16,267	1,504

Table C.1. (continued)

Location	SPFH[a]	Heating[b]			Cooling[c]
		Primary	Auxiliary	Total	
Virginia					
Norfolk	1.853	4,446	344	4,790	4,170
Richmond	1.838	4,520	362	4,882	3,853
Roanoke	1.825	5,172	609	5,781	3,250
Washington					
Moses Lake	1.735	7,690	963	8,653	2,478
Seattle	2.013	5,903	476	6,379	1,029
Spokane	1.709	8,680	2,231	10,911	1,643
West Virginia					
Charleston	1.751	5,422	872	6,294	3,186
Elkins	1.597	6,301	3,257	9,558	1,900
Wisconsin					
Green Bay	1.401	7,669	9,517	17,186	1,693
Madison	1.488	8,760	5,886	14,646	2,129
Wyoming					
Casper	1.535	9,185	5,281	14,466	2,017
Cheyenne	1.552	8,972	4,722	13,694	1,641
Lander	1.509	8,723	4,798	13,521	1,667
Sheridan	1.529	8,779	4,913	13,692	2,009

[a]The heating seasonal performance factor (SPFH) of the heat pump is calculated in the MAD program using the performance simulation model described in Sect. 2.3. The heating and cooling loads of the reference house, described in Sect. 2.1, are calculated in MAD using characteristic climatic data for each locality. The air-to-air heat pump assumed for all locations is a middle-line model with Air-Conditioning and Refrigeration Institute ratings of 2.0 at −8.3°C (17°F) and 2.75 at +8.3°C (47°F).

[b]Annual heating mode energy consumptions (in kWh) of the heat pump unit and the auxiliary resistance heaters are listed separately and as a sum.

[c]The annual energy consumption (in kWh) of the heat pump during cooling mode operation is calculated under the assumption that the seasonal performance factor for cooling (SPFC) is 1.88 at all geographical locations.

APPENDIX D

ESTIMATION OF COAL-BASED ELECTRICITY AND SYNTHETIC FUELS PRICES

The price of power produced in a newly constructed coal-fired steam plant and delivered by an interconnecting power transmission and distribution system is estimated from the following data (Table D.1) and assumptions.

Table D.1. Electricity from coal-fired power station

In 1980 dollars

Cost and operating parameters	Coal power plant	Transmission system
Facility size	1000 MW	
Facility cost	$1.2 billion	$540/kW
Fixed charge rate	17%	17%
Operating or capacity factor	70%	
Annual operating and maintenance	$48 million	$48/kW
Unit fuel cost (coal)	$30/ton	
Efficiency	36%	90%
Fuel energy content	22 million Btu/ton	

$$\text{Annual energy output} = (8760\ \text{h/year})(0.70\ \text{capacity factor})(10^6\text{-kW capacity}),$$

$$= 6132 \times 10^6\ \text{kWh/year}.$$

$$\text{Annual fuel cost} = \frac{(6132 \times 10^6\ \text{kWh/year})(3413\ \text{Btu/kWh})(30\ \$/\text{ton})}{(0.36)(22 \times 10^6\ \text{Btu/ton})},$$

$$= \$79.27\ \text{million}.$$

$$\text{Power cost} = \frac{\text{annual cost of power generation, transmission, and distribution}}{\text{annual amount of electric energy distributed}},$$

$$= \frac{0.17(1200 \times 10^6) + (48 \times 10^6) + 0.17(540 \times 10^6) + (48 \times 10^6) + (79.27 \times 10^6)}{0.90(6132 \times 10^6)},$$

$$= \$0.085/\text{kWh}.$$

The price of synthetic gas produced in a high Btu gasification plant and delivered by a conventional gas transmission and distribution pipeline system is estimated from the following data (Table D.2) and assumptions.

Table D.2. Synthetic gas from coal gasification plant

In end-of-year 1980 dollars

Cost and operating parameters	Synthetic gas plant	Gas pipeline
Facility size	250 thousand ft^3/d	
Facility cost	\$2.1 billion	\$900/1000 ft^3
Fixed charge rate	17%	17%
Capacity factor	90%	
Annual operating and maintenance	\$60 million	\$84/1000 ft^3
Unit fuel cost (coal)	\$30/ton	
Load factor		50%
Efficiency	60%	93%
Fuel energy content	22 million Btu/ton	

$$\text{Annual gas output} = (365\ \text{d/year})(0.90\ \text{capacity factor})(250\ \text{million ft}^3/\text{d}),$$

$$= 82.125 \times 10^9\ \text{ft}^3/\text{year}.$$

$$\text{Annual fuel cost} = \frac{(82.125 \times 10^9\ \text{ft}^3/\text{year})(1.093 \times 10^6\ \text{Btu}/1000\ \text{ft}^3)(\$30/\text{ton})}{(0.60)(22 \times 10^6) + (81 \times 10^6\ \text{Btu/ton})},$$

$$= \$204\ \text{million}.$$

$$\text{Delivered gas cost} = \frac{\text{annual cost of gas production and delivery}}{\text{amount of gas delivered annually}},$$

$$= \frac{0.17(2325 \times 10^6) + (81 \times 10^6) + (204 \times 10^6)}{0.93(82.125 \times 10^6)},$$

$$= \$8.91/1000\ \text{ft}^3,$$

$$= \$8.15/\text{million Btu},$$

$$= \$0.815/\text{therm}.$$

The price of synthetic oil produced in a coal liquefaction plant and delivered by conventional methods is estimated from the following data (Table D.3) and assumptions.

Table D.3. Synthetic oil from coal liquefaction plant

In 1980 dollars. Oil delivered by conventional truck and rail delivery for 42¢/gal

Cost and operating parameters	Synthetic oil plant
Facility size	50,000 bbl/d
Facility cost	$2.4 billion
Fixed charge rate	17%
Capacity factor	90%
Annual operating and maintenance	$72 million
Unit fuel cost (coal)	$30/ton
Efficiency	60%
Fuel energy content	22 million Btu/ton

$$\text{Annual oil output} = (365\ \text{d/year})(0.90\ \text{capacity factor})(50{,}000\ \text{bbl/d}),$$

$$= 16{,}425{,}000\ \text{bbl/year}.$$

$$\text{Annual fuel cost} = \frac{(16{,}425{,}000\ \text{bbl/year})(153{,}000\ \text{Btu/gal})(42\ \text{gal/bbl})(\$30/\text{ton})}{(0.60)(22 \times 10^6\ \text{Btu/ton})},$$

$$= \$240\ \text{million}.$$

$$\text{Synthetic oil cost} = \frac{0.17(2400 \times 10^6) + (72 \times 10^6) + (240 \times 10^6)}{16{,}425{,}000},$$

$$= \$43.84/\text{bbl},$$

$$= \$1.04/\text{gal}.$$

$$\text{Delivered oil cost} = \$1.46/\text{gal}.$$

APPENDIX E

COMPUTER OUTPUT TABLES OF SYSTEMS EVALUATIONS IN 115 U.S. CITIES

UT-ACES HOUSE--MODEL TWO-FOR ECONOMIC REPORT

HOT WATER TANK		ICE TANK		IN-BIN HEAT PUMP	
WATER TANK SURFACE AREA (FT**2)	30.000	ICE BIN HEIGHT (FT)	8.000	DISCOUNT RATE	0.1178
WATER TANK U(BTU/HR*FT**2)	0.083	DEPTH BELOW SURFACE (FT)	1.100	RATE PER KILOWATT-HR	0.0
WATER STORAGE TEMP (F)	120.000	ICE BIN TOP R VALUE	40.000	ESCALATION RATE ELEC.	0.081
WATER DELIVERY EFFICIENCY	1.000	ICE BIN SIDE R VALUE	37.000	LIFETIME (YRS)	25.000
		ICE BIN BOT R VALUE	37.000	PANEL COST($/SQFT)	4.46
		ICE PACKING FRACTION	0.800 0.400	INSULATION COST($/SQFT)	0.410
		BRINE TEMPERATURE	15.00F	COIL COST($/FT)	0.800
				COIL OD (INCHES)	1.000
				COIL ID (INCHES)	0.850
COMPRESSOR COP CC(H)	0.0	HEAT PUMP COP 47F	2.750	COIL CONDUCTIVITY	0.085
COMPRESSOR COP CC(BR)	0.0	HEAT PUMP COP 17F	2.000		
COMPRESSOR COP CC(HW)	0.0				
ACES HEATING COP (H)	2.550				
ACES COOLING COP (IM)	19.000				
ACES COOLING COP (CW)	10.000				
ACES COP FOR NIGHT HEAT REMOVAL (H)	2.050				
ACES HOT WATER COP (HW)	2.400				
ACES COMPRESSOR MOTOR (BTUH)	0.0				
ACES INDOOR FAN COIL MOTOR (BTUH)	0.0				
ACES HOT BRINE PUMP MOTOR (BTUH)	0.0				
ACES COLD BRINE PUMP MOTOR (BTUH)	0.0				
ACES OUTDOOR FAN MOTOR (BTUH)	0.0				
ACES HOT WATER PUMP (BTUH)	0.0				

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
INTERNAL SOURCES	3548.	3548.	3548.	3548.	3548.	3548.	3548.	3548.	3548.	3548.	3548.	3548.

DESCRIPTION OF HOUSE

	N	E	S	W
OVERALL WINDOW AREA	49.0	18.0	47.5	4.5
OVERALL WALL AREA	709.0	466.0	657.0	479.5

ROOF AREA	1155.000	WALL ABSORPTANCE	0.780
OUTDOOR FILM COEFF	4.000	ROOF ABSORPTANCE	0.870
GLASS TYPE	1.000	WALL THERMAL RESISTANCE	20.530
NO OF PANES	1.000	ROOF THERMAL RESISTANCE	31.000
WINDOW SHADING FAC	0.42	U ADJUSTMENT FACTOR	0.95

THERMOSTAT SETTING WINTER	70.
THERMOSTAT SETTING SUMMER	78.
HOUSE VOLUME (FT**3)	16047.90
AIR CHANGES PER HOUR	1.15

SOLAR PANEL: SIDES(CONVECTION) 1. EXCHANGER DELTA T (F) 0.

BUILDING HEAT TRANSFER SURFACES	AREA (SQFT)	H-INSIDE	U(SLAB)	H-OUTSIDE	UTOTAL)	DELTA T (DEG-F)	HEAT LOSS (BTU/HR)
		**********	(BTU/HR/SQFT/DEG-F)	**********			
ROOF KIT	429.00	0.0	0.04880	0.0	0.04880	50.00	1046.76
TYPE 8 WALL	483.00	0.0	0.08620	0.0	0.08620	50.00	2081.73
TYPE 2 WALL	1738.50	0.0	0.04870	0.0	0.04870	50.00	4233.25
DOOR	20.00	0.0	0.25000	0.0	0.25000	50.00	250.00
WINDOW	166.50	0.0	0.58000	0.0	0.58000	50.00	4828.50
ROOF BEDROOM	594.00	0.0	0.02520	0.0	0.02520	48.00	718.50
ROOF CONSOLE	132.00	0.0	0.02520	0.0	0.02520	39.00	129.73
						SUM =	13288.46
FLOOR	1155.00	0.0	0.04000	0.0	0.04000		

UA(FLOOR) 46.20

BIRMINGHAM, ALABAMA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 8666.
DESIGN COOLING LOAD (WATTS) = 7005.

EL. ($/KWHR) = 0.0582, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3667, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -7 C 34 C
TOTAL/SENSIBLE COOLING = 1.26

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1688.	6143.	0.	2175.	1404.	1309.	914.	853.	111.	19.	70.	488.	91.	19.
FEB	1516.	3968.	0.	1524.	1052.	966.	660.	597.	79.	13.	46.	434.	66.	13.
MAR	1582.	3068.	691.	1367.	960.	855.	553.	517.	68.	85.	36.	525.	58.	85.
APR	1381.	1087.	1939.	897.	809.	681.	307.	307.	38.	215.	14.	598.	34.	215.
MAY	1247.	0.	3868.	768.	951.	777.	463.	201.	25.	421.	4.	768.	21.	421.
JUN	1065.	0.	5758.	923.	1149.	938.	1054.	207.	18.	627.	0.	923.	18.	627.
JUL	1017.	0.	7323.	1080.	1365.	1122.	1330.	1097.	17.	798.	0.	1080.	17.	798.
AUG	1027.	0.	7195.	1069.	1349.	1111.	1310.	1362.	17.	784.	0.	1069.	17.	784.
SEP	1086.	0.	4776.	822.	1017.	831.	886.	934.	19.	520.	1.	822.	18.	520.
OCT	1284.	1027.	2162.	877.	808.	679.	435.	478.	36.	239.	14.	595.	32.	239.
NOV	1411.	3021.	0.	1231.	898.	802.	499.	447.	65.	10.	36.	402.	54.	10.
DEC	1609.	4856.	0.	1796.	1185.	1096.	752.	704.	92.	15.	56.	462.	76.	15.
ANNUAL	15914.	23169.	33712.	14530.	12946.	11167.	9162.	7705.	586.	3746.	277.	8167.	501.	3746.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	534.	3412.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	634.	3972.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 9.7 M3 PANEL= 4.8 M2	3130.	2117.	1135.	636.	335.	1049.	534.	8936.
5	FULL ACES, BIN= 53.5 M3 PANEL= 0.0 M2	3130.	4711.	0.	636.	335.	1049.	534.	10395.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.39	914.	845.51	REF.	REF.	15718.	20191.	24827.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.56	2162.	753.35	92.16	-147.	14005.	19579.	23709.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.81	2468.	649.79	195.72	413.	12080.	18519.	22082.
4	MIN. ACES, BIN= 9.7 M3 PANEL= 4.8 M2	2.21	2432.	533.14	312.37	5377.	9911.	21279.	24202.
5	FULL ACES, BIN= 53.5 M3 PANEL= 0.0 M2	2.62	2432.	448.33	397.18	6836.	8334.	21162.	23620.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.14	889.	432.72	412.79	628.	10853.	15929.	18189.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.69	914.	799.74	45.77	1084.	17028.	22585.	23670.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.34	960.	401.62	443.89	868.	9868.	15255.	17360.

MONTGOMERY, ALABAMA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 7853.
DESIGN COOLING LOAD (WATTS) = 7726.

EL. ($/KWHR) = 0.0582, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3667, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -5 C 36 C
TOTAL/SENSIBLE COOLING = 1.31

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1619.	4847.	0.	1796.	1188.	1091.	767.	704.	93.	15.	56.	465.	76.	15.
FEB	1454.	3092.	0.	1263.	908.	821.	559.	495.	66.	10.	36.	414.	56.	10.
MAR	1518.	2262.	862.	1144.	845.	784.	452.	424.	57.	101.	28.	523.	48.	101.
APR	1327.	593.	2459.	801.	805.	669.	254.	254.	31.	270.	8.	638.	28.	270.
MAY	1199.	0.	4708.	846.	1042.	848.	872.	208.	22.	513.	2.	846.	20.	513.
JUN	1025.	0.	6725.	1017.	1279.	1051.	1222.	736.	17.	733.	0.	1017.	17.	733.
JUL	980.	0.	8147.	1160.	1477.	1229.	1473.	1512.	16.	888.	0.	1160.	16.	888.
AUG	989.	0.	8184.	1166.	1485.	1237.	1481.	1522.	16.	892.	0.	1166.	16.	892.
SEP	1045.	0.	5689.	910.	1134.	929.	1044.	1082.	18.	620.	0.	910.	17.	620.
OCT	1234.	598.	2685.	801.	814.	676.	523.	558.	29.	294.	9.	637.	27.	294.
NOV	1355.	2071.	984.	1059.	797.	698.	375.	346.	51.	114.	26.	490.	44.	114.
DEC	1543.	3916.	0.	1517.	1021.	931.	645.	587.	79.	12.	46.	441.	66.	12.
ANNUAL	15289.	17379.	40444.	13481.	12793.	10923.	9667.	8429.	496.	4461.	211.	8708.	431.	4461.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 8.0 M3 PANEL= 3.8 M2	3130.	1925.	1078.	636.	335.	1049.	534.	8687.
5	FULL ACES, BIN= 38.4 M3 PANEL= 0.0 M2	3130.	3889.	0.	636.	335.	1049.	534.	9572.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.51	914.	784.48	REF.	REF.	14583.	19056.	23357.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.59	2162.	744.44	40.03	80.	13839.	19640.	23722.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.86	2468.	635.62	148.85	640.	11816.	18483.	21968.
4	MIN. ACES, BIN= 8.0 M3 PANEL= 3.8 M2	2.10	2432.	562.53	221.94	5128.	10457.	21577.	24661.
5	FULL ACES, BIN= 38.4 M3 PANEL= 0.0 M2	2.41	2432.	490.48	294.00	6014.	9118.	21122.	23812.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.18	889.	441.30	343.17	628.	10581.	15656.	17981.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.75	914.	753.36	31.12	1084.	15647.	21204.	22827.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.34	960.	417.78	366.70	868.	9835.	15222.	17430.

TUCSON, ARIZONA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 6321.
DESIGN COOLING LOAD (WATTS) = 7214.

EL. ($/KWHR) = 0.0587, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3022, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1200, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -1 C 39 C
TOTAL/SENSIBLE COOLING = 1.02

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1544.	3187.	667.	1387.	953.	843.	594.	525.	70.	83.	38.	512.	58.	83.
FEB	1395.	2579.	842.	1196.	856.	751.	511.	445.	59.	100.	31.	487.	49.	100.
MAR	1460.	1984.	1833.	1156.	931.	790.	402.	402.	52.	206.	25.	612.	44.	206.
APR	1274.	694.	3198.	895.	912.	755.	442.	270.	31.	351.	10.	704.	28.	351.
MAY	1144.	0.	4838.	845.	1057.	880.	890.	732.	22.	527.	3.	845.	19.	527.
JUN	966.	0.	6878.	1018.	1286.	1091.	1245.	1261.	16.	749.	0.	1018.	16.	749.
JUL	910.	0.	7711.	1093.	1393.	1172.	1393.	1411.	15.	840.	0.	1093.	15.	840.
AUG	910.	0.	7241.	1042.	1323.	1099.	1312.	1331.	15.	789.	0.	1042.	15.	789.
SEP	962.	0.	6023.	923.	1158.	976.	1099.	1117.	16.	656.	0.	923.	16.	656.
OCT	1143.	0.	3830.	735.	917.	767.	718.	735.	23.	417.	4.	735.	19.	417.
NOV	1268.	1861.	1620.	1046.	830.	708.	333.	318.	47.	182.	24.	535.	40.	182.
DEC	1460.	2857.	931.	1301.	914.	795.	537.	468.	64.	110.	34.	516.	53.	110.
ANNUAL	14435.	13161.	45612.	12635.	12529.	10626.	9477.	9013.	431.	5011.	170.	9021.	374.	5011.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 5.9 M3 PANEL= 1.2 M2	2950.	1638.	931.	636.	335.	843.	482.	7816.
5	FULL ACES, BIN= 16.5 M3 PANEL= 0.0 M2	2950.	2499.	0.	636.	335.	843.	482.	7744.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.61	914.	741.32	REF.	REF.	13781.	18254.	22172.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.62	2162.	735.10	6.21	80.	13666.	19466.	23352.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.91	2468.	623.40	117.91	640.	11589.	18256.	21551.
4	MIN. ACES, BIN= 5.9 M3 PANEL= 1.2 M2	2.15	2432.	556.03	185.29	4257.	10337.	20584.	23523.
5	FULL ACES, BIN= 16.5 M3 PANEL= 0.0 M2	2.26	2432.	528.79	212.53	4186.	9830.	20007.	22802.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.20	889.	424.36	316.96	628.	9594.	14670.	17890.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.79	914.	719.28	22.04	1084.	14637.	20194.	22275.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.35	960.	407.06	334.26	868.	9046.	14433.	17432.

PHOENIX, ARIZONA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 5769.
DESIGN COOLING LOAD (WATTS) = 8235.

EL. ($/KWHR) = 0.0630, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3571, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = 0 C 42 C
TOTAL/SENSIBLE COOLING = 1.03

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1533.	2989.	746.	1338.	936.	825.	580.	504.	67.	91.	36.	517.	56.	91.
FEB	1382.	2090.	1073.	1081.	815.	706.	460.	394.	52.	124.	26.	507.	44.	124.
MAR	1431.	1507.	2159.	1051.	906.	762.	352.	352.	45.	240.	20.	637.	39.	240.
APR	1224.	0.	3566.	729.	920.	762.	669.	318.	27.	389.	7.	729.	20.	389.
MAY	1068.	0.	5589.	906.	1135.	952.	1021.	1033.	19.	609.	2.	906.	18.	609.
JUN	875.	0.	8032.	1118.	1431.	1238.	1447.	1460.	15.	875.	0.	1118.	15.	875.
JUL	807.	0.	10093.	1324.	1716.	1508.	1809.	1825.	13.	1100.	0.	1324.	13.	1100.
AUG	810.	0.	9775.	1290.	1670.	1460.	1755.	1772.	13.	1065.	0.	1290.	13.	1065.
SEP	879.	0.	7090.	1017.	1293.	1111.	1285.	1301.	15.	772.	0.	1017.	15.	772.
OCT	1081.	0.	4307.	770.	960.	810.	801.	816.	21.	469.	3.	770.	18.	469.
NOV	1230.	1597.	1945.	997.	833.	706.	395.	407.	43.	217.	21.	559.	37.	217.
DEC	1440.	2853.	940.	1295.	914.	796.	540.	465.	64.	111.	35.	511.	53.	111.
ANNUAL	13760.	11037.	55317.	12915.	13528.	11638.	11113.	10646.	395.	6061.	149.	9884.	341.	6061.

SYSTEMS FIRST COSTS

NO.		COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1379.	48.	236.	275.	1005.	534.	3757.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 5.6 M3 PANEL= 1.1 M2	2950.	1583.	927.	636.	335.	843.	482.	7756.
5	FULL ACES, BIN= 13.9 M3 PANEL= 0.0 M2	2950.	2277.	0.	636.	335.	843.	482.	7523.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1379.	26.	376.	270.	1005.	584.	4385.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1379.	26.	632.	275.	1005.	834.	4841.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1379.	26.	236.	270.	1005.	584.	4625.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.72	914.	813.26	REF.	REF.	15119.	19790.	22763.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.65	2162.	851.88	-38.61	-119.	15836.	21637.	24751.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.91	2468.	732.85	80.42	441.	13624.	20290.	22969.
4	MIN. ACES, BIN= 5.6 M3 PANEL= 1.1 M2	2.00	2432.	699.77	113.50	3998.	13009.	23196.	25754.
5	FULL ACES, BIN= 13.9 M3 PANEL= 0.0 M2	2.09	2432.	670.39	142.88	3765.	12463.	22417.	24868.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.24	889.	522.70	290.56	628.	11562.	16836.	19069.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.87	914.	781.84	31.42	1084.	15596.	21351.	23186.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.37	960.	503.56	309.70	868.	10955.	16541.	18660.

YUMA, ARIZONA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 5025.
DESIGN COOLING LOAD (WATTS) = 8564.

EL. ($/KWHR) = 0.0631, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3478, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0400, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = 2 C 43 C
TOTAL/SENSIBLE COOLING = 1.03

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1438.	2284.	967.	1139.	834.	724.	515.	420.	56.	113.	29.	512.	47.	113.
FEB	1304.	1506.	1493.	944.	773.	657.	328.	328.	43.	167.	20.	530.	37.	167.
MAR	1362.	919.	2839.	943.	910.	756.	428.	367.	36.	312.	13.	691.	32.	312.
APR	1175.	0.	4078.	771.	962.	797.	756.	758.	24.	444.	4.	771.	20.	444.
MAY	1033.	0.	5370.	872.	1091.	918.	981.	985.	18.	585.	1.	872.	17.	585.
JUN	849.	0.	8111.	1119.	1435.	1246.	1459.	1462.	14.	884.	0.	1119.	14.	884.
JUL	778.	0.	11044.	1419.	1849.	1647.	1973.	1978.	13.	1203.	0.	1419.	13.	1203.
AUG	771.	0.	10958.	1408.	1834.	1634.	1959.	1964.	13.	1194.	0.	1408.	13.	1194.
SEP	826.	0.	8189.	1122.	1440.	1248.	1475.	1479.	14.	892.	0.	1122.	14.	892.
OCT	1007.	0.	4981.	822.	1026.	863.	917.	921.	18.	543.	1.	822.	17.	543.
NOV	1144.	805.	2370.	800.	767.	643.	464.	467.	31.	261.	12.	579.	27.	261.
DEC	1343.	2060.	1064.	1061.	789.	680.	472.	373.	52.	122.	27.	495.	43.	122.
ANNUAL	13030.	7574.	61465.	12420.	13709.	11812.	11726.	11502.	332.	6720.	107.	10340.	294.	6720.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1379.	48.	236.	275.	1005.	534.	3757.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1479.	45.	236.	275.	1060.	534.	3909.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1479.	45.	636.	335.	1060.	634.	4469.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 4.6 M3 PANEL= 0.0 M2	2950.	1438.	0.	636.	335.	843.	482.	6684.
5	FULL ACES, BIN= 6.4 M3 PANEL= 0.0 M2	2950.	1623.	0.	636.	335.	843.	482.	6869.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1379.	26.	376.	270.	1005.	584.	4385.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1379.	26.	632.	275.	1005.	834.	4841.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1379.	26.	236.	270.	1005.	584.	4625.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.84	914.	784.19	REF.	REF.	14578.	19249.	22069.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.66	2162.	865.58	-81.39	152.	16091.	22162.	25274.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.93	2468.	745.81	38.38	712.	13865.	20801.	23483.
4	MIN. ACES, BIN= 4.6 M3 PANEL= 0.0 M2	1.94	2432.	740.40	43.79	2926.	13764.	22880.	25542.
5	FULL ACES, BIN= 6.4 M3 PANEL= 0.0 M2	1.98	2432.	726.25	57.94	3111.	13501.	22801.	25413.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.29	889.	539.61	244.58	628.	11539.	16814.	19140.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.93	914.	764.16	20.03	1084.	14947.	20702.	22814.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.38	960.	526.51	257.68	868.	11125.	16710.	18946.

LITTLE ROCK, ARKANSAS

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 9076.
DESIGN COOLING LOAD (WATTS) = 7613.

EL. ($/KWHR) = 0.0515, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3667, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -8 C 36 C
TOTAL/SENSIBLE COOLING = 1.30

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1725.	6414.	0.	2261.	1446.	1325.	947.	887.	115.	20.	73.	500.	94.	20.
FEB	1551.	4456.	0.	1669.	1091.	990.	717.	654.	86.	14.	52.	445.	71.	14.
MAR	1613.	3435.	0.	1402.	990.	885.	596.	550.	74.	11.	40.	459.	62.	11.
APR	1397.	1079.	1613.	864.	761.	646.	303.	303.	39.	179.	14.	567.	34.	179.
MAY	1247.	0.	3831.	764.	940.	769.	462.	200.	24.	417.	3.	764.	21.	417.
JUN	1050.	0.	6671.	1018.	1279.	1054.	1214.	219.	18.	727.	0.	1018.	17.	727.
JUL	992.	0.	8616.	1214.	1549.	1300.	1557.	1281.	17.	939.	0.	1214.	17.	939.
AUG	1002.	0.	8264.	1178.	1500.	1259.	1497.	1558.	17.	900.	0.	1178.	17.	900.
SEP	1069.	0.	4812.	821.	1015.	834.	893.	948.	19.	524.	1.	821.	18.	524.
OCT	1280.	1004.	2013.	854.	780.	659.	410.	458.	36.	222.	14.	578.	32.	222.
NOV	1424.	3426.	0.	1347.	948.	847.	539.	490.	71.	11.	40.	406.	59.	11.
DEC	1637.	5515.	0.	1987.	1268.	1157.	819.	779.	102.	17.	63.	472.	83.	17.
ANNUAL	15987.	25329.	35820.	15380.	13567.	11724.	9952.	8327.	615.	3983.	301.	8424.	524.	3983.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 10.1 M3 PANEL= 6.0 M2	3130.	2171.	1204.	636.	335.	1049.	534.	9059.
5	FULL ACES, BIN= 60.8 M3 PANEL= 0.0 M2	3130.	5090.	0.	636.	335.	1049.	534.	10774.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.39	914.	791.77	REF.	REF.	14719.	19192.	26017.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.58	2162.	698.43	93.33	80.	12984.	18784.	24805.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.83	2468.	603.57	188.19	640.	11220.	17887.	23090.
4	MIN. ACES, BIN= 10.1 M3 PANEL= 6.0 M2	2.15	2432.	512.35	279.41	5500.	9525.	21015.	25432.
5	FULL ACES, BIN= 60.8 M3 PANEL= 0.0 M2	2.57	2432.	428.69	363.08	7215.	7969.	21175.	24871.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.14	889.	430.60	361.17	628.	10955.	16031.	18917.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.71	914.	785.25	6.52	1084.	16939.	22496.	24587.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.35	960.	397.18	394.59	868.	9897.	15284.	18004.

LOS ANGELES, CALIFORNIA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 4935.
DESIGN COOLING LOAD (WATTS) = 5048.

EL. ($/KWHR) = 0.0681, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3008, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1300, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = 3 C 31 C
TOTAL/SENSIBLE COOLING = 1.06

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1469.	2040.	438.	1023.	723.	646.	452.	389.	54.	54.	27.	462.	45.	54.
FEB	1346.	1575.	408.	856.	625.	562.	386.	324.	45.	49.	22.	423.	38.	49.
MAR	1479.	1536.	657.	909.	693.	616.	407.	338.	47.	76.	22.	487.	40.	76.
APR	1391.	1000.	841.	756.	630.	556.	313.	282.	38.	95.	16.	481.	33.	95.
MAY	1375.	546.	1307.	676.	640.	550.	238.	238.	31.	144.	10.	526.	28.	144.
JUN	1269.	0.	1870.	556.	646.	539.	273.	174.	23.	204.	3.	556.	21.	204.
JUL	1260.	0.	3161.	694.	819.	665.	596.	300.	21.	344.	0.	694.	21.	344.
AUG	1237.	0.	3232.	696.	822.	667.	608.	623.	21.	352.	0.	696.	21.	352.
SEP	1208.	0.	3083.	672.	794.	644.	581.	596.	20.	336.	0.	672.	20.	336.
OCT	1292.	0.	1866.	562.	666.	556.	370.	385.	26.	203.	5.	562.	21.	203.
NOV	1309.	904.	1122.	737.	638.	554.	269.	253.	35.	125.	14.	489.	31.	125.
DEC	1418.	1659.	644.	925.	690.	612.	401.	329.	48.	75.	23.	469.	40.	75.
ANNUAL	16054.	9261.	18631.	9062.	8385.	7167.	4895.	4230.	409.	2059.	141.	6519.	361.	2059.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
		COMPONENTS COSTS, $							
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1129.	48.	236.	275.	811.	482.	3261.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	482.	3360.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	582.	3920.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 4.4 M3 PANEL= 1.0 M2	2950.	1404.	921.	636.	335.	843.	482.	7571.
5	FULL ACES, BIN= 17.2 M3 PANEL= 0.0 M2	2950.	2463.	0.	636.	335.	843.	482.	7709.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.35	914.	616.78	REF.	REF.	11466.	15641.	16870.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.46	2162.	570.66	46.11	99.	10609.	16130.	17267.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.70	2468.	487.80	128.97	659.	9068.	15456.	16428.
4	MIN. ACES, BIN= 4.4 M3 PANEL= 1.0 M2	2.49	2432.	333.18	283.59	4309.	6194.	16197.	16860.
5	FULL ACES, BIN= 17.2 M3 PANEL= 0.0 M2	2.89	2432.	287.90	328.88	4448.	5352.	15493.	16066.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.02	889.	263.20	353.58	628.	6502.	11281.	13157.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.45	914.	603.05	13.73	1084.	12272.	17531.	17784.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.18	960.	248.83	367.94	868.	6048.	11137.	12827.

MERCED, CALIFORNIA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 6398.
DESIGN COOLING LOAD (WATTS) = 6293.

EL. ($/KWHR) = 0.0503, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3477, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0400, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -1 C 37 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1723.	4848.	0.	1825.	1152.	1046.	761.	716.	95.	15.	56.	494.	78.	15.
FEB	1551.	2927.	0.	1244.	830.	755.	525.	488.	66.	9.	35.	440.	56.	9.
MAR	1596.	2536.	688.	1223.	865.	763.	481.	460.	62.	83.	31.	526.	52.	83.
APR	1348.	1376.	1892.	963.	823.	695.	325.	325.	42.	210.	18.	585.	36.	210.
MAY	1154.	694.	2935.	833.	838.	695.	412.	252.	29.	322.	11.	642.	26.	322.
JUN	924.	0.	4713.	770.	974.	826.	868.	176.	18.	513.	3.	770.	15.	513.
JUL	838.	0.	26204.	3088.	4119.	3970.	4634.	4696.	16.	2855.	2.	3088.	14.	2855.
AUG	844.	0.	5451.	828.	1045.	902.	1002.	1060.	15.	594.	1.	828.	14.	594.
SEP	934.	0.	4171.	714.	892.	756.	779.	832.	18.	454.	3.	714.	16.	454.
OCT	1176.	676.	2528.	790.	782.	652.	497.	544.	30.	278.	11.	604.	26.	278.
NOV	1362.	2658.	0.	1117.	790.	701.	431.	406.	60.	8.	33.	387.	50.	8.
DEC	1611.	4456.	0.	1686.	1061.	961.	684.	661.	88.	14.	52.	462.	72.	14.
ANNUAL	15062.	20173.	48581.	15081.	14171.	12722.	11399.	10615.	539.	5356.	255.	9541.	456.	5356.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1129.	48.	236.	275.	811.	482.	3261.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	482.	3360.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	582.	3920.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 8.2 M3 PANEL= 5.6 M2	2950.	1858.	1176.	636.	335.	843.	482.	8280.
5	FULL ACES, BIN= 45.9 M3 PANEL= 0.0 M2	2950.	4189.	0.	636.	335.	843.	482.	9434.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.54	914.	758.88	REF.	REF.	14108.	18283.	25301.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.64	2162.	713.07	45.81	99.	13256.	18778.	25372.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.83	2468.	640.16	118.72	659.	11901.	18288.	24208.
4	MIN. ACES, BIN= 8.2 M3 PANEL= 5.6 M2	2.04	2432.	573.59	185.29	5019.	10663.	21375.	26680.
5	FULL ACES, BIN= 45.9 M3 PANEL= 0.0 M2	2.19	2432.	534.15	224.73	6173.	9930.	21796.	26736.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.19	889.	456.85	302.03	628.	10943.	15721.	19517.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.79	914.	745.51	13.37	1084.	15627.	20886.	24765.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.37	960.	428.11	330.76	868.	10033.	15122.	18718.

OAKLAND, CALIFORNIA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 4832.
DESIGN COOLING LOAD (WATTS) = 3539.

EL. ($/KWHR) = 0.0503, 0.0850
GAS ($/THERM) = 0.3098, 0.8150
OIL ($/GAL.) = 1.1200, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = 3 C 26 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1565.	3508.	0.	1409.	880.	795.	597.	597.	75.	11.	43.	446.	62.	11.
FEB	1426.	2074.	0.	972.	660.	604.	422.	434.	53.	7.	27.	403.	45.	7.
MAR	1563.	2195.	0.	1044.	735.	665.	448.	471.	57.	7.	28.	441.	48.	7.
APR	1473.	1870.	593.	993.	722.	641.	394.	405.	51.	71.	25.	480.	44.	71.
MAY	1465.	1623.	798.	945.	719.	630.	363.	370.	48.	92.	23.	499.	41.	92.
JUN	1364.	933.	1519.	804.	714.	606.	282.	282.	37.	168.	15.	547.	32.	168.
JUL	1368.	862.	1670.	801.	729.	616.	277.	277.	36.	185.	14.	565.	32.	185.
AUG	1353.	671.	1840.	763.	728.	612.	285.	257.	33.	203.	11.	579.	29.	203.
SEP	1325.	448.	1996.	710.	716.	598.	395.	231.	29.	219.	8.	587.	27.	219.
OCT	1412.	704.	1222.	721.	656.	569.	263.	250.	34.	135.	12.	528.	31.	135.
NOV	1420.	1502.	0.	812.	613.	559.	340.	358.	46.	5.	22.	399.	39.	5.
DEC	1524.	3042.	0.	1269.	807.	733.	529.	539.	68.	10.	38.	433.	56.	10.
ANNUAL	17258.	19431.	9639.	11242.	8680.	7628.	4594.	4471.	567.	1112.	265.	5906.	485.	1112.

SYSTEMS FIRST COSTS

NO.		COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1129.	48.	236.	275.	811.	482.	3261.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	482.	3360.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	582.	3920.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 6.3 M3 PANEL= 3.6 M2	2950.	1600.	1066.	636.	335.	843.	482.	7911.
5	FULL ACES, BIN= 13.5 M3 PANEL= 2.2 M2	2950.	2193.	987.	636.	335.	843.	482.	8426.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.19	914.	565.72	REF.	REF.	10517.	14692.	19924.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.48	2162.	436.79	128.93	99.	8120.	13642.	17681.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.69	2468.	383.85	181.87	659.	7136.	13524.	17073.
4	MIN. ACES, BIN= 6.3 M3 PANEL= 3.6 M2	2.80	2432.	231.19	334.53	4650.	4298.	14641.	16779.
5	FULL ACES, BIN= 13.5 M3 PANEL= 2.2 M2	2.88	2432.	224.96	340.76	5165.	4182.	15040.	17120.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	1.93	889.	231.70	334.02	628.	6606.	11384.	13955.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.35	914.	594.08	-28.36	1084.	13021.	18281.	19910.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.20	960.	206.20	359.52	868.	5799.	10888.	13161.

SAN DIEGO, CALIFORNIA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 3787.
DESIGN COOLING LOAD (WATTS) = 5158.

EL. ($/KWHR) = 0.0962, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3511, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = 7 C 31 C
TOTAL/SENSIBLE COOLING = 1.12

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1463.	1803.	0.	907.	665.	604.	424.	356.	50.	6.	25.	412.	43.	6.
FEB	1340.	1382.	0.	756.	576.	526.	362.	297.	42.	4.	20.	377.	36.	4.
MAR	1472.	1284.	390.	808.	620.	564.	373.	316.	44.	47.	20.	456.	38.	47.
APR	1385.	734.	660.	661.	570.	513.	273.	250.	34.	74.	12.	459.	31.	74.
MAY	1370.	369.	947.	586.	564.	498.	213.	213.	28.	104.	7.	485.	27.	104.
JUN	1265.	0.	1398.	504.	569.	485.	167.	167.	22.	152.	2.	504.	21.	152.
JUL	1257.	0.	2550.	627.	726.	583.	490.	183.	21.	278.	0.	627.	21.	278.
AUG	1235.	0.	3046.	675.	793.	633.	575.	394.	21.	332.	0.	675.	21.	332.
SEP	1206.	0.	2717.	631.	737.	590.	517.	535.	20.	296.	0.	631.	20.	296.
OCT	1289.	0.	1727.	546.	627.	524.	346.	363.	23.	188.	2.	546.	21.	188.
NOV	1305.	768.	872.	671.	583.	514.	226.	237.	33.	97.	12.	460.	30.	97.
DEC	1413.	1427.	366.	829.	618.	560.	378.	303.	44.	44.	21.	437.	38.	44.
ANNUAL	16001.	7767.	14673.	8201.	7649.	6595.	4343.	3613.	384.	1623.	121.	6068.	345.	1623.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1129.	48.	236.	275.	811.	482.	3261.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	482.	3360.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	582.	3920.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 4.1 M3 PANEL= 1.5 M2	2950.	1308.	950.	636.	335.	843.	482.	7504.
5	FULL ACES, BIN= 20.4 M3 PANEL= 0.0 M2	2950.	2597.	0.	636.	335.	843.	482.	7843.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.30	914.	789.07	REF.	REF.	14669.	18844.	15664.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.40	2162.	735.90	53.16	99.	13680.	19202.	16236.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.62	2468.	634.51	154.55	659.	11796.	18183.	15626.
4	MIN. ACES, BIN= 4.1 M3 PANEL= 1.5 M2	2.46	2432.	417.89	371.18	4243.	7768.	17705.	16021.
5	FULL ACES, BIN= 20.4 M3 PANEL= 0.0 M2	2.96	2432.	347.63	441.43	4581.	6462.	16737.	15336.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	1.99	889.	291.01	498.06	628.	7174.	11952.	12210.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.38	914.	713.01	76.05	1084.	14115.	19375.	16665.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.14	960.	277.38	511.69	868.	6742.	11831.	12000.

COLORADO SPRINGS, COLORADO

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 13069.
DESIGN COOLING LOAD (WATTS) = 4481.

EL. ($/KWHR) = 0.0345, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3022, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1200, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -18 C 31 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1867.	11971.	0.	3844.	2856.	2796.	1557.	1557.	189.	38.	131.	557.	153.	38.
FEB	1730.	9310.	0.	3067.	2183.	2115.	1255.	1255.	152.	29.	102.	510.	124.	29.
MAR	1899.	9096.	0.	3054.	2082.	1993.	1251.	1264.	153.	29.	100.	556.	124.	29.
APR	1758.	5375.	0.	1982.	1350.	1229.	811.	821.	103.	17.	61.	505.	84.	17.
MAY	1686.	2631.	1414.	1353.	1016.	875.	499.	501.	65.	162.	32.	631.	55.	162.
JUN	1500.	879.	2661.	951.	916.	762.	308.	308.	38.	293.	12.	709.	34.	293.
JUL	1437.	0.	3613.	793.	964.	797.	340.	219.	28.	394.	4.	793.	24.	394.
AUG	1383.	0.	3339.	748.	912.	756.	639.	209.	28.	364.	5.	748.	23.	364.
SEP	1356.	1469.	2279.	1033.	900.	758.	457.	321.	44.	253.	19.	630.	38.	253.
OCT	1488.	3909.	945.	1602.	1093.	962.	551.	560.	79.	115.	45.	529.	65.	115.
NOV	1563.	7844.	0.	2613.	1725.	1639.	974.	1002.	131.	25.	87.	459.	106.	25.
DEC	1756.	10206.	0.	3323.	2272.	2199.	1327.	1343.	165.	32.	113.	520.	133.	32.
ANNUAL	19423.	62688.	14251.	24363.	18268.	16880.	9968.	9359.	1175.	1751.	711.	7147.	962.	1751.

SYSTEMS FIRST COSTS

NO.		COMPONENTS COSTS, $: PAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 17.2 M3 PANEL= 13.3 M2	3500.	2925.	1609.	710.	335.	1267.	638.	10984.
5	FULL ACES, BIN= 35.3 M3 PANEL= 10.1 M2	3500.	4039.	1430.	710.	335.	1267.	638.	11919.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.10	914.	839.56	REF.	REF.	15607.	19830.	38350.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.47	2162.	629.53	210.03	131.	11703.	17304.	31191.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.59	2468.	581.70	257.86	691.	10814.	17281.	30113.
4	MIN. ACES, BIN= 17.2 M3 PANEL= 13.3 M2	2.69	2432.	343.51	496.05	7676.	6386.	19802.	27380.
5	FULL ACES, BIN= 35.3 M3 PANEL= 10.1 M2	2.86	2432.	322.52	517.04	8611.	5996.	20347.	27462.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.02	889.	415.52	424.04	611.	12370.	17179.	23047.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.59	914.	1043.11	-203.55	1037.	24698.	29957.	32389.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.40	960.	351.03	488.53	821.	10328.	15417.	20462.

DENVER, COLORADO

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 13514.
DESIGN COOLING LOAD (WATTS) = 4428.

EL. ($/KWHR) = 0.0567, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.4281, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -20 C 33 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1881.	12208.	0.	3914.	2894.	2825.	1586.	1586.	193.	39.	134.	561.	156.	39.
FEB	1742.	9722.	0.	3185.	2268.	2198.	1299.	1299.	158.	31.	107.	515.	128.	31.
MAR	1903.	9062.	0.	3046.	2088.	1997.	1242.	1261.	153.	29.	100.	557.	124.	29.
APR	1747.	4972.	0.	1866.	1279.	1161.	762.	774.	97.	16.	57.	501.	80.	16.
MAY	1656.	2245.	1348.	1231.	947.	816.	451.	453.	60.	154.	28.	614.	50.	154.
JUN	1457.	636.	2691.	875.	879.	729.	277.	277.	34.	295.	9.	700.	31.	295.
JUL	1384.	0.	3690.	786.	945.	780.	338.	214.	25.	402.	2.	786.	23.	402.
AUG	1331.	0.	3314.	731.	882.	730.	635.	203.	25.	361.	3.	731.	22.	361.
SEP	1315.	1273.	2228.	962.	856.	722.	448.	316.	40.	247.	17.	612.	35.	247.
OCT	1462.	3423.	1014.	1468.	1020.	890.	499.	508.	72.	121.	40.	527.	59.	121.
NOV	1554.	7738.	0.	2581.	1679.	1589.	966.	994.	130.	25.	86.	456.	105.	25.
DEC	1762.	10193.	0.	3321.	2288.	2208.	1330.	1347.	165.	32.	112.	522.	133.	32.
ANNUAL	19193.	61471.	14286.	23965.	18025.	16646.	9835.	9232.	1152.	1751.	694.	7083.	946.	1751.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 17.5 M3 PANEL= 15.9 M2	4000.	2972.	1755.	830.	335.	1520.	638.	12049.
5	FULL ACES, BIN= 37.4 M3 PANEL= 11.3 M2	4000.	4180.	1499.	830.	335.	1520.	638.	13002.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.10	914.	1358.35	REF.	REF.	25252.	29474.	37793.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.46	2162.	1021.67	336.68	131.	18993.	24594.	30850.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.58	2468.	943.48	414.87	691.	17539.	24006.	29784.
4	MIN. ACES, BIN= 17.5 M3 PANEL= 15.9 M2	2.68	2432.	557.45	800.90	8741.	10363.	24844.	28258.
5	FULL ACES, BIN= 37.4 M3 PANEL= 11.3 M2	2.86	2432.	523.24	835.10	9694.	9727.	25161.	28365.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.03	889.	592.34	766.00	611.	17461.	22270.	22731.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.59	914.	1144.46	213.89	1037.	26224.	31483.	31889.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.40	960.	504.10	854.25	821.	14667.	19756.	20244.

GRAND JUNCTION, COLORADO

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 11941.
DESIGN COOLING LOAD (WATTS) = 5415.

EL. ($/KWHR) = 0.0567, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3477, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0400, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -16 C 34 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1889.	10858.	0.	3541.	2362.	2252.	1435.	1435.	174.	34.	120.	559.	142.	34.
FEB	1735.	7996.	0.	2703.	1787.	1679.	1100.	1109.	135.	25.	89.	507.	110.	25.
MAR	1861.	6343.	0.	2279.	1473.	1351.	924.	968.	116.	20.	71.	537.	96.	20.
APR	1669.	3329.	814.	1477.	1032.	909.	570.	601.	73.	99.	39.	563.	62.	99.
MAY	1539.	1312.	2088.	1020.	900.	757.	352.	352.	44.	232.	17.	659.	39.	232.
JUN	1322.	0.	4315.	837.	1030.	847.	367.	216.	25.	470.	3.	837.	22.	470.
JUL	1241.	0.	5437.	937.	1149.	952.	1006.	223.	21.	592.	0.	937.	21.	592.
AUG	1205.	0.	4578.	833.	1016.	840.	858.	206.	21.	499.	1.	833.	20.	499.
SEP	1224.	610.	3001.	836.	858.	717.	582.	345.	29.	329.	9.	669.	27.	329.
OCT	1408.	2612.	1074.	1234.	890.	771.	408.	436.	60.	125.	32.	516.	50.	125.
NOV	1537.	6624.	0.	2267.	1428.	1318.	816.	887.	114.	21.	74.	448.	93.	21.
DEC	1766.	10639.	0.	3446.	2301.	2195.	1353.	1400.	169.	34.	117.	524.	138.	34.
ANNUAL	18394.	50323.	21308.	21411.	16227.	14587.	9771.	8178.	981.	2481.	573.	7591.	919.	2481.

SYSTEMS FIRST COSTS

NO.		COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	CONVENTIONAL ELECTRIC SYSTEMS: EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES):	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 15.8 M3 PANEL= 16.0 M2	3500.	2767.	1764.	710.	335.	1267.	638.	10981.
5	FULL ACES, BIN= 71.4 M3 PANEL= 4.4 M2	3500.	5767.	1112.	710.	335.	1267.	638.	13329.
	POSSIL FUEL FIRED SYSTEMS:	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.17	914.	1213.60	REF.	REF.	22561.	26783.	34215.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.54	2162.	919.74	293.86	131.	17098.	22699.	28331.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.71	2468.	826.82	386.78	691.	15371.	21837.	26901.
4	MIN. ACES, BIN= 15.8 M3 PANEL= 16.0 M2	2.56	2432.	553.80	659.79	7673.	10295.	23708.	27100.
5	FULL ACES, BIN= 71.4 M3 PANEL= 4.4 M2	3.06	2432.	463.55	750.05	10021.	8617.	24378.	27217.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.07	889.	481.66	731.94	581.	13415.	18193.	21428.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.62	914.	1025.70	187.90	1037.	23033.	28293.	29668.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.39	960.	425.30	788.30	821.	11630.	16719.	19562.

WASHINGTON, DISTRICT OF COLUMBIA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 9373.
DESIGN COOLING LOAD (WATTS) = 6781.

EL. ($/KWHR) = 0.0493, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.4457, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -9 C 35 C
TOTAL/SENSIBLE COOLING = 1.24

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1895.	10258.	0.	3376.	2228.	2117.	1366.	1366.	167.	32.	113.	559.	136.	32.
FEB	1715.	8147.	0.	2740.	1768.	1668.	1117.	1117.	136.	26.	91.	502.	112.	26.
MAR	1800.	6466.	0.	2296.	1468.	1346.	932.	962.	117.	20.	73.	521.	96.	20.
APR	1576.	2738.	784.	1284.	912.	805.	492.	544.	64.	94.	33.	532.	54.	94.
MAY	1420.	857.	2379.	892.	850.	706.	292.	292.	36.	262.	12.	656.	32.	262.
JUN	1201.	0.	3976.	767.	938.	764.	474.	197.	22.	433.	2.	767.	20.	433.
JUL	1131.	0.	5712.	937.	1160.	945.	1051.	214.	19.	622.	0.	937.	19.	622.
AUG	1127.	0.	5025.	861.	1060.	860.	933.	204.	19.	547.	1.	861.	19.	547.
SEP	1185.	0.	3138.	671.	843.	691.	603.	305.	26.	342.	6.	671.	20.	342.
OCT	1404.	1900.	1188.	1047.	808.	696.	336.	349.	50.	135.	24.	525.	43.	135.
NOV	1554.	4328.	0.	1634.	1054.	958.	601.	654.	85.	14.	50.	446.	70.	14.
DEC	1789.	8856.	0.	2957.	1903.	1798.	1169.	1209.	147.	28.	99.	525.	120.	28.
ANNUAL	17797.	43550.	22202.	19461.	14993.	13354.	9367.	7414.	888.	2557.	504.	7501.	740.	2557.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	534.	3412.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	634.	3972.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 15.1 M3 PANEL= 13.9 M2	3130.	2571.	1645.	636.	335.	1049.	534.	9900.
5	FULL ACES, BIN= 80.6 M3 PANEL= 2.0 M2	3130.	6012.	975.	636.	335.	1049.	534.	12671.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.19	914.	960.22	REF.	REF.	17850.	22323.	31734.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.55	2162.	739.77	220.46	-147.	13752.	19326.	26576.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.74	2468.	658.90	301.32	413.	12249.	18689.	25147.
4	MIN. ACES, BIN= 15.1 M3 PANEL= 13.9 M2	2.48	2432.	462.18	498.04	6342.	8592.	20924.	25454.
5	FULL ACES, BIN= 80.6 M3 PANEL= 2.0 M2	3.13	2432.	365.82	594.40	9112.	6801.	21904.	25489.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.07	889.	522.00	438.23	628.	14882.	19957.	20586.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.61	914.	959.83	0.39	1084.	21771.	27328.	28192.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.37	960.	455.89	504.33	868.	12788.	18175.	18905.

APPALACHICOLA, FLORIDA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 6301.
DESIGN COOLING LOAD (WATTS) = 7372.

EL. ($/KWHR) = 0.0641, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3685, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1900, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -1 C 33 C
TOTAL/SENSIBLE COOLING = 1.45

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	BUILDING LOADS: SPACE HEAT MJ	BUILDING LOADS: SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1487.	2891.	0.	1216.	872.	783.	553.	477.	65.	9.	34.	422.	54.	9.
FEB	1345.	1811.	825.	967.	733.	645.	414.	356.	48.	96.	22.	469.	41.	96.
MAR	1422.	1113.	1341.	850.	732.	629.	305.	305.	40.	150.	15.	545.	35.	150.
APR	1262.	0.	2991.	676.	818.	665.	379.	190.	24.	326.	3.	676.	21.	326.
MAY	1160.	0.	5773.	951.	1178.	954.	1054.	1070.	20.	629.	0.	951.	19.	629.
JUN	1004.	0.	7798.	1128.	1432.	1181.	1406.	1421.	17.	850.	0.	1128.	17.	850.
JUL	962.	0.	9196.	1269.	1627.	1373.	1653.	1669.	16.	1002.	0.	1269.	16.	1002.
AUG	959.	0.	9152.	1264.	1619.	1366.	1646.	1663.	16.	997.	0.	1264.	16.	997.
SEP	993.	0.	7417.	1084.	1373.	1131.	1342.	1359.	17.	808.	0.	1084.	17.	808.
OCT	1149.	0.	4165.	773.	954.	785.	776.	791.	22.	454.	3.	773.	19.	454.
NOV	1247.	907.	1953.	811.	749.	628.	392.	405.	34.	216.	12.	562.	30.	216.
DEC	1414.	2173.	797.	1083.	796.	701.	472.	384.	54.	94.	27.	487.	46.	94.
ANNUAL	14404.	8895.	51408.	12073.	12882.	10840.	10392.	10091.	370.	5629.	117.	9630.	330.	5629.

SYSTEMS FIRST COSTS

NO.		COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 5.4 M3 PANEL= 1.2 M2	2950.	1592.	933.	636.	335.	843.	482.	7771.
5	FULL ACES, BIN= 15.6 M3 PANEL= 0.0 M2	2950.	2435.	0.	636.	335.	843.	482.	7681.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.72	914.	773.77	REF.	REF.	14384.	18857.	21385.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.61	2162.	825.61	-51.83	80.	15348.	21149.	23846.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.91	2468.	694.73	79.04	640.	12915.	19582.	21851.
4	MIN. ACES, BIN= 5.4 M3 PANEL= 1.2 M2	2.00	2432.	666.04	107.74	4213.	12382.	22585.	24761.
5	FULL ACES, BIN= 15.6 M3 PANEL= 0.0 M2	2.06	2432.	646.73	127.04	4122.	12023.	22135.	24248.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.25	889.	497.07	276.70	628.	11024.	16100.	17929.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.85	914.	756.37	17.40	1084.	14988.	20545.	21861.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.34	960.	482.42	291.35	868.	10560.	15947.	17706.

JACKSONVILLE, FLORIDA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 6117.
DESIGN COOLING LOAD (WATTS) = 7683.

EL. ($/KWHR) = 0.0828, 0.0850
GAS ($/THERM) = 0.3550, 0.8150
OIL ($/GAL.) = 1.1700, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = 0 C 34 C
TOTAL/SENSIBLE COOLING = 1.40

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1469.	2825.	660.	1265.	889.	791.	559.	477.	63.	81.	34.	489.	53.	81.
FEB	1322.	1603.	1233.	947.	761.	658.	361.	337.	44.	139.	20.	507.	38.	139.
MAR	1393.	1265.	1732.	927.	806.	688.	324.	324.	41.	193.	16.	580.	36.	193.
APR	1237.	0.	2987.	669.	826.	681.	473.	187.	26.	325.	5.	669.	21.	325.
MAY	1143.	0.	5526.	919.	1139.	924.	1010.	1020.	20.	602.	1.	919.	19.	602.
JUN	998.	0.	7172.	1059.	1338.	1095.	1297.	1307.	17.	781.	0.	1059.	17.	781.
JUL	967.	0.	8854.	1233.	1577.	1325.	1593.	1605.	16.	965.	0.	1233.	16.	965.
AUG	973.	0.	8761.	1225.	1565.	1313.	1577.	1590.	16.	954.	0.	1225.	16.	954.
SEP	1009.	0.	7348.	1081.	1367.	1118.	1330.	1342.	17.	801.	0.	1081.	17.	801.
OCT	1163.	0.	4070.	767.	956.	777.	759.	770.	23.	443.	4.	767.	19.	443.
NOV	1252.	1048.	1822.	837.	750.	635.	369.	379.	36.	202.	14.	550.	32.	202.
DEC	1408.	2508.	722.	1166.	839.	745.	509.	422.	58.	87.	30.	478.	49.	87.
ANNUAL	14335.	9248.	50887.	12095.	12814.	10751.	10161.	9760.	377.	5573.	124.	9555.	333.	5573.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 5.3 M3 PANEL= 1.0 M2	2950.	1572.	921.	636.	335.	843.	482.	7739.
5	FULL ACES, BIN= 12.3 M3 PANEL= 0.0 M2	2950.	2181.	0.	636.	335.	843.	482.	7427.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.71	914.	1001.48	REF.	REF.	18618.	23090.	21416.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.61	2162.	1061.00	-59.51	80.	19724.	25525.	23750.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.92	2468.	890.16	111.32	640.	16548.	23215.	21726.
4	MIN. ACES, BIN= 5.3 M3 PANEL= 1.0 M2	2.04	2432.	841.34	160.14	4180.	15641.	25811.	24404.
5	FULL ACES, BIN= 12.3 M3 PANEL= 0.0 M2	2.12	2432.	808.17	193.32	3868.	15024.	24883.	23531.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.24	889.	595.20	406.28	628.	12814.	17890.	17943.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.84	914.	935.92	65.57	1084.	18363.	23920.	21918.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.34	960.	579.53	421.95	868.	12318.	17705.	17661.

MIAMI, FLORIDA

HEATING LOADS ARE ZERO

ORLANDO, FLORIDA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 5195.
DESIGN COOLING LOAD (WATTS) = 4999.

EL. ($/KWHR) = 0.0530, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3667, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = 2 C 26 C
TOTAL/SENSIBLE COOLING = 1.39

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1371.	1484.	1415.	947.	782.	672.	388.	321.	44.	159.	19.	540.	38.	159.
FEB	1242.	1235.	1412.	842.	712.	608.	299.	299.	38.	158.	16.	503.	33.	158.
MAR	1329.	703.	2351.	821.	803.	668.	364.	455.	32.	258.	10.	627.	29.	258.
APR	1203.	0.	3584.	725.	882.	718.	668.	662.	22.	390.	2.	725.	20.	390.
MAY	1137.	0.	5361.	900.	1111.	908.	979.	972.	19.	584.	0.	900.	19.	584.
JUN	1012.	0.	7002.	1044.	1316.	1078.	1264.	1256.	17.	763.	0.	1044.	17.	763.
JUL	987.	0.	8290.	1177.	1500.	1245.	1491.	1482.	16.	903.	0.	1177.	16.	903.
AUG	982.	0.	8360.	1184.	1509.	1254.	1503.	1494.	16.	911.	0.	1184.	16.	911.
SEP	996.	0.	7022.	1042.	1315.	1070.	1269.	1260.	17.	765.	0.	1042.	17.	765.
OCT	1118.	0.	4845.	838.	1033.	838.	891.	882.	19.	528.	1.	838.	19.	528.
NOV	1181.	0.	2760.	629.	792.	657.	525.	518.	26.	301.	7.	629.	20.	301.
DEC	1314.	1204.	1622.	876.	759.	647.	334.	327.	39.	181.	16.	546.	34.	181.
ANNUAL	13872.	4627.	54025.	11025.	12514.	10364.	9976.	9927.	307.	5900.	71.	9754.	278.	5900.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1129.	48.	236.	275.	811.	482.	3261.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	482.	3360.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	582.	3920.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 3.5 M3 PANEL= 0.0 M2	2950.	1322.	0.	636.	335.	843.	482.	6568.
5	FULL ACES, BIN= 3.5 M3 PANEL= 0.0 M2	2950.	1322.	0.	636.	335.	843.	482.	6568.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.83	914.	584.42	REF.	REF.	10864.	15040.	19619.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.61	2162.	663.38	-78.96	99.	12332.	17854.	23052.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.94	2468.	549.41	35.02	659.	10214.	16601.	20906.
4	MIN. ACES, BIN= 3.5 M3 PANEL= 0.0 M2	2.02	2432.	528.81	55.61	3306.	9831.	18830.	22974.
5	FULL ACES, BIN= 3.5 M3 PANEL= 0.0 M2	2.03	2432.	528.81	55.61	3306.	9831.	18830.	22974.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.26	889.	425.21	159.21	628.	9375.	14154.	17162.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.88	914.	600.19	-15.77	1084.	11711.	16971.	20632.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.34	960.	414.66	169.77	868.	9041.	14130.	17086.

ATLANTA, GEORGIA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 8704.
DESIGN COOLING LOAD (WATTS) = 6635.

EL. ($/KWHR) = 0.0494, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.4195, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -7 C 33 C
TOTAL/SENSIBLE COOLING = 1.26

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1753.	7370.	0.	2534.	1637.	1535.	1049.	994.	127.	23.	83.	510.	104.	23.
FEB	1578.	5149.	0.	1869.	1216.	1122.	790.	733.	96.	16.	59.	455.	79.	16.
MAR	1651.	4239.	0.	1636.	1100.	995.	687.	642.	85.	13.	49.	472.	71.	13.
APR	1447.	1538.	1423.	984.	809.	692.	347.	346.	46.	160.	19.	562.	40.	160.
MAY	1312.	0.	3244.	718.	883.	722.	199.	199.	27.	353.	5.	718.	22.	353.
JUN	1123.	0.	4909.	847.	1040.	844.	907.	202.	19.	535.	0.	847.	19.	535.
JUL	1073.	0.	6191.	973.	1213.	991.	1133.	215.	18.	674.	0.	973.	18.	674.
AUG	1079.	0.	6257.	982.	1225.	1006.	1147.	963.	18.	682.	0.	982.	18.	682.
SEP	1136.	0.	3953.	746.	916.	749.	743.	797.	21.	431.	2.	746.	19.	431.
OCT	1336.	1345.	1606.	920.	779.	663.	340.	387.	41.	179.	18.	550.	36.	179.
NOV	1465.	3436.	0.	1362.	947.	852.	532.	495.	71.	11.	40.	418.	59.	11.
DEC	1669.	6206.	0.	2188.	1398.	1297.	889.	858.	111.	20.	71.	483.	91.	20.
ANNUAL	16622.	29283.	27584.	15758.	13164.	11467.	8764.	6829.	680.	3098.	346.	7716.	575.	3098.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1129.	48.	236.	275.	811.	534.	3313.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	534.	3412.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	634.	3972.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 11.3 M3 PANEL= 6.2 M2	3130.	2250.	1214.	636.	335.	1049.	534.	9148.
5	FULL ACES, BIN= 68.3 M3 PANEL= 0.0 M2	3130.	5413.	0.	636.	335.	1049.	534.	11097.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	584.	3941.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	834.	4397.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	584.	4181.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.30	914.	778.91	REF.	REF.	14480.	18707.	26301.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.55	2162.	650.69	128.22	99.	12096.	17670.	24014.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.78	2468.	566.82	212.09	659.	10537.	16977.	22503.
4	MIN. ACES, BIN= 11.3 M3 PANEL= 6.2 M2	2.33	2432.	433.22	345.69	5835.	8054.	19633.	23857.
5	FULL ACES, BIN= 68.3 M3 PANEL= 0.0 M2	2.99	2432.	337.58	441.33	7784.	6276.	19805.	23096.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.10	889.	438.29	340.62	628.	11878.	16708.	18300.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.64	914.	786.36	-7.45	1084.	17316.	22627.	24447.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.34	960.	394.29	384.62	868.	10484.	15625.	17202.

AUGUSTA, GEORGIA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 8070.
DESIGN COOLING LOAD (WATTS) = 7412.

EL. ($/KWHR) = 0.0494, 0.0850
GAS ($/THERM) = 0.3685, 0.8150
OIL ($/GAL.) = 1.1900, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -6 C 35 C
TOTAL/SENSIBLE COOLING = 1.30

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1658.	4879.	0.	1816.	1212.	1117.	776.	712.	94.	15.	56.	476.	77.	15.
FEB	1486.	3377.	0.	1351.	951.	863.	590.	530.	71.	11.	39.	424.	59.	11.
MAR	1551.	2787.	848.	1297.	935.	826.	518.	485.	64.	101.	33.	532.	54.	101.
APR	1357.	1042.	2135.	899.	824.	690.	302.	302.	37.	236.	14.	613.	33.	236.
MAY	1231.	0.	4206.	800.	995.	820.	639.	204.	24.	458.	4.	800.	20.	458.
JUN	1058.	0.	6182.	967.	1211.	1001.	1126.	458.	18.	673.	0.	967.	18.	673.
JUL	1019.	0.	7785.	1131.	1434.	1190.	1409.	1452.	17.	848.	0.	1131.	17.	848.
AUG	1032.	0.	7346.	1087.	1373.	1139.	1334.	1379.	17.	800.	0.	1087.	17.	800.
SEP	1090.	0.	5060.	854.	1059.	872.	934.	975.	19.	551.	1.	854.	18.	551.
OCT	1281.	1114.	2352.	922.	847.	712.	467.	504.	37.	260.	15.	616.	33.	260.
NOV	1399.	2948.	832.	1298.	922.	816.	478.	445.	64.	100.	35.	489.	53.	100.
DEC	1587.	4533.	0.	1700.	1147.	1054.	709.	667.	88.	14.	52.	455.	73.	14.
ANNUAL	15749.	20680.	36746.	14123.	12910.	11099.	9282.	8112.	550.	4069.	250.	8444.	473.	4069.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 8.1 M3 PANEL= 4.4 M2	3130.	1945.	1109.	636.	335.	1049.	534.	8738.
5	FULL ACES, BIN= 44.4 M3 PANEL= 0.0 M2	3130.	4216.	0.	636.	335.	1049.	534.	9900.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.44	914.	698.12	REF.	REF.	12978.	17451.	24257.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.57	2162.	638.16	59.95	80.	11863.	17664.	23886.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.83	2468.	548.64	149.47	640.	10199.	16866.	22215.
4	MIN. ACES, BIN= 8.1 M3 PANEL= 4.4 M2	2.19	2432.	458.83	239.29	5179.	8530.	19699.	24173.
5	FULL ACES, BIN= 44.4 M3 PANEL= 0.0 M2	2.51	2432.	400.99	297.13	6341.	7454.	19787.	23696.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.15	889.	403.94	294.18	628.	10162.	15238.	18168.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.71	914.	715.23	-17.11	1084.	15280.	20837.	23407.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.34	960.	375.30	322.82	868.	9255.	14642.	17435.

MACON, GEORGIA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 7848.
DESIGN COOLING LOAD (WATTS) = 7830.

EL. ($/KWHR) = 0.0494, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3667, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -5 C 36 C
TOTAL/SENSIBLE COOLING = 1.32

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1604.	4850.	0.	1793.	1167.	1060.	768.	703.	92.	15.	56.	461.	76.	15.
FEB	1445.	3222.	0.	1296.	905.	814.	571.	508.	68.	10.	38.	412.	57.	10.
MAR	1517.	2413.	778.	1177.	854.	753.	471.	440.	59.	92.	29.	514.	50.	92.
APR	1337.	753.	2164.	816.	784.	651.	268.	268.	33.	238.	10.	609.	30.	238.
MAY	1220.	0.	4585.	838.	1035.	847.	851.	208.	23.	499.	2.	838.	20.	499.
JUN	1051.	0.	6313.	980.	1226.	1003.	1149.	701.	18.	688.	0.	980.	17.	688.
JUL	1008.	0.	7769.	1127.	1429.	1180.	1407.	1444.	17.	846.	0.	1127.	17.	846.
AUG	1013.	0.	7627.	1112.	1409.	1171.	1383.	1422.	17.	831.	0.	1112.	17.	831.
SEP	1059.	0.	5303.	872.	1085.	889.	976.	1013.	19.	578.	1.	872.	18.	578.
OCT	1236.	790.	2393.	823.	796.	663.	473.	506.	32.	263.	11.	607.	29.	263.
NOV	1347.	1560.	1622.	984.	825.	703.	298.	366.	44.	182.	20.	556.	38.	182.
DEC	1529.	4100.	0.	1564.	1044.	944.	661.	584.	81.	13.	48.	438.	67.	13.
ANNUAL	15367.	17688.	38552.	13383.	12556.	10679.	9277.	8164.	502.	4256.	216.	8525.	436.	4256.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 8.0 M3 PANEL= 3.7 M2	3130.	1923.	1072.	636.	335.	1049.	534.	8679.
5	FULL ACES, BIN= 37.8 M3 PANEL= 0.0 M2	3130.	3855.	0.	636.	335.	1049.	534.	9539.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.49	914.	661.51	REF.	REF.	12297.	16770.	23219.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.58	2162.	620.66	40.84	80.	11538.	17339.	23390.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.86	2468.	527.85	133.66	640.	9813.	16479.	21625.
4	MIN. ACES, BIN= 8.0 M3 PANEL= 3.7 M2	2.14	2432.	458.54	202.96	5121.	8524.	19636.	24106.
5	FULL ACES, BIN= 37.8 M3 PANEL= 0.0 M2	2.44	2432.	403.54	257.96	5980.	7502.	19473.	23407.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.17	889.	394.52	266.99	628.	9743.	14819.	17782.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.73	914.	673.71	-12.20	1084.	14205.	19762.	22687.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.34	960.	370.19	291.32	868.	8972.	14359.	17202.

BOISE, IDAHO

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 11727.
DESIGN COOLING LOAD (WATTS) = 5486.

EL. ($/KWHR) = 0.0315, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3022, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1200, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -15 C 34 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1883.	11513.	0.	3722.	2492.	2367.	1502.	1502.	182.	36.	126.	560.	149.	36.
FEB	1730.	8371.	0.	2806.	1808.	1683.	1132.	1150.	140.	27.	93.	507.	114.	27.
MAR	1870.	6851.	0.	2423.	1538.	1409.	973.	1002.	123.	22.	77.	541.	101.	22.
APR	1701.	4092.	0.	1609.	1092.	981.	646.	664.	84.	13.	47.	485.	70.	13.
MAY	1601.	2375.	1318.	1248.	945.	817.	456.	459.	60.	151.	29.	596.	51.	151.
JUN	1404.	811.	2847.	926.	910.	749.	293.	293.	35.	313.	11.	703.	32.	313.
JUL	1340.	0.	4965.	913.	1133.	929.	576.	228.	26.	541.	3.	913.	22.	541.
AUG	1303.	0.	4159.	815.	1014.	832.	783.	212.	26.	453.	5.	815.	22.	453.
SEP	1306.	1225.	2361.	960.	866.	725.	471.	311.	39.	261.	16.	624.	34.	261.
OCT	1468.	3509.	0.	1383.	965.	854.	491.	519.	73.	11.	41.	419.	60.	11.
NOV	1568.	7187.	0.	2432.	1527.	1412.	873.	935.	122.	23.	81.	458.	99.	23.
DEC	1774.	10675.	0.	3459.	2197.	2054.	1360.	1389.	170.	34.	118.	527.	138.	34.
ANNUAL	18947.	56610.	15651.	22695.	16487.	14810.	9554.	8661.	1079.	1884.	648.	7148.	892.	1884.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 16.6 M3 PANEL= 24.7 M2	3500.	2813.	2246.	710.	335.	1267.	638.	11509.
5	FULL ACES, BIN= 48.5 M3 PANEL= 10.8 M2	3500.	4655.	1468.	710.	335.	1267.	638.	12573.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.12	914.	713.98	REF.	REF.	13273.	17495.	36013.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.54	2162.	518.68	195.30	131.	9642.	15243.	28696.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.71	2468.	465.93	248.06	691.	8662.	15128.	27213.
4	MIN. ACES, BIN= 16.6 M3 PANEL= 24.7 M2	2.65	2432.	300.58	413.40	8201.	5588.	19529.	27325.
5	FULL ACES, BIN= 48.5 M3 PANEL= 10.8 M2	2.93	2432.	272.48	441.51	9265.	5065.	20071.	27138.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.04	889.	385.43	328.56	581.	11431.	16209.	21913.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.58	914.	950.57	-236.58	1037.	22504.	27763.	30862.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.39	960.	328.86	385.13	821.	9639.	14729.	19710.

IDAHO FALLS, IDAHO

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 14999.
DESIGN COOLING LOAD (WATTS) = 4397.

EL. ($/KWHR) = 0.0180, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3477, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0400, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -23 C 31 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1827.	15304.	0.	4759.	3710.	3660.	1892.	1892.	231.	48.	166.	556.	186.	48.
FEB	1707.	11611.	0.	3700.	2688.	2624.	1472.	1472.	182.	37.	127.	511.	147.	37.
MAR	1926.	10441.	0.	3435.	2310.	2222.	1363.	1362.	171.	33.	115.	568.	138.	33.
APR	1857.	5534.	0.	2053.	1351.	1238.	813.	813.	106.	18.	63.	533.	87.	18.
MAY	1869.	3358.	1032.	1565.	1121.	985.	589.	589.	78.	123.	39.	642.	65.	123.
JUN	1736.	1894.	1800.	1205.	987.	839.	422.	422.	56.	202.	24.	684.	48.	202.
JUL	1709.	0.	3486.	854.	1069.	876.	249.	249.	38.	380.	10.	854.	28.	380.
AUG	1639.	931.	3142.	1056.	1033.	852.	337.	337.	41.	345.	13.	801.	37.	345.
SEP	1554.	2235.	1958.	1266.	1011.	859.	385.	385.	58.	220.	27.	652.	49.	220.
OCT	1614.	5233.	0.	1902.	1283.	1165.	655.	654.	99.	17.	59.	465.	80.	17.
NOV	1609.	8930.	0.	2928.	1935.	1853.	1013.	1012.	147.	28.	99.	475.	118.	28.
DEC	1741.	14796.	0.	4594.	3421.	3380.	1765.	1765.	224.	47.	161.	531.	180.	47.
ANNUAL	20788.	80266.	11418.	29317.	21918.	20553.	10956.	10952.	1431.	1498.	903.	7273.	1164.	1498.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 21.3 M3 PANEL= 70.2 M2	4000.	3309.	4799.	830.	335.	1520.	638.	15431.
5	FULL ACES, BIN= 21.3 M3 PANEL= 70.2 M2	4000.	3309.	4799.	830.	335.	1520.	638.	15431.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.07	914.	527.71	REF.	REF.	9810.	14032.	45290.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.43	2162.	394.53	133.18	131.	7334.	12935.	36304.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.52	2468.	369.95	157.76	691.	6877.	13344.	35257.
4	MIN. ACES, BIN= 21.3 M3 PANEL= 70.2 M2	2.85	2432.	197.20	330.51	12123.	3666.	21529.	33209.
5	FULL ACES, BIN= 21.3 M3 PANEL= 70.2 M2	2.85	2432.	197.20	330.51	12123.	3666.	21529.	33209.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.02	889.	524.61	3.09	611.	16262.	21070.	26130.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.59	914.	1070.22	-542.51	1037.	26151.	31410.	37179.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.43	960.	431.61	96.10	821.	13316.	18406.	22819.

CHICAGO, ILLINOIS

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 14228.
DESIGN COOLING LOAD (WATTS) = 5661.

EL. ($/KWHR) = 0.0564, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3953, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1300, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -21 C 33 C
TOTAL/SENSIBLE COOLING = 1.21

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE GAS THERMS	(6) GAS FURNACE ELEC. KWH	(7) OIL FURNACE OIL GAL	(7) OIL FURNACE ELEC. KWH	(8) PULSE GAS FURN. GAS THERMS	(8) PULSE GAS FURN. ELEC. KWH
JAN	1851.	14941.	0.	4665.	3425.	3362.	1837.	1837.	227.	47.	162.	561.	183.	47.
FEB	1729.	12057.	0.	3830.	2708.	2627.	1522.	1529.	188.	38.	132.	519.	152.	38.
MAR	1915.	10203.	0.	3366.	2193.	2075.	1339.	1351.	168.	32.	113.	564.	136.	32.
APR	1784.	4856.	0.	1845.	1225.	1108.	731.	736.	97.	15.	56.	511.	79.	15.
MAY	1717.	2120.	1199.	1197.	924.	805.	437.	438.	59.	137.	26.	615.	50.	137.
JUN	1526.	0.	3249.	778.	955.	784.	224.	224.	32.	354.	6.	778.	25.	354.
JUL	1451.	0.	4583.	902.	1090.	876.	552.	235.	25.	499.	1.	902.	24.	499.
AUG	1380.	0.	3845.	802.	972.	789.	733.	216.	26.	419.	3.	802.	23.	419.
SEP	1337.	1050.	1656.	844.	748.	636.	351.	283.	38.	184.	14.	555.	33.	184.
OCT	1457.	2975.	0.	1231.	884.	788.	427.	434.	66.	9.	36.	414.	55.	9.
NOV	1529.	8299.	0.	2730.	1739.	1636.	964.	989.	137.	26.	93.	451.	110.	26.
DEC	1726.	13455.	0.	4217.	2970.	2887.	1613.	1613.	207.	43.	147.	522.	166.	43.
ANNUAL	19401.	69956.	14532.	26407.	19832.	18374.	10732.	9885.	1270.	1805.	788.	7194.	1036.	1805.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 20.8 M3 PANEL= 76.3 M2	4000.	3238.	5140.	830.	335.	1520.	638.	15701.
5	FULL ACES, BIN= 45.6 M3 PANEL= 46.9 M2	4000.	4660.	3492.	830.	335.	1520.	638.	15474.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST AVERAGE $	LIFE CYCLE COST MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.09	914.	1489.61	REF.	REF.	27692.	31914.	41213.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.46	2162.	1118.70	370.91	131.	20797.	26397.	33381.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.57	2468.	1036.50	453.11	691.	19268.	25735.	32206.
4	MIN. ACES, BIN= 20.8 M3 PANEL= 76.3 M2	2.69	2432.	605.36	884.24	12393.	11254.	29387.	33166.
5	FULL ACES, BIN= 45.6 M3 PANEL= 46.9 M2	2.92	2432.	557.63	931.98	12166.	10366.	28272.	31753.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.03	889.	603.78	885.82	611.	17790.	22598.	24392.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.61	914.	1295.85	193.75	1037.	30017.	35277.	34288.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.42	960.	511.19	978.42	821.	14858.	19947.	21527.

EAST ST. LOUIS, ILLINOIS

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 12124.
DESIGN COOLING LOAD (WATTS) = 6955.

EL. ($/KWHR) = 0.0446, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3702, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0600, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -16 C 35 C
TOTAL/SENSIBLE COOLING = 1.24

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1920.	12016.	0.	3871.	2746.	2659.	1563.	1563.	189.	38.	132.	571.	154.	38.
FEB	1743.	8986.	0.	2980.	1999.	1905.	1213.	1221.	147.	28.	99.	513.	121.	28.
MAR	1832.	6983.	0.	2449.	1588.	1472.	991.	1041.	124.	22.	79.	531.	102.	22.
APR	1600.	2494.	888.	1234.	903.	795.	467.	532.	61.	105.	30.	549.	52.	105.
MAY	1433.	655.	2698.	874.	878.	728.	277.	277.	33.	296.	9.	694.	31.	296.
JUN	1201.	0.	4675.	843.	1035.	843.	541.	207.	21.	509.	1.	843.	20.	509.
JUL	1120.	0.	6378.	1006.	1256.	1031.	1171.	223.	19.	695.	0.	1006.	19.	695.
AUG	1109.	0.	6042.	966.	1205.	993.	1115.	217.	19.	658.	1.	966.	18.	658.
SEP	1167.	0.	3501.	706.	890.	734.	669.	186.	25.	381.	6.	706.	19.	381.
OCT	1392.	1812.	1326.	1034.	817.	705.	325.	336.	49.	150.	23.	537.	42.	150.
NOV	1554.	5458.	0.	1948.	1260.	1166.	710.	787.	99.	17.	62.	449.	81.	17.
DEC	1802.	10311.	0.	3365.	2258.	2159.	1329.	1375.	166.	33.	114.	533.	135.	33.
ANNUAL	17872.	48715.	25508.	21277.	16836.	15190.	10372.	7964.	953.	2933.	556.	7898.	794.	2933.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1279.	48.	253.	275.	907.	534.	3606.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	534.	3491.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	634.	4051.
	ANNUAL CYCLE ENERGY SYSTEMS (ACFS)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 17.3 M3 PANEL= 20.8 M2	3500.	2882.	2031.	710.	335.	1267.	638.	11363.
5	FULL ACES, BIN= 97.5 M3 PANEL= 1.7 M2	3500.	6931.	960.	710.	335.	1267.	638.	14342.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.20	914.	948.74	REF.	REF.	17637.	22157.	34325.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.52	2162.	750.71	198.03	-115.	13956.	19609.	29237.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.68	2468.	677.30	271.44	445.	12591.	19110.	27796.
4	MIN. ACES, BIN= 17.3 M3 PANEL= 20.8 M2	2.47	2432.	462.48	486.26	7757.	8598.	22393.	28324.
5	FULL ACES, BIN= 97.5 M3 PANEL= 1.7 M2	3.21	2432.	355.13	593.61	10736.	6602.	23376.	27930.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.09	889.	483.55	465.19	581.	13603.	18679.	21983.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.65	914.	941.54	7.19	1037.	21429.	26985.	29998.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.39	960.	424.62	524.12	821.	11737.	17124.	20156.

URBANA, ILLINOIS

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 13299.
DESIGN COOLING LOAD (WATTS) = 6208.

EL. ($/KWHR) = 0.0481, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3702, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0600, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -19 C 33 C
TOTAL/SENSIBLE COOLING = 1.19

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1853.	15610.	0.	4851.	3684.	3632.	1936.	1936.	236.	49.	169.	564.	190.	49.
FEB	1729.	12078.	0.	3836.	2739.	2668.	1538.	1544.	188.	38.	132.	519.	152.	38.
MAR	1901.	9487.	0.	3164.	2074.	1963.	1262.	1289.	159.	30.	105.	558.	128.	30.
APR	1751.	3991.	0.	1595.	1110.	996.	635.	647.	84.	13.	46.	499.	70.	13.
MAY	1661.	1221.	1966.	1015.	906.	768.	354.	354.	45.	218.	16.	680.	40.	218.
JUN	1454.	0.	3842.	823.	1000.	810.	224.	224.	28.	419.	4.	823.	24.	419.
JUL	1368.	0.	5016.	927.	1127.	906.	765.	232.	23.	546.	1.	927.	23.	546.
AUG	1300.	0.	4977.	903.	1106.	900.	933.	223.	23.	542.	1.	903.	22.	542.
SEP	1274.	682.	2750.	843.	844.	699.	543.	339.	31.	302.	10.	656.	28.	302.
OCT	1412.	2629.	897.	1220.	871.	763.	401.	263.	61.	106.	32.	498.	50.	106.
NOV	1507.	7682.	0.	2553.	1630.	1528.	907.	960.	129.	24.	86.	443.	103.	24.
DEC	1720.	13383.	0.	4196.	2993.	2916.	1632.	1646.	205.	42.	146.	520.	165.	42.
ANNUAL	18931.	66764.	19447.	25925.	20083.	18549.	11131.	9659.	1213.	2330.	748.	7589.	995.	2330.

SYSTEMS FIRST COSTS

NO.		COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 21.7 M3 PANEL= 42.6 M2	4000.	3241.	3253.	710.	335.	1520.	638.	13696.
5	FULL ACES, BIN= 64.9 M3 PANEL= 18.5 M2	4000.	5550.	1903.	710.	335.	1520.	638.	14655.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.13	914.	1246.48	REF.	REF.	23172.	27394.	40538.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.45	2162.	965.57	280.91	131.	17950.	23551.	33732.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.57	2468.	891.84	354.64	691.	16579.	23046.	32450.
4	MIN. ACES, BIN= 21.7 M3 PANEL= 42.6 M2	2.62	2432.	535.16	711.31	10388.	9949.	26077.	31720.
5	FULL ACES, BIN= 64.9 M3 PANEL= 18.5 M2	3.02	2432.	464.39	782.09	11347.	8633.	25720.	30617.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.06	889.	560.95	685.53	611.	16300.	21108.	24359.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.64	914.	1157.65	88.82	1037.	26801.	32060.	33885.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.42	960.	480.48	766.00	821.	13751.	18841.	21721.

FORT WAYNE, INDIANA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 13292.
DESIGN COOLING LOAD (WATTS) = 5651.

EL. ($/KWHR) = 0.0400, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3697, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1100, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -19 C 32 C
TOTAL/SENSIBLE COOLING = 1.16

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1866.	14016.	0.	4412.	3165.	3094.	1769.	1769.	216.	44.	153.	563.	174.	44.
FEB	1734.	10623.	0.	3433.	2342.	2250.	1382.	1394.	170.	34.	117.	515.	137.	34.
MAR	1898.	9189.	0.	3080.	2011.	1899.	1232.	1262.	155.	29.	102.	556.	125.	29.
APR	1743.	4186.	0.	1647.	1140.	1024.	657.	672.	87.	13.	49.	498.	72.	13.
MAY	1651.	1741.	1472.	1102.	898.	774.	392.	392.	52.	166.	22.	624.	45.	166.
JUN	1446.	0.	3510.	784.	956.	781.	219.	219.	29.	382.	5.	784.	24.	382.
JUL	1366.	0.	4823.	905.	1099.	880.	738.	229.	24.	525.	1.	905.	23.	525.
AUG	1306.	0.	4490.	852.	1041.	846.	845.	217.	24.	489.	2.	852.	22.	489.
SEP	1287.	798.	2601.	862.	841.	697.	515.	271.	33.	286.	11.	643.	30.	286.
OCT	1431.	3034.	701.	1317.	910.	803.	442.	456.	67.	86.	36.	484.	55.	86.
NOV	1527.	7808.	0.	2593.	1628.	1524.	938.	995.	131.	25.	88.	449.	105.	25.
DEC	1739.	11888.	0.	3786.	2582.	2485.	1480.	1517.	187.	38.	130.	521.	150.	38.
ANNUAL	18994.	63282.	17595.	24773.	18613.	17058.	10608.	9390.	1174.	2117.	714.	7394.	961.	2117.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 19.7 M3 PANEL= 40.2 M2	4000.	3111.	3117.	710.	335.	1520.	638.	13430.
5	FULL ACES, BIN= 56.9 M3 PANEL= 17.3 M2	4000.	5168.	1836.	710.	335.	1520.	638.	14206.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.12	914.	991.43	REF.	REF.	18431.	22653.	38925.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.49	2162.	744.87	246.55	131.	13847.	19448.	31673.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.63	2468.	682.65	308.78	691.	12690.	19157.	30361.
4	MIN. ACES, BIN= 19.7 M3 PANEL= 40.2 M2	2.62	2432.	424.52	566.91	10122.	7892.	23754.	30722.
5	FULL ACES, BIN= 56.9 M3 PANEL= 17.3 M2	2.95	2432.	375.80	615.63	10898.	6986.	23624.	29792.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.04	889.	518.68	472.74	611.	15318.	20127.	23539.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.62	914.	1088.61	-97.18	1037.	25517.	30776.	32800.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.41	960.	439.95	551.48	821.	12825.	17914.	20960.

INDIANAPOLIS, INDIANA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 12814.
DESIGN COOLING LOAD (WATTS) = 5980.

EL. ($/KWHR) = 0.0401, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3633, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1400, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -18 C 32 C
TOTAL/SENSIBLE COOLING = 1.22

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1901.	12869.	0.	4103.	2881.	2798.	1655.	1655.	202.	41.	141.	569.	163.	41.
FEB	1744.	9577.	0.	3145.	2103.	2004.	1276.	1286.	157.	30.	106.	515.	127.	30.
MAR	1869.	8164.	0.	2787.	1806.	1693.	1123.	1169.	141.	26.	91.	545.	114.	26.
APR	1674.	3489.	0.	1434.	1035.	923.	577.	604.	76.	11.	41.	476.	63.	11.
MAY	1544.	1351.	1653.	984.	844.	719.	350.	350.	45.	184.	17.	613.	39.	184.
JUN	1326.	0.	4110.	816.	998.	807.	214.	214.	25.	448.	3.	816.	22.	448.
JUL	1246.	0.	5418.	936.	1150.	930.	1008.	223.	21.	590.	0.	936.	21.	590.
AUG	1212.	0.	4993.	881.	1081.	882.	931.	213.	21.	544.	1.	881.	20.	544.
SEP	1233.	0.	2932.	662.	842.	696.	569.	293.	29.	319.	8.	662.	21.	319.
OCT	1420.	2656.	916.	1232.	881.	771.	408.	429.	61.	108.	32.	503.	51.	108.
NOV	1549.	7173.	0.	2423.	1538.	1440.	883.	949.	123.	23.	81.	453.	99.	23.
DEC	1779.	11076.	0.	3571.	2406.	2306.	1407.	1456.	177.	35.	122.	529.	142.	35.
ANNUAL	18497.	56356.	20023.	22976.	17564.	15970.	10401.	8841.	1079.	2360.	642.	7498.	882.	2360.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 18.3 M3 PANEL= 26.5 M2	3500.	2991.	2351.	710.	335.	1267.	638.	11793.
5	FULL ACES, BIN= 70.3 M3 PANEL= 8.4 M2	3500.	5772.	1333.	710.	335.	1267.	638.	13556.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.15	914.	920.64	REF.	REF.	17115.	21337.	36407.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.50	2162.	703.81	216.83	131.	13084.	18685.	30205.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.65	2468.	639.90	280.74	691.	11896.	18363.	28837.
4	MIN. ACES, BIN= 18.3 M3 PANEL= 26.5 M2	2.53	2432.	416.76	503.88	8485.	7747.	21972.	28794.
5	FULL ACES, BIN= 70.3 M3 PANEL= 8.4 M2	2.98	2432.	354.26	566.38	10248.	6586.	22574.	28372.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.04	889.	486.53	434.11	611.	14172.	18980.	22605.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.62	914.	1032.89	-112.25	1037.	24079.	29339.	31222.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.40	960.	414.98	505.66	821.	11906.	16995.	20241.

SOUTH BEND, INDIANA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 13078.
DESIGN COOLING LOAD (WATTS) = 5472.

EL. ($/KWHR) = 0.0400, 0.0850
GAS ($/THERM) = 0.3697, 0.8150
OIL ($/GAL.) = 1.1100, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -18 C 32 C
TOTAL/SENSIBLE COOLING = 1.16

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1860.	15081.	0.	4706.	3462.	3405.	1861.	1861.	229.	48.	164.	565.	185.	48.
FEB	1736.	11394.	0.	3648.	2541.	2458.	1457.	1472.	180.	36.	125.	518.	145.	36.
MAR	1914.	9751.	0.	3241.	2134.	2024.	1288.	1306.	162.	31.	108.	562.	131.	31.
APR	1773.	4562.	0.	1760.	1189.	1075.	699.	709.	93.	14.	53.	507.	76.	14.
MAY	1694.	1861.	1481.	1149.	930.	804.	410.	410.	55.	167.	23.	638.	47.	167.
JUN	1495.	0.	3168.	760.	938.	769.	219.	219.	32.	345.	6.	760.	25.	345.
JUL	1415.	0.	4359.	868.	1048.	844.	529.	228.	25.	475.	2.	868.	24.	475.
AUG	1347.	0.	4342.	847.	1032.	839.	820.	219.	24.	473.	2.	847.	22.	473.
SEP	1313.	899.	2347.	870.	823.	687.	471.	279.	35.	259.	12.	623.	31.	259.
OCT	1443.	2925.	650.	1284.	886.	782.	429.	438.	65.	80.	35.	481.	54.	80.
NOV	1527.	7624.	0.	2542.	1582.	1474.	904.	936.	129.	24.	86.	448.	103.	24.
DEC	1732.	12815.	0.	4041.	2794.	2708.	1569.	1574.	199.	41.	140.	522.	159.	41.
ANNUAL	19248.	66913.	16347.	25717.	19360.	17870.	10658.	9651.	1227.	1993.	755.	7340.	1002.	1993.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 21.0 M3 PANEL= 52.8 M2	3500.	3186.	3824.	710.	335.	1267.	638.	13461.
5	FULL ACES, BIN= 50.4 M3 PANEL= 26.1 M2	3500.	4835.	2329.	710.	335.	1267.	638.	13615.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.11	914.	1029.19	REF.	REF.	19133.	23355.	40246.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.47	2162.	774.78	254.41	131.	14403.	20004.	32720.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.59	2468.	715.14	314.04	691.	13295.	19761.	31499.
4	MIN. ACES, BIN= 21.0 M3 PANEL= 52.8 M2	2.67	2432.	426.53	602.66	10153.	7929.	23822.	30822.
5	FULL ACES, BIN= 50.4 M3 PANEL= 26.1 M2	2.95	2432.	386.24	642.95	10307.	7180.	23227.	29566.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.04	889.	533.47	495.72	611.	15852.	20660.	24083.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.61	914.	1132.18	-102.99	1037.	26631.	31891.	33715.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.42	960.	450.22	578.97	821.	13215.	18304.	21340.

DES MOINES, IOWA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 14704.
DESIGN COOLING LOAD (WATTS) = 6181.

EL. ($/KWHR) = 0.0546, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3697, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1100, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -22 C 33 C
TOTAL/SENSIBLE COOLING = 1.20

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE GAS THERMS	(6) GAS FURNACE ELEC. KWH	(7) OIL FURNACE OIL GAL	(7) OIL FURNACE ELEC. KWH	(8) PULSE GAS FURN. GAS THERMS	(8) PULSE GAS FURN. ELEC. KWH
JAN	1839.	16871.	0.	5198.	4116.	4076.	2065.	2065.	251.	53.	182.	564.	203.	53.
FEB	1726.	12627.	0.	3987.	2953.	2891.	1592.	1602.	195.	40.	137.	520.	157.	40.
MAR	1917.	10346.	0.	3407.	2294.	2189.	1357.	1380.	170.	33.	114.	565.	137.	33.
APR	1788.	4358.	0.	1707.	1175.	1058.	679.	689.	90.	14.	50.	510.	74.	14.
MAY	1717.	1344.	1612.	1026.	884.	759.	369.	369.	48.	180.	17.	657.	42.	180.
JUN	1517.	0.	3668.	821.	989.	805.	229.	229.	28.	400.	3.	821.	25.	400.
JUL	1432.	0.	5253.	970.	1178.	941.	614.	243.	24.	572.	1.	970.	24.	572.
AUG	1352.	0.	5094.	931.	1136.	916.	956.	231.	23.	555.	1.	931.	22.	555.
SEP	1305.	830.	2072.	819.	770.	647.	426.	312.	34.	228.	12.	591.	30.	228.
OCT	1423.	2760.	780.	1247.	878.	774.	413.	421.	63.	94.	33.	489.	52.	94.
NOV	1500.	8230.	0.	2703.	1744.	1643.	952.	993.	136.	26.	92.	443.	109.	26.
DEC	1704.	13785.	0.	4303.	3125.	3055.	1670.	1675.	210.	44.	150.	517.	169.	44.
ANNUAL	19220.	71152.	18479.	27119.	21243.	19755.	11323.	10208.	1273.	2239.	794.	7578.	1045.	2239.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 23.2 M3 PANEL= 51.5 M2	4000.	3419.	3747.	830.	335.	1520.	638.	14489.
5	FULL ACES, BIN= 59.5 M3 PANEL= 24.6 M2	4000.	5378.	2242.	830.	335.	1520.	638.	14942.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.12	914.	1480.69	REF.	REF.	27526.	31748.	42210.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.42	2162.	1159.84	320.85	131.	21561.	27162.	35357.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.53	2468.	1078.60	402.09	691.	20051.	26518.	34139.
4	MIN. ACES, BIN= 23.2 M3 PANEL= 51.5 M2	2.67	2432.	618.22	862.47	11180.	11493.	28413.	32782.
5	FULL ACES, BIN= 59.5 M3 PANEL= 24.6 M2	2.96	2432.	557.37	923.32	11634.	10361.	27736.	31674.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.06	889.	592.82	887.87	611.	17176.	21984.	25041.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.64	914.	1294.76	185.93	1037.	29937.	35196.	34971.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.43	960.	508.49	972.20	821.	14505.	19594.	22258.

SIOUX CITY, IOWA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 14960.
DESIGN COOLING LOAD (WATTS) = 6496.

EL. ($/KWHR) = 0.0606, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3697, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1100, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -23 C 34 C
TOTAL/SENSIBLE COOLING = 1.16

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1821.	17503.	0.	5368.	4352.	4319.	2128.	2128.	259.	55.	189.	561.	209.	55.
FEB	1716.	13175.	0.	4137.	3181.	3124.	1648.	1656.	202.	42.	143.	518.	163.	42.
MAR	1920.	10518.	0.	3456.	2366.	2264.	1374.	1397.	172.	33.	116.	567.	139.	33.
APR	1809.	4489.	0.	1750.	1220.	1098.	695.	706.	92.	14.	51.	517.	76.	14.
MAY	1757.	1465.	1789.	1090.	937.	798.	389.	389.	50.	200.	19.	688.	44.	200.
JUN	1567.	0.	3890.	859.	1038.	841.	238.	238.	30.	424.	4.	859.	26.	424.
JUL	1487.	0.	5577.	1021.	1243.	1000.	647.	254.	25.	608.	1.	1021.	25.	608.
AUG	1400.	0.	5353.	972.	1189.	960.	1003.	240.	24.	583.	1.	972.	23.	583.
SEP	1337.	994.	2360.	905.	844.	704.	479.	344.	37.	260.	13.	632.	32.	260.
OCT	1437.	3244.	781.	1385.	952.	842.	461.	471.	69.	95.	38.	494.	57.	95.
NOV	1497.	8697.	0.	2832.	1860.	1764.	991.	1029.	142.	28.	97.	443.	114.	28.
DEC	1689.	13819.	0.	4308.	3154.	3087.	1669.	1675.	210.	44.	151.	513.	169.	44.
ANNUAL	19436.	73905.	19751.	28082.	22335.	20802.	11723.	10527.	1313.	2386.	823.	7785.	1076.	2386.

SYSTEMS FIRST COSTS

NO.		COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	534.	3360.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	534.	3491.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	634.	4051.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 24.0 M3 PANEL= 53.7 M2	4000.	3482.	3873.	830.	335.	1520.	638.	14678.
5	FULL ACES, BIN= 63.6 M3 PANEL= 24.5 M2	4000.	5590.	2235.	830.	335.	1520.	638.	15148.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	584.	3971.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	834.	4397.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	584.	4181.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.12	914.	1700.94	REF.	REF.	31620.	35895.	43612.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.41	2162.	1352.83	348.11	131.	25149.	30802.	36940.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.51	2468.	1260.00	440.94	691.	23423.	29942.	35659.
4	MIN. ACES, BIN= 24.0 M3 PANEL= 53.7 M2	2.68	2432.	710.06	990.88	11317.	13200.	30310.	33531.
5	FULL ACES, BIN= 63.6 M3 PANEL= 24.5 M2	2.98	2432.	637.63	1063.31	11787.	11854.	29433.	32326.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.07	889.	629.74	1071.20	611.	18054.	22914.	25831.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.65	914.	1385.22	315.71	1037.	31836.	37148.	36022.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.44	960.	542.47	1158.47	821.	15290.	20431.	22941.

DODGE CITY, KANSAS

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 12350.
DESIGN COOLING LOAD (WATTS) = 6176.

EL. ($/KWHR) = 0.0526, 0.0850
GAS ($/THERM) = 0.3702, 0.8150
OIL ($/GAL.) = 1.0600, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -17 C 36 C
TOTAL/SENSIBLE COOLING = 1.03

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1903.	11270.	0.	3660.	2568.	2465.	1482.	1482.	179.	36.	124.	564.	147.	36.
FEB	1741.	8645.	0.	2885.	1967.	1867.	1182.	1182.	143.	27.	95.	511.	117.	27.
MAR	1848.	7507.	0.	2599.	1741.	1607.	1065.	1095.	130.	24.	84.	537.	107.	24.
APR	1631.	3474.	949.	1522.	1067.	939.	586.	640.	75.	114.	41.	568.	63.	114.
MAY	1475.	1199.	2134.	975.	874.	736.	332.	332.	42.	236.	16.	646.	37.	236.
JUN	1242.	0.	4527.	838.	1030.	844.	370.	210.	23.	493.	2.	838.	21.	493.
JUL	1152.	0.	5800.	952.	1178.	969.	1070.	218.	19.	632.	0.	952.	19.	632.
AUG	1125.	0.	5687.	932.	1156.	953.	1052.	213.	19.	620.	0.	932.	19.	620.
SEP	1166.	0.	3445.	699.	886.	737.	659.	185.	26.	375.	6.	699.	19.	375.
OCT	1374.	2309.	1543.	1191.	913.	785.	377.	386.	55.	175.	28.	557.	46.	175.
NOV	1528.	6649.	0.	2272.	1482.	1366.	835.	899.	114.	21.	74.	446.	93.	21.
DEC	1776.	9647.	0.	3173.	2088.	1969.	1257.	1300.	157.	31.	107.	524.	128.	31.
ANNUAL	17960.	50701.	24085.	21698.	16950.	15238.	10266.	8142.	980.	2784.	578.	7774.	815.	2784.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 16.4 M3 PANEL= 12.2 M2	3500.	2827.	1547.	710.	335.	1267.	638.	10824.
5	FULL ACES, BIN= 86.5 M3 PANEL= 2.4 M2	3500.	6471.	1000.	710.	335.	1267.	638.	13921.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING %	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.19	914.	1141.11	REF.	REF.	21213.	25435.	34617.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.52	2162.	891.42	249.69	131.	16572.	22172.	29345.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.69	2468.	801.37	339.74	691.	14897.	21364.	27812.
4	MIN. ACES, BIN= 16.4 M3 PANEL= 12.2 M2	2.51	2432.	539.86	601.24	7516.	10036.	23292.	27636.
5	FULL ACES, BIN= 86.5 M3 PANEL= 2.4 M2	3.16	2432.	428.19	712.92	10613.	7960.	24313.	27758.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.08	889.	509.42	631.69	581.	14218.	18996.	21848.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.64	914.	1021.28	119.82	1037.	23065.	28324.	30051.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.40	960.	448.30	692.81	821.	12282.	17372.	19942.

TOPEKA, KANSAS

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 12362.
DESIGN COOLING LOAD (WATTS) = 6982.

EL. ($/KWHR) = 0.0507, 0.0850 PWF = 18.59, 16.48
GAS (*/THERM) = 0.3697, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1100, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -17 C 36 C
TOTAL/SENSIBLE COOLING = 1.23

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE GAS THERMS	(6) GAS FURNACE ELEC. KWH	(7) OIL FURNACE OIL GAL	(7) OIL FURNACE ELEC. KWH	(8) PULSE GAS FURN. GAS THERMS	(8) PULSE GAS FURN. ELEC. KWH
JAN	1896.	13243.	0.	4206.	3039.	2945.	1687.	1687.	204.	42.	145.	569.	167.	42.
FEB	1743.	9718.	0.	3184.	2155.	2047.	1289.	1293.	157.	31.	107.	515.	128.	31.
MAR	1864.	7927.	0.	2720.	1784.	1652.	1097.	1140.	136.	25.	89.	543.	112.	25.
APR	1658.	3038.	750.	1386.	978.	866.	532.	574.	69.	91.	36.	552.	59.	91.
MAY	1511.	722.	2531.	896.	882.	735.	291.	291.	36.	278.	10.	698.	32.	278.
JUN	1279.	0.	4588.	855.	1043.	848.	376.	215.	23.	500.	1.	855.	21.	500.
JUL	1185.	0.	6580.	1046.	1303.	1063.	1209.	233.	20.	717.	0.	1046.	20.	717.
AUG	1148.	0.	6246.	999.	1246.	1026.	1153.	224.	20.	680.	1.	999.	19.	680.
SEP	1175.	0.	3118.	666.	843.	697.	604.	182.	26.	340.	7.	666.	20.	340.
OCT	1372.	1913.	1225.	1046.	809.	699.	332.	344.	50.	140.	24.	521.	42.	140.
NOV	1518.	6143.	0.	2128.	1372.	1264.	765.	845.	107.	19.	69.	441.	88.	19.
DEC	1764.	11132.	0.	3583.	2420.	2309.	1407.	1455.	175.	35.	123.	525.	143.	35.
ANNUAL	18114.	53834.	25038.	22715.	17873.	16150.	10742.	8483.	1023.	2898.	611.	7930.	850.	2898.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1279.	48.	253.	275.	907.	534.	3606.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	534.	3491.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	634.	4051.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 18.8 M3 PANEL= 22.3 M2	3500.	2997.	2112.	710.	335.	1267.	638.	11560.
5	FULL ACES, BIN= 94.2 M3 PANEL= 3.6 M2	3500.	6805.	1065.	710.	335.	1267.	638.	14320.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST AVERAGE $	LIFE CYCLE COST MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.19	914.	1150.75	REF.	REF.	21393.	25912.	36339.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.51	2162.	905.44	245.32	-115.	16832.	22485.	30689.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.67	2468.	818.18	332.58	445.	15210.	21729.	29142.
4	MIN. ACES, BIN= 18.8 M3 PANEL= 22.3 M2	2.51	2432.	544.20	606.55	7954.	10117.	24108.	29039.
5	FULL ACES, BIN= 94.2 M3 PANEL= 3.6 M2	3.18	2432.	429.77	720.98	10715.	7989.	24742.	28636.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.09	889.	524.85	625.91	581.	14701.	19777.	22869.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.65	914.	1079.65	71.11	1037.	24585.	30142.	31360.
8	PULSE GAS FURNACE, GAS HW. CENTRAL AC	2.41	960.	461.03	689.72	821.	12680.	18067.	20862.

LOUISVILLE, KENTUCKY

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 11225.
DESIGN COOLING LOAD (WATTS) = 6640.

EL. ($/KWHR) = 0.0415, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3667, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -14 C 34 C
TOTAL/SENSIBLE COOLING = 1.21

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1877.	9932.	0.	3281.	2188.	2084.	1341.	1287.	162.	31.	110.	553.	132.	31.
FEB	1691.	6955.	0.	2402.	1566.	1470.	993.	942.	121.	22.	78.	492.	99.	22.
MAR	1765.	5834.	0.	2111.	1374.	1264.	869.	828.	108.	18.	66.	509.	89.	18.
APR	1535.	2261.	1196.	1185.	903.	786.	439.	431.	57.	137.	27.	564.	49.	137.
MAY	1373.	704.	2910.	894.	900.	744.	278.	278.	33.	319.	10.	701.	30.	319.
JUN	1158.	0.	4839.	849.	1051.	859.	726.	205.	21.	527.	2.	849.	19.	527.
JUL	1092.	0.	6636.	1026.	1286.	1060.	1214.	223.	18.	723.	0.	1026.	18.	723.
AUG	1097.	0.	6097.	969.	1209.	999.	1122.	216.	19.	664.	0.	969.	18.	664.
SEP	1164.	0.	3992.	758.	951.	781.	753.	505.	24.	435.	5.	758.	19.	435.
OCT	1390.	1941.	1417.	1080.	848.	729.	341.	334.	50.	161.	24.	547.	43.	161.
NOV	1544.	4847.	0.	1775.	1184.	1085.	663.	645.	91.	15.	56.	444.	75.	15.
DEC	1777.	8087.	0.	2740.	1769.	1665.	1104.	1075.	137.	26.	91.	519.	112.	26.
ANNUAL	17462.	40561.	27088.	19070.	15227.	13527.	9841.	6969.	841.	3079.	469.	7930.	704.	3079.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	534.	3360.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	534.	3491.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	634.	4051.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 14.7 M3 PANEL= 12.2 M2	3500.	2643.	1548.	710.	335.	1267.	638.	10642.
5	FULL ACES, BIN= 93.3 M3 PANEL= 0.0 M2	3500.	6690.	0.	710.	335.	1267.	638.	13140.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	584.	3941.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	834.	4397.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	584.	4181.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.24	914.	791.60	REF.	REF.	14716.	18990.	30988.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.55	2162.	632.06	159.54	131.	11750.	17403.	26982.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.75	2468.	561.51	230.09	691.	10438.	16957.	25468.
4	MIN. ACES, BIN= 14.7 M3 PANEL= 12.2 M2	2.40	2432.	408.50	383.10	7282.	7594.	20668.	26859.
5	FULL ACES, BIN= 93.3 M3 PANEL= 0.0 M2	3.39	2432.	289.27	502.33	9780.	5378.	20949.	25334.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.09	889.	436.23	355.37	581.	12143.	16974.	20440.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.65	914.	877.61	-86.01	1037.	19967.	25279.	27698.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.38	960.	385.91	405.69	821.	10550.	15691.	18908.

LAKE CHARLES, LOUISIANA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 6680.
DESIGN COOLING LOAD (WATTS) = 7571.

EL. ($/KWHR) = 0.0477, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3667, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -2 C 34 C
TOTAL/SENSIBLE COOLING = 1.43

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1517.	3590.	0.	1419.	986.	888.	630.	556.	74.	11.	42.	433.	62.	11.
FEB	1366.	2147.	820.	1065.	783.	688.	446.	395.	53.	96.	26.	476.	45.	96.
MAR	1435.	1433.	1578.	969.	814.	694.	345.	345.	44.	176.	18.	575.	38.	176.
APR	1266.	0.	3094.	689.	853.	697.	391.	192.	26.	337.	5.	689.	21.	337.
MAY	1158.	0.	5729.	946.	1174.	950.	1047.	856.	20.	624.	1.	946.	19.	624.
JUN	1001.	0.	7781.	1126.	1428.	1184.	1405.	1422.	17.	848.	0.	1126.	17.	848.
JUL	962.	0.	8889.	1236.	1581.	1328.	1600.	1621.	16.	968.	0.	1236.	16.	968.
AUG	967.	0.	8671.	1213.	1551.	1298.	1563.	1585.	16.	945.	0.	1213.	16.	945.
SEP	1010.	0.	6796.	1021.	1286.	1061.	1235.	1255.	17.	740.	0.	1021.	17.	740.
OCT	1176.	0.	3963.	759.	945.	781.	742.	761.	23.	432.	4.	759.	20.	432.
NOV	1279.	1537.	1557.	952.	782.	667.	290.	342.	43.	175.	20.	530.	37.	175.
DEC	1448.	2570.	567.	1178.	827.	737.	515.	425.	60.	70.	31.	472.	50.	70.
ANNUAL	14587.	11277.	49446.	12572.	13010.	10974.	10209.	9756.	409.	5422.	148.	9475.	358.	5422.

SYSTEMS FIRST COSTS

NO.		COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 6.3 M3 PANEL= 1.8 M2	2950.	1704.	964.	636.	335.	843.	482.	7914.
5	FULL ACES, BIN= 19.7 M3 PANEL= 0.0 M2	2950.	2728.	0.	636.	335.	843.	482.	7974.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.66	914.	599.94	REF.	REF.	11153.	15626.	22084.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.61	2162.	620.82	-20.88	80.	11541.	17342.	24024.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.91	2468.	523.66	76.28	640.	9735.	16402.	22039.
4	MIN. ACES, BIN= 6.3 M3 PANEL= 1.8 M2	2.05	2432.	487.19	112.75	4355.	9057.	19403.	24647.
5	FULL ACES, BIN= 19.7 M3 PANEL= 0.0 M2	2.14	2432.	465.57	134.37	4415.	8655.	19061.	24073.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.22	889.	408.89	191.05	628.	9565.	14641.	18170.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.82	914.	625.42	-25.48	1084.	12781.	18337.	22393.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.35	960.	389.86	210.08	868.	8962.	14349.	17785.

NEW ORLEANS, LOUISIANA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 6304.
DESIGN COOLING LOAD (WATTS) = 7351.

EL. ($/KWHR) = 0.0454, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3550, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -1 C 33 C
TOTAL/SENSIBLE COOLING = 1.51

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1485.	2954.	0.	1233.	892.	798.	560.	484.	66.	9.	35.	422.	55.	9.
FEB	1336.	1681.	938.	940.	728.	636.	382.	342.	46.	107.	21.	479.	39.	107.
MAR	1407.	1161.	1632.	891.	778.	664.	313.	313.	40.	182.	15.	572.	35.	182.
APR	1247.	0.	3094.	683.	841.	687.	488.	190.	25.	337.	5.	683.	21.	337.
MAY	1150.	0.	5521.	921.	1140.	922.	1010.	1027.	20.	601.	1.	921.	19.	601.
JUN	1002.	0.	7295.	1073.	1357.	1112.	1318.	1334.	17.	795.	0.	1073.	17.	795.
JUL	970.	0.	8586.	1205.	1539.	1285.	1546.	1564.	16.	935.	0.	1205.	16.	935.
AUG	976.	0.	8586.	1206.	1540.	1287.	1547.	1565.	16.	935.	0.	1206.	16.	935.
SEP	1014.	0.	6878.	1031.	1298.	1058.	1248.	1265.	17.	749.	0.	1031.	17.	749.
OCT	1171.	0.	3927.	753.	931.	762.	734.	750.	23.	428.	3.	753.	19.	428.
NOV	1263.	1204.	1505.	849.	724.	620.	315.	328.	38.	168.	16.	519.	33.	168.
DEC	1422.	2359.	618.	1118.	799.	711.	491.	401.	57.	75.	29.	470.	48.	75.
ANNUAL	14442.	9359.	48581.	11904.	12568.	10542.	9951.	9563.	380.	5322.	126.	9334.	336.	5322.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 5.5 M3 PANEL= 1.6 M2	2950.	1600.	956.	636.	335.	843.	482.	7802.
5	FULL ACES, BIN= 16.2 M3 PANEL= 0.0 M2	2950.	2474.	0.	636.	335.	843.	482.	7720.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.69	914.	541.06	REF.	REF.	10058.	14531.	21149.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.60	2162.	571.23	-30.17	80.	10619.	16420.	23406.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.91	2468.	479.13	61.93	640.	8907.	15574.	21434.
4	MIN. ACES, BIN= 5.5 M3 PANEL= 1.6 M2	2.02	2432.	452.29	88.77	4243.	8408.	18642.	24174.
5	FULL ACES, BIN= 16.2 M3 PANEL= 0.0 M2	2.10	2432.	434.63	106.43	4161.	8080.	18232.	23548.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.23	889.	376.70	164.36	628.	8766.	13842.	17632.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.82	914.	571.35	-30.29	1084.	11601.	17158.	21657.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.34	960.	361.01	180.05	868.	8269.	13656.	17349.

SHREVEPORT, LOUISIANA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 8057.
DESIGN COOLING LOAD (WATTS) = 7905.

EL. ($/KWHR) = 0.0356, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3667, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -6 C 36 C
TOTAL/SENSIBLE COOLING = 1.34

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1647.	5495.	0.	1984.	1302.	1196.	839.	778.	101.	17.	63.	475.	83.	17.
FEB	1482.	3518.	0.	1389.	956.	860.	608.	545.	73.	11.	41.	423.	60.	11.
MAR	1548.	2710.	831.	1273.	914.	804.	507.	476.	63.	99.	32.	529.	53.	99.
APR	1350.	754.	2177.	822.	790.	658.	270.	270.	33.	240.	10.	615.	30.	240.
MAY	1216.	0.	4761.	856.	1057.	863.	882.	210.	22.	519.	2.	856.	20.	519.
JUN	1032.	0.	6545.	1000.	1255.	1037.	1191.	469.	17.	713.	0.	1000.	17.	713.
JUL	981.	0.	8815.	1233.	1575.	1330.	1591.	1635.	16.	960.	0.	1233.	16.	960.
AUG	987.	0.	8356.	1184.	1509.	1269.	1512.	1558.	16.	910.	0.	1184.	16.	910.
SEP	1044.	0.	5612.	901.	1126.	925.	1032.	1074.	18.	611.	1.	901.	17.	611.
OCT	1238.	716.	2848.	853.	854.	711.	554.	592.	31.	313.	10.	656.	28.	313.
NOV	1366.	2552.	937.	1191.	869.	765.	276.	398.	58.	110.	31.	490.	49.	110.
DEC	1564.	4488.	0.	1681.	1113.	1012.	706.	651.	87.	14.	52.	449.	72.	14.
ANNUAL	15454.	20233.	40883.	14368.	13323.	11431.	9968.	8657.	537.	4518.	242.	8811.	463.	4518.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 8.9 M3 PANEL= 4.1 M2	3130.	2010.	1093.	636.	335.	1049.	534.	8787.
5	FULL ACES, BIN= 44.1 M3 PANEL= 0.0 M2	3130.	4202.	0.	636.	335.	1049.	534.	9885.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.48	914.	511.21	REF.	REF.	9503.	13976.	24599.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.60	2162.	474.03	37.18	80.	8812.	14613.	24463.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.86	2468.	406.70	104.50	640.	7561.	14227.	22679.
4	MIN. ACES, BIN= 8.9 M3 PANEL= 4.1 M2	2.13	2432.	354.65	156.56	5228.	6593.	17812.	25182.
5	FULL ACES, BIN= 44.1 M3 PANEL= 0.0 M2	2.46	2432.	308.01	203.20	6327.	5726.	18043.	24444.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.18	889.	357.57	153.64	628.	9222.	14297.	18613.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.75	914.	597.03	-85.82	1084.	12987.	18544.	23730.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.35	960.	330.61	180.60	868.	8368.	13755.	17937.

PORTLAND, MAINE

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 13797.
DESIGN COOLING LOAD (WATTS) = 4619.

EL. ($/KWHR) = 0.0629, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.6319, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1800, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -20 C 30 C
TOTAL/SENSIBLE COOLING = 1.10

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1825.	15276.	0.	4751.	3604.	3545.	1895.	1895.	231.	48.	166.	555.	186.	48.
FEB	1710.	12308.	0.	3894.	2863.	2794.	1563.	1562.	191.	39.	134.	514.	154.	39.
MAR	1923.	10185.	0.	3364.	2247.	2146.	1344.	1343.	168.	32.	113.	567.	136.	32.
APR	1839.	5782.	0.	2117.	1340.	1223.	844.	843.	110.	18.	66.	529.	90.	18.
MAY	1828.	2960.	656.	1402.	986.	878.	539.	538.	72.	81.	35.	589.	61.	81.
JUN	1675.	1027.	1747.	941.	848.	726.	331.	331.	43.	194.	14.	659.	38.	194.
JUL	1629.	0.	3041.	784.	941.	775.	233.	233.	32.	331.	5.	784.	27.	331.
AUG	1553.	0.	2920.	750.	921.	764.	222.	312.	33.	318.	7.	750.	26.	318.
SEP	1476.	1518.	1399.	984.	811.	702.	304.	304.	46.	157.	19.	567.	40.	157.
OCT	1551.	3845.	0.	1499.	989.	896.	527.	526.	80.	12.	45.	443.	65.	12.
NOV	1570.	7173.	0.	2429.	1508.	1401.	868.	866.	124.	23.	81.	459.	99.	23.
DEC	1723.	13076.	0.	4111.	2945.	2876.	1598.	1598.	202.	41.	143.	520.	162.	41.
ANNUAL	20301.	73151.	9762.	27025.	20002.	18727.	10267.	10353.	1332.	1295.	829.	6935.	1083.	1295.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 21.2 M3 PANEL= 42.7 M2	4000.	3240.	3258.	830.	335.	1520.	638.	13820.
5	FULL ACES, BIN= 21.2 M3 PANEL= 42.7 M2	4000.	3240.	3258.	830.	335.	1520.	638.	13820.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.06	914.	1698.79	REF.	REF.	31580.	35803.	42079.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.43	2162.	1257.34	441.45	131.	23374.	28975.	33620.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.53	2468.	1177.18	521.61	691.	21884.	28351.	32700.
4	MIN. ACES, BIN= 21.2 M3 PANEL= 42.7 M2	2.79	2432.	645.41	1053.37	10512.	11998.	28251.	30635.
5	FULL ACES, BIN= 21.2 M3 PANEL= 42.7 M2	2.77	2432.	645.41	1053.37	10512.	11998.	28251.	30635.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.00	889.	923.22	775.57	611.	28173.	32982.	24515.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.57	914.	1414.29	284.49	1037.	32808.	38067.	34923.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.41	960.	765.86	932.92	821.	23190.	28279.	21452.

FALMOUTH, MASSACHUSETTS

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 11294.
DESIGN COOLING LOAD (WATTS) = 4563.

EL. ($/KWHR) = 0.0786, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.6319, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1800, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -14 C 28 C
TOTAL/SENSIBLE COOLING = 1.29

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1876.	12472.	0.	3986.	2883.	2851.	1604.	1604.	194.	39.	137.	561.	158.	39.
FEB	1743.	11128.	0.	3575.	2557.	2526.	1441.	1441.	175.	35.	122.	519.	142.	35.
MAR	1912.	9023.	0.	3038.	1963.	1900.	1222.	1231.	151.	29.	101.	560.	124.	29.
APR	1763.	5177.	0.	1928.	1207.	1119.	772.	777.	99.	16.	60.	506.	82.	16.
MAY	1679.	2711.	0.	1220.	881.	786.	488.	491.	66.	9.	33.	475.	56.	9.
JUN	1480.	570.	1875.	774.	756.	641.	261.	261.	33.	206.	9.	617.	30.	206.
JUL	1405.	0.	3454.	767.	907.	736.	213.	213.	24.	376.	1.	767.	23.	376.
AUG	1345.	0.	3298.	733.	873.	709.	635.	204.	24.	359.	2.	733.	22.	359.
SEP	1321.	741.	1758.	764.	716.	607.	363.	254.	33.	194.	11.	561.	30.	194.
OCT	1459.	2505.	0.	1101.	770.	694.	393.	399.	59.	8.	31.	413.	50.	8.
NOV	1547.	5161.	0.	1864.	1153.	1068.	677.	690.	96.	16.	60.	446.	78.	16.
DEC	1753.	10542.	0.	3416.	2360.	2308.	1338.	1343.	168.	33.	116.	520.	137.	33.
ANNUAL	19281.	60031.	10384.	23164.	17029.	15945.	9408.	8909.	1123.	1321.	681.	6678.	932.	1321.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 17.8 M3 PANEL= 27.1 M2	3500.	2871.	2383.	710.	335.	1267.	638.	11704.
5	FULL ACES, BIN= 31.2 M3 PANEL= 20.8 M2	3500.	3701.	2032.	710.	335.	1267.	638.	12183.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.08	914.	1820.94	REF.	REF.	33851.	38074.	36671.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.46	2162.	1338.62	482.32	131.	24885.	30486.	29455.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.56	2468.	1253.43	567.51	691.	23301.	29768.	28802.
4	MIN. ACES, BIN= 17.8 M3 PANEL= 27.1 M2	2.65	2432.	739.60	1081.34	8396.	13749.	27886.	27316.
5	FULL ACES, BIN= 31.2 M3 PANEL= 20.8 M2	2.80	2432.	700.30	1120.64	8875.	13019.	27634.	27095.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.03	889.	813.75	1007.20	581.	24413.	29191.	21718.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.56	914.	1328.97	491.97	1037.	30060.	35320.	31008.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.39	960.	693.10	1127.85	821.	20592.	25681.	19464.

BATTLE CREEK, MICHIGAN

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 12208.
DESIGN COOLING LOAD (WATTS) = 4888.

EL. ($/KWHR) = 0.0542, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3702, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0600, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -16 C 32 C
TOTAL/SENSIBLE COOLING = 1.12

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1863.	13804.	0.	4352.	3095.	3028.	1738.	1738.	211.	44.	150.	561.	172.	44.
FEB	1738.	11449.	0.	3663.	2543.	2467.	1463.	1471.	179.	36.	125.	519.	146.	36.
MAR	1922.	9728.	0.	3236.	2174.	2081.	1287.	1298.	160.	31.	108.	565.	131.	31.
APR	1790.	5297.	0.	1969.	1293.	1183.	783.	789.	101.	17.	61.	514.	84.	17.
MAY	1725.	1894.	1274.	1144.	910.	791.	415.	415.	55.	145.	24.	624.	48.	145.
JUN	1534.	0.	3515.	809.	983.	801.	229.	229.	30.	383.	5.	809.	26.	383.
JUL	1463.	0.	4198.	864.	1042.	839.	512.	231.	26.	457.	2.	864.	24.	457.
AUG	1395.	0.	3526.	772.	935.	757.	675.	213.	26.	384.	4.	772.	23.	384.
SEP	1354.	1179.	1512.	869.	747.	636.	324.	294.	39.	168.	16.	545.	35.	168.
OCT	1475.	3334.	0.	1336.	947.	843.	464.	471.	70.	11.	39.	420.	59.	11.
NOV	1546.	8189.	0.	2705.	1690.	1582.	963.	1005.	135.	26.	91.	455.	109.	26.
DEC	1741.	12925.	0.	4074.	2818.	2740.	1579.	1593.	198.	41.	141.	525.	161.	41.
ANNUAL	19547.	67800.	14025.	25793.	19176.	17749.	10432.	9747.	1231.	1743.	766.	7173.	1016.	1743.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 19.5 M3 PANEL= 56.7 M2	3500.	3033.	4039.	710.	335.	1267.	638.	13522.
5	FULL ACES, BIN= 42.4 M3 PANEL= 35.3 M2	3500.	4368.	2844.	710.	335.	1267.	638.	13662.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.09	914.	1398.77	REF.	REF.	26003.	30225.	40353.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.47	2162.	1039.90	358.87	131.	19332.	24933.	32462.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.59	2468.	962.50	436.26	691.	17893.	24360.	31329.
4	MIN. ACES, BIN= 19.5 M3 PANEL= 56.7 M2	2.70	2432.	565.74	833.02	10214.	10517.	26472.	30568.
5	FULL ACES, BIN= 42.4 M3 PANEL= 35.3 M2	2.89	2432.	528.56	870.21	10354.	9826.	25920.	29747.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.04	889.	550.38	848.39	581.	16194.	20973.	23759.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.60	914.	1200.87	197.90	1037.	27731.	32990.	33736.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.41	960.	470.66	928.11	821.	13670.	18759.	21177.

DETROIT, MICHIGAN

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 11773.
DESIGN COOLING LOAD (WATTS) = 5560.

EL. ($/KWHR) = 0.0557, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.4034, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1300, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -15 C 32 C
TOTAL/SENSIBLE COOLING = 1.19

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1841.	15490.	0.	4814.	3576.	3528.	1911.	1911.	232.	49.	168.	560.	188.	49.
FEB	1728.	12889.	0.	4061.	2956.	2893.	1615.	1619.	197.	41.	140.	521.	160.	41.
MAR	1929.	10643.	0.	3493.	2296.	2179.	1384.	1391.	172.	34.	117.	570.	141.	34.
APR	1814.	5224.	0.	1955.	1274.	1159.	773.	777.	101.	17.	60.	520.	83.	17.
MAY	1762.	2092.	1119.	1193.	923.	808.	438.	438.	59.	129.	26.	618.	51.	129.
JUN	1575.	560.	2684.	886.	902.	747.	283.	283.	34.	294.	8.	732.	32.	294.
JUL	1500.	0.	4439.	900.	1085.	868.	392.	239.	27.	484.	2.	900.	25.	484.
AUG	1419.	0.	3951.	825.	998.	804.	752.	222.	26.	430.	3.	825.	24.	430.
SEP	1361.	907.	1993.	847.	786.	661.	410.	279.	36.	220.	12.	598.	32.	220.
OCT	1465.	2912.	0.	1216.	863.	769.	419.	423.	65.	9.	35.	416.	54.	9.
NOV	1524.	7393.	0.	2477.	1533.	1421.	866.	881.	124.	23.	83.	447.	101.	23.
DEC	1714.	13276.	0.	4164.	2893.	2814.	1595.	1597.	202.	42.	145.	518.	164.	42.
ANNUAL	19632.	71386.	14186.	26831.	20084.	18653.	10837.	10059.	1273.	1772.	799.	7225.	1054.	1772.

SYSTEMS FIRST COSTS

NO.		COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 21.5 M3 PANEL= 75.4 M2	3500.	3144.	5086.	710.	335.	1267.	638.	14680.
5	FULL ACES, BIN= 42.5 M3 PANEL= 50.0 M2	3500.	4349.	3663.	710.	335.	1267.	638.	14462.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.09	914.	1495.00	REF.	REF.	27792.	32014.	41806.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.46	2162.	1119.09	375.91	131.	20804.	26405.	33735.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.57	2468.	1039.35	455.65	691.	19321.	25788.	32596.
4	MIN. ACES, BIN= 21.5 M3 PANEL= 75.4 M2	2.70	2432.	603.86	891.14	11372.	11226.	28338.	32293.
5	FULL ACES, BIN= 42.5 M3 PANEL= 50.0 M2	2.91	2432.	560.48	934.52	11154.	10419.	27314.	30985.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.06	889.	612.19	882.80	581.	18097.	22875.	24356.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.61	914.	1305.68	189.32	1037.	30287.	35546.	34610.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.42	960.	523.91	971.09	821.	15301.	20390.	21728.

SAULT SAINTE MARIE, MICHIGAN

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 15759.
DESIGN COOLING LOAD (WATTS) = 3703.

EL. ($/KWHR) = 0.0327, 0.0850
GAS ($/THERM) = 0.3702, 0.8150
OIL ($/GAL.) = 1.0600, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -25 C 27 C
TOTAL/SENSIBLE COOLING = 1.06

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1803.	19580.	0.	5940.	5185.	5184.	2341.	2341.	284.	62.	213.	563.	230.	62.
FEB	1665.	16916.	0.	5162.	4464.	4461.	2035.	2031.	248.	54.	184.	516.	200.	54.
MAR	1887.	13985.	0.	4409.	3416.	3400.	1737.	1734.	216.	44.	155.	569.	174.	44.
APR	1855.	8005.	0.	2739.	1798.	1731.	1078.	1077.	139.	25.	91.	541.	112.	25.
MAY	1927.	4103.	0.	1675.	1171.	1069.	659.	659.	89.	13.	49.	548.	74.	13.
JUN	1852.	1783.	1471.	1170.	956.	828.	430.	430.	57.	166.	25.	680.	49.	166.
JUL	1880.	741.	2560.	1007.	990.	829.	336.	336.	42.	281.	12.	804.	39.	281.
AUG	1835.	823.	2162.	974.	930.	786.	334.	334.	43.	238.	13.	748.	39.	238.
SEP	1735.	2332.	657.	1201.	878.	789.	394.	393.	62.	79.	30.	561.	53.	79.
OCT	1762.	4894.	0.	1849.	1179.	1091.	632.	630.	97.	16.	59.	505.	79.	16.
NOV	1696.	10400.	0.	3360.	2269.	2224.	1164.	1154.	167.	33.	117.	504.	134.	33.
DEC	1768.	17032.	0.	5223.	4304.	4300.	1995.	1991.	252.	54.	186.	545.	203.	54.
ANNUAL	21665.	100594.	6851.	34710.	27540.	26693.	13136.	13109.	1696.	1065.	1134.	7083.	1386.	1065.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	350.	1129.	48.	305.	275.	811.	482.	3400.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	350.	1199.	77.	305.	275.	843.	482.	3531.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	350.	1199.	77.	705.	335.	843.	582.	4091.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 26.5 M3 PANEL=226.1 M2*	4000.	3685.	13527.	830.	335.	1520.	638.	24535.*
5	FULL ACES, BIN= 26.5 M3 PANEL=226.1 M2*	4000.	3685.	13527.	830.	335.	1520.	638.	24535.*
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	720.	1129.	26.	632.	275.	811.	782.	4375.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.03	914.	1135.72	REF.	REF.	21113.	25427.	52936.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.30	2162.	901.11	234.61	131.	16752.	22444.	44271.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.34	2468.	873.40	262.32	691.	16237.	22795.	43951.
4	MIN. ACES, BIN= 26.5 M3 PANEL=226.1 M2	2.73	2432.	429.80	705.92	21135.	7990.	34957.*	45368.
5	FULL ACES, BIN= 26.5 M3 PANEL=226.1 M2	2.74	2432.	429.80	705.92	21135.	7990.	34957.*	45368.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.03	889.	662.79	472.93	519.	20535.	25343.	29082.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.59	914.	1433.58	-297.86	975.	34654.	39944.	42491.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.46	960.	547.77	587.95	729.	16892.	21981.	25190.

*UNGI ?D PANEL EXCEEDS A PRACTICAL SIZE, AN ALTERNATIVE SUPPLEMENTARY HEAT SOURCE SHOULD BE USED IN THIS DESIGN.

DULUTH, MINNESOTA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 17514.
DESIGN COOLING LOAD (WATTS) = 3661.

EL. ($/KWHR) = 0.0508, 0.0850
GAS ($/THERM) = 0.3697, 0.8150
OIL ($/GAL.) = 1.1100, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -28 C 28 C
TOTAL/SENSIBLE COOLING = 1.03

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1828.	23689.	0.	7089.	6526.	6526.	2785.	2688.	338.	75.	256.	583.	272.	75.
FEB	1670.	18333.	0.	5557.	4919.	4916.	2184.	2181.	267.	58.	199.	522.	215.	58.
MAR	1878.	14760.	0.	4622.	3653.	3635.	1817.	1814.	227.	47.	162.	568.	182.	47.
APR	1843.	8497.	0.	2872.	1919.	1855.	1129.	1127.	146.	27.	97.	539.	117.	27.
MAY	1923.	4455.	0.	1772.	1212.	1109.	696.	695.	95.	14.	53.	548.	77.	14.
JUN	1866.	1694.	1370.	1138.	930.	809.	421.	421.	56.	155.	24.	673.	48.	155.
JUL	1918.	714.	2366.	989.	968.	817.	334.	334.	43.	260.	12.	793.	39.	260.
AUG	1896.	760.	2128.	970.	932.	792.	333.	333.	43.	234.	12.	761.	39.	234.
SEP	1807.	2678.	582.	1309.	932.	839.	431.	430.	69.	72.	34.	574.	57.	72.
OCT	1840.	5461.	0.	2028.	1307.	1214.	689.	687.	107.	17.	65.	528.	86.	17.
NOV	1763.	12649.	0.	4004.	2938.	2913.	1371.	1360.	198.	40.	140.	530.	158.	40.
DEC	1817.	19704.	0.	5979.	5219.	5217.	2274.	2030.	288.	62.	214.	567.	231.	62.
ANNUAL	22049.	113393.	6447.	38329.	31455.	30642.	14464.	14102.	1877.	1061.	1268.	7187.	1522.	1061.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	350.	1129.	48.	305.	275.	811.	482.	3400.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	350.	1199.	77.	305.	275.	843.	482.	3531.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	350.	1199.	77.	705.	335.	843.	582.	4091.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 31.7 M3 PANEL=466.5 M2*	4000.	4091.	26993.	830.	335.	1520.	638.	38406.*
5	FULL ACES, BIN= 31.7 M3 PANEL=466.5 M2*	4000.	4091.	26993.	830.	335.	1520.	638.	38406.*
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	815.	1129.	26.	376.	270.	811.	532.	3959.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	720.	1129.	26.	632.	275.	811.	782.	4375.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.03	914.	1947.48	REF.	REF.	36204.	40518.	58005.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.25	2162.	1598.23	349.25	131.	29711.	35404.	49755.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.29	2468.	1556.91	390.57	691.	28943.	35502.	49482.
4	MIN. ACES, BIN= 31.7 M3 PANEL=466.5 M2	2.73	2432.	734.94	1212.55	35006.	13662.	54501.*	61100.
5	FULL ACES, BIN= 31.7 M3 PANEL=466.5 M2	2.80	2432.	734.94	1212.55	35006.	13662.	54501.*	61100.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.03	889.	747.86	1199.62	559.	22979.	27828.	31546.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.61	914.	1772.92	174.56	975.	42334.	47624.	45872.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.47	960.	616.75	1330.73	729.	18827.	23916.	27023.

*UNGLAZED PANEL EXCEEDS A PRACTICAL SIZE, AN ALTERNATIVE SUPPLEMENTARY HEAT SOURCE SHOULD BE USED IN THIS DESIGN.

CAPACITY EXCEEDED ON GAS FURNACE IN SUBROUTINE COST, DHEAT= 66872.

INTERNATIONAL FALLS, MINNESOTA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 19598.
DESIGN COOLING LOAD (WATTS) = 3711.

EL. ($/KWHR) = 0.0497, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3702, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0600, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -33 C 28 C
TOTAL/SENSIBLE COOLING = 1.02

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1878.	24913.	0.	7443.	6995.	6995.	2822.	2822.	354.	79.	269.	601.	285.	79.
FEB	1697.	19185.	0.	5801.	5258.	5254.	2280.	2277.	278.	61.	208.	532.	224.	61.
MAR	1887.	14308.	0.	4499.	3596.	3576.	1768.	1766.	221.	45.	158.	570.	177.	45.
APR	1838.	8251.	0.	2803.	1918.	1852.	1101.	1100.	143.	26.	94.	537.	115.	26.
MAY	1913.	3819.	0.	1592.	1147.	1041.	626.	625.	86.	12.	47.	544.	71.	12.
JUN	1862.	1377.	1722.	1087.	944.	810.	391.	391.	51.	192.	20.	709.	45.	192.
JUL	1930.	634.	2664.	1002.	1006.	838.	331.	331.	42.	292.	10.	828.	39.	292.
AUG	1929.	847.	2372.	1030.	990.	832.	350.	387.	45.	261.	13.	797.	41.	261.
SEP	1859.	3043.	0.	1362.	1005.	910.	462.	462.	74.	10.	38.	526.	62.	10.
OCT	1908.	5801.	0.	2142.	1400.	1309.	727.	726.	113.	18.	68.	549.	91.	18.
NOV	1834.	13499.	0.	4260.	3258.	3239.	1454.	1448.	210.	43.	149.	552.	168.	43.
DEC	1884.	21230.	0.	6421.	5800.	5797.	2184.	2178.	308.	67.	230.	591.	248.	67.
ANNUAL	22419.	116905.	6757.	39441.	33317.	32453.	14496.	14514.	1925.	1106.	1303.	7335.	1564.	1106.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	350.	1129.	48.	305.	275.	811.	482.	3400.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	350.	1199.	77.	305.	275.	843.	482.	3531.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	350.	1199.	77.	705.	335.	843.	582.	4091.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 33.3 M3 PANEL=588.4 M2*	4450.	4300.	33820.	915.	335.	1716.	638.	46174.*
5	FULL ACES, BIN= 33.3 M3 PANEL=588.4 M2*	4450.	4300.	33820.	915.	335.	1716.	638.	46174.*
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	690.	1129.	26.	376.	270.	811.	532.	3834.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	720.	1129.	26.	632.	275.	811.	782.	4375.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.03	914.	1961.41	REF.	REF.	36463.	40777.	59563.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.22	2162.	1656.87	304.54	131.	30801.	36494.	52364.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.25	2468.	1613.89	347.52	691.	30002.	36561.	52019.
4	MIN. ACES, BIN= 33.3 M3 PANEL=588.4 M2	2.80	2432.	720.87	1240.54	42773.	13401.	62007.*	68911.
5	FULL ACES, BIN= 33.3 M3 PANEL=588.4 M2	2.80	2432.	720.87	1240.54	42773.	13401.	62007.*	68911.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.04	889.	767.82	1193.59	434.	23597.	28320.	32134.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.61	914.	1745.88	215.53	975.	41654.	46943.	46914.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.48	960.	634.14	1327.27	729.	19363.	24453.	27650.

*UNGLAZED PANEL EXCEEDS A PRACTICAL SIZE, AN ALTERNATIVE SUPPLEMENTARY HEAT SOURCE SHOULD BE USED IN THIS DESIGN.

MINNEAPOLIS, MINNESOTA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 16205.
DESIGN COOLING LOAD (WATTS) = 5391.

EL. ($/KWHR) = 0.0580, 0.0850
GAS ($/THERM) = 0.3697, 0.8150
OIL ($/GAL.) = 1.1100, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -26 C 32 C
TOTAL/SENSIBLE COOLING = 1.13

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1802.	19753.	0.	5988.	5058.	5043.	2359.	2359.	287.	63.	215.	563.	231.	63.
FEB	1700.	15044.	0.	4651.	3721.	3679.	1837.	1843.	225.	48.	165.	520.	182.	48.
MAR	1929.	11892.	0.	3840.	2699.	2616.	1515.	1520.	190.	38.	132.	574.	153.	38.
APR	1860.	5614.	0.	2077.	1377.	1260.	819.	821.	108.	18.	66.	535.	88.	18.
MAY	1862.	2004.	1256.	1211.	959.	838.	441.	441.	60.	143.	27.	661.	51.	143.
JUN	1712.	0.	2778.	778.	937.	777.	239.	239.	35.	303.	7.	778.	28.	303.
JUL	1661.	0.	4305.	930.	1109.	891.	255.	255.	29.	469.	2.	930.	28.	469.
AUG	1572.	0.	4150.	889.	1065.	860.	656.	243.	28.	452.	2.	889.	26.	452.
SEP	1478.	1375.	1543.	961.	810.	695.	323.	328.	45.	172.	20.	583.	39.	172.
OCT	1536.	3698.	0.	1454.	992.	888.	499.	502.	77.	12.	46.	439.	63.	12.
NOV	1544.	10289.	0.	3287.	2177.	2081.	1139.	1154.	163.	33.	115.	462.	131.	33.
DEC	1693.	16365.	0.	5017.	3901.	3858.	1922.	1929.	242.	52.	179.	522.	195.	52.
ANNUAL	20352.	86035.	14031.	31083.	24803.	23486.	12003.	11635.	1488.	1801.	975.	7455.	1215.	1801.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	350.	1129.	48.	305.	275.	811.	482.	3400.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	350.	1199.	77.	305.	275.	843.	482.	3531.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	350.	1199.	77.	705.	335.	843.	582.	4091.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 26.8 M3 PANEL=147.6 M2*	4000.	3724.	9131.	830.	335.	1520.	638.	20178.*
5	FULL ACES, BIN= 40.0 M3 PANEL= 95.3 M2*	4000.	4478.	6203.	830.	335.	1520.	638.	18004.*
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	720.	1129.	26.	632.	275.	811.	782.	4375.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.08	914.	1801.89	REF.	REF.	33497.	37811.	47855.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.35	2162.	1437.83	364.06	131.	26729.	32422.	40437.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.42	2468.	1361.48	440.41	691.	25310.	31869.	39458.
4	MIN. ACES, BIN= 26.8 M3 PANEL=147.6 M2	2.79	2432.	695.81	1106.08	16777.	12935.	35545.*	39423.
5	FULL ACES, BIN= 40.0 M3 PANEL= 95.3 M2	2.88	2432.	674.47	1127.42	14604.	12538.	32974.*	36734.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.05	889.	654.56	1147.33	519.	19364.	24172.	27318.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.61	914.	1514.50	287.39	975.	35363.	40652.	39193.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.45	960.	553.71	1248.18	729.	16170.	21259.	23935.

*UNGLAZED PANEL EXCEEDS A PRACTICAL SIZE, AN ALTERNATIVE SUPPLEMENTARY HEAT SOURCE SHOULD BE USED IN THIS DESIGN.

BILOXI, MISSISSIPPI

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 6502.
DESIGN COOLING LOAD (WATTS) = 7304.

EL. ($/KWHR) = 0.0563, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3685, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1900, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -1 C 33 C
TOTAL/SENSIBLE COOLING = 1.55

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1529.	3813.	0.	1484.	985.	897.	654.	582.	78.	12.	45.	437.	64.	12.
FEB	1375.	2400.	509.	1104.	777.	694.	477.	419.	56.	63.	29.	445.	47.	63.
MAR	1440.	1420.	908.	893.	713.	625.	356.	335.	44.	103.	18.	503.	38.	103.
APR	1264.	0.	3261.	706.	868.	700.	407.	194.	25.	355.	4.	706.	21.	355.
MAY	1149.	0.	5947.	967.	1203.	968.	1086.	669.	20.	648.	1.	967.	19.	648.
JUN	987.	0.	8049.	1151.	1464.	1215.	1452.	1477.	16.	877.	0.	1151.	16.	877.
JUL	946.	0.	9410.	1288.	1654.	1405.	1692.	1722.	16.	1025.	0.	1288.	16.	1025.
AUG	952.	0.	9091.	1255.	1608.	1361.	1637.	1668.	16.	990.	0.	1255.	16.	990.
SEP	1001.	0.	7185.	1061.	1340.	1106.	1304.	1333.	17.	783.	0.	1061.	17.	783.
OCT	1173.	0.	3824.	743.	926.	760.	718.	745.	24.	417.	4.	743.	20.	417.
NOV	1282.	1368.	1492.	899.	752.	640.	315.	337.	41.	167.	17.	523.	35.	167.
DEC	1458.	2875.	0.	1204.	854.	771.	536.	450.	64.	9.	35.	414.	54.	9.
ANNUAL	14555.	11877.	49675.	12755.	13144.	11143.	10633.	9930.	416.	5449.	153.	9493.	363.	5449.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 6.6 M3 PANEL= 2.2 M2	2950.	1723.	990.	636.	335.	843.	482.	7958.
5	FULL ACES, BIN= 26.4 M3 PANEL= 0.0 M2	2950.	3132.	0.	636.	335.	843.	482.	8378.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.66	914.	717.84	REF.	REF.	13345.	17817.	22340.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.61	2162.	739.75	-21.91	80.	13752.	19553.	24213.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.90	2468.	627.10	90.74	640.	11658.	18324.	22275.
4	MIN. ACES, BIN= 6.6 M3 PANEL= 2.2 M2	1.99	2432.	598.44	119.40	4399.	11125.	21515.	25285.
5	FULL ACES, BIN= 26.4 M3 PANEL= 0.0 M2	2.13	2432.	558.84	159.00	4819.	10389.	21199.	24719.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.22	889.	459.84	258.00	628.	10552.	15627.	18291.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.82	914.	716.72	1.12	1084.	14539.	20096.	22544.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.35	960.	440.49	277.35	868.	9939.	15326.	17897.

COLUMBUS, MISSISSIPPI

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 9067.
DESIGN COOLING LOAD (WATTS) = 7713.

EL. ($/KWHR) = 0.0369, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3685, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1900, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -8 C 35 C
TOTAL/SENSIBLE COOLING = 1.32

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1699.	6580.	0.	2300.	1493.	1393.	965.	902.	116.	21.	74.	493.	95.	21.
FEB	1522.	4383.	0.	1640.	1092.	1000.	703.	643.	85.	14.	51.	437.	70.	14.
MAR	1581.	3103.	727.	1380.	973.	866.	553.	521.	69.	89.	37.	528.	58.	89.
APR	1373.	998.	1913.	867.	789.	664.	296.	296.	37.	212.	13.	593.	33.	212.
MAY	1234.	0.	4331.	815.	1016.	834.	658.	206.	25.	472.	4.	815.	21.	472.
JUN	1049.	0.	6553.	1005.	1261.	1040.	1194.	217.	18.	714.	0.	1005.	17.	714.
JUL	1003.	0.	7953.	1145.	1454.	1214.	1442.	1502.	17.	866.	0.	1145.	17.	866.
AUG	1018.	0.	7834.	1136.	1441.	1204.	1422.	1477.	17.	853.	0.	1136.	17.	853.
SEP	1084.	0.	5188.	866.	1085.	894.	959.	1009.	20.	565.	2.	866.	18.	565.
OCT	1289.	1204.	2395.	953.	865.	726.	478.	521.	39.	265.	16.	623.	34.	265.
NOV	1421.	3142.	676.	1341.	923.	821.	495.	464.	67.	84.	37.	478.	56.	84.
DEC	1621.	6041.	0.	2129.	1360.	1259.	872.	835.	108.	19.	69.	469.	89.	19.
ANNUAL	15894.	25451.	37570.	15579.	13753.	11915.	10037.	8593.	616.	4174.	302.	8589.	524.	4174.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $1
4	MIN. ACES, BIN= 10.3 M3 PANEL= 5.4 M2	3130.	2185.	1166.	636.	335.	1049.	534.	9035.
5	FULL ACES, BIN= 55.6 M3 PANEL= 0.0 M2	3130.	4837.	0.	636.	335.	1049.	534.	10521.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $1
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.41	914.	574.86	REF.	REF.	10687.	15159.	26296.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.59	2162.	507.48	67.38	80.	9434.	15235.	25066.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.84	2468.	439.67	135.18	640.	8174.	14840.	23358.
4	MIN. ACES, BIN= 10.3 M3 PANEL= 5.4 M2	2.18	2432.	370.35	204.51	5476.	6885.	18352.	25526.
5	FULL ACES, BIN= 55.6 M3 PANEL= 0.0 M2	2.55	2432.	317.06	257.79	6962.	5894.	18847.	24989.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.15	889.	380.94	193.92	628.	10050.	15126.	19193.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.72	914.	676.60	-101.74	1084.	14973.	20530.	24860.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.36	960.	346.99	227.87	868.	8975.	14362.	18267.

JACKSON, MISSISSIPPI

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 7860.
DESIGN COOLING LOAD (WATTS) = 7735.

EL. ($/KWHR) = 0.0630, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3667, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -5 C 36 C
TOTAL/SENSIBLE COOLING = 1.33

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1629.	5225.	0.	1904.	1258.	1159.	809.	747.	98.	17.	60.	469.	80.	17.
FEB	1463.	3242.	0.	1307.	923.	834.	574.	513.	69.	10.	38.	417.	57.	10.
MAR	1529.	2516.	879.	1220.	892.	786.	482.	454.	60.	104.	30.	528.	51.	104.
APR	1338.	844.	2214.	847.	804.	674.	279.	279.	34.	244.	11.	615.	31.	244.
MAY	1212.	0.	4535.	831.	1028.	840.	842.	207.	23.	494.	3.	831.	20.	494.
JUN	1038.	0.	6503.	997.	1251.	1028.	1183.	466.	17.	708.	0.	997.	17.	708.
JUL	995.	0.	8348.	1186.	1510.	1259.	1509.	1551.	17.	909.	0.	1186.	17.	909.
AUG	1005.	0.	7813.	1130.	1434.	1195.	1416.	1461.	17.	851.	0.	1130.	17.	851.
SEP	1060.	0.	5592.	904.	1127.	926.	1027.	1069.	18.	609.	1.	904.	18.	609.
OCT	1248.	807.	2751.	870.	855.	711.	536.	573.	32.	302.	11.	649.	29.	302.
NOV	1367.	2712.	822.	1223.	870.	768.	454.	418.	60.	98.	32.	478.	50.	98.
DEC	1555.	4276.	0.	1620.	1069.	977.	683.	635.	84.	14.	50.	445.	69.	14.
ANNUAL	15438.	19623.	39456.	14039.	13022.	11156.	9794.	8372.	529.	4361.	237.	8649.	457.	4361.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 8.5 M3 PANEL= 4.0 M2	3130.	1968.	1087.	636.	335.	1049.	534.	8739.
5	FULL ACES, BIN= 42.7 M3 PANEL= 0.0 M2	3130.	4114.	0.	636.	335.	1049.	534.	9798.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.47	914.	885.13	REF.	REF.	16455.	20927.	24138.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.59	2162.	821.02	64.11	80.	15263.	21063.	24041.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.86	2468.	703.40	181.73	640.	13076.	19743.	22294.
4	MIN. ACES, BIN= 8.5 M3 PANEL= 4.0 M2	2.11	2432.	617.54	267.59	5181.	11480.	22651.	24891.
5	FULL ACES, BIN= 42.7 M3 PANEL= 0.0 M2	2.47	2432.	527.83	357.29	6239.	9812.	22043.	23957.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.17	889.	469.02	416.11	628.	11258.	16333.	18293.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.74	914.	822.16	62.96	1084.	17128.	22684.	23366.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.35	960.	442.42	442.71	868.	10415.	15802.	17630.

COLUMBIA, MISSOURI

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 12563.
DESIGN COOLING LOAD (WATTS) = 6447.

EL. ($/KWHR) = 0.0540, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3702, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0600, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -17 C 34 C
TOTAL/SENSIBLE COOLING = 1.17

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1918.	12084.	0.	3890.	2766.	2685.	1570.	1570.	192.	38.	132.	571.	155.	38.
FEB	1744.	8577.	0.	2867.	1936.	1844.	1172.	1179.	144.	27.	95.	512.	116.	27.
MAR	1836.	7250.	0.	2524.	1660.	1546.	1027.	1072.	129.	23.	81.	533.	104.	23.
APR	1606.	2805.	914.	1325.	956.	842.	505.	570.	66.	108.	33.	555.	55.	108.
MAY	1440.	818.	2358.	884.	850.	712.	290.	290.	36.	260.	11.	660.	32.	260.
JUN	1207.	0.	4626.	839.	1033.	843.	537.	207.	22.	504.	2.	839.	20.	504.
JUL	1123.	0.	6404.	1010.	1261.	1037.	1176.	224.	19.	698.	0.	1010.	19.	698.
AUG	1109.	0.	6021.	964.	1202.	990.	1111.	216.	19.	656.	1.	964.	18.	656.
SEP	1165.	0.	3285.	681.	859.	707.	631.	183.	26.	358.	6.	681.	19.	358.
OCT	1387.	1888.	1350.	1057.	829.	716.	333.	343.	50.	153.	24.	538.	42.	153.
NOV	1549.	5782.	0.	2037.	1320.	1221.	744.	817.	105.	18.	66.	449.	85.	18.
DEC	1798.	9917.	0.	3254.	2176.	2077.	1292.	1336.	163.	31.	110.	531.	131.	31.
ANNUAL	17884.	49121.	24959.	21333.	16848.	15218.	10389.	8008.	970.	2875.	561.	7843.	798.	2875.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	534.	3360.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	534.	3491.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	634.	4051.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 17.4 M3 PANEL= 17.0 M2	3500.	2912.	1816.	710.	335.	1267.	638.	11178.
5	FULL ACES, BIN= 93.7 M3 PANEL= 1.9 M2	3500.	6797.	972.	710.	335.	1267.	638.	14219.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	584.	3971.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	834.	4397.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	584.	4181.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.20	914.	1151.13	REF.	REF.	21400.	25674.	34158.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.52	2162.	909.11	242.02	131.	16900.	22553.	29253.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.68	2468.	821.19	329.95	691.	15266.	21785.	27837.
4	MIN. ACES, BIN= 17.4 M3 PANEL= 17.0 M2	2.46	2432.	560.60	590.53	7818.	10422.	24032.	28163.
5	FULL ACES, BIN= 93.7 M3 PANEL= 1.9 M2	3.19	2432.	432.09	719.04	10859.	8033.	24684.	27868.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.07	889.	514.11	637.02	611.	14253.	19113.	21912.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.65	914.	1018.02	133.12	1037.	22886.	28198.	29799.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.39	960.	450.55	700.59	821.	12240.	17381.	19887.

KANSAS CITY, MISSOURI

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 11890.
DESIGN COOLING LOAD (WATTS) = 6762.

EL. ($/KWHR) = 0.0612, 0.0850
GAS ($/THERM) = 0.3032, 0.8150
OIL ($/GAL.) = 1.1300, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -16 C 36 C
TOTAL/SENSIBLE COOLING = 1.17

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1903.	11774.	0.	3800.	2625.	2514.	1531.	1490.	186.	37.	129.	566.	152.	37.
FEB	1733.	8430.	0.	2823.	1874.	1762.	1151.	1107.	140.	27.	94.	508.	115.	27.
MAR	1822.	6856.	0.	2411.	1580.	1453.	980.	945.	122.	22.	77.	528.	100.	22.
APR	1586.	2544.	875.	1243.	909.	801.	472.	463.	62.	103.	31.	544.	52.	103.
MAY	1409.	604.	2471.	828.	831.	690.	265.	265.	32.	271.	8.	663.	30.	271.
JUN	1168.	0.	5109.	881.	1086.	878.	580.	210.	20.	557.	1.	881.	19.	557.
JUL	1075.	0.	7279.	1092.	1375.	1134.	1329.	231.	18.	793.	0.	1092.	18.	793.
AUG	1058.	0.	6865.	1042.	1310.	1079.	1260.	223.	18.	748.	0.	1042.	18.	748.
SEP	1118.	0.	3410.	682.	846.	689.	654.	179.	23.	371.	4.	682.	19.	371.
OCT	1346.	1422.	1346.	915.	753.	646.	282.	280.	43.	151.	18.	525.	37.	151.
NOV	1518.	5351.	0.	1908.	1231.	1124.	701.	684.	97.	17.	61.	439.	80.	17.
DEC	1776.	9467.	0.	3123.	2034.	1911.	1240.	1225.	155.	30.	105.	523.	126.	30.
ANNUAL	17510.	46448.	27355.	20748.	16455.	14682.	10444.	7301.	915.	3127.	529.	7992.	765.	3127.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1279.	48.	253.	275.	907.	534.	3606.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	534.	3491.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	634.	4051.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 17.0 M3 PANEL= 17.4 M2	3500.	2846.	1842.	710.	335.	1267.	638.	11138.
5	FULL ACES, BIN=108.9 M3 PANEL= 0.0 M2	3500.	7394.	0.	710.	335.	1267.	638.	13844.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.22	914.	1269.15	REF.	REF.	23593.	28113.	33584.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.54	2162.	1006.53	262.61	-115.	18711.	24364.	28703.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.73	2468.	898.07	371.08	445.	16695.	23214.	27085.
4	MIN. ACES, BIN= 17.0 M3 PANEL= 17.4 M2	2.43	2432.	638.85	630.30	7533.	11876.	25447.	28200.
5	FULL ACES, BIN=108.9 M3 PANEL= 0.0 M2	3.47	2432.	446.61	822.54	10238.	8303.	24579.	26504.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.10	889.	468.61	800.54	581.	12339.	17415.	21741.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.67	914.	1086.53	182.62	1037.	24179.	29736.	29478.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.39	960.	423.11	846.03	821.	10898.	16285.	20037.

SPRINGFIELD, MISSOURI

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 11672.
DESIGN COOLING LOAD (WATTS) = 6756.

EL. ($/KWHR) = 0.0504, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3697, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1100, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -15 C 34 C
TOTAL/SENSIBLE COOLING = 1.24

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1915.	11688.	0.	3779.	2666.	2581.	1529.	1529.	185.	37.	128.	569.	151.	37.
FEB	1728.	8609.	0.	2872.	1919.	1823.	1175.	1179.	142.	27.	95.	507.	116.	27.
MAR	1803.	6787.	0.	2386.	1573.	1454.	971.	1018.	120.	21.	76.	522.	99.	21.
APR	1565.	2492.	1042.	1241.	919.	804.	466.	552.	60.	121.	30.	556.	51.	121.
MAY	1394.	700.	2547.	859.	851.	714.	275.	275.	33.	280.	9.	667.	30.	280.
JUN	1168.	0.	4589.	824.	1019.	840.	531.	202.	21.	500.	2.	824.	19.	500.
JUL	1095.	0.	6560.	1019.	1276.	1057.	1202.	223.	18.	715.	0.	1019.	18.	715.
AUG	1097.	0.	6185.	978.	1223.	1015.	1139.	217.	19.	674.	1.	978.	18.	674.
SEP	1167.	0.	3440.	699.	877.	725.	658.	185.	25.	375.	5.	699.	19.	375.
OCT	1400.	1838.	1497.	1063.	849.	732.	330.	326.	49.	169.	23.	558.	42.	169.
NOV	1564.	5778.	0.	2040.	1325.	1225.	750.	824.	103.	18.	66.	453.	85.	18.
DEC	1808.	9834.	0.	3234.	2157.	2054.	1283.	1326.	160.	31.	109.	533.	130.	31.
ANNUAL	17704.	47728.	25861.	20995.	16654.	15025.	10309.	7856.	937.	2969.	545.	7887.	781.	2969.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1279.	48.	253.	275.	907.	534.	3606.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	534.	3491.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	634.	4051.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 16.9 M3 PANEL= 14.7 M2	3500.	2828.	1687.	710.	335.	1267.	638.	10965.
5	FULL ACES, BIN= 98.7 M3 PANEL= 0.0 M2	3500.	6950.	0.	710.	335.	1267.	638.	13400.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.21	914.	1058.13	REF.	REF.	19671.	24190.	33929.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.52	2162.	839.38	218.75	-115.	15604.	21257.	28982.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.69	2468.	757.24	300.89	445.	14077.	20596.	27565.
4	MIN. ACES, BIN= 16.9 M3 PANEL= 14.7 M2	2.46	2432.	519.56	538.57	7359.	9659.	23055.	27837.
5	FULL ACES, BIN= 98.7 M3 PANEL= 0.0 M2	3.23	2432.	395.97	662.16	9794.	7361.	23193.	26838.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.09	889.	495.94	562.19	581.	13750.	18825.	21816.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.65	914.	1002.31	55.81	1037.	22661.	28218.	29715.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.39	960.	438.29	619.83	821.	11924.	17311.	20033.

BILLINGS, MONTANA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 15891.
DESIGN COOLING LOAD (WATTS) = 4924.

EL. ($/KWHR) = 0.0322, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3478, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0400, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -25 C 33 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1864.	14444.	0.	4531.	3513.	3440.	1824.	1824.	221.	46.	159.	564.	178.	46.
FEB	1741.	11100.	0.	3567.	2643.	2570.	1449.	1449.	176.	35.	123.	519.	142.	35.
MAR	1930.	9669.	0.	3222.	2246.	2148.	1307.	1318.	161.	31.	109.	567.	131.	31.
APR	1805.	5812.	0.	2116.	1382.	1268.	858.	866.	109.	18.	67.	520.	89.	18.
MAY	1747.	2690.	1152.	1358.	1007.	879.	509.	511.	67.	134.	34.	619.	56.	134.
JUN	1561.	868.	2482.	945.	906.	755.	312.	312.	39.	273.	13.	707.	35.	273.
JUL	1493.	0.	4214.	874.	1061.	866.	234.	234.	28.	459.	4.	874.	25.	459.
AUG	1423.	0.	3824.	812.	993.	814.	728.	221.	28.	417.	5.	812.	24.	417.
SEP	1377.	1700.	1831.	1054.	871.	742.	382.	327.	47.	205.	23.	587.	40.	205.
OCT	1491.	3947.	0.	1511.	1063.	945.	548.	557.	80.	13.	48.	427.	65.	13.
NOV	1555.	8723.	0.	2855.	1920.	1822.	1045.	1074.	143.	28.	99.	460.	115.	28.
DEC	1745.	11805.	0.	3764.	2613.	2514.	1488.	1501.	186.	37.	132.	522.	149.	37.
ANNUAL	19730.	70758.	13504.	26609.	20218.	18762.	10683.	10194.	1284.	1695.	816.	7176.	1049.	1695.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	350.	1129.	48.	305.	275.	811.	482.	3400.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	350.	1199.	77.	305.	275.	843.	482.	3531.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	350.	1199.	77.	705.	335.	843.	582.	4091.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 20.2 M3 PANEL= 21.5 M2	4000.	3290.	2068.	830.	335.	1520.	638.	12681.
5	FULL ACES, BIN= 36.3 M3 PANEL= 16.9 M2	4000.	4257.	1811.	830.	335.	1520.	638.	13391.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	720.	1129.	26.	632.	275.	811.	782.	4375.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.09	914.	855.74	REF.	REF.	15906.	20222.	41588.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.43	2162.	650.21	205.53	131.	12087.	17780.	34014.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.54	2468.	603.40	252.35	691.	11217.	17776.	32841.
4	MIN. ACES, BIN= 20.2 M3 PANEL= 21.5 M2	2.70	2432.	343.58	512.17	9281.	6387.	21500.	30078.
5	FULL ACES, BIN= 36.3 M3 PANEL= 16.9 M2	2.83	2432.	327.84	527.91	9991.	6094.	21918.	30103.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.03	889.	501.22	354.52	519.	15160.	19969.	24433.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.58	914.	1079.34	-223.60	975.	25716.	31006.	34973.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.42	960.	419.45	436.29	729.	12571.	17660.	21557.

GREAT FALLS, MONTANA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 17392.
DESIGN COOLING LOAD (WATTS) = 4469.

EL. ($/KWHR) = 0.0322, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3478, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0400, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -28 C 31 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE GAS THERMS	(6) GAS FURNACE ELEC. KWH	(7) OIL FURNACE OIL GAL	(7) OIL FURNACE ELEC. KWH	(8) PULSE GAS FURN. GAS THERMS	(8) PULSE GAS FURN. ELEC. KWH
JAN	1832.	16458.	0.	5081.	4067.	4006.	2042.	2042.	247.	52.	180.	561.	198.	52.
FEB	1714.	12731.	0.	4013.	3092.	3033.	1627.	1627.	197.	40.	140.	517.	158.	40.
MAR	1924.	10994.	0.	3588.	2618.	2530.	1453.	1454.	179.	35.	123.	569.	144.	35.
APR	1834.	6255.	0.	2247.	1450.	1332.	911.	911.	117.	20.	72.	529.	94.	20.
MAY	1818.	3074.	952.	1463.	1047.	920.	559.	559.	74.	113.	38.	619.	62.	113.
JUN	1663.	1286.	1949.	1032.	906.	767.	361.	361.	47.	216.	19.	678.	41.	216.
JUL	1616.	0.	3667.	848.	1048.	857.	241.	241.	34.	399.	8.	848.	27.	399.
AUG	1543.	0.	3287.	787.	984.	811.	330.	333.	35.	358.	9.	787.	26.	358.
SEP	1470.	2185.	1479.	1177.	911.	784.	372.	372.	56.	168.	28.	577.	47.	168.
OCT	1550.	4601.	0.	1709.	1168.	1054.	621.	621.	90.	15.	55.	445.	73.	15.
NOV	1573.	10557.	0.	3370.	2383.	2290.	1336.	1337.	168.	33.	118.	471.	134.	33.
DEC	1730.	14092.	0.	4395.	3335.	3255.	1787.	1787.	216.	45.	156.	525.	172.	45.
ANNUAL	20267.	82232.	11334.	29710.	23011.	21638.	11638.	11645.	1460.	1495.	947.	7126.	1175.	1495.

SYSTEMS FIRST COSTS

NO.		COMPONENTS COSTS, $ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	350.	1129.	48.	305.	275.	811.	482.	3400.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	350.	1199.	77.	305.	275.	843.	482.	3531.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	350.	1199.	77.	705.	335.	843.	582.	4091.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 22.7 M3 PANEL= 24.3 M2	4000.	3535.	2226.	830.	335.	1520.	638.	13083.
5	FULL ACES, BIN= 24.4 M3 PANEL= 23.9 M2	4000.	3641.	2201.	830.	335.	1520.	638.	13165.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	815.	1129.	26.	376.	270.	811.	532.	3959.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	720.	1129.	26.	632.	275.	811.	782.	4375.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST AVERAGE $	LIFE CYCLE COST MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.06	914.	955.46	REF.	REF.	17762.	22076.	45931.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.37	2162.	740.02	215.44	131.	13757.	19450.	37926.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.46	2468.	695.89	259.57	691.	12937.	19495.	36870.
4	MIN. ACES, BIN= 22.7 M3 PANEL= 24.3 M2	2.72	2432.	374.29	581.17	9683.	6958.	22473.	31818.
5	FULL ACES, BIN= 24.4 M3 PANEL= 23.9 M2	2.72	2432.	374.49	580.97	9764.	6962.	22558.	31908.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.01	889.	555.99	399.47	559.	16979.	21828.	26557.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.57	914.	1214.41	-258.95	975.	29138.	34427.	38065.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.44	960.	456.80	498.66	729.	13838.	18927.	22967.

CAPACITY EXCEEDED ON GAS FURNACE IN SUBROUTINE COST, DHEAT= 68175.

MISSOULA, MONTANA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 19980.
DESIGN COOLING LOAD (WATTS) = 4416.

EL. ($/KWHR) = 0.0322, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3478, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0400, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -34 C 31 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1841.	14168.	0.	4447.	3344.	3278.	1791.	1791.	219.	45.	156.	556.	175.	45.
FEB	1715.	10575.	0.	3414.	2363.	2285.	1377.	1374.	171.	33.	118.	510.	136.	33.
MAR	1924.	9226.	0.	3098.	2050.	1951.	1244.	1242.	157.	29.	105.	564.	126.	29.
APR	1843.	5347.	0.	1997.	1293.	1183.	800.	799.	105.	17.	62.	529.	85.	17.
MAY	1843.	3220.	795.	1493.	1057.	937.	572.	572.	77.	97.	40.	609.	63.	97.
JUN	1704.	1615.	1657.	1102.	919.	785.	397.	398.	52.	186.	23.	659.	45.	186.
JUL	1674.	736.	3538.	1055.	1078.	883.	326.	326.	39.	388.	12.	853.	35.	388.
AUG	1610.	950.	2898.	1027.	991.	820.	332.	398.	41.	319.	15.	766.	36.	319.
SEP	1536.	2395.	1284.	1232.	930.	805.	395.	394.	60.	147.	31.	574.	50.	147.
OCT	1609.	5181.	0.	1886.	1215.	1107.	665.	663.	99.	16.	61.	463.	80.	16.
NOV	1615.	9667.	0.	3134.	2053.	1963.	1128.	1123.	158.	31.	109.	479.	125.	31.
DEC	1754.	12095.	0.	3847.	2634.	2552.	1516.	1516.	192.	38.	134.	526.	152.	38.
ANNUAL	20668.	75176.	10171.	27734.	19928.	18548.	10543.	10595.	1371.	1346.	866.	7088.	1110.	1346.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	350.	1129.	48.	305.	275.	811.	482.	3400.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	350.	1199.	77.	305.	275.	843.	482.	3531.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	350.	1199.	77.	705.	335.	843.	582.	4091.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 19.9 M3 PANEL= 50.2 M2	4450.	3486.	3675.	915.	335.	1716.	638.	15215.
5	FULL ACES, BIN= 19.9 M3 PANEL= 50.2 M2	4450.	3486.	3675.	915.	335.	1716.	638.	15215.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	690.	1129.	26.	376.	270.	811.	532.	3834.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	720.	1129.	26.	632.	275.	811.	782.	4375.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.06	914.	891.92	REF.	REF.	16581.	20895.	43164.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.48	2162.	640.90	251.02	131.	11914.	17607.	33609.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.59	2468.	596.52	295.40	691.	11089.	17648.	32541.
4	MIN. ACES, BIN= 19.9 M3 PANEL= 50.2 M2	2.79	2432.	339.06	552.86	11815.	6303.	23950.	32416.
5	FULL ACES, BIN= 19.9 M3 PANEL= 50.2 M2	2.78	2432.	339.06	552.86	11815.	6303.	23950.	32416.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.00	889.	520.08	371.84	434.	15905.	20628.	25021.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.56	914.	1128.22	-236.30	975.	26969.	32259.	36046.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.42	960.	429.31	462.61	729.	13030.	18119.	21882.

GRAND ISLAND, NEBRASKA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 14233.
DESIGN COOLING LOAD (WATTS) = 6252.

EL. ($/KWHR) = 0.0611, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3702, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0600, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -21 C 35 C
TOTAL/SENSIBLE COOLING = 1.10

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1857.	15809.	0.	4908.	3734.	3671.	1959.	1959.	238.	50.	171.	566.	192.	50.
FEB	1738.	11829.	0.	3769.	2736.	2655.	1518.	1520.	185.	37.	129.	520.	149.	37.
MAR	1921.	9974.	0.	3304.	2236.	2113.	1325.	1354.	165.	32.	110.	565.	134.	32.
APR	1780.	4641.	0.	1784.	1239.	1109.	715.	729.	93.	15.	53.	509.	77.	15.
MAY	1699.	1646.	1709.	1115.	934.	798.	401.	401.	52.	191.	21.	663.	45.	191.
JUN	1493.	0.	3638.	811.	988.	807.	226.	226.	29.	396.	4.	811.	25.	396.
JUL	1406.	0.	5459.	985.	1203.	975.	828.	243.	24.	595.	1.	985.	23.	595.
AUG	1331.	0.	5237.	940.	1155.	939.	979.	231.	24.	571.	1.	940.	22.	571.
SEP	1294.	1052.	2455.	919.	853.	711.	493.	351.	37.	271.	14.	630.	32.	271.
OCT	1422.	3339.	942.	1425.	989.	869.	475.	487.	70.	113.	39.	508.	58.	113.
NOV	1510.	8491.	0.	2778.	1811.	1698.	988.	1038.	139.	27.	94.	446.	112.	27.
DEC	1721.	12711.	0.	4009.	2791.	2698.	1567.	1581.	197.	40.	139.	518.	158.	40.
ANNUAL	19172.	69492.	19441.	26749.	20669.	19043.	11473.	10120.	1253.	2338.	777.	7664.	1027.	2338.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
		COMPONENTS COSTS, $							
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 21.9 M3 PANEL= 28.8 M2	4000.	3310.	2479.	830.	335.	1520.	638.	13111.
5	FULL ACES, BIN= 62.2 M3 PANEL= 14.4 M2	4000.	5481.	1671.	830.	335.	1520.	638.	14475.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST AVERAGE $	LIFE CYCLE COST MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.12	914.	1634.62	REF.	REF.	30388.	34610.	41692.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.45	2162.	1263.11	371.52	131.	23481.	29082.	34555.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.58	2468.	1163.74	470.88	691.	21634.	28101.	33143.
4	MIN. ACES, BIN= 21.9 M3 PANEL= 28.8 M2	2.62	2432.	701.15	933.48	9803.	13034.	28578.	31615.
5	FULL ACES, BIN= 62.2 M3 PANEL= 14.4 M2	2.97	2432.	618.42	1016.21	11167.	11496.	28403.	31083.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.06	889.	606.63	1027.99	611.	17343.	22152.	24909.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.64	914.	1292.30	342.32	1037.	29511.	34771.	34698.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.43	960.	523.10	1111.53	821.	14698.	19787.	22159.

LINCOLN, NEBRASKA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 13541.
DESIGN COOLING LOAD (WATTS) = 6500.

EL. ($/KWHR) = 0.0451, 0.0850
GAS ($/THERM) = 0.3697, 0.8150
OIL ($/GAL.) = 1.1100, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -20 C 36 C
TOTAL/SENSIBLE COOLING = 1.20

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1851.	15776.	0.	4897.	3852.	3803.	1946.	1948.	238.	50.	171.	564.	192.	50.
FEB	1733.	12242.	0.	3882.	2879.	2816.	1540.	1557.	190.	39.	133.	520.	154.	39.
MAR	1913.	9525.	0.	3178.	2151.	2046.	1259.	1283.	159.	30.	106.	562.	129.	30.
APR	1770.	3733.	0.	1529.	1100.	981.	605.	615.	81.	12.	43.	503.	67.	12.
MAY	1683.	943.	2107.	959.	895.	756.	328.	328.	42.	233.	13.	700.	38.	233.
JUN	1474.	0.	3925.	837.	1007.	815.	228.	228.	27.	428.	2.	837.	25.	428.
JUL	1384.	0.	5443.	977.	1191.	952.	821.	240.	23.	593.	0.	977.	23.	593.
AUG	1309.	0.	5062.	915.	1120.	902.	949.	225.	23.	551.	1.	915.	22.	551.
SEP	1274.	729.	2079.	783.	750.	631.	427.	304.	32.	229.	10.	583.	29.	229.
OCT	1406.	2557.	702.	1178.	835.	738.	389.	231.	60.	85.	31.	475.	49.	85.
NOV	1498.	7857.	0.	2599.	1675.	1577.	908.	952.	131.	25.	88.	441.	105.	25.
DEC	1713.	14341.	0.	4460.	3259.	3195.	1698.	1698.	217.	45.	156.	521.	175.	45.
ANNUAL	19009.	67702.	19318.	26193.	20714.	19212.	11100.	9609.	1223.	2319.	755.	7600.	1006.	2319.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	534.	3360.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	534.	3491.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	634.	4051.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 21.9 M3 PANEL= 70.1 M2	4000.	3268.	4791.	830.	335.	1520.	638.	15381.
5	FULL ACES, BIN= 66.1 M3 PANEL= 24.5 M2	4000.	5620.	2237.	830.	335.	1520.	638.	15180.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	584.	3971.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	834.	4397.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	584.	4181.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.12	914.	1182.36	REF.	REF.	21980.	26254.	40966.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.42	2162.	935.05	247.32	131.	17383.	23035.	34670.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.53	2468.	867.21	315.15	691.	16121.	22640.	33430.
4	MIN. ACES, BIN= 21.9 M3 PANEL= 70.1 M2	2.65	2432.	501.06	681.30	12021.	9315.	27128.	33362.
5	FULL ACES, BIN= 66.1 M3 PANEL= 24.5 M2	3.07	2432.	433.76	748.60	11819.	8064.	25675.	31072.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.06	889.	556.92	625.44	611.	16269.	21129.	24539.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.64	914.	1181.60	0.76	1037.	27551.	32862.	34134.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.42	960.	476.65	705.72	821.	13726.	18867.	21903.

NORTH PLATTE, NEBRASKA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 14245.
DESIGN COOLING LOAD (WATTS) = 5581.

EL. ($/KWHR) = 0.0384, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3702, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0600, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -21 C 34 C
TOTAL/SENSIBLE COOLING = 1.04

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1853.	14654.	0.	4586.	3573.	3529.	1839.	1839.	223.	46.	159.	561.	180.	46.
FEB	1735.	11656.	0.	3720.	2784.	2728.	1503.	1503.	183.	37.	127.	519.	148.	37.
MAR	1925.	9855.	0.	3273.	2267.	2174.	1317.	1337.	163.	31.	109.	566.	132.	31.
APR	1798.	5212.	0.	1947.	1332.	1210.	784.	795.	101.	17.	59.	516.	83.	17.
MAY	1734.	2153.	1520.	1246.	984.	847.	449.	449.	60.	172.	27.	654.	51.	172.
JUN	1542.	0.	2982.	753.	927.	762.	222.	222.	33.	325.	7.	753.	26.	325.
JUL	1465.	0.	4762.	926.	1122.	908.	570.	239.	26.	519.	2.	926.	24.	519.
AUG	1390.	0.	4538.	880.	1073.	877.	855.	227.	25.	494.	2.	880.	23.	494.
SEP	1343.	1413.	2341.	1021.	899.	756.	472.	315.	43.	259.	18.	633.	37.	259.
OCT	1458.	3999.	916.	1616.	1099.	978.	546.	557.	80.	112.	46.	518.	65.	112.
NOV	1529.	8955.	0.	2912.	1950.	1867.	1039.	1081.	145.	28.	99.	453.	117.	28.
DEC	1725.	12605.	0.	3981.	2883.	2823.	1559.	1573.	195.	40.	138.	519.	157.	40.
ANNUAL	19497.	70502.	17058.	26860.	20893.	19457.	11155.	10136.	1276.	2082.	792.	7498.	1043.	2082.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 20.5 M3 PANEL= 25.2 M2	4000.	3216.	2277.	830.	335.	1520.	638.	12816.
5	FULL ACES, BIN= 50.5 M3 PANEL= 15.9 M2	4000.	4907.	1755.	830.	335.	1520.	638.	13984.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.11	914.	1030.10	REF.	REF.	19150.	23372.	41848.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.42	2162.	801.24	228.85	131.	14895.	20496.	34868.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.53	2468.	746.18	283.92	691.	13871.	20338.	33722.
4	MIN. ACES, BIN= 20.5 M3 PANEL= 25.2 M2	2.67	2432.	427.79	602.31	9507.	7953.	23200.	30874.
5	FULL ACES, BIN= 50.5 M3 PANEL= 15.9 M2	2.93	2432.	388.73	641.37	10676.	7226.	23643.	30615.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.04	889.	552.28	477.81	611.	16447.	21255.	24865.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.62	914.	1127.57	-97.47	1037.	26556.	31815.	34830.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.42	960.	465.87	564.23	821.	13710.	18799.	22011.

ELY, NEVADA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 14737.
DESIGN COOLING LOAD (WATTS) = 4600.

EL. ($/KWHR) = 0.0404, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3478, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0400, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -22 C 31 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1833.	14717.	0.	4598.	3634.	3583.	1856.	1856.	224.	47.	160.	556.	180.	47.
FEB	1711.	10958.	0.	3520.	2579.	2519.	1434.	1435.	173.	35.	120.	510.	140.	35.
MAR	1921.	9349.	0.	3131.	2135.	2050.	1270.	1273.	156.	30.	103.	563.	127.	30.
APR	1836.	6244.	0.	2245.	1513.	1399.	910.	913.	115.	20.	70.	530.	94.	20.
MAY	1828.	4478.	1009.	1862.	1283.	1134.	719.	720.	92.	124.	51.	632.	76.	124.
JUN	1681.	1847.	2838.	1289.	1126.	940.	426.	426.	54.	315.	23.	782.	47.	315.
JUL	1644.	815.	3827.	1100.	1123.	929.	335.	335.	39.	420.	11.	876.	36.	420.
AUG	1575.	1035.	3596.	1117.	1100.	913.	522.	348.	41.	395.	14.	833.	37.	395.
SEP	1502.	2749.	2328.	1434.	1134.	968.	474.	435.	64.	262.	33.	680.	53.	262.
OCT	1578.	5734.	0.	2031.	1402.	1270.	726.	729.	104.	18.	64.	456.	85.	18.
NOV	1592.	9574.	0.	3102.	2179.	2119.	1112.	1116.	153.	30.	105.	473.	124.	30.
DEC	1739.	12990.	0.	4092.	3096.	3043.	1611.	1611.	200.	41.	142.	524.	161.	41.
ANNUAL	20440.	80491.	13600.	29521.	22304.	20866.	11395.	11197.	1417.	1736.	896.	7415.	1160.	1736.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 20.5 M3 PANEL= 18.0 M2	4000.	3247.	1873.	830.	335.	1520.	638.	12442.
5	FULL ACES, BIN= 25.6 M3 PANEL= 16.7 M2	4000.	3571.	1802.	830.	335.	1520.	638.	12695.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.08	914.	1192.92	REF.	REF.	22176.	26399.	45575.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.43	2162.	901.29	291.63	131.	16755.	22356.	36844.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.52	2468.	843.19	349.73	691.	15675.	22142.	35696.
4	MIN. ACES, BIN= 20.5 M3 PANEL= 18.0 M2	2.79	2432.	460.48	732.44	9134.	8560.	23434.	30836.
5	FULL ACES, BIN= 25.6 M3 PANEL= 16.7 M2	2.84	2432.	452.46	740.46	9387.	8411.	23539.	30812.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.04	889.	562.86	630.06	611.	16908.	21716.	26267.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.62	914.	1231.62	-38.70	1037.	29103.	34362.	37208.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.43	960.	473.71	719.21	821.	14085.	19174.	23106.

LAS VEGAS, NEVADA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 7101.
DESIGN COOLING LOAD (WATTS) = 7283.

EL. ($/KWHR) = 0.0424, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3022, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1200, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -3 C 41 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1662.	5058.	0.	1867.	1217.	1108.	781.	732.	96.	16.	57.	478.	79.	16.
FEB	1493.	3225.	0.	1311.	936.	831.	563.	514.	69.	10.	38.	425.	58.	10.
MAR	1538.	2489.	1547.	1287.	978.	839.	472.	461.	60.	176.	30.	604.	51.	176.
APR	1306.	864.	2931.	922.	902.	752.	288.	288.	34.	322.	12.	685.	31.	322.
MAY	1129.	0.	4828.	840.	1053.	879.	893.	201.	22.	526.	3.	840.	19.	526.
JUN	917.	0.	7644.	1087.	1386.	1194.	1382.	1128.	15.	833.	0.	1087.	15.	833.
JUL	843.	0.	9677.	1288.	1665.	1461.	1741.	1789.	14.	1054.	0.	1288.	14.	1054.
AUG	852.	0.	8857.	1201.	1546.	1344.	1599.	1650.	14.	965.	0.	1201.	14.	965.
SEP	935.	0.	6340.	951.	1200.	1031.	1159.	1206.	16.	691.	1.	951.	16.	691.
OCT	1162.	0.	3659.	721.	924.	779.	693.	735.	27.	399.	8.	721.	19.	399.
NOV	1331.	2948.	990.	1297.	912.	796.	460.	435.	63.	117.	35.	487.	52.	117.
DEC	1562.	4722.	0.	1746.	1140.	1031.	709.	685.	90.	15.	54.	449.	74.	15.
ANNUAL	14728.	19307.	46473.	14518.	13860.	12045.	10741.	9824.	520.	5124.	237.	9216.	442.	5124.

SYSTEMS FIRST COSTS

NO.		COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 8.3 M3 PANEL= 3.6 M2	2950.	1913.	1064.	636.	335.	843.	482.	8223.
5	FULL ACES, BIN= 40.9 M3 PANEL= 0.0 M2	2950.	3975.	0.	636.	335.	843.	482.	9221.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.54	914.	615.99	REF.	REF.	11451.	15924.	24809.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.61	2162.	588.08	27.91	80.	10932.	16733.	25216.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.86	2468.	511.05	104.94	640.	9500.	16167.	23539.
4	MIN. ACES, BIN= 8.3 M3 PANEL= 3.6 M2	2.08	2432.	455.73	160.26	4664.	8472.	19127.	25701.
5	FULL ACES, BIN= 40.9 M3 PANEL= 0.0 M2	2.28	2432.	416.85	199.14	5662.	7749.	19402.	25415.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.19	889.	374.62	241.38	628.	9020.	14096.	19240.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.79	914.	656.71	-40.72	1084.	13978.	19535.	24174.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.37	960.	350.89	265.10	868.	8269.	13656.	18497.

WINNEMUCCA, NEVADA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 12623.
DESIGN COOLING LOAD (WATTS) = 5728.

EL. ($/KWHR) = 0.0602, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3478, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0400, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -17 C 35 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1891.	12258.	0.	3931.	2799.	2691.	1591.	1591.	194.	39.	134.	564.	156.	39.
FEB	1742.	8020.	0.	2712.	1796.	1686.	1101.	1121.	137.	25.	89.	509.	111.	25.
MAR	1892.	7232.	0.	2535.	1661.	1543.	1026.	1067.	129.	23.	81.	549.	105.	23.
APR	1730.	4716.	0.	1791.	1249.	1124.	724.	751.	93.	15.	54.	496.	77.	15.
MAY	1638.	2704.	1611.	1382.	1054.	907.	501.	504.	65.	184.	32.	639.	55.	184.
JUN	1443.	1111.	3222.	1060.	1018.	845.	335.	335.	40.	354.	14.	755.	35.	354.
JUL	1379.	0.	4935.	921.	1164.	964.	576.	232.	29.	538.	6.	921.	23.	538.
AUG	1337.	0.	4615.	874.	1136.	950.	863.	222.	32.	503.	9.	874.	22.	503.
SEP	1330.	1789.	2955.	1189.	1046.	887.	578.	365.	48.	328.	22.	697.	40.	328.
OCT	1484.	4151.	1106.	1686.	1172.	1036.	566.	589.	82.	134.	48.	546.	67.	134.
NOV	1577.	7775.	0.	2598.	1734.	1642.	931.	1012.	131.	25.	87.	463.	105.	25.
DEC	1781.	10983.	0.	3546.	2460.	2359.	1403.	1451.	176.	35.	121.	530.	142.	35.
ANNUAL	19226.	60739.	18444.	24224.	18288.	16634.	10195.	9239.	1156.	2202.	697.	7543.	939.	2202.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 17.6 M3 PANEL= 20.0 M2	3500.	2928.	1987.	710.	335.	1267.	638.	11365.
5	FULL ACES, BIN= 52.1 M3 PANEL= 8.7 M2	3500.	4888.	1354.	710.	335.	1267.	638.	12692.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.13	914.	1457.06	REF.	REF.	27087.	31309.	38155.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.49	2162.	1100.03	357.04	131.	20450.	26050.	31219.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.64	2468.	1000.53	456.53	691.	18600.	25067.	29768.
4	MIN. ACES, BIN= 17.6 M3 PANEL= 20.0 M2	2.68	2432.	613.21	843.85	8057.	11400.	25196.	28078.
5	FULL ACES, BIN= 52.1 M3 PANEL= 8.7 M2	2.96	2432.	555.72	901.34	9384.	10331.	25455.	28066.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.03	889.	534.49	922.58	611.	15195.	20003.	23419.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.60	914.	1178.52	278.54	1037.	26736.	31995.	32594.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.40	960.	458.93	998.13	821.	12802.	17892.	20782.

TRENTON, NEW JERSEY

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 10013.
DESIGN COOLING LOAD (WATTS) = 5531.

EL. ($/KWHR) = 0.0768, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.4657, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1900, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -11 C 31 C
TOTAL/SENSIBLE COOLING = 1.21

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE GAS THERMS	(6) GAS FURNACE ELEC. KWH	(7) OIL FURNACE OIL GAL	(7) OIL FURNACE ELEC. KWH	(8) PULSE GAS FURN. GAS THERMS	(8) PULSE GAS FURN. ELEC. KWH
JAN	1892.	11406.	0.	3694.	2496.	2397.	1489.	1489.	181.	36.	125.	562.	148.	36.
FEB	1736.	9192.	0.	3036.	2005.	1910.	1229.	1230.	150.	29.	102.	511.	123.	29.
MAR	1860.	7527.	0.	2608.	1655.	1530.	1050.	1079.	131.	24.	85.	541.	108.	24.
APR	1667.	3601.	0.	1464.	1021.	911.	589.	611.	77.	11.	42.	475.	64.	11.
MAY	1539.	1377.	1703.	996.	849.	723.	353.	353.	45.	190.	18.	617.	40.	190.
JUN	1323.	0.	3444.	743.	907.	744.	204.	204.	26.	375.	4.	743.	22.	375.
JUL	1245.	0.	4867.	876.	1069.	866.	908.	215.	21.	530.	1.	876.	21.	530.
AUG	1212.	0.	4493.	826.	1011.	822.	841.	206.	21.	490.	2.	826.	20.	490.
SEP	1233.	553.	2705.	791.	810.	674.	529.	321.	29.	296.	8.	639.	26.	296.
OCT	1418.	2168.	819.	1085.	794.	696.	219.	375.	54.	96.	27.	490.	46.	96.
NOV	1545.	4847.	0.	1776.	1121.	1022.	642.	690.	91.	15.	56.	445.	75.	15.
DEC	1773.	9965.	0.	3261.	2130.	2029.	1280.	1291.	161.	32.	110.	524.	131.	32.
ANNUAL	18442.	50636.	18031.	21154.	15866.	14323.	9333.	8065.	989.	2125.	579.	7248.	823.	2125.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1129.	49.	236.	275.	811.	482.	3261.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	482.	3360.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	582.	3920.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 16.5 M3 PANEL= 20.9 M2	3500.	2708.	2036.	636.	335.	1267.	534.	11017.
5	FULL ACES, BIN= 59.9 M3 PANEL= 7.9 M2	3500.	5104.	1306.	636.	335.	1267.	534.	12683.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.14	914.	1624.66	REF.	REF.	30202.	34378.	33808.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.53	2162.	1218.51	406.15	99.	22652.	28174.	27747.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.69	2468.	1100.04	524.62	659.	20450.	26838.	26452.
4	MIN. ACES, BIN= 16.5 M3 PANEL= 20.9 M2	2.59	2432.	716.74	907.92	7755.	13324.	26773.	26522.
5	FULL ACES, BIN= 59.9 M3 PANEL= 7.9 M2	3.00	2432.	619.38	1005.29	9421.	11514.	26629.	26412.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.05	889.	623.58	1001.08	628.	17614.	22393.	21033.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.59	914.	1246.18	378.48	1084.	27759.	33018.	29354.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.38	960.	546.34	1078.33	868.	15168.	20257.	19116.

ALBUQUERQUE, NEW MEXICO

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 9762.
DESIGN COOLING LOAD (WATTS) = 5425.

EL. ($/KWHR) = 0.0749, 0.0850
GAS ($/THERM) = 0.3022, 0.8150
OIL ($/GAL.) = 1.1200, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -10 C 34 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1865.	7958.	0.	2729.	1772.	1654.	1119.	1070.	136.	25.	89.	543.	112.	25.
FEB	1676.	6074.	0.	2153.	1394.	1288.	895.	844.	109.	19.	68.	485.	90.	19.
MAR	1744.	4938.	0.	1856.	1240.	1120.	772.	728.	96.	16.	56.	500.	79.	16.
APR	1515.	2505.	1437.	1273.	959.	823.	468.	459.	60.	165.	30.	585.	51.	165.
MAY	1357.	917.	2847.	942.	911.	757.	299.	299.	36.	313.	12.	690.	32.	313.
JUN	1148.	0.	4735.	835.	1030.	858.	709.	202.	20.	516.	1.	835.	19.	516.
JUL	1089.	0.	5080.	856.	1054.	882.	939.	200.	18.	553.	0.	856.	18.	553.
AUG	1100.	0.	4641.	811.	992.	830.	864.	195.	18.	506.	0.	811.	18.	506.
SEP	1171.	0.	3644.	722.	891.	744.	689.	331.	23.	397.	4.	722.	19.	397.
OCT	1396.	1806.	1662.	1071.	862.	735.	328.	402.	49.	187.	23.	575.	42.	187.
NOV	1547.	5013.	0.	1822.	1167.	1061.	696.	662.	93.	16.	57.	446.	77.	16.
DEC	1773.	7560.	0.	2593.	1665.	1546.	1041.	1017.	130.	24.	85.	516.	107.	24.
ANNUAL	17381.	36770.	24046.	17663.	13936.	12296.	8817.	6410.	788.	2736.	425.	7565.	664.	2736.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1129.	48.	236.	275.	811.	482.	3261.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	482.	3360.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	582.	3920.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 12.2 M3 PANEL= 6.8 M2	3130.	2376.	1245.	636.	335.	1049.	534.	9305.
5	FULL ACES, BIN= 84.1 M3 PANEL= 0.0 M2	3130.	6193.	0.	636.	335.	1049.	534.	11877.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.23	914.	1323.14	REF.	REF.	24597.	28772.	28918.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.56	2162.	1043.95	279.19	99.	19407.	24929.	25044.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.77	2468.	921.11	402.03	659.	17123.	23511.	23612.
4	MIN. ACES, BIN= 12.2 M3 PANEL= 6.8 M2	2.46	2432.	660.50	662.64	6044.	12279.	24016.	24088.
5	FULL ACES, BIN= 84.1 M3 PANEL= 0.0 M2	3.39	2432.	480.16	842.98	8615.	8926.	23235.	23288.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.08	889.	443.14	880.00	628.	11353.	16132.	19197.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.62	914.	1042.94	280.20	1084.	22560.	27819.	26087.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.36	960.	405.56	917.58	868.	10163.	15252.	17838.

ROSWELL, NEW MEXICO

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 9509.
DESIGN COOLING LOAD (WATTS) = 5905.

EL. ($/KWHR) = 0.0515, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3478, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0400, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -10 C 37 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1782.	7202.	0.	2496.	1667.	1551.	1032.	979.	125.	23.	80.	518.	103.	23.
FEB	1596.	5251.	0.	1902.	1300.	1185.	803.	746.	97.	17.	59.	460.	80.	17.
MAR	1651.	4072.	984.	1697.	1172.	1034.	669.	638.	83.	120.	47.	579.	69.	120.
APR	1422.	1664.	2258.	1103.	941.	793.	369.	369.	47.	251.	21.	646.	41.	251.
MAY	1261.	0.	3953.	781.	972.	807.	474.	204.	26.	431.	5.	781.	21.	431.
JUN	1058.	0.	5497.	893.	1111.	935.	1009.	203.	18.	599.	1.	893.	18.	599.
JUL	1002.	0.	5906.	922.	1151.	968.	1084.	446.	17.	643.	0.	922.	17.	643.
AUG	1019.	0.	5656.	899.	1119.	940.	1042.	1105.	17.	616.	0.	899.	17.	616.
SEP	1097.	0.	4086.	750.	922.	771.	767.	824.	20.	445.	2.	750.	18.	445.
OCT	1322.	1244.	2229.	956.	851.	720.	450.	498.	40.	247.	17.	614.	35.	247.
NOV	1475.	4138.	0.	1559.	1090.	973.	600.	567.	81.	13.	48.	423.	67.	13.
DEC	1695.	6430.	0.	2257.	1469.	1352.	911.	885.	114.	20.	72.	491.	94.	20.
ANNUAL	16380.	30001.	30569.	16215.	13765.	12027.	9210.	7463.	684.	3425.	352.	7976.	578.	3425.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1129.	48.	236.	275.	811.	482.	3261.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	482.	3360.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	582.	3920.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 11.2 M3 PANEL= 5.5 M2	3130.	2280.	1172.	636.	335.	1049.	534.	9136.
5	FULL ACES, BIN= 66.5 M3 PANEL= 0.0 M2	3130.	5385.	0.	636.	335.	1049.	534.	11069.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.32	914.	835.23	REF.	REF.	15527.	19702.	26889.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.55	2162.	709.01	126.22	99.	13180.	18702.	24803.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.78	2468.	619.52	215.71	659.	11517.	17905.	23236.
4	MIN. ACES, BIN= 11.2 M3 PANEL= 5.5 M2	2.32	2432.	474.42	360.81	5875.	8819.	20387.	24470.
5	FULL ACES, BIN= 66.5 M3 PANEL= 0.0 M2	2.86	2432.	384.40	450.83	7807.	7146.	20647.	23954.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.12	889.	414.22	421.01	628.	10811.	15589.	18759.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.67	914.	776.45	58.78	1084.	16869.	22128.	24890.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.36	960.	377.52	457.71	868.	9648.	14737.	17653.

ALBANY, NEW YORK

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 13782.
DESIGN COOLING LOAD (WATTS) = 4735.

EL. ($/KWHR) = 0.0465, 0.0850
GAS ($/THERM) = 0.4657, 0.8150
OIL ($/GAL.) = 1.1900, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -20 C 31 C
TOTAL/SENSIBLE COOLING = 1.14

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1851.	15847.	0.	4917.	3962.	3952.	1954.	1954.	239.	50.	172.	565.	192.	50.
FEB	1733.	12468.	0.	3945.	3023.	2998.	1573.	1585.	193.	39.	136.	521.	156.	39.
MAR	1927.	10329.	0.	3405.	2356.	2302.	1354.	1362.	170.	33.	114.	568.	137.	33.
APR	1807.	4802.	0.	1836.	1217.	1124.	728.	732.	96.	15.	55.	517.	79.	15.
MAY	1752.	1983.	1122.	1160.	904.	792.	425.	426.	58.	129.	25.	615.	49.	129.
JUN	1567.	0.	2520.	710.	861.	717.	218.	218.	33.	275.	7.	710.	26.	275.
JUL	1496.	0.	3588.	806.	965.	780.	226.	226.	27.	391.	3.	806.	25.	391.
AUG	1421.	0.	3393.	764.	927.	751.	659.	214.	28.	370.	4.	764.	24.	370.
SEP	1369.	1120.	1737.	881.	779.	664.	365.	296.	39.	193.	15.	573.	34.	193.
OCT	1479.	3286.	0.	1324.	896.	813.	461.	466.	71.	10.	39.	421.	58.	10.
NOV	1540.	7289.	0.	2453.	1545.	1467.	870.	888.	125.	23.	82.	451.	100.	23.
DEC	1729.	13079.	0.	4114.	3053.	3026.	1597.	1600.	202.	41.	143.	522.	162.	41.
ANNUAL	19670.	70202.	12361.	26314.	20486.	19387.	10429.	9967.	1281.	1569.	795.	7033.	1043.	1569.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 22.0 M3 PANEL= 70.4 M2	4000.	3287.	4806.	830.	335.	1520.	638.	15415.
5	FULL ACES, BIN= 35.2 M3 PANEL= 48.7 M2	4000.	4077.	3592.	830.	335.	1520.	638.	14991.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.08	914.	1224.63	REF.	REF.	22766.	26988.	41082.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.39	2162.	953.44	271.20	131.	17724.	23325.	34298.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.46	2468.	902.29	322.34	691.	16774.	23240.	33625.
4	MIN. ACES, BIN= 22.0 M3 PANEL= 70.4 M2	2.72	2432.	485.38	739.25	12107.	9023.	26870.	32457.
5	FULL ACES, BIN= 35.2 M3 PANEL= 48.7 M2	2.85	2432.	463.85	760.78	11683.	8623.	26046.	31385.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.02	889.	669.43	555.20	611.	20246.	25054.	24207.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.59	914.	1272.81	-48.18	1037.	29958.	35218.	34228.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.42	960.	558.56	666.07	821.	16735.	21824.	21291.

BINGHAMTON, NEW YORK

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 12897.
DESIGN COOLING LOAD (WATTS) = 4186.

EL. ($/KWHR) = 0.0500, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.6319, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1800, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -18 C 29 C
TOTAL/SENSIBLE COOLING = 1.10

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1826.	16861.	0.	5191.	4215.	4209.	2044.	2044.	251.	53.	182.	561.	202.	53.
FEB	1713.	13269.	0.	4162.	3230.	3216.	1649.	1648.	203.	42.	144.	518.	164.	42.
MAR	1926.	11866.	0.	3831.	2748.	2711.	1517.	1515.	190.	38.	130.	573.	153.	38.
APR	1838.	5859.	0.	2138.	1393.	1310.	845.	844.	111.	19.	67.	529.	90.	19.
MAY	1821.	2661.	816.	1334.	973.	865.	502.	502.	68.	97.	32.	603.	57.	97.
JUN	1662.	753.	1953.	884.	841.	713.	303.	303.	39.	215.	11.	677.	35.	215.
JUL	1611.	0.	2808.	753.	895.	735.	227.	227.	31.	306.	4.	753.	27.	306.
AUG	1533.	0.	2601.	709.	849.	702.	215.	215.	30.	283.	5.	709.	25.	283.
SEP	1457.	1338.	1383.	927.	777.	672.	315.	315.	44.	155.	17.	560.	38.	155.
OCT	1535.	3752.	0.	1469.	970.	881.	505.	504.	78.	12.	44.	438.	64.	12.
NOV	1560.	8533.	0.	2804.	1786.	1726.	981.	977.	141.	27.	95.	460.	113.	27.
DEC	1719.	14506.	0.	4507.	3435.	3418.	1724.	1723.	220.	46.	158.	524.	176.	46.
ANNUAL	20202.	79398.	9560.	28711.	22112.	21159.	10828.	10818.	1405.	1293.	890.	6905.	1145.	1293.

SYSTEMS FIRST COSTS

NO.		COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 23.2 M3 PANEL=105.6 M2*	3500.	3315.	6779.	710.	335.	1267.	638.	16545.*
5	FULL ACES, BIN= 23.2 M3 PANEL=105.6 M2*	3500.	3315.	6779.	710.	335.	1267.	638.	16545.*
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.06	914.	1435.26	REF.	REF.	26681.	30904.	44440.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.37	2162.	1105.36	329.89	131.	20549.	26150.	36575.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.43	2468.	1057.72	377.54	691.	19663.	26130.	36106.
4	MIN. ACES, BIN= 23.2 M3 PANEL=105.6 M2	2.80	2432.	541.29	893.96	13237.	10063.	29039.*	34145.
5	FULL ACES, BIN= 23.2 M3 PANEL=105.6 M2	2.80	2432.	541.29	893.96	13237.	10063.	29039.*	34145.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.02	889.	952.57	482.68	611.	29323.	34131.	25493.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.59	914.	1395.50	39.76	1037.	32937.	38197.	36348.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.43	960.	788.28	646.98	821.	24119.	29208.	22282.

*UNGLAZED PANEL EXCEEDS A PRACTICAL SIZE, AN ALTERNATIVE SUPPLEMENTARY HEAT SOURCE SHOULD BE USED IN THIS DESIGN.

NIAGARA FALLS, NEW YORK

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 11557.
DESIGN COOLING LOAD (WATTS) = 4826.

EL. ($/KWHR) = 0.0465, 0.0850
GAS ($/THERM) = 0.6319, 0.8150
OIL ($/GAL.) = 1.1800, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -15 C 30 C
TOTAL/SENSIBLE COOLING = 1.17

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1841.	16136.	0.	4994.	3940.	3934.	1967.	1967.	240.	51.	175.	563.	195.	51.
FEB	1726.	13507.	0.	4232.	3266.	3256.	1682.	1686.	204.	43.	147.	522.	166.	43.
MAR	1927.	11627.	0.	3765.	2651.	2615.	1492.	1497.	185.	37.	128.	572.	151.	37.
APR	1815.	5529.	0.	2040.	1328.	1245.	807.	809.	105.	18.	63.	522.	87.	18.
MAY	1769.	2564.	944.	1306.	960.	847.	488.	489.	65.	111.	31.	602.	56.	111.
JUN	1588.	632.	2541.	894.	893.	742.	290.	290.	36.	279.	9.	720.	33.	279.
JUL	1519.	0.	3700.	825.	987.	797.	230.	230.	28.	403.	3.	825.	25.	403.
AUG	1441.	0.	3407.	771.	934.	762.	548.	217.	28.	371.	4.	771.	24.	371.
SEP	1382.	1333.	1536.	921.	776.	663.	331.	313.	42.	172.	17.	555.	37.	172.
OCT	1483.	3259.	0.	1317.	888.	798.	454.	457.	70.	10.	39.	422.	58.	10.
NOV	1536.	7617.	0.	2543.	1578.	1509.	891.	901.	127.	24.	85.	451.	103.	24.
DEC	1720.	13450.	0.	4214.	3052.	3031.	1606.	1608.	204.	43.	147.	520.	166.	43.
ANNUAL	19745.	75655.	12126.	27824.	21253.	20198.	10785.	10463.	1332.	1561.	847.	7046.	1099.	1561.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 22.3 M3 PANEL= 76.6 M2	3500.	3183.	5155.	710.	335.	1267.	638.	14788.
5	FULL ACES, BIN= 32.4 M3 PANEL= 57.9 M2	3500.	3784.	4109.	710.	335.	1267.	638.	14344.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.07	914.	1294.91	REF.	REF.	24072.	28295.	43198.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.41	2162.	989.10	305.81	131.	18387.	23988.	35372.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.48	2468.	940.02	354.89	691.	17475.	23942.	34760.
4	MIN. ACES, BIN= 22.3 M3 PANEL= 76.6 M2	2.77	2432.	501.95	792.96	11480.	9331.	26551.	32328.
5	FULL ACES, BIN= 32.4 M3 PANEL= 57.9 M2	2.86	2432.	486.93	807.98	11036.	9052.	25828.	31432.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.05	889.	914.37	380.54	581.	28008.	32786.	24856.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.60	914.	1327.91	-33.00	1037.	31346.	36605.	35520.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.43	960.	767.37	527.54	821.	23352.	28442.	22042.

SYRACUSE, NEW YORK

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 13091.
DESIGN COOLING LOAD (WATTS) = 4742.

EL. ($/KWHR) = 0.0465, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.4657, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1900, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -18 C 31 C
TOTAL/SENSIBLE COOLING = 1.12

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1857.	15356.	0.	4782.	3592.	3543.	1900.	1900.	233.	49.	167.	565.	187.	49.
FEB	1738.	12303.	0.	3901.	2821.	2751.	1554.	1564.	191.	39.	134.	522.	154.	39.
MAR	1929.	10632.	0.	3490.	2325.	2216.	1387.	1397.	174.	34.	117.	570.	140.	34.
APR	1803.	4857.	0.	1850.	1222.	1106.	733.	738.	97.	15.	56.	516.	79.	15.
MAY	1740.	2092.	1115.	1186.	916.	802.	436.	437.	59.	128.	26.	612.	50.	128.
JUN	1549.	0.	2583.	712.	869.	721.	217.	217.	33.	281.	7.	712.	26.	281.
JUL	1474.	0.	3734.	816.	977.	789.	225.	225.	27.	407.	2.	816.	25.	407.
AUG	1399.	0.	3517.	772.	933.	753.	677.	213.	26.	383.	3.	772.	23.	383.
SEP	1351.	1026.	1907.	868.	784.	664.	394.	289.	38.	211.	14.	586.	33.	211.
OCT	1467.	3079.	0.	1263.	877.	783.	438.	444.	68.	10.	37.	417.	56.	10.
NOV	1535.	7188.	0.	2423.	1483.	1365.	855.	875.	124.	23.	81.	449.	99.	23.
DEC	1731.	12822.	0.	4043.	2834.	2745.	1554.	1559.	199.	41.	140.	521.	159.	41.
ANNUAL	19573.	69355.	12857.	26105.	19633.	18235.	10369.	9857.	1268.	1620.	785.	7058.	1032.	1620.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 21.4 M3 PANEL= 72.3 M2	3500.	3209.	4914.	710.	335.	1267.	638.	14574.
5	FULL ACES, BIN= 38.0 M3 PANEL= 45.8 M2	3500.	4187.	3428.	710.	335.	1267.	638.	14065.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.08	914.	1214.93	REF.	REF.	22586.	26808.	40790.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.44	2162.	913.71	301.22	131.	16986.	22587.	33102.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.55	2468.	848.68	366.25	691.	15777.	22244.	32011.
4	MIN. ACES, BIN= 21.4 M3 PANEL= 72.3 M2	2.73	2432.	482.58	732.35	11266.	8971.	25977.	31531.
5	FULL ACES, BIN= 38.0 M3 PANEL= 45.8 M2	2.87	2432.	458.73	756.20	10757.	8528.	25025.	30304.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.02	889.	665.71	549.22	611.	20097.	24905.	24103.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.59	914.	1262.19	-47.26	1037.	29683.	34942.	34025.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.42	960.	556.17	658.76	821.	16628.	21717.	21225.

WESTHAMPTON BEACH, NEW YORK

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 10860.
DESIGN COOLING LOAD (WATTS) = 4838.

EL. ($/KWHR) = 0.0675, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.6319, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1800, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -13 C 28 C
TOTAL/SENSIBLE COOLING = 1.24

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1861.	11334.	0.	3665.	2594.	2543.	1476.	1476.	180.	36.	125.	553.	146.	36.
FEB	1728.	9440.	0.	3102.	2151.	2103.	1254.	1254.	153.	30.	104.	510.	125.	30.
MAR	1893.	7897.	0.	2720.	1744.	1662.	1096.	1117.	137.	25.	89.	551.	112.	25.
APR	1742.	4404.	0.	1707.	1094.	1004.	687.	699.	89.	14.	51.	498.	74.	14.
MAY	1654.	1992.	600.	1078.	796.	712.	415.	421.	56.	72.	26.	531.	48.	72.
JUN	1454.	0.	2228.	647.	777.	648.	201.	201.	30.	243.	6.	647.	24.	243.
JUL	1378.	0.	4045.	824.	988.	791.	493.	219.	24.	441.	1.	824.	23.	441.
AUG	1320.	0.	3825.	783.	945.	757.	723.	209.	24.	417.	2.	783.	22.	417.
SEP	1299.	577.	2033.	742.	732.	609.	411.	240.	30.	223.	8.	584.	27.	223.
OCT	1440.	2150.	485.	1050.	752.	675.	361.	371.	54.	60.	27.	460.	46.	60.
NOV	1531.	4769.	0.	1750.	1095.	1019.	637.	669.	90.	15.	56.	440.	74.	15.
DEC	1738.	9705.	0.	3179.	2154.	2090.	1253.	1253.	157.	31.	108.	513.	128.	31.
ANNUAL	19036.	52267.	13217.	21248.	15821.	14614.	9009.	8129.	1024.	1605.	601.	6894.	849.	1605.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 16.4 M3 PANEL= 22.3 M2	3500.	2747.	2116.	710.	335.	1267.	638.	11313.
5	FULL ACES, BIN= 41.7 M3 PANEL= 13.1 M2	3500.	4250.	1597.	710.	335.	1267.	638.	12297.
	POSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.11	914.	1434.89	REF.	REF.	26675.	30897.	33987.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.48	2162.	1068.42	366.46	131.	19862.	25463.	27764.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.61	2468.	986.87	448.02	691.	18346.	24813.	26938.
4	MIN. ACES, BIN= 16.4 M3 PANEL= 22.3 M2	2.61	2432.	608.41	826.48	8005.	11310.	25055.	26365.
5	FULL ACES, BIN= 41.7 M3 PANEL= 13.1 M2	2.89	2432.	548.93	885.96	8989.	10205.	24934.	26116.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.02	889.	755.24	679.65	581.	22500.	27279.	20776.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.55	914.	1174.93	259.95	1037.	26567.	31826.	29381.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.37	960.	645.06	789.82	821.	19011.	24100.	18745.

NEW BERN, NORTH CAROLINA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 8059.
DESIGN COOLING LOAD (WATTS) = 7954.

EL. ($/KWHR) = 0.0544, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3685, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1900, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -6 C 33 C
TOTAL/SENSIBLE COOLING = 1.43

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1639.	4377.	0.	1671.	1116.	1014.	726.	655.	87.	14.	51.	469.	72.	14.
FEB	1481.	3669.	0.	1431.	970.	879.	629.	561.	75.	12.	43.	423.	62.	12.
MAR	1560.	3048.	648.	1351.	932.	826.	554.	512.	68.	80.	36.	514.	57.	80.
APR	1379.	1154.	1816.	901.	794.	675.	312.	312.	39.	201.	15.	584.	35.	201.
MAY	1261.	0.	3964.	782.	959.	790.	607.	204.	24.	432.	3.	782.	21.	432.
JUN	1087.	0.	6524.	1013.	1267.	1045.	1185.	478.	18.	711.	0.	1013.	18.	711.
JUI	1040.	0.	8764.	1244.	1584.	1325.	1580.	1622.	17.	955.	0.	1244.	17.	955.
AUG	1039.	0.	8175.	1179.	1497.	1245.	1478.	1522.	17.	891.	0.	1179.	17.	891.
SEP	1082.	0.	5697.	921.	1146.	936.	1044.	1085.	18.	621.	0.	921.	18.	621.
OCT	1259.	594.	2615.	800.	810.	670.	510.	548.	30.	287.	9.	636.	27.	287.
NOV	1371.	2449.	807.	1149.	825.	725.	430.	387.	57.	96.	30.	477.	48.	96.
DEC	1558.	4429.	0.	1663.	1120.	1017.	699.	652.	86.	14.	51.	447.	71.	14.
ANNUAL	15755.	19720.	39009.	14105.	13021.	11147.	9753.	8538.	536.	4312.	238.	8689.	463.	4312.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 7.5 M3 PANEL= 3.3 M2	3130.	1885.	1052.	636.	335.	1049.	534.	8621.
5	FULL ACES, BIN= 43.7 M3 PANEL= 0.0 M2	3130.	4179.	0.	636.	335.	1049.	534.	9863.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.47	914.	767.31	REF.	REF.	14264.	18737.	24231.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.59	2162.	708.34	58.98	80.	13168.	18969.	24040.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.86	2468.	606.38	160.94	640.	11273.	17939.	22281.
4	MIN. ACES, BIN= 7.5 M3 PANEL= 3.3 M2	2.12	2432.	530.54	236.77	5062.	9863.	20916.	24714.
5	FULL ACES, BIN= 43.7 M3 PANEL= 0.0 M2	2.42	2432.	464.48	302.83	6304.	8635.	20930.	24256.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.17	889.	432.11	335.20	628.	10617.	15692.	18316.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.73	914.	755.65	11.66	1084.	15932.	21489.	23450.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.34	960.	405.19	362.12	868.	9764.	15151.	17646.

GREENSBORO, NORTH CAROLINA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 9332.
DESIGN COOLING LOAD (WATTS) = 6335.

EL. ($/KWHR) = 0.0461, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3667, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -9 C 33 C
TOTAL/SENSIBLE COOLING = 1.23

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1810.	7363.	0.	2548.	1640.	1540.	1057.	999.	128.	23.	83.	526.	105.	23.
FEB	1626.	5710.	0.	2038.	1314.	1222.	855.	799.	104.	18.	65.	470.	85.	18.
MAR	1698.	4099.	0.	1610.	1106.	1008.	681.	632.	84.	13.	48.	485.	70.	13.
APR	1485.	1754.	1364.	1048.	842.	727.	377.	373.	49.	154.	22.	567.	43.	154.
MAY	1345.	0.	2686.	666.	835.	692.	195.	195.	30.	293.	8.	666.	22.	293.
JUN	1151.	0.	4681.	830.	1020.	833.	868.	202.	20.	510.	1.	830.	19.	510.
JUL	1101.	0.	6096.	970.	1208.	992.	1116.	217.	18.	664.	0.	970.	18.	664.
AUG	1111.	0.	5628.	922.	1142.	935.	1036.	436.	19.	613.	0.	922.	18.	613.
SEP	1173.	0.	3458.	703.	870.	712.	656.	710.	24.	377.	4.	703.	20.	377.
OCT	1382.	1742.	1284.	1008.	799.	691.	323.	312.	48.	145.	22.	529.	41.	145.
NOV	1516.	4299.	0.	1615.	1085.	988.	619.	587.	83.	14.	50.	435.	69.	14.
DEC	1725.	7059.	0.	2440.	1570.	1476.	982.	957.	123.	22.	80.	502.	101.	22.
ANNUAL	17122.	32026.	25197.	16398.	13431.	11815.	8766.	6419.	730.	2846.	382.	7603.	611.	2846.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1129.	48.	236.	275.	811.	482.	3261.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	482.	3360.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	582.	3920.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 11.4 M3 PANEL= 7.9 M2	3130.	2289.	1308.	636.	335.	1049.	534.	9281.
5	FULL ACES, BIN= 74.1 M3 PANEL= 0.0 M2	3130.	5720.	0.	636.	335.	1049.	534.	11404.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.26	914.	756.13	REF.	REF.	14056.	18232.	27146.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.54	2162.	619.29	136.84	99.	11513.	17034.	24336.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.75	2468.	544.79	211.34	659.	10128.	16515.	22938.
4	MIN. ACES, BIN= 11.4 M3 PANEL= 7.9 M2	2.36	2432.	404.19	351.94	6020.	7514.	19227.	23992.
5	FULL ACES, BIN= 74.1 M3 PANEL= 0.0 M2	3.22	2432.	295.96	460.17	8143.	5502.	19338.	22827.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.07	889.	399.07	357.06	628.	10922.	15700.	18575.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.61	914.	797.79	-41.66	1084.	17809.	23069.	25106.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.34	960.	355.35	400.78	868.	9537.	14627.	17285.

BISMARCK, NORTH DAKOTA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 17994.
DESIGN COOLING LOAD (WATTS) = 4764.

EL. ($/KWHR) = 0.0469, 0.0850
GAS ($/THERM) = 0.3702, 0.8150
OIL ($/GAL.) = 1.0600, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -30 C 32 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1786.	21467.	0.	6460.	5708.	5690.	2551.	2551.	310.	68.	233.	564.	248.	68.
FEB	1670.	17255.	0.	5257.	4480.	4452.	2082.	2083.	254.	55.	188.	518.	204.	55.
MAR	1903.	12630.	0.	4037.	2954.	2875.	1597.	1598.	200.	40.	140.	569.	160.	40.
APR	1866.	6441.	0.	2308.	1521.	1403.	912.	912.	120.	20.	74.	539.	97.	20.
MAY	1919.	2760.	1286.	1440.	1081.	942.	530.	530.	71.	149.	35.	682.	60.	149.
JUN	1816.	854.	2514.	1016.	980.	816.	340.	340.	43.	277.	13.	781.	39.	277.
JUL	1812.	0.	3917.	930.	1118.	906.	267.	267.	35.	427.	5.	930.	30.	427.
AUG	1743.	0.	3738.	891.	1096.	897.	376.	379.	36.	407.	8.	891.	29.	407.
SEP	1636.	2397.	1453.	1279.	984.	849.	402.	402.	62.	166.	31.	620.	52.	166.
OCT	1665.	4992.	0.	1849.	1252.	1132.	636.	636.	97.	16.	59.	478.	79.	16.
NOV	1622.	12117.	0.	3817.	2750.	2673.	1324.	1325.	189.	38.	135.	489.	150.	38.
DEC	1720.	18733.	0.	5682.	4776.	4747.	2179.	2179.	274.	59.	204.	537.	220.	59.
ANNUAL	21158.	99647.	12909.	34966.	28699.	27383.	13198.	13202.	1691.	1722.	1124.	7600.	1367.	1722.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	350.	1129.	48.	305.	275.	811.	482.	3400.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	350.	1199.	77.	305.	275.	843.	482.	3531.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	350.	1199.	77.	705.	335.	843.	582.	4091.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 28.9 M3 PANEL=108.0 M2*	4450.	3952.	6911.	915.	335.	1716.	638.	18917.*
5	FULL ACES, BIN= 30.1 M3 PANEL=106.1 M2*	4450.	4025.	6805.	915.	335.	1716.	638.	18884.*
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	815.	1129.	26.	376.	270.	811.	532.	3959.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	720.	1129.	26.	632.	275.	811.	782.	4375.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.06	914.	1639.57	REF.	REF.	30480.	34794.	53295.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.29	2162.	1345.70	293.87	131.	25017.	30709.	45895.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.36	2468.	1283.97	355.60	691.	23869.	30428.	44916.
4	MIN. ACES, BIN= 28.9 M3 PANEL=108.0 M2	2.81	2432.	618.85	1020.73	15517.	11504.	32853.*	39836.
5	FULL ACES, BIN= 30.1 M3 PANEL=106.1 M2	2.81	2432.	619.03	1020.54	15484.	11508.	32824.*	39809.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.04	889.	706.63	932.94	559.	21323.	26171.	29968.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.62	914.	1547.53	92.04	975.	36702.	41991.	42973.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.46	960.	586.97	1052.60	729.	17533.	22623.	25868.

*UNGLAZED PANEL EXCEEDS A PRACTICAL SIZE, AN ALTERNATIVE SUPPLEMENTARY HEAT SOURCE SHOULD BE USED IN THIS DESIGN.

GRAND FORKS, NORTH DAKOTA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 18808.
DESIGN COOLING LOAD (WATTS) = 4575.

EL. ($/KWHR) = 0.0430, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3702, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0600, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -31 C 31 C
TOTAL/SENSIBLE COOLING = 1.05

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1814.	25591.	0.	7613.	7077.	7073.	2913.	2887.	362.	81.	276.	585.	291.	81.
FEB	1661.	19103.	0.	5768.	5075.	5056.	2267.	2266.	277.	60.	207.	522.	222.	60.
MAR	1872.	15560.	0.	4843.	3799.	3746.	1903.	1902.	237.	49.	171.	569.	190.	49.
APR	1842.	7195.	0.	2510.	1667.	1552.	986.	986.	129.	23.	82.	534.	104.	23.
MAY	1924.	3105.	1091.	1516.	1109.	976.	565.	564.	76.	129.	39.	663.	64.	129.
JUN	1866.	1015.	2122.	1032.	956.	810.	358.	358.	46.	234.	15.	753.	41.	234.
JUL	1915.	0.	3733.	939.	1125.	919.	276.	276.	37.	407.	6.	939.	32.	407.
AUG	1888.	0.	3091.	861.	1047.	868.	264.	353.	40.	337.	9.	861.	31.	337.
SEP	1796.	2252.	1128.	1247.	957.	839.	397.	397.	62.	130.	30.	629.	53.	130.
OCT	1824.	5404.	0.	2008.	1323.	1213.	682.	681.	106.	17.	64.	524.	85.	17.
NOV	1746.	12649.	0.	3999.	2893.	2816.	1362.	1359.	198.	40.	140.	525.	158.	40.
DEC	1800.	20707.	0.	6253.	5421.	5405.	2191.	2127.	300.	66.	225.	566.	241.	66.
ANNUAL	21948.	112580.	11166.	38589.	32449.	31272.	14164.	14156.	1870.	1573.	1262.	7670.	1512.	1573.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	350.	1129.	48.	305.	275.	811.	482.	3400.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	350.	1199.	77.	305.	275.	843.	482.	3531.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	350.	1199.	77.	705.	335.	843.	582.	4091.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 34.0 M3 PANEL=512.5 M2*	4450.	4299.	29569.	915.	335.	1716.	638.	41921.*
5	FULL ACES, BIN= 34.0 M3 PANEL=512.5 M2*	4450.	4299.	29569.	915.	335.	1716.	638.	41921.*
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	815.	1129.	26.	376.	270.	811.	532.	3959.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	720.	1129.	26.	632.	275.	811.	782.	4375.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.05	914.	1660.10	REF.	REF.	30861.	35175.	58370.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.25	2162.	1395.95	264.15	131.	25951.	31644.	51147.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.29	2468.	1345.34	314.76	691.	25010.	31569.	50365.
4	MIN. ACES, BIN= 34.0 M3 PANEL=512.5 M2	2.86	2432.	609.33	1050.77	38521.	11327.	55681.*	64194.
5	FULL ACES, BIN= 34.0 M3 PANEL=512.5 M2	2.86	2432.	609.33	1050.77	38521.	11327.	55681.*	64194.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.04	889.	759.84	900.26	559.	23179.	28027.	32164.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.62	914.	1668.16	-8.06	975.	39924.	45213.	46409.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.48	960.	627.56	1032.54	729.	18990.	24079.	27606.

*UNGLAZED PANEL EXCEEDS A PRACTICAL SIZE, AN ALTERNATIVE SUPPLEMENTARY HEAT SOURCE SHOULD BE USED IN THIS DESIGN.

WILLISTON, NORTH DAKOTA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 17470.
DESIGN COOLING LOAD (WATTS) = 4581.

EL. ($/KWHR) = 0.0469, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3702, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0600, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -28 C 31 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE GAS THERMS	(6) GAS FURNACE ELEC. KWH	(7) OIL FURNACE OIL GAL	(7) OIL FURNACE ELEC. KWH	(8) PULSE GAS FURN. GAS THERMS	(8) PULSE GAS FURN. ELEC. KWH
JAN	1786.	20069.	0.	6071.	5286.	5266.	2363.	2394.	292.	64.	218.	560.	234.	64.
FEB	1677.	14881.	0.	4600.	3766.	3728.	1821.	1824.	224.	47.	163.	513.	180.	47.
MAR	1911.	12088.	0.	3889.	2859.	2790.	1539.	1541.	193.	38.	135.	569.	155.	38.
APR	1866.	5717.	0.	2107.	1408.	1305.	834.	835.	110.	18.	67.	536.	89.	18.
MAY	1904.	2294.	1148.	1291.	1001.	880.	476.	476.	65.	132.	30.	661.	55.	132.
JUN	1786.	643.	2352.	931.	922.	767.	311.	311.	39.	258.	10.	754.	36.	258.
JUL	1766.	0.	4013.	928.	1109.	881.	263.	263.	33.	437.	4.	928.	29.	437.
AUG	1689.	0.	3770.	880.	1061.	848.	494.	376.	33.	411.	5.	880.	28.	411.
SEP	1584.	1786.	1255.	1073.	857.	742.	337.	293.	52.	142.	24.	582.	45.	142.
OCT	1620.	4542.	0.	1712.	1169.	1060.	589.	591.	91.	14.	54.	464.	73.	14.
NOV	1592.	10568.	0.	3378.	2356.	2277.	1170.	1174.	169.	33.	118.	476.	134.	33.
DEC	1706.	15636.	0.	4818.	3770.	3721.	1781.	1856.	235.	50.	172.	523.	188.	50.
ANNUAL	20887.	88224.	12538.	31677.	25563.	24265.	11978.	11935.	1536.	1645.	999.	7448.	1247.	1645.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	350.	1129.	48.	305.	275.	811.	482.	3400.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	350.	1199.	77.	305.	275.	843.	482.	3531.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	350.	1199.	77.	705.	335.	843.	582.	4091.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 27.1 M3 PANEL=103.9 M2*	4000.	3817.	6684.	830.	335.	1520.	638.	17824.*
5	FULL ACES, BIN= 30.9 M3 PANEL= 89.4 M2*	4000.	4041.	5870.	830.	335.	1520.	638.	17233.*
	POSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	815.	1129.	26.	376.	270.	811.	532.	3959.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	720.	1129.	26.	632.	275.	811.	782.	4375.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST AVERAGE $	LIFE CYCLE COST MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.07	914.	1485.35	REF.	REF.	27613.	31927.	48688.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.32	2162.	1198.63	286.72	131.	22283.	27975.	41501.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.39	2468.	1137.77	347.58	691.	21151.	27710.	40549.
4	MIN. ACES, BIN= 27.1 M3 PANEL=103.9 M2	2.82	2432.	561.65	923.70	14424.	10441.	30697.*	37035.
5	FULL ACES, BIN= 30.9 M3 PANEL= 89.4 M2	2.83	2432.	559.62	925.73	13833.	10403.	30069.*	36383.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.03	889.	645.88	839.47	559.	19446.	24294.	27787.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.60	914.	1408.21	77.14	975.	33232.	38521.	39760.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.44	960.	538.61	946.74	729.	16049.	21138.	24136.

*UNGLAZED PANEL EXCEEDS A PRACTICAL SIZE, AN ALTERNATIVE SUPPLEMENTARY HEAT SOURCE SHOULD BE USED IN THIS DESIGN.

AKRON, OHIO

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 12183.
DESIGN COOLING LOAD (WATTS) = 4935.

EL. ($/KWHR) = 0.0568, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3697, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1100, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -16 C 31 C
TOTAL/SENSIBLE COOLING = 1.14

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1871.	13941.	0.	4393.	3128.	3063.	1742.	1742.	213.	44.	152.	564.	173.	44.
FEB	1738.	11003.	0.	3540.	2433.	2352.	1423.	1429.	173.	35.	121.	518.	141.	35.
MAR	1908.	9698.	0.	3224.	2118.	2018.	1288.	1302.	160.	31.	107.	561.	131.	31.
APR	1762.	4604.	0.	1768.	1194.	1080.	706.	712.	92.	15.	53.	504.	76.	15.
MAY	1681.	2038.	1118.	1155.	895.	782.	424.	425.	56.	128.	25.	595.	49.	128.
JUN	1485.	0.	2860.	724.	896.	738.	214.	214.	32.	312.	7.	724.	25.	312.
JUL	1412.	0.	3988.	827.	997.	805.	355.	222.	25.	434.	2.	827.	23.	434.
AUG	1352.	0.	3706.	779.	943.	769.	706.	211.	25.	404.	3.	779.	22.	404.
SEP	1326.	887.	1979.	830.	771.	649.	405.	273.	35.	218.	12.	587.	31.	218.
OCT	1462.	3149.	0.	1281.	907.	805.	448.	457.	68.	10.	37.	416.	56.	10.
NOV	1547.	7403.	0.	2486.	1548.	1440.	894.	914.	124.	23.	83.	453.	101.	23.
DEC	1750.	12266.	0.	3894.	2680.	2591.	1505.	1507.	190.	39.	134.	525.	154.	39.
ANNUAL	19293.	64989.	13651.	24901.	18509.	17092.	10110.	9407.	1193.	1693.	737.	7053.	983.	1693.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 19.6 M3 PANEL= 40.7 M2	3500.	3044.	3145.	710.	335.	1267.	638.	12639.
5	FULL ACES, BIN= 42.6 M3 PANEL= 25.7 M2	3500.	4377.	2305.	710.	335.	1267.	638.	13132.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.09	914.	1415.37	REF.	REF.	26312.	30534.	39104.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.47	2162.	1052.06	363.31	131.	19558.	25159.	31528.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.59	2468.	971.50	443.87	691.	18060.	24527.	30409.
4	MIN. ACES, BIN= 19.6 M3 PANEL= 40.7 M2	2.69	2432.	574.66	840.72	9331.	10683.	25754.	29233.
5	FULL ACES, BIN= 42.6 M3 PANEL= 25.7 M2	2.89	2432.	534.71	880.66	9824.	9940.	25505.	28742.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.04	889.	537.17	878.20	581.	15753.	20532.	23169.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.59	914.	1219.40	195.97	1037.	28120.	33379.	32881.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.41	960.	459.72	955.65	821.	13301.	18390.	20666.

COLUMBUS, OHIO

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 12358.
DESIGN COOLING LOAD (WATTS) = 5200.

EL. ($/KWHR) = 0.0624, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3633, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1400, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -17 C 32 C
TOTAL/SENSIBLE COOLING = 1.15

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1897.	9994.	0.	3303.	2152.	2042.	1356.	1356.	163.	32.	111.	559.	133.	32.
FEB	1730.	9056.	0.	2996.	1953.	1859.	1226.	1226.	148.	29.	100.	509.	121.	29.
MAR	1845.	7595.	0.	2622.	1675.	1566.	1067.	1107.	132.	24.	85.	537.	108.	24.
APR	1648.	3475.	0.	1423.	1013.	905.	578.	605.	75.	11.	41.	469.	63.	11.
MAY	1520.	1363.	1615.	977.	830.	708.	348.	348.	45.	180.	18.	603.	39.	180.
JUN	1312.	0.	3970.	797.	982.	802.	210.	210.	26.	433.	4.	797.	22.	433.
JUL	1245.	0.	4856.	875.	1073.	876.	902.	215.	22.	529.	1.	875.	21.	529.
AUG	1224.	0.	4136.	791.	966.	789.	777.	202.	22.	451.	2.	791.	20.	451.
SEP	1253.	614.	2584.	800.	806.	667.	507.	321.	30.	284.	9.	632.	27.	284.
OCT	1443.	2861.	947.	1299.	933.	822.	436.	458.	63.	112.	34.	513.	53.	112.
NOV	1568.	6774.	0.	2318.	1473.	1375.	863.	922.	117.	21.	77.	457.	95.	21.
DEC	1789.	10117.	0.	3307.	2206.	2106.	1310.	1355.	163.	32.	112.	529.	133.	32.
ANNUAL	18475.	51850.	18109.	21509.	16063.	14518.	9580.	8326.	1006.	2137.	594.	7269.	836.	2137.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 14.8 M3 PANEL= 20.8 M2	3500.	2713.	2030.	710.	335.	1267.	638.	11193.
5	FULL ACES, BIN= 59.5 M3 PANEL= 8.1 M2	3500.	5236.	1320.	710.	335.	1267.	638.	13007.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.14	914.	1342.40	REF.	REF.	24955.	29177.	34353.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.53	2162.	1002.47	339.93	131.	18636.	24237.	28101.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.69	2468.	906.08	436.32	691.	16844.	23311.	26804.
4	MIN. ACES, BIN= 14.8 M3 PANEL= 20.8 M2	2.56	2432.	597.91	744.49	7885.	11115.	24740.	27045.
5	FULL ACES, BIN= 59.5 M3 PANEL= 8.1 M2	2.95	2432.	519.62	822.78	9698.	9660.	25098.	27102.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.05	889.	498.98	843.42	581.	14058.	18836.	21288.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.60	914.	1130.51	211.89	1037.	25524.	30783.	29727.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.38	960.	436.98	905.42	821.	12095.	17184.	19307.

DAYTON, OHIO

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 12573.
DESIGN COOLING LOAD (WATTS) = 5724.

EL. ($/KWHR) = 0.0620, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3697, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1100, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -17 C 32 C
TOTAL/SENSIBLE COOLING = 1.18

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1899.	12864.	0.	4101.	2868.	2785.	1636.	1636.	202.	41.	141.	568.	163.	41.
FEB	1736.	9432.	0.	3103.	2069.	1969.	1257.	1271.	155.	30.	104.	512.	125.	30.
MAR	1849.	7421.	0.	2575.	1673.	1558.	1037.	1092.	131.	24.	83.	537.	106.	24.
APR	1642.	2963.	731.	1359.	962.	854.	521.	544.	69.	89.	35.	545.	57.	89.
MAY	1498.	1144.	1919.	943.	844.	714.	326.	326.	41.	213.	15.	629.	37.	213.
JUN	1276.	0.	3771.	765.	938.	761.	203.	203.	25.	411.	3.	765.	21.	411.
JUL	1194.	0.	5453.	926.	1141.	923.	1014.	218.	20.	594.	0.	926.	20.	594.
AUG	1168.	0.	5183.	889.	1095.	891.	965.	211.	20.	565.	1.	889.	19.	565.
SEP	1202.	0.	3252.	688.	863.	708.	626.	310.	26.	354.	6.	688.	20.	354.
OCT	1401.	2106.	934.	1076.	799.	697.	352.	373.	53.	108.	26.	498.	45.	108.
NOV	1542.	6022.	0.	2102.	1325.	1224.	763.	834.	108.	19.	68.	448.	87.	19.
DEC	1779.	10937.	0.	3532.	2379.	2275.	1380.	1411.	176.	35.	120.	529.	141.	35.
ANNUAL	18186.	52889.	21243.	22059.	16956.	15359.	10080.	8429.	1026.	2482.	603.	7534.	841.	2482.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 18.3 M3 PANEL= 27.0 M2	3500.	2977.	2375.	710.	335.	1267.	638.	11803.
5	FULL ACES, BIN= 74.6 M3 PANEL= 6.5 M2	3500.	5952.	1230.	710.	335.	1267.	638.	13632.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.16	914.	1367.88	REF.	REF.	25429.	29651.	35122.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.51	2162.	1051.43	316.45	131.	19546.	25147.	29353.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.67	2468.	952.43	415.45	691.	17706.	24173.	27982.
4	MIN. ACES, BIN= 18.3 M3 PANEL= 27.0 M2	2.54	2432.	625.09	742.79	8494.	11620.	25855.	28355.
5	FULL ACES, BIN= 74.6 M3 PANEL= 6.5 M2	3.04	2432.	522.66	845.22	10324.	9716.	25780.	27871.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.05	889.	533.28	834.60	611.	14876.	19684.	22068.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.62	914.	1136.82	231.06	1037.	25593.	30852.	30328.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.40	960.	464.98	902.90	821.	12713.	17802.	19868.

TOLEDO, OHIO

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 13089.
DESIGN COOLING LOAD (WATTS) = 5660.

EL. ($/KWHR) = 0.0643, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3697, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1100, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -18 C 32 C
TOTAL/SENSIBLE COOLING = 1.16

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1853.	15770.	0.	4896.	3677.	3630.	1935.	1935.	238.	50.	171.	565.	192.	50.
FEB	1732.	12236.	0.	3880.	2766.	2695.	1550.	1557.	190.	39.	133.	520.	154.	39.
MAR	1918.	9987.	0.	3307.	2167.	2050.	1315.	1326.	166.	32.	110.	564.	134.	32.
APR	1787.	4851.	0.	1844.	1244.	1125.	731.	736.	96.	15.	56.	512.	79.	15.
MAY	1720.	1860.	1457.	1153.	932.	806.	412.	412.	55.	165.	23.	642.	48.	165.
JUN	1527.	0.	3040.	755.	937.	770.	221.	221.	33.	331.	7.	755.	25.	331.
JUL	1451.	0.	4432.	886.	1076.	868.	384.	233.	26.	483.	2.	886.	24.	483.
AUG	1380.	0.	4120.	832.	1021.	832.	782.	220.	27.	449.	4.	832.	23.	449.
SEP	1337.	989.	2226.	889.	826.	693.	451.	288.	37.	246.	13.	617.	32.	246.
OCT	1457.	3220.	683.	1374.	936.	829.	457.	462.	69.	85.	38.	489.	57.	85.
NOV	1530.	7543.	0.	2521.	1582.	1480.	890.	915.	128.	24.	85.	449.	102.	24.
DEC	1727.	13644.	0.	4270.	3047.	2978.	1642.	1644.	209.	43.	149.	523.	168.	43.
ANNUAL	19418.	70100.	15958.	26607.	20210.	18755.	10771.	9949.	1274.	1961.	792.	7355.	1037.	1961.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 21.9 M3 PANEL= 61.0 M2	3500.	3242.	4283.	710.	335.	1267.	638.	13975.
5	FULL ACES, BIN= 47.9 M3 PANEL= 37.0 M2	3500.	4708.	2938.	710.	335.	1267.	638.	14097.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.10	914.	1710.31	REF.	REF.	31795.	36017.	41494.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.45	2162.	1299.07	411.24	131.	24150.	29751.	33910.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.56	2468.	1205.57	504.74	591.	22412.	28878.	32739.
4	MIN. ACES, BIN= 21.9 M3 PANEL= 61.0 M2	2.72	2432.	692.34	1017.97	10667.	12871.	29278.	31495.
5	FULL ACES, BIN= 47.9 M3 PANEL= 37.0 M2	2.95	2432.	639.51	1070.80	10789.	11888.	28418.	30466.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.03	889.	597.08	1113.23	611.	17261.	22069.	24668.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.61	914.	1351.84	358.47	1037.	30985.	36245.	34617.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.42	960.	509.54	1200.77	821.	14489.	19578.	21769.

ALTUS, OKLAHOMA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 9912.
DESIGN COOLING LOAD (WATTS) = 7196.

EL. ($/KWHR) = 0.0425, 0.0850
GAS ($/THERM) = 0.3685, 0.8150
OIL ($/GAL.) = 1.1900, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -11 C 38 C
TOTAL/SENSIBLE COOLING = 1.13

DESIGN AND PERFORMANCE

	BUILDING LOADS			SYSTEM ENERGY CONSUMPTION											
				(1)	(2)	(3)	(4)	(5)	(6)		(7)		(8)	
MONTH	WATER HEAT	SPACE HEAT	SPACE COOL	ELEC. RES.	HEAT PUMP	HP DS	MIN. ACES	FULL ACES	GAS FURNACE		OIL FURNACE		PULSE GAS FURN.	
									GAS	ELEC.	OIL	ELEC.	GAS	ELEC.
	MJ	MJ	MJ	KWH	KWH	KWH	KWH	KWH	THERMS	KWH	GAL	KWH	THERMS	KWH
JAN	1796.	8339.	0.	2815.	1863.	1746.	1155.	1104.	140.	26.	93.	525.	115.	26.
FEB	1617.	6013.	0.	2120.	1387.	1271.	888.	831.	107.	19.	68.	468.	88.	19.
MAR	1674.	4651.	0.	1757.	1234.	1100.	735.	689.	91.	15.	53.	480.	75.	15.
APR	1434.	1490.	1907.	1020.	869.	735.	346.	346.	45.	212.	19.	611.	39.	212.
MAY	1255.	0.	3821.	765.	938.	768.	332.	201.	24.	416.	3.	765.	21.	416.
JUN	1032.	0.	6430.	987.	1238.	1026.	1174.	213.	17.	700.	0.	987.	17.	700.
JUL	955.	0.	8456.	1187.	1515.	1278.	1532.	581.	16.	921.	0.	1187.	16.	921.
AUG	961.	0.	7814.	1118.	1422.	1197.	1422.	1496.	16.	851.	0.	1118.	16.	851.
SEP	1042.	0.	4828.	815.	1014.	837.	899.	967.	19.	526.	2.	815.	17.	526.
OCT	1276.	910.	2274.	855.	803.	675.	458.	516.	34.	251.	13.	605.	30.	251.
NOV	1448.	3968.	0.	1505.	1042.	929.	581.	547.	78.	13.	46.	415.	65.	13.
DEC	1689.	6822.	0.	2365.	1512.	1390.	954.	927.	119.	22.	76.	491.	98.	22.
ANNUAL	16179.	32193.	35531.	17309.	14838.	12953.	10478.	8420.	706.	3973.	372.	8467.	597.	3973.

SYSTEMS FIRST COSTS

		COMPONENTS COSTS, $							TOTAL
NO.	CONVENTIONAL ELECTRIC SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $

$HASP170 PRINTER5 BACKSPACED

DAYTON, OHIO

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 12573.
DESIGN COOLING LOAD (WATTS) = 5724.

EL. ($/KWHR) = 0.0620, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3697, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1100, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -17 C 32 C
TOTAL/SENSIBLE COOLING = 1.18

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1899.	12864.	0.	4101.	2868.	2785.	1636.	1636.	202.	41.	141.	568.	163.	41.
FEB	1736.	9432.	0.	3103.	2069.	1969.	1257.	1271.	155.	30.	104.	512.	125.	30.
MAR	1849.	7421.	0.	2575.	1673.	1558.	1037.	1092.	131.	24.	83.	537.	106.	24.
APR	1642.	2963.	731.	1359.	962.	854.	521.	544.	69.	89.	35.	545.	57.	89.
MAY	1498.	1144.	1919.	943.	844.	714.	326.	326.	41.	213.	15.	629.	37.	213.
JUN	1276.	0.	3771.	765.	938.	761.	203.	203.	25.	411.	3.	765.	21.	411.
JUL	1194.	0.	5453.	926.	1141.	923.	1014.	218.	20.	594.	0.	926.	20.	594.
AUG	1168.	0.	5183.	889.	1095.	891.	965.	211.	20.	565.	1.	889.	19.	565.
SEP	1202.	0.	3252.	688.	863.	708.	626.	310.	26.	354.	6.	688.	20.	354.
OCT	1401.	2106.	934.	1076.	799.	697.	352.	373.	53.	108.	26.	498.	45.	108.
NOV	1542.	6022.	0.	2102.	1325.	1224.	763.	834.	108.	19.	68.	448.	87.	19.
DEC	1779.	10937.	0.	3532.	2379.	2275.	1380.	1411.	176.	35.	120.	529.	141.	35.
ANNUAL	18186.	52889.	21243.	22059.	16956.	15359.	10080.	8429.	1026.	2482.	603.	7534.	841.	2482.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL,
4	MIN. ACES, BIN= 18.3 M3 PANEL= 27.0 M2	3500.	2977.	2375.	710.	335.	1267.	638.	11803.
5	FULL ACES, BIN= 74.6 M3 PANEL= 6.5 M2	3500.	5952.	1230.	710.	335.	1267.	638.	13632.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.16	914.	1367.88	REF.	REF.	25429.	29651.	35122.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.51	2162.	1051.43	316.45	131.	19546.	25147.	29353.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.67	2468.	952.43	415.45	691.	17706.	24173.	27982.
4	MIN. ACES, BIN= 18.3 M3 PANEL= 27.0 M2	2.54	2432.	625.09	742.79	8494.	11620.	25855.	28355.
5	FULL ACES, BIN= 74.6 M3 PANEL= 6.5 M2	3.04	2432.	522.66	845.22	10324.	9716.	25780.	27871.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.05	889.	533.28	834.60	611.	14876.	19684.	22068.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.62	914.	1136.82	231.06	1037.	25593.	30852.	30328.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.40	960.	464.98	902.90	821.	12713.	17802.	19868.

TOLEDO, OHIO

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 13089.
DESIGN COOLING LOAD (WATTS) = 5660.

EL. ($/KWHR) = 0.0643, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3697, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1100, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -18 C 32 C
TOTAL/SENSIBLE COOLING = 1.16

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1853.	15770.	0.	4896.	3677.	3630.	1935.	1935.	238.	50.	171.	565.	192.	50.
FEB	1732.	12236.	0.	3880.	2766.	2695.	1550.	1557.	190.	39.	133.	520.	154.	39.
MAR	1918.	9987.	0.	3307.	2167.	2050.	1315.	1326.	166.	32.	110.	564.	134.	32.
APR	1787.	4851.	0.	1844.	1244.	1125.	731.	736.	96.	15.	56.	512.	79.	15.
MAY	1720.	1860.	1457.	1153.	932.	806.	412.	412.	55.	165.	23.	642.	48.	165.
JUN	1527.	0.	3040.	755.	937.	770.	221.	221.	33.	331.	7.	755.	25.	331.
JUL	1451.	0.	4432.	886.	1076.	868.	384.	233.	26.	483.	2.	886.	24.	483.
AUG	1380.	0.	4120.	832.	1021.	832.	782.	220.	27.	449.	4.	832.	23.	449.
SEP	1337.	989.	2226.	889.	826.	693.	451.	288.	37.	246.	13.	617.	32.	246.
OCT	1457.	3220.	683.	1374.	936.	829.	457.	462.	69.	85.	38.	489.	57.	85.
NOV	1530.	7543.	0.	2521.	1582.	1480.	890.	915.	128.	24.	85.	449.	102.	24.
DEC	1727.	13644.	0.	4270.	3047.	2978.	1642.	1644.	209.	43.	149.	523.	168.	43.
ANNUAL	19418.	70100.	15958.	26607.	20210.	18755.	10771.	9949.	1274.	1961.	792.	7355.	1037.	1961.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 21.9 M3 PANEL= 61.0 M2	3500.	3242.	4283.	710.	335.	1267.	638.	13975.
5	FULL ACES, BIN= 47.9 M3 PANEL= 37.0 M2	3500.	4708.	2938.	710.	335.	1267.	638.	14097.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.10	914.	1710.31	REF.	REF.	31795.	36017.	41494.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.45	2162.	1299.07	411.24	131.	24150.	29751.	33910.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.56	2468.	1205.57	504.74	691.	22412.	28878.	32739.
4	MIN. ACES, BIN= 21.9 M3 PANEL= 61.0 M2	2.72	2432.	692.34	1017.97	10667.	12871.	29278.	31495.
5	FULL ACES, BIN= 47.9 M3 PANEL= 37.0 M2	2.95	2432.	639.51	1070.80	10789.	11888.	28418.	30466.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.03	869.	597.08	1113.23	611.	17261.	22069.	24668.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.61	914.	1351.84	358.47	1037.	30985.	36245.	34617.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.42	960.	509.54	1200.77	821.	14489.	19578.	21769.

ALTUS, OKLAHOMA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 9912.
DESIGN COOLING LOAD (WATTS) = 7196.

EL. ($/KWHR) = 0.0425, 0.0850
GAS ($/THERM) = 0.3685, 0.8150
OIL ($/GAL.) = 1.1900, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -11 C 38 C
TOTAL/SENSIBLE COOLING = 1.13

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1796.	8339.	0.	2815.	1863.	1746.	1155.	1104.	140.	26.	93.	525.	115.	26.
FEB	1617.	6013.	0.	2120.	1387.	1271.	888.	831.	107.	19.	68.	468.	88.	19.
MAR	1674.	4651.	0.	1757.	1234.	1100.	735.	689.	91.	15.	53.	480.	75.	15.
APR	1434.	1490.	1907.	1020.	869.	735.	346.	346.	45.	212.	19.	611.	39.	212.
MAY	1255.	0.	3821.	765.	938.	768.	332.	201.	24.	416.	3.	765.	21.	416.
JUN	1032.	0.	6430.	987.	1238.	1026.	1174.	213.	17.	700.	0.	987.	17.	700.
JUL	955.	0.	8456.	1187.	1515.	1278.	1532.	581.	16.	921.	0.	1187.	16.	921.
AUG	961.	0.	7814.	1118.	1422.	1197.	1422.	1496.	16.	851.	0.	1118.	16.	851.
SEP	1042.	0.	4828.	815.	1014.	837.	899.	967.	19.	526.	2.	815.	17.	526.
OCT	1276.	910.	2274.	855.	803.	675.	458.	516.	34.	251.	13.	605.	30.	251.
NOV	1448.	3968.	0.	1505.	1042.	929.	581.	547.	78.	13.	46.	415.	65.	13.
DEC	1689.	6822.	0.	2365.	1512.	1390.	954.	927.	119.	22.	76.	491.	98.	22.
ANNUAL	16179.	32193.	35531.	17309.	14838.	12953.	10478.	8420.	706.	3973.	372.	8467.	597.	3973.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 12.6 M3 PANEL= 6.4 M2	3130.	2415.	1222.	636.	335.	1049.	534.	9321.
5	FULL ACES, BIN= 75.3 M3 PANEL= 0.0 M2	3130.	5813.	0.	636.	335.	1049.	534.	11497.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.35	914.	735.28	REF.	REF.	13669.	18142.	28719.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.57	2162.	630.31	104.96	80.	11717.	17518.	26585.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.80	2468.	550.26	185.01	640.	10229.	16896.	24812.
4	MIN. ACES, BIN= 12.6 M3 PANEL= 6.4 M2	2.22	2432.	445.10	290.17	5762.	8274.	20027.	26430.
5	FULL ACES, BIN= 75.3 M3 PANEL= 0.0 M2	2.77	2432.	357.70	377.58	7938.	6650.	20579.	25725.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.14	889.	428.91	306.37	628.	11376.	16452.	20123.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.72	914.	802.48	-67.20	1084.	17867.	23424.	26371.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.38	960.	388.82	346.46	868.	10106.	15493.	18972.

OKLAHOMA CITY, OKLAHOMA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 10341.
DESIGN COOLING LOAD (WATTS) = 7276.

EL. ($/KWHR) = 0.0457, 0.0850
GAS ($/THERM) = 0.3667, 0.8150
OIL ($/GAL.) = 1.1700, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -12 C 36 C
TOTAL/SENSIBLE COOLING = 1.22

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1818.	9484.	0.	3140.	2094.	1977.	1284.	1231.	155.	30.	105.	535.	127.	30.
FEB	1640.	6885.	0.	2368.	1538.	1423.	986.	929.	119.	22.	77.	478.	97.	22.
MAR	1707.	5323.	0.	1953.	1310.	1182.	813.	766.	100.	17.	61.	491.	83.	17.
APR	1472.	1720.	1488.	1049.	849.	727.	371.	369.	49.	168.	21.	577.	42.	168.
MAY	1300.	0.	3293.	720.	878.	719.	199.	199.	25.	359.	4.	720.	22.	359.
JUN	1077.	0.	6014.	955.	1190.	978.	1105.	213.	18.	655.	0.	955.	18.	655.
JUL	1002.	0.	8078.	1158.	1472.	1233.	1467.	234.	17.	880.	0.	1158.	17.	880.
AUG	1003.	0.	7668.	1114.	1412.	1184.	1398.	1166.	17.	835.	0.	1114.	17.	835.
SEP	1076.	0.	4523.	792.	983.	807.	847.	916.	20.	493.	2.	792.	18.	493.
OCT	1305.	1019.	2035.	867.	790.	668.	418.	477.	36.	225.	14.	587.	32.	225.
NOV	1471.	4220.	0.	1581.	1070.	961.	606.	575.	82.	13.	49.	422.	67.	13.
DEC	1711.	7605.	0.	2588.	1656.	1538.	1049.	1015.	129.	24.	85.	499.	106.	24.
ANNUAL	16583.	36255.	33099.	18285.	15243.	13397.	10534.	8088.	767.	3721.	417.	8328.	645.	3721.

SYSTEMS FIRST COSTS

NO.		COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	77.	236.	275.	940.	534.	3671.
3	HEAT PUMP, DESUPER HEATER WATER HEATER	280.	1329.	77.	636.	335.	940.	634.	4231.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 14.0 M3 PANEL= 7.3 M2	3500.	2548.	1275.	710.	335.	1267.	638.	10273.
5	FULL ACES, BIN= 83.8 M3 PANEL= 0.0 M2	3500.	6217.	0.	710.	335.	1267.	638.	12668.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.31	914.	834.69	REF.	REF.	15517.	19990.	30086.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.57	2162.	695.86	138.83	112.	12936.	18769.	27186.
3	HEAT PUMP, DESUPER HEATER WATER HEATER	1.78	2468.	611.55	223.14	672.	11369.	18067.	25465.
4	MIN. ACES, BIN= 14.0 M3 PANEL= 7.3 M2	2.27	2432.	480.86	353.83	6714.	8939.	21644.	27460.
5	FULL ACES, BIN= 83.8 M3 PANEL= 0.0 M2	2.95	2432.	369.23	465.46	9109.	6864.	21964.	26430.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.13	889.	450.93	383.76	628.	12059.	17135.	20583.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.70	914.	868.56	-33.87	1084.	19399.	24956.	27266.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.38	960.	406.47	428.21	868.	10651.	16038.	19266.

TULSA, OKLAHOMA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 10547.
DESIGN COOLING LOAD (WATTS) = 7777.

EL. ($/KWHR) = 0.0436, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3667, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -12 C 37 C
TOTAL/SENSIBLE COOLING = 1.25

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1815.	9522.	0.	3149.	2110.	1996.	1287.	1235.	156.	30.	105.	534.	127.	30.
FEB	1639.	6420.	0.	2239.	1458.	1345.	938.	878.	113.	20.	72.	476.	93.	20.
MAR	1707.	4769.	0.	1799.	1233.	1112.	749.	705.	93.	15.	55.	489.	77.	15.
APR	1472.	1709.	1372.	1033.	832.	715.	370.	367.	48.	155.	21.	564.	42.	155.
MAY	1299.	0.	3551.	748.	929.	760.	202.	202.	27.	387.	5.	748.	22.	387.
JUN	1075.	0.	6201.	974.	1218.	1004.	1138.	215.	18.	676.	0.	974.	18.	676.
JUL	998.	0.	8466.	1199.	1529.	1287.	1535.	239.	17.	922.	0.	1199.	17.	922.
AUG	997.	0.	7960.	1144.	1454.	1221.	1449.	1528.	17.	867.	0.	1144.	17.	867.
SEP	1070.	0.	4660.	805.	1003.	824.	871.	937.	20.	508.	2.	805.	18.	508.
OCT	1298.	1084.	2078.	888.	805.	679.	426.	483.	37.	230.	14.	590.	33.	230.
NOV	1465.	4028.	0.	1526.	1038.	931.	584.	555.	79.	13.	47.	420.	65.	13.
DEC	1706.	6985.	0.	2414.	1542.	1425.	980.	947.	122.	22.	79.	496.	100.	22.
ANNUAL	16542.	34517.	34288.	17920.	15151.	13300.	10528.	8291.	746.	3845.	401.	8440.	627.	3845.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1279.	48.	253.	275.	907.	534.	3606.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1329.	77.	253.	275.	940.	534.	3718.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1329.	77.	653.	335.	940.	634.	4278.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 14.1 M3 PANEL= 8.1 M2	3500.	2563.	1317.	710.	335.	1267.	638.	10330.
5	FULL ACES, BIN= 80.0 M3 PANEL= 0.0 M2	3500.	6063.	0.	710.	335.	1267.	638.	12514.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.32	914.	781.84	REF.	REF.	14534.	19054.	29622.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.56	2162.	661.04	120.80	112.	12289.	18168.	27103.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.78	2468.	580.29	201.55	672.	10788.	17533.	25376.
4	MIN. ACES, BIN= 14.1 M3 PANEL= 8.1 M2	2.25	2432.	459.35	322.49	6724.	8539.	21302.	27510.
5	FULL ACES, BIN= 80.0 M3 PANEL= 0.0 M2	2.86	2432.	361.72	420.12	8908.	6724.	21670.	26559.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.13	889.	441.17	340.67	581.	11778.	16854.	20476.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.70	914.	837.23	-55.39	1037.	18687.	24244.	27024.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.38	960.	397.62	384.22	821.	10399.	15785.	19192.

ASTORIA, OREGON

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 7231.
DESIGN COOLING LOAD (WATTS) = 2434.

EL. ($/KWHR) = 0.0341, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3478, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0400, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -3 C 22 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1764.	6647.	0.	2337.	1515.	1436.	927.	906.	119.	21.	76.	511.	97.	21.
FEB	1606.	5166.	0.	1881.	1208.	1136.	777.	746.	97.	16.	60.	463.	79.	16.
MAR	1750.	5174.	0.	1923.	1241.	1166.	787.	762.	100.	16.	60.	502.	82.	16.
APR	1631.	3737.	0.	1491.	959.	880.	611.	591.	79.	12.	43.	465.	65.	12.
MAY	1599.	2690.	0.	1192.	800.	728.	493.	473.	65.	9.	33.	453.	54.	9.
JUN	1470.	1587.	0.	849.	643.	585.	354.	338.	48.	5.	22.	413.	41.	5.
JUL	1462.	1073.	824.	794.	656.	581.	303.	300.	40.	93.	17.	499.	35.	93.
AUG	1446.	971.	960.	776.	659.	578.	290.	288.	39.	108.	15.	509.	34.	108.
SEP	1427.	1397.	636.	854.	660.	588.	337.	329.	44.	74.	20.	470.	38.	74.
OCT	1542.	2532.	0.	1132.	769.	706.	472.	450.	61.	8.	32.	436.	51.	8.
NOV	1573.	4589.	0.	1712.	1097.	1026.	716.	682.	89.	15.	54.	452.	73.	15.
DEC	1708.	5972.	0.	2133.	1340.	1252.	885.	849.	110.	19.	69.	493.	89.	19.
ANNUAL	18979.	41533.	2420.	17074.	11547.	10662.	6951.	6713.	891.	395.	502.	5668.	739.	395.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1129.	48.	236.	275.	811.	482.	3261.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	482.	3360.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	582.	3920.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 10.4 M3 PANEL= 9.2 M2	3130.	2097.	1380.	636.	335.	1049.	534.	9162.
5	FULL ACES, BIN= 10.4 M3 PANEL= 9.2 M2	3130.	2097.	1380.	636.	335.	1049.	534.	9162.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.02	914.	582.05	REF.	REF.	10820.	14996.	28092.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.51	2162.	393.63	188.43	99.	7317.	12839.	21696.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.64	2468.	363.47	218.58	659.	6757.	13145.	21323.
4	MIN. ACES, BIN= 10.4 M3 PANEL= 9.2 M2	2.52	2432.	236.96	345.09	5901.	4405.	15999.	21331.
5	FULL ACES, BIN= 10.4 M3 PANEL= 9.2 M2	2.60	2432.	236.96	345.09	5901.	4405.	15999.	21331.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	1.92	889.	323.20	258.85	628.	10060.	14838.	17293.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.40	914.	714.93	-132.88	1084.	16765.	22025.	25269.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.30	960.	270.46	311.59	868.	8389.	13479.	15567.

BEDFORD, OREGON

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 8392.
DESIGN COOLING LOAD (WATTS) = 5422.

EL. ($/KWHR) = 0.0341, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3478, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0400, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -6 C 34 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1859.	7698.	0.	2655.	1656.	1510.	1087.	1087.	134.	24.	87.	541.	109.	24.
FEB	1677.	5446.	0.	1979.	1256.	1147.	800.	821.	101.	17.	62.	483.	83.	17.
MAR	1777.	4862.	0.	1845.	1197.	1086.	742.	778.	95.	15.	55.	509.	79.	15.
APR	1591.	3351.	0.	1373.	985.	872.	552.	580.	73.	11.	39.	453.	61.	11.
MAY	1486.	2194.	1421.	1177.	900.	774.	424.	427.	56.	162.	27.	575.	47.	162.
JUN	1309.	940.	2750.	925.	885.	737.	294.	294.	35.	303.	13.	666.	31.	303.
JUL	1274.	0.	4477.	842.	1060.	884.	680.	213.	27.	488.	6.	842.	21.	488.
AUG	1277.	0.	3990.	789.	994.	827.	748.	206.	27.	435.	7.	789.	21.	435.
SEP	1312.	1150.	2571.	964.	888.	745.	504.	310.	38.	284.	16.	648.	34.	284.
OCT	1494.	3000.	724.	1327.	920.	811.	450.	485.	67.	88.	36.	503.	55.	88.
NOV	1594.	5191.	0.	1885.	1191.	1084.	681.	740.	97.	16.	60.	459.	79.	16.
DEC	1783.	7700.	0.	2635.	1630.	1482.	1040.	1075.	133.	24.	87.	520.	108.	24.
ANNUAL	18434.	41533.	15933.	18395.	13560.	11958.	8001.	7016.	884.	1867.	495.	6988.	730.	1867.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
		COMPONENTS COSTS, $							
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1129.	48.	236.	275.	811.	482.	3261.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	482.	3360.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	582.	3920.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 11.9 M3 PANEL= 19.2 M2	3130.	2275.	1943.	636.	335.	1049.	534.	9902.
5	FULL ACES, BIN= 46.3 M3 PANEL= 5.9 M2	3130.	4336.	1193.	636.	335.	1049.	534.	11214.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.15	914.	627.08	REF.	REF.	11657.	15833.	29943.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.55	2162.	462.27	164.81	99.	8594.	14115.	24517.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.76	2468.	407.65	219.43	659.	7578.	13966.	23139.
4	MIN. ACES, BIN= 11.9 M3 PANEL= 19.2 M2	2.64	2432.	272.75	354.33	6641.	5070.	17404.	23542.
5	FULL ACES, BIN= 46.3 M3 PANEL= 5.9 M2	3.01	2432.	239.19	387.90	7952.	4446.	18092.	23474.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.01	889.	371.01	256.07	628.	10917.	15696.	19263.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.53	914.	753.05	-125.97	1084.	17428.	22687.	26959.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.34	960.	317.50	309.58	868.	9223.	14312.	17508.

PORTLAND, OREGON

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 8763.
DESIGN COOLING LOAD (WATTS) = 4795.

EL. ($/KWHR) = 0.0402, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3022, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1200, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -7 C 32 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1804.	8337.	0.	2817.	1730.	1589.	1145.	1145.	141.	26.	93.	527.	115.	26.
FEB	1634.	5415.	0.	1958.	1202.	1089.	805.	817.	101.	17.	62.	471.	82.	17.
MAR	1753.	4908.	0.	1850.	1155.	1047.	754.	765.	96.	16.	57.	503.	79.	16.
APR	1598.	3233.	0.	1342.	894.	802.	548.	556.	71.	10.	38.	454.	60.	10.
MAY	1525.	1934.	785.	1046.	776.	684.	399.	402.	53.	92.	25.	515.	45.	92.
JUN	1370.	916.	1402.	788.	697.	598.	279.	279.	36.	156.	14.	536.	32.	156.
JUL	1346.	0.	2936.	694.	856.	705.	199.	199.	29.	320.	7.	694.	22.	320.
AUG	1339.	0.	2592.	654.	800.	661.	506.	193.	28.	282.	7.	654.	22.	282.
SEP	1350.	913.	1521.	795.	710.	608.	319.	284.	36.	169.	14.	544.	32.	169.
OCT	1502.	2323.	0.	1062.	761.	683.	402.	418.	58.	7.	30.	425.	49.	7.
NOV	1572.	4734.	0.	1752.	1084.	984.	665.	698.	91.	15.	55.	452.	74.	15.
DEC	1736.	7060.	0.	2444.	1460.	1313.	982.	994.	124.	22.	80.	505.	101.	22.
ANNUAL	18527.	39772.	9237.	17202.	12126.	10764.	7003.	6749.	865.	1132.	482.	6279.	713.	1132.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C. H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1129.	48.	236.	275.	811.	482.	3261.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	482.	3360.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	582.	3920.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 12.6 M3 PANEL= 12.3 M2	3130.	2352.	1556.	636.	335.	1049.	534.	9591.
5	FULL ACES, BIN= 21.1 M3 PANEL= 8.9 M2	3130.	2946.	1365.	636.	335.	1049.	534.	9994.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.09	914.	691.70	REF.	REF.	12859.	17034.	28272.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.55	2162.	487.60	204.10	99.	9065.	14586.	22509.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.74	2468.	432.82	258.88	659.	8046.	14434.	21466.
4	MIN. ACES, BIN= 12.6 M3 PANEL= 12.3 M2	2.68	2432.	281.57	410.13	6330.	5234.	17258.	21833.
5	FULL ACES, BIN= 21.1 M3 PANEL= 8.9 M2	2.78	2432.	271.37	420.33	6733.	5045.	17471.	21880.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	1.96	889.	306.87	384.83	628.	9123.	13901.	17980.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.46	914.	791.86	-100.16	1084.	18313.	23572.	25642.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.32	960.	261.14	430.56	868.	7675.	12764.	16258.

MIDDLETOWN, PENNSYLVANIA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 10857.
DESIGN COOLING LOAD (WATTS) = 5965.

EL. ($/KWHR) = 0.0261, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.6319, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1800, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -13 C 33 C
TOTAL/SENSIBLE COOLING = 1.21

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1890.	12307.	0.	3944.	2683.	2583.	1586.	1586.	193.	39.	135.	564.	157.	39.
FEB	1736.	10230.	0.	3324.	2218.	2121.	1343.	1344.	163.	32.	112.	515.	133.	32.
MAR	1864.	7694.	0.	2655.	1686.	1558.	1062.	1098.	133.	24.	86.	542.	109.	24.
APR	1673.	3345.	0.	1394.	990.	883.	558.	577.	74.	11.	39.	475.	62.	11.
MAY	1546.	1092.	1725.	921.	819.	697.	323.	323.	41.	191.	15.	621.	37.	191.
JUN	1329.	0.	3632.	765.	926.	752.	207.	207.	25.	396.	3.	765.	22.	396.
JUL	1249.	0.	5194.	913.	1118.	900.	968.	220.	21.	566.	0.	913.	21.	566.
AUG	1213.	0.	4556.	833.	1017.	823.	854.	207.	21.	496.	1.	833.	20.	496.
SEP	1231.	565.	2552.	777.	789.	654.	504.	315.	29.	280.	8.	622.	26.	280.
OCT	1413.	2289.	672.	1102.	787.	694.	370.	388.	56.	80.	28.	473.	47.	80.
NOV	1540.	5616.	0.	1988.	1226.	1119.	723.	770.	102.	18.	65.	446.	83.	18.
DEC	1768.	11114.	0.	3579.	2369.	2264.	1400.	1429.	176.	35.	122.	526.	143.	35.
ANNUAL	18451.	54250.	18330.	22194.	16628.	15048.	9897.	8463.	1033.	2169.	615.	7294.	860.	2169.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 17.6 M3 PANEL= 28.2 M2	3500.	2833.	2444.	710.	335.	1267.	638.	11728.
5	FULL ACES, BIN= 63.1 M3 PANEL= 10.0 M2	3500.	5312.	1425.	710.	335.	1267.	638.	13187.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.14	914.	579.25	REF.	REF.	10768.	14991.	35311.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.52	2162.	433.99	145.26	131.	8068.	13669.	28894.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.68	2468.	392.76	186.50	691.	7301.	13768.	27546.
4	MIN. ACES, BIN= 17.6 M3 PANEL= 28.2 M2	2.56	2432.	258.32	320.94	8420.	4802.	18962.	28024.
5	FULL ACES, BIN= 63.1 M3 PANEL= 10.0 M2	2.99	2432.	220.89	358.36	9879.	4106.	19725.	27475.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.06	889.	709.31	-130.06	581.	21723.	26502.	21690.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.61	914.	916.58	-337.33	1037.	21876.	27135.	30285.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.39	960.	599.88	-20.63	821.	18258.	23347.	19675.

PHILADELPHIA, PENNSYLVANIA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 10215.
DESIGN COOLING LOAD (WATTS) = 4655.

EL. ($/KWHR) = 0.0718, 0.0850
GAS ($/THERM) = 0.5407, 0.8150
OIL ($/GAL.) = 1.1500, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -11 C 32 C
TOTAL/SENSIBLE COOLING = 1.20

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1916.	11780.	0.	3805.	2545.	2455.	1521.	1521.	186.	37.	129.	570.	152.	37.
FEB	1740.	9459.	0.	3111.	2023.	1914.	1255.	1258.	154.	30.	104.	513.	125.	30.
MAR	1839.	7070.	0.	2875.	1536.	1405.	989.	1022.	125.	22.	80.	533.	103.	22.
APR	1622.	2872.	595.	1313.	922.	823.	506.	518.	67.	74.	35.	525.	56.	74.
MAY	1474.	970.	1725.	867.	785.	662.	301.	301.	38.	191.	13.	600.	34.	191.
JUN	1255.	0.	3312.	710.	852.	679.	194.	194.	23.	361.	2.	710.	21.	361.
JUL	1183.	0.	5275.	903.	1109.	874.	981.	214.	20.	575.	0.	903.	20.	575.
AUG	1171.	0.	3707.	729.	881.	693.	704.	190.	20.	404.	1.	729.	19.	404.
SEP	1218.	0.	2175.	575.	692.	570.	435.	248.	24.	237.	4.	575.	20.	237.
OCT	1429.	2148.	646.	1064.	771.	682.	356.	372.	54.	77.	27.	474.	46.	77.
NOV	1572.	5164.	0.	1871.	1184.	1086.	676.	732.	96.	16.	59.	453.	79.	16.
DEC	1806.	10793.	0.	3500.	2240.	2126.	1367.	1379.	172.	34.	119.	536.	140.	34.
ANNUAL	18227.	50255.	17436.	20924.	15540.	13967.	9284.	7948.	980.	2059.	574.	7122.	815.	2059.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1129.	48.	236.	275.	811.	482.	3261.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	482.	3360.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	582.	3920.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 17.0 M3 PANEL= 30.4 M2	3500.	2754.	2565.	636.	335.	1267.	638.	11696.
5	FULL ACES, BIN= 59.2 M3 PANEL= 10.6 M2	3500.	5087.	1458.	636.	335.	1267.	638.	12921.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.14	914.	1501.50	REF.	REF.	27913.	32088.	33486.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.54	2162.	1115.15	386.35	99.	20731.	26253.	27290.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.71	2468.	1002.29	499.21	659.	18633.	25021.	25953.
4	MIN. ACES, BIN= 17.0 M3 PANEL= 30.4 M2	2.57	2432.	666.25	835.25	8435.	12386.	26513.	27133.
5	FULL ACES, BIN= 59.2 M3 PANEL= 10.6 M2	3.00	2432.	570.35	931.16	9660.	10603.	25956.	26487.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.05	889.	677.57	823.93	628.	19526.	24305.	20823.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.59	914.	1171.00	330.51	1084.	26164.	31423.	29043.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.38	960.	588.56	912.94	868.	16707.	21797.	18923.

PITTSBURGH, PENNSYLVANIA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 12175.
DESIGN COOLING LOAD (WATTS) = 4600.

EL. ($/KWHR) = 0.0588, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3592, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1500, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -16 C 31 C
TOTAL/SENSIBLE COOLING = 1.15

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1882.	14102.	0.	4441.	3376.	3357.	1753.	1753.	215.	45.	154.	567.	175.	45.
FEB	1742.	11230.	0.	3604.	2648.	2619.	1440.	1453.	176.	36.	123.	519.	143.	36.
MAR	1898.	9004.	0.	3029.	2029.	1971.	1206.	1218.	151.	29.	100.	556.	123.	29.
APR	1737.	4017.	0.	1599.	1106.	1015.	635.	640.	84.	13.	47.	495.	70.	13.
MAY	1641.	1607.	1416.	1057.	871.	753.	386.	386.	50.	159.	20.	615.	44.	159.
JUN	1439.	0.	2746.	699.	860.	705.	207.	207.	31.	299.	7.	699.	24.	299.
JUL	1364.	0.	3831.	796.	959.	775.	344.	214.	24.	417.	2.	796.	23.	417.
AUG	1313.	0.	3463.	742.	897.	728.	664.	203.	24.	377.	3.	742.	22.	377.
SEP	1301.	824.	2013.	810.	762.	641.	411.	265.	33.	222.	11.	583.	30.	222.
OCT	1453.	2772.	0.	1174.	851.	758.	409.	416.	63.	9.	34.	412.	52.	9.
NOV	1551.	6797.	0.	2319.	1456.	1381.	827.	854.	117.	22.	77.	452.	95.	22.
DEC	1761.	12661.	0.	4006.	2934.	2906.	1538.	1538.	195.	40.	139.	529.	158.	40.
ANNUAL	19079.	63015.	13468.	24273.	18749.	17609.	9821.	9146.	1163.	1667.	716.	6967.	960.	1667.

SYSTEMS FIRST COSTS

NO.		FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
		COMPONENTS COSTS, $							
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 19.8 M3 PANEL= 59.3 M2	3500.	3057.	4187.	710.	335.	1267.	638.	13695.
5	FULL ACES, BIN= 41.2 M3 PANEL= 36.1 M2	3500.	4304.	2887.	710.	335.	1267.	638.	13642.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.09	914.	1427.75	REF.	REF.	26542.	30764.	38224.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.42	2162.	1102.84	324.92	131.	20502.	26103.	31865.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.51	2468.	1035.75	392.00	691.	19255.	25722.	31133.
4	MIN. ACES, BIN= 19.8 M3 PANEL= 59.3 M2	2.70	2432.	577.66	850.10	10387.	10739.	26866.	29884.
5	FULL ACES, BIN= 41.2 M3 PANEL= 36.1 M2	2.90	2432.	537.97	889.78	10333.	10001.	26075.	28885.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.04	889.	515.66	912.09	581.	15049.	19827.	22729.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.58	914.	1232.89	194.86	1037.	28401.	33660.	32240.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.40	960.	442.71	985.05	821.	12738.	17827.	20312.

WILKES-BARRE, PENNSYLVANIA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 12186.
DESIGN COOLING LOAD (WATTS) = 4737.

EL. ($/KWHR) = 0.0442, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.6319, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1800, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -16 C 31 C
TOTAL/SENSIBLE COOLING = 1.15

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE GAS THERMS	(6) GAS FURNACE ELEC. KWH	(7) OIL FURNACE OIL GAL	(7) OIL FURNACE ELEC. KWH	(8) PULSE GAS FURN. GAS THERMS	(8) PULSE GAS FURN. ELEC. KWH
JAN	1876.	13310.	0.	4219.	3156.	3133.	1686.	1686.	205.	42.	145.	563.	167.	42.
FEB	1741.	10246.	0.	3330.	2381.	2340.	1338.	1348.	164.	32.	113.	516.	133.	32.
MAR	1909.	9032.	0.	3039.	2039.	1978.	1216.	1231.	151.	29.	101.	559.	124.	29.
APR	1761.	4012.	0.	1604.	1091.	1001.	641.	647.	84.	13.	47.	502.	70.	13.
MAY	1678.	1799.	1129.	1089.	860.	751.	398.	399.	53.	129.	23.	595.	46.	129.
JUN	1481.	0.	2676.	703.	855.	710.	211.	211.	31.	292.	6.	703.	25.	292.
JUL	1409.	0.	3883.	814.	979.	789.	350.	220.	25.	423.	2.	814.	23.	423.
AUG	1351.	0.	3419.	748.	901.	732.	655.	206.	25.	373.	3.	748.	22.	373.
SEP	1327.	870.	1921.	819.	761.	643.	394.	270.	35.	212.	12.	581.	31.	212.
OCT	1465.	2959.	0.	1229.	869.	780.	433.	443.	65.	9.	35.	416.	55.	9.
NOV	1551.	6739.	0.	2303.	1440.	1365.	831.	854.	116.	21.	76.	452.	94.	21.
DEC	1755.	11293.	0.	3625.	2576.	2531.	1419.	1419.	178.	36.	124.	523.	144.	36.
ANNUAL	19305.	60259.	13029.	23523.	17909.	16753.	9571.	8934.	1132.	1610.	687.	6973.	935.	1610.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
		COMPONENTS COSTS, $							
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 18.9 M3 PANEL= 42.5 M2	3500.	2991.	3248.	710.	335.	1267.	638.	12690.
5	FULL ACES, BIN= 39.8 M3 PANEL= 26.5 M2	3500.	4229.	2349.	710.	335.	1267.	638.	13028.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST AVERAGE $	LIFE CYCLE COST MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.09	914.	1040.64	REF.	REF.	19345.	23568.	37173.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.44	2162.	792.27	248.36	131.	14728.	20329.	30687.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.54	2468.	741.17	299.47	691.	13778.	20245.	29935.
4	MIN. ACES, BIN= 18.9 M3 PANEL= 42.5 M2	2.69	2432.	423.42	617.22	9382.	7871.	22993.	28529.
5	FULL ACES, BIN= 39.8 M3 PANEL= 26.5 M2	2.88	2432.	395.24	645.40	9720.	7348.	22808.	27975.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.03	889.	786.60	254.03	581.	23980.	28758.	22239.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.57	914.	1119.43	-78.79	1037.	26211.	31470.	31563.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.39	960.	662.18	378.46	821.	20040.	25129.	19906.

CHARLESTON, SOUTH CAROLINA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 7293.
DESIGN COOLING LOAD (WATTS) = 7502.

EL. ($/KWHR) = 0.0511, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3685, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1900, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -3 C 33 C
TOTAL/SENSIBLE COOLING = 1.44

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1618.	4825.	0.	1790.	1172.	1071.	763.	702.	92.	15.	55.	465.	76.	15.
FEB	1456.	3212.	0.	1297.	923.	828.	567.	509.	68.	10.	38.	415.	57.	10.
MAR	1530.	2607.	942.	1252.	910.	800.	493.	464.	62.	111.	31.	536.	52.	111.
APR	1351.	848.	2154.	846.	799.	674.	280.	280.	35.	237.	11.	613.	31.	237.
MAY	1239.	0.	4346.	818.	1005.	821.	809.	207.	23.	473.	2.	818.	21.	473.
JUN	1073.	0.	6244.	978.	1222.	1001.	1137.	454.	18.	680.	0.	978.	18.	680.
JUL	1034.	0.	8034.	1163.	1475.	1221.	1453.	1491.	17.	875.	0.	1163.	17.	875.
AUG	1040.	0.	7854.	1145.	1450.	1202.	1423.	1463.	17.	856.	0.	1145.	17.	856.
SEP	1086.	0.	5507.	902.	1121.	914.	1012.	1049.	19.	600.	1.	902.	18.	600.
OCT	1261.	732.	2629.	840.	830.	691.	514.	547.	32.	289.	10.	639.	28.	289.
NOV	1368.	2144.	1099.	1095.	829.	722.	382.	353.	53.	127.	26.	507.	45.	127.
DEC	1546.	4440.	0.	1663.	1112.	1014.	692.	644.	86.	14.	51.	444.	71.	14.
ANNUAL	15602.	18809.	38808.	13787.	12848.	10960.	9524.	8163.	521.	4287.	227.	8622.	451.	4287.

SYSTEMS FIRST COSTS

NO.		COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
	CONVENTIONAL ELECTRIC SYSTEMS								
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 8.0 M3 PANEL= 3.4 M2	3130.	1892.	1058.	636.	335.	1049.	534.	8634.
5	FULL ACES, BIN= 39.9 M3 PANEL= 0.0 M2	3130.	3937.	0.	636.	335.	1049.	534.	9621.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.48	914.	704.39	REF.	REF.	13095.	17567.	23786.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.58	2162.	656.42	47.97	80.	12203.	18004.	23799.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.86	2468.	559.93	144.46	640.	10409.	17076.	22019.
4	MIN. ACES, BIN= 8.0 M3 PANEL= 3.4 M2	2.14	2432.	486.58	217.81	5075.	9046.	20111.	24407.
5	FULL ACES, BIN= 39.9 M3 PANEL= 0.0 M2	2.49	2432.	417.03	287.36	6062.	7753.	19805.	23487.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.17	889.	410.89	293.50	628.	10148.	15224.	18074.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.73	914.	710.56	-6.17	1084.	15008.	20565.	23095.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.34	969.	385.29	319.10	868.	9337.	14724.	17452.

GREENVILLE, SOUTH CAROLINA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 8499.
DESIGN COOLING LOAD (WATTS) = 6596.

EL. ($/KWHR) = 0.0400, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3685, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1900, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -7 C 34 C
TOTAL/SENSIBLE COOLING = 1.24

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1735.	6470.	0.	2280.	1437.	1330.	948.	894.	116.	20.	74.	503.	95.	20.
FEB	1563.	4725.	0.	1747.	1131.	1040.	742.	685.	90.	15.	54.	449.	74.	15.
MAR	1638.	3852.	0.	1525.	1049.	945.	643.	598.	80.	12.	45.	467.	67.	12.
APR	1438.	1336.	1502.	935.	790.	675.	334.	334.	43.	168.	17.	567.	38.	168.
MAY	1307.	0.	2970.	686.	834.	693.	195.	195.	26.	324.	4.	686.	22.	324.
JUN	1120.	0.	4755.	829.	1017.	833.	878.	199.	19.	518.	0.	829.	19.	518.
JUL	1070.	0.	6434.	998.	1248.	1021.	1175.	218.	18.	701.	0.	998.	18.	701.
AUG	1075.	0.	6244.	979.	1221.	997.	1143.	1206.	18.	680.	0.	979.	18.	680.
SEP	1128.	0.	3868.	735.	897.	735.	727.	778.	20.	421.	2.	735.	19.	421.
OCT	1324.	1043.	1300.	799.	690.	600.	270.	329.	37.	145.	14.	513.	33.	145.
NOV	1450.	3004.	0.	1237.	876.	786.	488.	450.	66.	10.	36.	412.	55.	10.
DEC	1651.	5926.	0.	2105.	1329.	1226.	857.	825.	107.	19.	68.	478.	88.	19.
ANNUAL	16501.	26357.	27072.	14855.	12519.	10880.	8400.	6712.	639.	3033.	314.	7617.	543.	3033.

SYSTEMS FIRST COSTS

NO.		COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1129.	48.	236.	275.	811.	534.	3313.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	534.	3412.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	634.	3972.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 10.2 M3 PANEL= 6.3 M2	3130.	2146.	1219.	636.	335.	1049.	534.	9049.
5	FULL ACES, BIN= 63.0 M3 PANEL= 0.0 M2	3130.	5153.	0.	636.	335.	1049.	534.	10837.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	584.	3941.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	834.	4397.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	584.	4181.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.31	914.	594.96	REF.	REF.	11060.	15287.	25037.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.55	2162.	501.39	93.56	99.	9321.	14895.	23111.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.79	2468.	435.75	159.20	659.	8101.	14540.	21681.
4	MIN. ACES, BIN= 10.2 M3 PANEL= 6.3 M2	2.31	2432.	336.42	258.54	5736.	6254.	17735.	23248.
5	FULL ACES, BIN= 63.0 M3 PANEL= 0.0 M2	2.89	2432.	268.80	326.15	7523.	4997.	18266.	22670.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.09	889.	356.91	238.04	628.	9715.	14545.	17660.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.63	914.	678.66	-83.70	1084.	15104.	20416.	23535.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.33	960.	321.57	273.39	868.	8595.	13737.	16683.

SUMTER, SOUTH CAROLINA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 7687.
DESIGN COOLING LOAD (WATTS) = 7301.

EL. ($/KWHR) = 0.0507, 0.0850
GAS ($/THERM) = 0.3685, 0.8150
OIL ($/GAL.) = 1.1900, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -5 C 34 C
TOTAL/SENSIBLE COOLING = 1.29

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1658.	5061.	0.	1866.	1224.	1122.	789.	732.	96.	16.	58.	477.	79.	16.
FEB	1491.	3627.	0.	1422.	967.	877.	616.	558.	74.	11.	42.	426.	62.	11.
MAR	1561.	2821.	638.	1287.	903.	802.	522.	487.	65.	78.	34.	512.	55.	78.
APR	1370.	912.	1964.	848.	783.	659.	287.	287.	36.	217.	12.	597.	32.	217.
MAY	1245.	0.	4133.	796.	974.	792.	630.	205.	23.	450.	2.	796.	21.	450.
JUN	1068.	0.	5872.	936.	1165.	949.	1072.	210.	18.	640.	0.	936.	18.	640.
JUL	1023.	0.	7322.	1082.	1367.	1121.	1328.	1372.	17.	798.	0.	1082.	17.	798.
AUG	1030.	0.	7196.	1070.	1350.	1109.	1308.	1352.	17.	784.	0.	1070.	17.	784.
SEP	1083.	0.	4804.	824.	1020.	830.	889.	930.	19.	523.	1.	824.	18.	523.
OCT	1271.	732.	2039.	779.	745.	627.	411.	447.	32.	224.	10.	577.	29.	224.
NOV	1390.	2036.	874.	1047.	783.	687.	375.	344.	52.	102.	25.	488.	44.	102.
DEC	1580.	4475.	0.	1682.	1119.	1023.	700.	651.	87.	14.	52.	453.	72.	14.
ANNUAL	15770.	19663.	34842.	13639.	12399.	10597.	8927.	7573.	536.	3858.	238.	8239.	463.	3858.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 8.3 M3 PANEL= 4.4 M2	3130.	1944.	1112.	636.	335.	1049.	534.	8740.
5	FULL ACES, BIN= 43.8 M3 PANEL= 0.0 M2	3130.	4164.	0.	636.	335.	1049.	534.	9848.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.43	914.	691.78	REF.	REF.	12860.	17333.	23579.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.57	2162.	628.88	62.90	80.	11691.	17492.	23169.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.84	2468.	537.46	154.33	640.	9991.	16658.	21510.
4	MIN. ACES, BIN= 8.3 M3 PANEL= 4.4 M2	2.19	2432.	452.76	239.02	5181.	8417.	19589.	23676.
5	FULL ACES, BIN= 43.8 M3 PANEL= 0.0 M2	2.58	2432.	384.10	307.68	6289.	7140.	19420.	22888.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.15	889.	393.07	298.72	628.	9889.	14965.	17675.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.70	914.	700.71	-8.93	1084.	14910.	20467.	22817.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.33	960.	366.17	325.61	868.	9037.	14424.	17005.

HURON, SOUTH DAKOTA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 16703.
DESIGN COOLING LOAD (WATTS) = 5787.

EL. ($/KWHR) = 0.0620, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3702, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0600, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -27 C 34 C
TOTAL/SENSIBLE COOLING = 1.10

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE GAS THERMS	(6) GAS FURNACE ELEC. KWH	(7) OIL FURNACE OIL GAL	(7) OIL FURNACE ELEC. KWH	(8) PULSE GAS FURN. GAS THERMS	(8) PULSE GAS FURN. ELEC. KWH
JAN	1793.	20546.	0.	6206.	5332.	5317.	2447.	2447.	298.	65.	223.	563.	239.	65.
FEB	1693.	15674.	0.	4825.	3951.	3915.	1908.	1920.	234.	50.	171.	520.	188.	50.
MAR	1926.	12310.	0.	3955.	2859.	2776.	1562.	1572.	196.	39.	137.	574.	157.	39.
APR	1863.	5866.	0.	2147.	1452.	1330.	848.	852.	112.	19.	68.	536.	91.	19.
MAY	1871.	2446.	1370.	1349.	1040.	905.	492.	493.	66.	157.	31.	677.	56.	157.
JUN	1725.	0.	3261.	834.	1028.	846.	247.	247.	37.	355.	9.	834.	29.	355.
JUL	1677.	0.	5022.	1013.	1229.	991.	443.	268.	31.	547.	3.	1013.	28.	547.
AUG	1587.	0.	4672.	950.	1156.	937.	887.	252.	30.	509.	3.	950.	26.	509.
SEP	1489.	1617.	2034.	1084.	921.	779.	426.	338.	48.	227.	22.	640.	41.	227.
OCT	1541.	4512.	0.	1682.	1158.	1040.	577.	584.	89.	14.	54.	442.	72.	14.
NOV	1543.	10748.	0.	3414.	2353.	2269.	1176.	1194.	170.	34.	120.	463.	135.	34.
DEC	1687.	16568.	0.	5071.	3996.	3954.	1945.	1954.	247.	52.	181.	521.	197.	52.
ANNUAL	20396.	90286.	16359.	32530.	26476.	25059.	12957.	12120.	1558.	2068.	1022.	7734.	1259.	2068.

SYSTEMS FIRST COSTS

NO.		COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	350.	1129.	48.	305.	275.	811.	482.	3400.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	350.	1199.	77.	305.	275.	843.	482.	3531.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	350.	1199.	77.	705.	335.	843.	582.	4091.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 27.7 M3 PANEL=115.1 M2*	4000.	3811.	7309.	830.	335.	1520.	638.	18442.*
5	FULL ACES, BIN= 49.3 M3 PANEL= 62.5 M2	4000.	4996.	4367.	830.	335.	1520.	638.	16686.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	815.	1129.	26.	376.	270.	811.	532.	3959.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	720.	1129.	26.	632.	275.	811.	782.	4375.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST AVERAGE $	LIFE CYCLE COST MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.08	914.	2015.89	REF.	REF.	37475.	41790.	49882.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.33	2162.	1640.69	375.20	131.	30500.	36193.	42780.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.41	2468.	1552.89	463.00	691.	28868.	35427.	41661.
4	MIN. ACES, BIN= 27.7 M3 PANEL=115.1 M2	2.72	2432.	802.96	1212.93	15042.	14927.	35801.*	39025.
5	FULL ACES, BIN= 49.3 M3 PANEL= 62.5 M2	2.91	2432.	751.08	1264.80	13286.	13963.	33081.*	36096.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.04	889.	704.82	1311.07	559.	20645.	25493.	28667.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.63	914.	1562.97	452.92	975.	36273.	41562.	40722.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.46	960.	594.38	1421.51	729.	17148.	22237.	24901.

*UNGLAZED PANEL EXCEEDS A PRACTICAL SIZE, AN ALTERNATIVE SUPPLEMENTARY HEAT SOURCE SHOULD BE USED IN THIS DESIGN.

RAPID CITY, SOUTH DAKOTA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 14950.
DESIGN COOLING LOAD (WATTS) = 5087.

EL. ($/KWHR) = 0.0583, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3702, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0600, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -23 C 33 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1838.	14565.	0.	4557.	3578.	3518.	1829.	1829.	222.	46.	158.	557.	179.	46.
FEB	1726.	12053.	0.	3828.	2938.	2881.	1544.	1544.	187.	38.	131.	518.	152.	38.
MAR	1930.	10531.	0.	3862.	2465.	2377.	1396.	1408.	172.	33.	116.	570.	139.	33.
APR	1821.	5841.	0.	2128.	1389.	1270.	858.	865.	110.	18.	66.	524.	90.	18.
MAY	1776.	2377.	1099.	1273.	958.	838.	475.	477.	63.	127.	29.	621.	54.	127.
JUN	1594.	555.	2508.	870.	880.	732.	282.	282.	35.	275.	8.	718.	32.	275.
JUL	1523.	0.	4029.	862.	1029.	837.	235.	235.	27.	439.	1.	862.	25.	439.
AUG	1442.	0.	4154.	853.	1040.	853.	788.	228.	27.	453.	3.	853.	24.	453.
SEP	1379.	1444.	2043.	1007.	870.	738.	420.	314.	44.	227.	18.	610.	38.	227.
OCT	1477.	3515.	853.	1480.	1019.	903.	501.	506.	74.	104.	41.	514.	60.	104.
NOV	1530.	9128.	0.	2961.	2004.	1917.	1066.	1098.	148.	29.	101.	454.	118.	29.
DEC	1714.	12415.	0.	3925.	2901.	2827.	1538.	1551.	193.	39.	136.	515.	155.	39.
ANNUAL	19751.	72424.	14685.	27207.	21070.	19689.	10932.	10337.	1301.	1829.	810.	7316.	1067.	1829.

SYSTEMS FIRST COSTS

NO.		COMPONENTS COSTS, $:						TOTAL COST, $
	CONVENTIONAL ELECTRIC SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 20.4 M3 PANEL= 24.7 M2	4000.	3246.	2246.	830.	335.	1520.	638.	12815.
5	FULL ACES, BIN= 39.4 M3 PANEL= 18.8 M2	4000.	4376.	1916.	830.	335.	1520.	638.	13614.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.09	914.	1585.05	REF.	REF.	29466.	33688.	42333.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.41	2162.	1227.54	357.51	131.	22820.	28421.	35116.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.51	2468.	1147.06	437.99	691.	21324.	27791.	34047.
4	MIN. ACES, BIN= 20.4 M3 PANEL= 24.7 M2	2.72	2432.	636.89	948.17	9506.	11840.	27086.	30560.
5	FULL ACES, BIN= 39.4 M3 PANEL= 18.8 M2	2.87	2432.	602.23	982.82	10306.	11196.	27242.	30527.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.04	889.	588.25	996.80	611.	17236.	22044.	24846.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.61	914.	1284.72	300.34	1037.	29600.	34860.	34994.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.42	960.	501.43	1083.63	821.	14486.	19575.	21977.

BRISTOL, TENNESSEE

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 10372.
DESIGN COOLING LOAD (WATTS) = 5487.

EL. ($/KWHR) = 0.0378, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3685, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1900, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -12 C 32 C
TOTAL/SENSIBLE COOLING = 1.15

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1842.	8384.	0.	2841.	1839.	1740.	1169.	1169.	142.	27.	94.	538.	116.	27.
FEB	1658.	5748.	0.	2057.	1356.	1268.	858.	870.	105.	18.	65.	479.	86.	18.
MAR	1735.	5106.	0.	1901.	1265.	1163.	786.	828.	98.	16.	59.	498.	81.	16.
APR	1520.	2173.	1101.	1146.	875.	763.	428.	537.	56.	127.	27.	549.	47.	127.
MAY	1377.	569.	2581.	822.	834.	689.	259.	259.	31.	283.	8.	666.	29.	283.
JUN	1178.	0.	3831.	745.	903.	731.	589.	192.	21.	417.	1.	745.	20.	417.
JUL	1125.	0.	5142.	873.	1074.	873.	950.	205.	19.	560.	0.	873.	19.	560.
AUG	1131.	0.	4794.	837.	1025.	837.	891.	201.	19.	522.	0.	837.	19.	522.
SEP	1191.	0.	3175.	677.	831.	680.	607.	184.	24.	346.	4.	677.	20.	346.
OCT	1402.	1647.	1209.	979.	783.	678.	314.	432.	47.	137.	21.	526.	40.	137.
NOV	1538.	4389.	0.	1647.	1096.	1001.	623.	680.	85.	14.	51.	441.	70.	14.
DEC	1753.	7697.	0.	2625.	1734.	1637.	1054.	1089.	132.	24.	86.	511.	108.	24.
ANNUAL	17451.	35713.	21832.	17148.	13617.	12060.	8528.	6646.	777.	2492.	417.	7340.	654.	2492.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
		COMPONENTS COSTS, $							
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 12.7 M3 PANEL= 11.8 M2	3500.	2449.	1527.	710.	335.	1267.	638.	10426.
5	FULL ACES, BIN= 79.8 M3 PANEL= 0.0 M2	3500.	6045.	0.	710.	335.	1267.	638.	12496.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW. CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.21	914.	648.87	REF.	REF.	12062.	16285.	28243.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.53	2162.	515.27	133.60	131.	9579.	15180.	24676.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.73	2468.	456.36	192.50	691.	8484.	14951.	23361.
4	MIN. ACES, BIN= 12.7 M3 PANEL= 11.8 M2	2.44	2432.	322.70	326.17	7118.	5999.	18857.	24804.
5	FULL ACES, BIN= 79.8 M3 PANEL= 0.0 M2	3.13	2432.	251.49	397.38	9188.	4675.	19603.	24238.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.07	889.	380.78	268.09	581.	10826.	15604.	18711.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.60	914.	773.42	-124.56	1037.	17679.	22939.	25563.
8	PULSE GAS FURNACE, GAS HW. CENTRAL AC	2.35	960.	335.35	313.52	821.	9387.	14477.	17366.

KNOXVILLE, TENNESSEE

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 9529.
DESIGN COOLING LOAD (WATTS) = 6783.

EL. ($/KWHR) = 0.0378, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3667, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -10 C 33 C
TOTAL/SENSIBLE COOLING = 1.26

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1808.	9071.	0.	3022.	1909.	1790.	1220.	1185.	151.	29.	101.	531.	123.	29.
FEB	1625.	5345.	0.	1936.	1288.	1203.	801.	759.	99.	17.	61.	468.	81.	17.
MAR	1694.	4612.	0.	1752.	1114.	1008.	716.	687.	91.	15.	54.	485.	75.	15.
APR	1475.	1220.	1079.	866.	726.	632.	322.	319.	42.	121.	16.	531.	37.	121.
MAY	1327.	0.	2552.	647.	793.	636.	191.	191.	27.	278.	5.	647.	22.	278.
JUN	1128.	0.	4498.	803.	995.	796.	679.	196.	21.	490.	2.	803.	19.	490.
JUL	1074.	0.	6120.	965.	1203.	966.	1123.	214.	18.	667.	0.	965.	18.	667.
AUG	1084.	0.	6145.	971.	1209.	962.	1130.	465.	18.	669.	0.	971.	18.	669.
SEP	1150.	0.	3309.	680.	821.	647.	633.	689.	21.	360.	2.	680.	19.	360.
OCT	1364.	1192.	903.	808.	662.	578.	291.	283.	40.	102.	16.	481.	35.	102.
NOV	1505.	3658.	0.	1434.	930.	847.	541.	521.	75.	12.	44.	430.	62.	12.
DEC	1721.	7092.	0.	2448.	1552.	1439.	985.	960.	124.	22.	80.	500.	101.	22.
ANNUAL	16955.	32190.	24605.	16333.	13202.	11503.	8631.	6470.	727.	2783.	381.	7493.	610.	2783.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
		COMPONENTS COSTS, $							
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	534.	3412.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	634.	3972.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 13.5 M3 PANEL= 14.6 M2	3130.	2464.	1684.	636.	335.	1049.	534.	9832.
5	FULL ACES, BIN= 76.4 M3 PANEL= 0.0 M2	3130.	5839.	0.	636.	335.	1049.	534.	11523.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.25	914.	618.05	REF.	REF.	11490.	15962.	27353.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.55	2162.	499.55	118.50	-147.	9287.	14861.	24067.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.78	2468.	435.26	182.79	413.	8091.	14531.	22553.
4	MIN. ACES, BIN= 13.5 M3 PANEL= 14.6 M2	2.37	2432.	326.61	291.44	6273.	6072.	18336.	24355.
5	FULL ACES, BIN= 76.4 M3 PANEL= 0.0 M2	3.17	2432.	244.83	373.22	7964.	4551.	18506.	23018.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.07	889.	371.88	246.17	628.	10400.	15476.	18738.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.61	914.	729.83	-111.78	1084.	16540.	22097.	25231.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.34	960.	328.99	289.06	868.	9042.	14429.	17478.

MEMPHIS, TENNESSEE

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 9497.
DESIGN COOLING LOAD (WATTS) = 7637.

EL. ($/KWHR) = 0.0388, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3550, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -10 C 36 C
TOTAL/SENSIBLE COOLING = 1.33

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1763.	8215.	0.	2772.	1788.	1679.	1142.	1087.	138.	26.	92.	516.	113.	26.
FEB	1586.	5368.	0.	1932.	1254.	1162.	816.	758.	98.	17.	61.	458.	81.	17.
MAR	1649.	4020.	0.	1575.	1069.	963.	659.	618.	82.	13.	47.	471.	68.	13.
APR	1428.	1191.	1679.	910.	794.	675.	320.	320.	41.	187.	15.	583.	36.	187.
MAY	1271.	0.	4026.	792.	977.	797.	343.	206.	25.	439.	4.	792.	21.	439.
JUN	1067.	0.	6005.	950.	1186.	968.	1099.	211.	18.	654.	0.	950.	18.	654.
JUL	1005.	0.	8292.	1182.	1505.	1259.	1503.	571.	17.	903.	0.	1182.	17.	903.
AUG	1013.	0.	7826.	1134.	1438.	1203.	1424.	1489.	17.	853.	0.	1134.	17.	853.
SEP	1082.	0.	4793.	823.	1017.	835.	892.	952.	19.	522.	1.	823.	18.	522.
OCT	1299.	1067.	2253.	903.	828.	696.	455.	506.	37.	249.	14.	610.	32.	249.
NOV	1449.	3637.	0.	1413.	975.	877.	550.	513.	74.	12.	43.	414.	61.	12.
DEC	1670.	6222.	0.	2192.	1382.	1279.	898.	869.	111.	20.	71.	484.	91.	20.
ANNUAL	16280.	29720.	34872.	16578.	14214.	12392.	10101.	8089.	677.	3893.	348.	8416.	574.	3893.

SYSTEMS FIRST COSTS

NO.		COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
	CONVENTIONAL ELECTRIC SYSTEMS								
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 12.4 M3 PANEL= 7.3 M2	3130.	2377.	1277.	636.	335.	1049.	534.	9337.
5	FULL ACES, BIN= 70.2 M3 PANEL= 0.0 M2	3130.	5554.	0.	636.	335.	1049.	534.	11238.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.36	914.	643.07	REF.	REF.	11955.	16428.	27696.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.58	2162.	551.35	91.72	80.	10250.	16050.	25711.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.81	2468.	480.70	162.37	640.	8936.	15603.	24026.
4	MIN. ACES, BIN= 12.4 M3 PANEL= 7.3 M2	2.22	2432.	391.81	251.26	5778.	7284.	19053.	25919.
5	FULL ACES, BIN= 70.2 M3 PANEL= 0.0 M2	2.78	2432.	313.78	329.29	7679.	5833.	19503.	25001.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.14	889.	391.42	251.65	628.	10421.	15497.	19625.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.71	914.	733.43	-90.36	1084.	16345.	21902.	25715.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.37	960.	354.66	288.41	868.	9257.	14694.	18545.

NASHVILLE, TENNESSEE

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 10354.
DESIGN COOLING LOAD (WATTS) = 6806.

EL. ($/KWHR) = 0.0369, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3550, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -12 C 35 C
TOTAL/SENSIBLE COOLING = 1.24

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1821.	8959.	0.	2995.	2000.	1900.	1232.	1174.	149.	28.	100.	534.	122.	28.
FEB	1639.	6399.	0.	2233.	1477.	1393.	934.	876.	113.	20.	72.	475.	92.	20.
MAR	1709.	4874.	0.	1829.	1204.	1101.	757.	717.	94.	15.	56.	490.	78.	15.
APR	1487.	1709.	1369.	1037.	837.	721.	371.	368.	49.	155.	21.	568.	42.	155.
MAY	1333.	0.	3207.	720.	902.	744.	201.	201.	29.	349.	7.	720.	22.	349.
JUN	1128.	0.	4972.	855.	1056.	865.	921.	203.	20.	542.	1.	855.	19.	542.
JUL	1069.	0.	6490.	1004.	1258.	1035.	1188.	219.	18.	707.	0.	1004.	18.	707.
AUG	1076.	0.	6114.	965.	1205.	992.	1124.	459.	18.	666.	0.	965.	18.	666.
SEP	1143.	0.	3930.	746.	929.	763.	741.	801.	23.	428.	4.	746.	19.	428.
OCT	1361.	1612.	1583.	998.	821.	702.	304.	390.	45.	178.	21.	556.	39.	178.
NOV	1507.	4163.	0.	1575.	1072.	978.	601.	572.	82.	13.	48.	432.	67.	13.
DEC	1728.	7294.	0.	2506.	1628.	1536.	1017.	983.	126.	23.	82.	503.	103.	23.
ANNUAL	17001.	35010.	27666.	17463.	14389.	12732.	9390.	6964.	765.	3125.	412.	7848.	649.	3125.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1279.	48.	253.	275.	907.	534.	3606.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	534.	3491.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	634.	4051.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 13.4 M3 PANEL= 11.1 M2	3500.	2500.	1487.	710.	335.	1267.	638.	10438.
5	FULL ACES, BIN= 80.6 M3 PANEL= 0.0 M2	3500.	6079.	0.	710.	335.	1267.	638.	12530.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.27	914.	644.38	REF.	REF.	11979.	16499.	28982.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.54	2162.	530.96	113.43	-115.	9870.	15523.	25809.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.74	2468.	469.80	174.58	445.	8734.	15252.	24353.
4	MIN. ACES, BIN= 13.4 M3 PANEL= 11.1 M2	2.36	2432.	346.49	297.89	6832.	6441.	19311.	26023.
5	FULL ACES, BIN= 80.6 M3 PANEL= 0.0 M2	3.18	2432.	256.99	387.40	8924.	4777.	19739.	24717.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.09	889.	386.93	257.46	581.	10746.	15822.	19730.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.64	914.	771.93	-127.54	1037.	17563.	23119.	26469.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.36	960.	342.35	302.04	821.	9334.	14721.	18354.

EL PASO, TEXAS

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 8077.
DESIGN COOLING LOAD (WATTS) = 5996.

EL. ($/KWHR) = 0.0725, 0.0850
GAS ($/THERM) = 0.3550, 0.8150
OIL ($/GAL.) = 1.1700, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -6 C 37 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1683.	5518.	0.	2001.	1310.	1207.	843.	785.	102.	17.	62.	485.	84.	17.
FEB	1502.	3914.	0.	1505.	1043.	942.	649.	590.	78.	12.	45.	430.	65.	12.
MAR	1552.	2734.	1241.	1326.	980.	850.	505.	485.	63.	144.	33.	575.	54.	144.
APR	1338.	956.	2638.	925.	879.	723.	298.	298.	36.	290.	13.	662.	32.	290.
MAY	1191.	0.	4331.	803.	994.	816.	807.	201.	23.	472.	3.	803.	20.	472.
JUN	1007.	0.	6193.	955.	1197.	1006.	1129.	456.	17.	675.	0.	955.	17.	675.
JUL	963.	0.	6330.	957.	1203.	1009.	1156.	1205.	16.	690.	0.	957.	16.	690.
AUG	984.	0.	5924.	919.	1149.	961.	1086.	1138.	16.	645.	0.	919.	16.	645.
SEP	1059.	0.	4546.	790.	971.	804.	845.	892.	18.	395.	1.	790.	18.	495.
OCT	1271.	752.	2793.	866.	858.	712.	544.	585.	32.	307.	11.	660.	29.	307.
NOV	1408.	3373.	752.	1410.	963.	849.	522.	494.	70.	93.	39.	484.	58.	93.
DEC	1609.	5328.	0.	1927.	1239.	1130.	786.	756.	98.	17.	60.	464.	81.	17.
ANNUAL	15568.	22575.	34749.	14382.	12785.	11008.	9170.	7884.	569.	3857.	267.	8182.	489.	3857.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1129.	48.	236.	275.	811.	482.	3261.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	482.	3360.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	582.	3920.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 8.9 M3 PANEL= 3.5 M2	3130.	2018.	1060.	636.	335.	1049.	534.	8762.
5	FULL ACES, BIN= 48.5 M3 PANEL= 0.0 M2	3130.	4424.	0.	636.	335.	1049.	534.	10108.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.41	914.	1042.41	REF.	REF.	19378.	23554.	24322.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.58	2162.	926.69	115.72	99.	17227.	22749.	23432.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.84	2468.	797.85	244.56	659.	14832.	21220.	21808.
4	MIN. ACES, BIN= 8.9 M3 PANEL= 3.5 M2	2.21	2432.	664.65	377.76	5500.	12356.	23550.	24039.
5	FULL ACES, BIN= 48.5 M3 PANEL= 0.0 M2	2.57	2432.	571.45	470.96	6847.	10623.	23164.	23584.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.15	889.	481.70	560.71	628.	11599.	16377.	17829.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.71	914.	905.13	137.28	1084.	18905.	24164.	23139.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.35	960.	453.15	589.26	868.	10695.	15784.	17960.

EL PASO, TEXAS

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 8077.
DESIGN COOLING LOAD (WATTS) = 5996.

EL. ($/KWHR) = 0.0725, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3550, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -6 C 37 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE GAS THERMS	(6) GAS FURNACE ELEC. KWH	(7) OIL FURNACE OIL GAL	(7) OIL FURNACE ELEC. KWH	(8) PULSE GAS FURN. GAS THERMS	(8) PULSE GAS FURN. ELEC. KWH
JAN	1683.	5518.	0.	2001.	1310.	1207.	843.	785.	102.	17.	62.	485.	84.	17.
FEB	1502.	3914.	0.	1505.	1043.	942.	649.	590.	78.	12.	45.	430.	65.	12.
MAR	1552.	2734.	1241.	1326.	980.	850.	505.	485.	63.	144.	33.	575.	54.	144.
APR	1338.	956.	2638.	925.	879.	723.	298.	298.	36.	290.	13.	662.	32.	290.
MAY	1191.	0.	4331.	803.	994.	816.	807.	201.	23.	472.	3.	803.	20.	472.
JUN	1007.	0.	6193.	955.	1197.	1006.	1129.	456.	17.	675.	0.	955.	17.	675.
JUL	963.	0.	6330.	957.	1203.	1009.	1156.	1205.	16.	690.	0.	957.	16.	690.
AUG	984.	0.	5924.	919.	1149.	961.	1086.	1138.	16.	645.	0.	919.	16.	645.
SEP	1059.	0.	4546.	790.	971.	804.	845.	892.	18.	495.	1.	790.	18.	495.
OCT	1271.	752.	2793.	866.	858.	712.	544.	585.	32.	307.	11.	660.	29.	307.
NOV	1408.	3373.	752.	1410.	963.	849.	522.	494.	70.	93.	39.	484.	58.	93.
DEC	1609.	5328.	0.	1927.	1239.	1130.	786.	756.	98.	17.	60.	464.	81.	17.
ANNUAL	15568.	22575.	34749.	14382.	12785.	11008.	9170.	7884.	569.	3857.	267.	8182.	489.	3857.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1129.	48.	236.	275.	811.	482.	3261.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	482.	3360.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	582.	3920.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 8.9 M3 PANEL= 3.5 M2	3130.	2018.	1060.	636.	335.	1049.	534.	8762.
5	FULL ACES, BIN= 48.5 M3 PANEL= 0.0 M2	3130.	4424.	0.	636.	335.	1049.	534.	10108.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST AVERAGE $	LIFE CYCLE COST MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.41	914.	1042.41	REF.	REF.	19378.	23554.	24322.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.58	2162.	926.69	115.72	99.	17227.	22749.	23432.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.84	2468.	797.85	244.56	659.	14832.	21220.	21808.
4	MIN. ACES, BIN= 8.9 M3 PANEL= 3.5 M2	2.21	2432.	664.65	377.76	5500.	12356.	23550.	24039.
5	FULL ACES, BIN= 48.5 M3 PANEL= 0.0 M2	2.57	2432.	571.45	470.96	6847.	10623.	23164.	23584.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.15	889.	481.70	560.71	628.	11599.	16377.	17829.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.71	914.	905.13	137.28	1084.	18905.	24164.	23139.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.35	960.	453.15	589.26	868.	10695.	15784.	17060.

FORTH WORTH, TEXAS

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 8634.
DESIGN COOLING LOAD (WATTS) = 7861.

EL. ($/KWHR) = 0.0566, 0.0850
GAS ($/THERM) = 0.3508, 0.8150
OIL ($/GAL.) = 1.1700, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -7 C 38 C
TOTAL/SENSIBLE COOLING = 1.23

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1658.	6255.	0.	2198.	1430.	1314.	923.	862.	111.	20.	71.	480.	91.	20.
FEB	1496.	4159.	0.	1571.	1053.	946.	685.	616.	81.	13.	48.	429.	67.	13.
MAR	1558.	2953.	954.	1357.	969.	850.	536.	505.	67.	113.	35.	546.	56.	113.
APR	1345.	801.	2121.	827.	786.	655.	274.	274.	34.	234.	11.	607.	31.	234.
MAY	1188.	0.	4804.	853.	1050.	850.	721.	208.	21.	523.	1.	853.	20.	523.
JUN	985.	0.	7817.	1125.	1429.	1197.	1415.	850.	16.	852.	0.	1125.	16.	852.
JUL	916.	0.	9814.	1324.	1705.	1464.	1767.	1817.	15.	1069.	0.	1324.	15.	1069.
AUG	917.	0.	9190.	1256.	1613.	1380.	1660.	1713.	15.	1001.	0.	1256.	15.	1001.
SEP	982.	0.	6333.	963.	1212.	1004.	1160.	1209.	17.	690.	0.	963.	16.	690.
OCT	1190.	0.	3027.	660.	831.	686.	584.	628.	26.	330.	6.	660.	20.	330.
NOV	1341.	2582.	924.	1190.	854.	746.	428.	399.	58.	109.	31.	481.	49.	109.
DEC	1560.	4835.	0.	1776.	1158.	1045.	744.	687.	91.	15.	56.	449.	75.	15.
ANNUAL	15135.	21585.	44983.	15102.	14089.	12138.	10896.	9767.	553.	4969.	259.	9174.	472.	4969.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 9.8 M3 PANEL= 3.7 M2	3130.	2123.	1072.	636.	335.	1049.	534.	8880.
5	FULL ACES, BIN= 47.7 M3 PANEL= 0.0 M2	3130.	4418.	0.	636.	335.	1049.	534.	10102.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.50	914.	854.60	REF.	REF.	15887.	20360.	25627.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.61	2162.	797.28	57.32	80.	14822.	20622.	25536.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.87	2468.	686.91	167.70	640.	12770.	19436.	23670.
4	MIN. ACES, BIN= 9.8 M3 PANEL= 3.7 M2	2.08	2432.	616.60	238.01	5321.	11463.	22774.	26575.
5	FULL ACES, BIN= 47.7 M3 PANEL= 0.0 M2	2.32	2432.	552.72	301.88	6543.	10275.	22809.	26216.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.19	889.	475.18	379.42	628.	11371.	16447.	19464.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.78	914.	822.15	32.46	1084.	17302.	22859.	24639.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.37	960.	446.66	407.94	868.	10468.	15855.	18683.

HOUSTON, TEXAS

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 6669.
DESIGN COOLING LOAD (WATTS) = 8124.

EL. ($/KWHR) = 0.0594, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3893, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1300, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -2 C 34 C
TOTAL/SENSIBLE COOLING = 1.47

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1501.	3423.	0.	1368.	979.	878.	619.	536.	72.	11.	40.	428.	60.	11.
FEB	1352.	2258.	823.	1093.	794.	698.	474.	405.	54.	97.	27.	472.	46.	97.
MAR	1421.	1375.	1623.	953.	809.	688.	338.	338.	43.	181.	18.	576.	38.	181.
APR	1252.	0.	3513.	731.	904.	737.	545.	196.	25.	383.	5.	731.	21.	383.
MAY	1143.	0.	6147.	987.	1229.	1001.	1120.	1139.	19.	670.	0.	987.	19.	670.
JUN	985.	0.	8361.	1184.	1510.	1264.	1506.	1523.	16.	911.	0.	1184.	16.	911.
JUL	984.	0.	9709.	1320.	1697.	1449.	1744.	1764.	16.	1058.	0.	1320.	16.	1058.
AUG	947.	0.	9609.	1310.	1684.	1435.	1727.	1748.	16.	1047.	0.	1310.	16.	1047.
SEP	990.	0.	7424.	1084.	1373.	1142.	1345.	1364.	17.	809.	0.	1084.	16.	809.
OCT	1156.	0.	4342.	794.	993.	824.	808.	826.	23.	473.	4.	794.	19.	473.
NOV	1259.	1392.	2072.	962.	835.	705.	416.	431.	41.	230.	18.	580.	35.	230.
DEC	1430.	2585.	804.	1203.	861.	760.	519.	428.	60.	96.	31.	493.	50.	96.
ANNUAL	14380.	11034.	54426.	12989.	13667.	11581.	11161.	10701.	401.	5964.	143.	9959.	352.	5964.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1379.	48.	236.	275.	1005.	534.	3757.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 6.1 M3 PANEL= 1.4 M2	2950.	1681.	945.	636.	335.	843.	482.	7871.
5	FULL ACES, BIN= 18.5 M3 PANEL= 0.0 M2	2950.	2653.	0.	636.	335.	843.	482.	7899.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1379.	26.	376.	270.	1005.	584.	4385.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1379.	26.	632.	275.	1005.	834.	4841.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1379.	26.	236.	270.	1005.	584.	4625.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.71	914.	771.57	REF.	REF.	14343.	19015.	22867.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.62	2162.	811.82	-40.25	-119.	15092.	20892.	24945.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.92	2468.	687.91	83.66	441.	12788.	19455.	22889.
4	MIN. ACES, BIN= 6.1 M3 PANEL= 1.4 M2	1.99	2432.	662.95	108.62	4114.	12324.	22628.	25937.
5	FULL ACES, BIN= 18.5 M3 PANEL= 0.0 M2	2.07	2432.	635.62	135.95	4142.	11816.	22147.	25320.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.24	889.	510.37	261.20	628.	11530.	16804.	19014.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.86	914.	753.04	18.52	1084.	15074.	20830.	23144.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.36	960.	491.15	280.42	868.	10921.	16506.	18662.

SAN ANTONIO, TEXAS

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 7018.
DESIGN COOLING LOAD (WATTS) = 7691.

EL. ($/KWHR) = 0.0468, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3550, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -3 C 36 C
TOTAL/SENSIBLE COOLING = 1.28

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1469.	2514.	844.	1199.	871.	767.	531.	446.	59.	100.	30.	508.	50.	100.
FEB	1322.	1787.	1092.	983.	766.	666.	421.	355.	47.	125.	22.	492.	40.	125.
MAR	1385.	1130.	1883.	904.	806.	683.	311.	311.	39.	209.	15.	594.	35.	209.
APR	1216.	0.	2942.	658.	810.	660.	464.	281.	25.	320.	5.	658.	20.	320.
MAY	1106.	0.	5784.	937.	1166.	950.	1055.	1064.	19.	630.	1.	937.	18.	630.
JUN	949.	0.	8604.	1201.	1536.	1297.	1546.	1557.	16.	937.	0.	1201.	16.	937.
JUL	909.	0.	10092.	1352.	1744.	1504.	1808.	1820.	15.	1099.	0.	1352.	15.	1099.
AUG	915.	0.	9639.	1304.	1679.	1439.	1730.	1742.	15.	1050.	0.	1304.	15.	1050.
SEP	961.	0.	7154.	1046.	1325.	1103.	1295.	1307.	16.	779.	0.	1046.	16.	779.
OCT	1127.	0.	4089.	758.	943.	777.	762.	772.	22.	445.	3.	758.	19.	445.
NOV	1232.	1365.	1611.	897.	755.	642.	333.	342.	40.	180.	18.	522.	34.	180.
DEC	1400.	2352.	800.	1129.	817.	718.	493.	406.	56.	95.	29.	484.	47.	95.
ANNUAL	13990.	9149.	58535.	12369.	13217.	11206.	10750.	10403.	369.	5970.	122.	9857.	326.	5970.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 4.9 M3 PANEL= 0.0 M2	2950.	1577.	0.	636.	335.	843.	482.	6823.
5	FULL ACES, BIN= 11.1 M3 PANEL= 0.0 M2	2950.	2136.	0.	636.	335.	843.	482.	7382.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.74	914.	578.52	REF.	REF.	10755.	15227.	21800.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.63	2162.	618.18	-39.66	80.	11492.	17293.	24316.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.93	2468.	524.11	54.41	640.	9743.	16410.	22364.
4	MIN. ACES, BIN= 4.9 M3 PANEL= 0.0 M2	2.01	2432.	502.79	75.72	3264.	9347.	18602.	24314.
5	FULL ACES, BIN= 11.1 M3 PANEL= 0.0 M2	2.07	2432.	486.55	91.96	3823.	9045.	18859.	24387.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.25	889.	410.17	168.34	628.	9338.	14414.	18393.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.87	914.	603.58	-25.06	1084.	12170.	17727.	22296.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.36	960.	394.92	183.60	868.	8855.	14242.	18127.

SALT LAKE CITY, UTAH

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 11738.
DESIGN COOLING LOAD (WATTS) = 5202.

EL. ($/KWHR) = 0.0583, 0.0850
GAS ($/THERM) = 0.3022, 0.8150
OIL ($/GAL.) = 1.1200, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -15 C 34 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1881.	12145.	0.	3897.	2682.	2605.	1563.	1563.	190.	38.	133.	561.	155.	38.
FEB	1742.	8890.	0.	2954.	1954.	1867.	1188.	1201.	146.	28.	99.	512.	120.	28.
MAR	1896.	7581.	9.	2633.	1711.	1602.	1056.	1085.	133.	24.	85.	551.	109.	24.
APR	1732.	4078.	0.	1614.	1087.	978.	647.	663.	84.	13.	47.	494.	70.	13.
MAY	1631.	1995.	1300.	1149.	901.	779.	417.	418.	55.	148.	25.	601.	47.	148.
JUN	1424.	0.	2853.	706.	886.	731.	207.	207.	32.	311.	8.	706.	24.	311.
JUL	1346.	0.	4788.	896.	1087.	888.	730.	226.	23.	522.	1.	896.	22.	522.
AUG	1294.	0.	4235.	821.	1001.	821.	798.	212.	23.	461.	2.	821.	22.	461.
SEP	1284.	884.	2241.	846.	798.	669.	450.	271.	34.	247.	12.	604.	30.	247.
OCT	1439.	2886.	656.	1273.	877.	772.	429.	444.	64.	81.	35.	480.	53.	81.
NOV	1542.	7494.	0.	2510.	1553.	1452.	894.	959.	126.	24.	84.	452.	102.	24.
DEC	1757.	10588.	0.	3429.	2214.	2121.	1344.	1372.	169.	34.	117.	522.	137.	34.
ANNUAL	18968.	56540.	16074.	22728.	16750.	15285.	9721.	8620.	1080.	1930.	647.	7200.	892.	1930.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 17.4 M3 PANEL= 29.0 M2	3500.	2868.	2489.	710.	335.	1267.	638.	11807.
5	FULL ACES, BIN= 50.8 M3 PANEL= 12.9 M2	3500.	4769.	1588.	710.	335.	1267.	638.	12808.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.12	914.	1324.11	REF.	REF.	24615.	28837.	36059.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.52	2162.	975.83	348.29	131.	18141.	23741.	29064.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.66	2468.	890.50	433.61	691.	16554.	23021.	27878.
4	MIN. ACES, BIN= 17.4 M3 PANEL= 29.0 M2	2.62	2432.	566.37	757.74	8499.	10529.	24768.	27857.
5	FULL ACES, BIN= 50.8 M3 PANEL= 12.9 M2	2.95	2432.	502.23	821.89	9499.	9336.	24576.	27315.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.04	889.	438.78	885.33	581.	12425.	17204.	21986.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.59	914.	1144.18	179.93	1037.	26097.	31356.	30914.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.39	960.	381.92	942.19	821.	10625.	15714.	19770.

BURLINGTON, VERMONT

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 15236.
DESIGN COOLING LOAD (WATTS) = 4666.

EL. ($/KWHR) = 0.0395, 0.0850
GAS ($/THERM) = 0.6319, 0.8150
OIL ($/GAL.) = 1.1800, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -23 C 31 C
TOTAL/SENSIBLE COOLING = 1.11

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1810.	18204.	0.	5560.	4538.	4508.	2199.	2199.	267.	58.	196.	561.	216.	58.
FEB	1701.	15236.	0.	4705.	3735.	3697.	1863.	1862.	227.	48.	165.	521.	184.	48.
MAR	1930.	12238.	0.	3936.	2744.	2656.	1557.	1556.	194.	39.	134.	575.	157.	39.
APR	1865.	5958.	0.	2173.	1404.	1289.	858.	857.	112.	19.	68.	537.	92.	19.
MAY	1877.	2588.	898.	1338.	996.	885.	502.	502.	68.	106.	31.	628.	58.	106.
JUN	1738.	791.	2120.	934.	893.	754.	318.	318.	41.	233.	11.	716.	37.	233.
JUL	1700.	0.	3188.	820.	977.	799.	243.	243.	33.	347.	4.	820.	28.	347.
AUG	1619.	0.	2655.	739.	903.	745.	226.	305.	35.	289.	8.	739.	27.	289.
SEP	1525.	1635.	1315.	1021.	829.	717.	317.	317.	49.	148.	20.	572.	42.	148.
OCT	1579.	4126.	0.	1585.	1031.	935.	545.	544.	84.	13.	49.	452.	68.	13.
NOV	1576.	8277.	0.	2737.	1699.	1591.	953.	950.	138.	26.	93.	464.	111.	26.
DEC	1714.	15857.	0.	4881.	3756.	3706.	1865.	1864.	236.	50.	172.	526.	190.	50.
ANNUAL	20635.	84912.	10176.	30430.	23504.	22280.	11448.	11517.	1485.	1377.	950.	7110.	1209.	1377.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
		COMPONENTS COSTS, $							
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 24.8 M3 PANEL=132.6 M2*	4000.	3551.	8289.	830.	335.	1520.	638.	19163.*
5	FULL ACES, BIN= 24.8 M3 PANEL=132.6 M2*	4000.	3551.	8289.	830.	335.	1520.	638.	19163.*
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST AVERAGE $	LIFE CYCLE COST MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.06	914.	1200.45	REF.	REF.	22316.	26539.	46848.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.37	2162.	927.24	273.21	131.	17237.	22838.	33525.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.44	2468.	878.94	321.51	691.	16339.	22806.	37676.
4	MIN. ACES, BIN= 24.8 M3 PANEL=132.6 M2	2.81	2432.	451.63	748.82	15854.	8396.	29990.*	37631.
5	FULL ACES, BIN= 24.8 M3 PANEL=132.6 M2	2.79	2432.	451.63	748.82	15854.	8396.	29990.*	37631.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.02	889.	992.61	207.84	611.	30725.	35533.	26681.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.60	914.	1402.01	-201.56	1037.	33533.	38792.	38087.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.44	960.	818.04	382.42	821.	25196.	30286.	23251.

*UNGLAZED PANEL EXCEEDS A PRACTICAL SIZE, AN ALTERNATIVE SUPPLEMENTARY HEAT SOURCE SHOULD BE USED IN THIS DESIGN.

NORFOLK, VIRGINIA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 8135.
DESIGN COOLING LOAD (WATTS) = 7332.

EL. ($/KWHR) = 0.0643, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3667, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -6 C 33 C
TOTAL/SENSIBLE COOLING = 1.40

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE GAS THERMS	(6) GAS FURNACE ELEC. KWH	(7) OIL FURNACE OIL GAL	(7) OIL FURNACE ELEC. KWH	(8) PULSE GAS FURN. GAS THERMS	(8) PULSE GAS FURN. ELEC. KWH
JAN	1788.	7928.	0.	2699.	1707.	1596.	1105.	1058.	135.	25.	89.	522.	111.	25.
FEB	1622.	6152.	0.	2160.	1367.	1261.	894.	847.	109.	19.	70.	470.	90.	19.
MAR	1709.	4853.	0.	1823.	1177.	1062.	753.	715.	94.	15.	56.	490.	78.	15.
APR	1503.	2035.	996.	1091.	823.	720.	409.	400.	53.	115.	25.	532.	46.	115.
MAY	1361.	0.	2591.	660.	819.	681.	195.	195.	30.	282.	7.	660.	23.	282.
JUN	1156.	0.	4999.	866.	1065.	863.	925.	207.	20.	545.	1.	866.	19.	545.
JUL	1089.	0.	7064.	1072.	1347.	1098.	1286.	229.	18.	770.	0.	1072.	18.	770.
AUG	1080.	0.	6918.	1054.	1324.	1080.	1263.	779.	18.	754.	0.	1054.	18.	754.
SEP	1129.	0.	4315.	784.	962.	776.	807.	866.	20.	470.	2.	784.	19.	470.
OCT	1329.	1078.	1323.	813.	699.	603.	290.	342.	38.	148.	14.	517.	33.	148.
NOV	1467.	3074.	0.	1261.	872.	784.	482.	452.	67.	10.	37.	417.	56.	10.
DEC	1686.	6834.	0.	2367.	1498.	1394.	952.	928.	120.	22.	77.	490.	98.	22.
ANNUAL	16918.	31953.	28206.	16649.	13659.	11918.	9361.	7019.	722.	3174.	378.	7874.	607.	3174.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1329.	45.	236.	275.	940.	534.	3639.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1329.	45.	636.	335.	940.	634.	4199.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 12.1 M3 PANEL= 7.4 M2	3130.	2276.	1277.	636.	335.	1049.	534.	9237.
5	FULL ACES, BIN= 77.0 M3 PANEL= 0.0 M2	3130.	5771.	0.	636.	335.	1049.	534.	11455.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.29	914.	1070.89	REF.	REF.	19908.	24381.	27795.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.57	2162.	878.54	192.35	80.	16332.	22133.	24934.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.80	2468.	766.56	304.34	640.	14250.	20917.	23361.
4	MIN. ACES, BIN= 12.1 M3 PANEL= 7.4 M2	2.29	2432.	602.13	468.77	5679.	11194.	22863.	24783.
5	FULL ACES, BIN= 77.0 M3 PANEL= 0.0 M2	3.05	2432.	451.47	619.42	7896.	8393.	22280.	23719.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.09	889.	468.97	601.92	628.	12182.	17258.	19221.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.64	914.	948.14	122.76	1084.	20567.	26124.	25670.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.35	960.	426.74	644.15	868.	10845.	16231.	17986.

RICHMOND, VIRGINIA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 9325.
DESIGN COOLING LOAD (WATTS) = 6741.

EL. ($/KWHR) = 0.0643, 0.0850
GAS ($/THERM) = 0.3667, 0.8150
OIL ($/GAL.) = 1.1700, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -9 C 33 C
TOTAL/SENSIBLE COOLING = 1.29

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1794.	6861.	0.	2404.	1541.	1438.	1005.	943.	122.	22.	78.	520.	100.	22.
FEB	1615.	5691.	0.	2030.	1308.	1215.	853.	796.	103.	18.	65.	467.	85.	18.
MAR	1693.	4690.	0.	1773.	1167.	1062.	741.	695.	92.	15.	54.	485.	76.	15.
APR	1487.	1963.	1278.	1097.	857.	742.	401.	394.	52.	145.	24.	558.	45.	145.
MAY	1352.	580.	2687.	829.	843.	703.	259.	259.	31.	295.	8.	670.	28.	295.
JUN	1160.	0.	4912.	857.	1060.	870.	908.	206.	21.	535.	2.	857.	19.	535.
JUL	1110.	0.	6592.	1026.	1284.	1053.	1202.	225.	19.	718.	0.	1026.	18.	718.
AUG	1116.	0.	5671.	928.	1150.	946.	1043.	435.	19.	618.	0.	928.	19.	618.
SEP	1171.	0.	3603.	718.	892.	736.	681.	736.	24.	393.	5.	718.	19.	393.
OCT	1373.	1522.	1320.	948.	770.	665.	299.	337.	45.	149.	20.	530.	38.	149.
NOV	1502.	4147.	0.	1569.	1054.	956.	606.	570.	81.	13.	48.	430.	67.	13.
DEC	1708.	6852.	0.	2378.	1553.	1457.	961.	933.	120.	22.	77.	496.	98.	22.
ANNUAL	17080.	32309.	26063.	16559.	13479.	11843.	8960.	6530.	728.	2942.	381.	7687.	613.	2942.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1279.	48.	236.	275.	907.	534.	3559.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	534.	3412.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	634.	3972.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 10.7 M3 PANEL= 8.1 M2	3130.	2237.	1321.	636.	335.	1049.	534.	9241.
5	FULL ACES, BIN= 75.1 M3 PANEL= 0.0 M2	3130.	5764.	0.	636.	335.	1049.	534.	11447.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1279.	26.	376.	270.	907.	584.	4187.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1279.	26.	632.	275.	907.	834.	4643.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1279.	26.	236.	270.	907.	584.	4427.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.27	914.	1065.05	REF.	REF.	19799.	24272.	27668.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.55	2162.	866.98	198.07	-147.	16117.	21691.	24455.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.77	2468.	761.74	303.30	413.	14161.	20601.	23030.
4	MIN. ACES, BIN= 10.7 M3 PANEL= 8.1 M2	2.34	2432.	576.30	488.75	5683.	10713.	22387.	24224.
5	FULL ACES, BIN= 75.1 M3 PANEL= 0.0 M2	3.21	2432.	420.02	645.03	7889.	7808.	21688.	23027.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.09	889.	456.08	608.97	628.	11969.	17045.	18971.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.62	914.	940.66	124.38	1084.	20459.	26016.	25502.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.35	969.	414.10	650.95	868.	10640.	16026.	17745.

ROANOKE, VIRGINIA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 9755.
DESIGN COOLING LOAD (WATTS) = 5733.

EL. ($/KWHR) = 0.0471, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3667, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1700, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -10 C 33 C
TOTAL/SENSIBLE COOLING = 1.15

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1844.	8628.	0.	2909.	1873.	1760.	1193.	1193.	145.	27.	96.	540.	119.	27.
FEB	1660.	6598.	0.	2294.	1469.	1368.	951.	954.	116.	21.	74.	482.	95.	21.
MAR	1738.	5652.	0.	2053.	1333.	1218.	847.	878.	105.	18.	65.	501.	87.	18.
APR	1523.	2157.	1204.	1154.	882.	766.	426.	478.	55.	138.	26.	561.	47.	138.
MAY	1380.	709.	2322.	833.	813.	678.	271.	271.	33.	255.	10.	638.	30.	255.
JUN	1180.	0.	3994.	763.	934.	766.	472.	195.	22.	435.	2.	763.	20.	435.
JUL	1126.	0.	5457.	907.	1121.	913.	1006.	210.	19.	595.	0.	907.	19.	595.
AUG	1132.	0.	4940.	853.	1048.	853.	917.	203.	19.	538.	1.	853.	19.	538.
SEP	1191.	0.	2983.	656.	815.	671.	574.	297.	25.	325.	5.	656.	20.	325.
OCT	1402.	1797.	1086.	1007.	780.	679.	331.	436.	49.	124.	23.	513.	42.	124.
NOV	1538.	4743.	0.	1745.	1138.	1042.	665.	710.	90.	15.	55.	442.	74.	15.
DEC	1754.	7700.	0.	2626.	1677.	1573.	1051.	1087.	132.	24.	86.	512.	108.	24.
ANNUAL	17467.	37984.	21986.	17800.	13884.	12287.	8703.	6913.	810.	2515.	444.	7368.	678.	2515.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1129.	48.	236.	275.	811.	482.	3261.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	482.	3360.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	582.	3920.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 13.0 M3 PANEL= 10.3 M2	3130.	2438.	1443.	636.	335.	1049.	534.	9565.
5	FULL ACES, BIN= 79.1 M3 PANEL= 0.0 M2	3130.	5971.	0.	636.	335.	1049.	534.	11655.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.21	914.	838.01	REF.	REF.	15579.	19754.	29109.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.55	2162.	653.67	184.33	99.	12152.	17674.	24971.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.75	2468.	578.46	259.55	659.	10753.	17141.	23599.
4	MIN. ACES, BIN= 13.0 M3 PANEL= 10.3 M2	2.47	2432.	409.74	428.26	6304.	7617.	19614.	24188.
5	FULL ACES, BIN= 79.1 M3 PANEL= 0.0 M2	3.11	2432.	325.44	512.56	8393.	6050.	20137.	23770.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.06	889.	415.49	422.52	628.	11609.	16388.	19182.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.60	914.	866.50	-28.49	1084.	19569.	24828.	26266.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.35	960.	366.90	471.10	868.	10071.	15160.	17714.

MOSES LAKE, WASHINGTON

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 12174.
DESIGN COOLING LOAD (WATTS) = 6028.

EL. ($/KWHR) = 0.0180, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3478, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0400, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -16 C 34 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1904.	12064.	0.	3880.	2656.	2530.	1561.	1561.	190.	38.	132.	567.	155.	38.
FEB	1739.	7849.	0.	2664.	1731.	1611.	1065.	1095.	133.	25.	88.	508.	109.	25.
MAR	1865.	6046.	0.	2198.	1401.	1278.	875.	902.	112.	19.	68.	537.	93.	19.
APR	1680.	3331.	0.	1392.	971.	866.	554.	570.	74.	11.	39.	477.	62.	11.
MAY	1568.	1651.	1765.	1086.	903.	767.	376.	376.	50.	198.	21.	633.	43.	198.
JUN	1368.	0.	3179.	727.	905.	735.	205.	205.	30.	346.	7.	727.	23.	346.
JUL	1307.	0.	4877.	895.	1103.	902.	741.	223.	24.	531.	3.	895.	22.	531.
AUG	1283.	0.	4584.	856.	1062.	877.	858.	216.	25.	499.	4.	856.	21.	499.
SEP	1301.	1016.	2358.	900.	835.	697.	470.	341.	36.	260.	14.	621.	32.	260.
OCT	1478.	3445.	0.	1368.	913.	817.	481.	516.	72.	11.	41.	422.	60.	11.
NOV	1589.	7857.	0.	2624.	1643.	1517.	937.	1039.	131.	25.	88.	466.	106.	25.
DEC	1800.	10788.	0.	3497.	2253.	2109.	1370.	1418.	172.	34.	119.	534.	140.	34.
ANNUAL	18882.	54046.	16764.	22086.	16376.	14706.	9495.	8461.	1049.	1998.	624.	7243.	865.	1998.

SYSTEMS FIRST COSTS

NO.		COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	CONVENTIONAL ELECTRIC SYSTEMS: EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES):	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 17.3 M3 PANEL= 41.0 M2	3500.	2887.	3163.	710.	335.	1267.	638.	12501.
5	FULL ACES, BIN= 54.9 M3 PANEL= 13.5 M2	3500.	5000.	1618.	710.	335.	1267.	638.	13069.
	FOSSIL FUEL FIRED SYSTEMS:	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.13	914.	397.55	REF.	REF.	7390.	11613.	35160.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.52	2162.	294.77	102.78	131.	5480.	11081.	28540.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.69	2468.	264.70	132.85	691.	4921.	11388.	27066.
4	MIN. ACES, BIN= 17.3 M3 PANEL= 41.0 M2	2.62	2432.	170.91	226.64	9192.	3177.	18110.	28233.
5	FULL ACES, BIN= 54.9 M3 PANEL= 13.5 M2	2.94	2432.	152.29	245.25	9760.	2831.	18332.	27353.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.04	889.	400.73	-3.18	581.	12221.	16999.	21663.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.58	914.	779.11	-381.56	1037.	18804.	24063.	30414.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.39	960.	336.74	60.80	821.	10194.	15284.	19503.

SEATTLE, WASHINGTON

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 7817.
DESIGN COOLING LOAD (WATTS) = 3516.

EL. ($/KWHR) = 0.0161, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.5402, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1300, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -5 C 28 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1824.	7980.	0.	2724.	1690.	1595.	1109.	1109.	137.	25.	90.	532.	112.	25.
FEB	1651.	5540.	0.	1998.	1228.	1133.	813.	810.	103.	18.	64.	476.	84.	18.
MAR	1774.	5616.	0.	2053.	1273.	1185.	827.	825.	105.	18.	64.	511.	87.	18.
APR	1626.	3789.	0.	1504.	970.	880.	606.	605.	79.	12.	44.	464.	66.	12.
MAY	1564.	2746.	624.	1265.	875.	776.	489.	488.	64.	77.	33.	511.	54.	77.
JUN	1418.	1445.	1243.	931.	752.	645.	332.	332.	44.	140.	20.	534.	38.	140.
JUL	1403.	778.	2266.	853.	818.	681.	280.	280.	35.	249.	12.	639.	31.	249.
AUG	1399.	763.	1937.	812.	766.	643.	273.	273.	35.	213.	12.	602.	31.	213.
SEP	1405.	1519.	895.	910.	709.	619.	297.	297.	45.	102.	21.	492.	39.	102.
OCT	1550.	2996.	0.	1263.	832.	756.	467.	463.	68.	9.	37.	440.	56.	9.
NOV	1609.	5592.	0.	2000.	1207.	1109.	796.	793.	103.	18.	65.	465.	84.	18.
DEC	1764.	7460.	0.	2562.	1564.	1463.	1039.	1039.	130.	24.	84.	514.	105.	24.
ANNUAL	18986.	46226.	6963.	18875.	12684.	11885.	7330.	7314.	949.	905.	585.	6179.	787.	905.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
		COMPONENTS COSTS, $							
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	280.	1129.	48.	236.	275.	811.	482.	3261.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	280.	1199.	45.	236.	275.	843.	482.	3360.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	280.	1199.	45.	636.	335.	843.	582.	3920.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 12.2 M3 PANEL= 15.3 M2	3130.	2267.	1724.	636.	335.	1049.	534.	9675.
5	FULL ACES, BIN= 12.2 M3 PANEL= 15.3 M2	3130.	2267.	1724.	636.	335.	1049.	534.	9675.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.06	914.	303.69	REF.	REF.	5646.	9821.	30615.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.58	2162.	204.08	99.61	99.	3794.	9316.	23289.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.75	2468.	184.79	118.90	659.	3435.	9823.	22476.
4	MIN. ACES, BIN= 12.2 M3 PANEL= 15.3 M2	2.74	2432.	117.94	185.75	6414.	2192.	14300.	22375.
5	FULL ACES, BIN= 12.2 M3 PANEL= 15.3 M2	2.74	2432.	117.94	185.75	6414.	2192.	14300.	22375.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	1.97	889.	527.08	-223.39	628.	16502.	21280.	18789.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.47	914.	714.87	-411.17	1084.	17388.	22647.	27020.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.33	960.	439.62	-135.93	868.	13732.	18822.	16925.

SPOKANE, WASHINGTON

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 13782.
DESIGN COOLING LOAD (WATTS) = 4702.

EL. ($/KWHR) = 0.0200, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3022, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1200, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -20 C 31 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1879.	13375.	0.	4238.	3004.	2922.	1697.	1697.	208.	42.	146.	564.	168.	42.
FEB	1740.	9563.	0.	3140.	2066.	1961.	1254.	1257.	157.	30.	106.	514.	126.	30.
MAR	1918.	8107.	0.	2785.	1767.	1647.	1107.	1110.	141.	26.	91.	559.	115.	26.
APR	1792.	4642.	0.	1787.	1157.	1049.	709.	711.	94.	15.	53.	512.	77.	15.
MAY	1740.	2739.	923.	1345.	976.	858.	506.	506.	68.	109.	33.	593.	57.	109.
JUN	1567.	1145.	1895.	960.	855.	721.	334.	334.	43.	210.	16.	646.	38.	210.
JUL	1517.	0.	3707.	825.	1019.	833.	230.	230.	32.	404.	6.	825.	25.	404.
AUG	1464.	0.	3116.	746.	934.	768.	508.	317.	33.	339.	8.	746.	24.	339.
SEP	1426.	1608.	1472.	1003.	814.	698.	308.	308.	47.	166.	21.	562.	40.	166.
OCT	1544.	4490.	0.	1676.	1064.	959.	586.	589.	88.	14.	52.	443.	71.	14.
NOV	1600.	9389.	0.	3053.	1925.	1813.	1088.	1116.	153.	30.	104.	474.	122.	30.
DEC	1777.	12069.	0.	3847.	2516.	2414.	1480.	1493.	190.	38.	132.	532.	153.	38.
ANNUAL	19963.	67128.	11112.	25405.	18098.	16642.	9807.	9668.	1254.	1423.	767.	6969.	1016.	1423.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 18.9 M3 PANEL= 53.5 M2	4000.	3086.	3862.	830.	335.	1520.	638.	14270.
5	FULL ACES, BIN= 25.0 M3 PANEL= 46.0 M2	4000.	3478.	3443.	830.	335.	1520.	638.	14244.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.07	914.	508.60	REF.	REF.	9455.	13677.	39809.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.51	2162.	362.32	146.28	131.	6735.	12336.	30952.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.64	2468.	333.16	175.44	691.	6193.	12660.	29778.
4	MIN. ACES, BIN= 18.9 M3 PANEL= 53.5 M2	2.78	2432.	196.34	312.26	10962.	3650.	20352.	30440.
5	FULL ACES, BIN= 25.0 M3 PANEL= 46.0 M2	2.82	2432.	193.55	315.05	10935.	3598.	20274.	30219.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.00	889.	407.45	101.15	611.	12531.	17339.	23644.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.56	914.	998.90	-490.30	1037.	24293.	29552.	33483.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.40	960.	335.57	173.03	821.	10255.	15344.	20731.

CHARLESTON, WEST VIRGINIA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 10803.
DESIGN COOLING LOAD (WATTS) = 5726.

EL. ($/KWHR) = 0.0468, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3685, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1900, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -13 C 32 C
TOTAL/SENSIBLE COOLING = 1.17

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1866.	9294.	0.	3100.	2058.	1962.	1270.	1270.	154.	29.	103.	548.	126.	29.
FEB	1681.	6832.	0.	2365.	1548.	1459.	986.	987.	119.	22.	77.	489.	98.	22.
MAR	1762.	5813.	0.	2104.	1385.	1281.	869.	907.	107.	18.	66.	508.	89.	18.
APR	1546.	2254.	1122.	1178.	898.	785.	439.	475.	57.	129.	27.	559.	49.	129.
MAY	1402.	879.	2256.	879.	832.	694.	291.	291.	36.	249.	12.	638.	32.	249.
JUN	1199.	0.	3918.	760.	935.	763.	468.	196.	23.	427.	3.	760.	20.	427.
JUL	1144.	0.	5256.	890.	1099.	899.	971.	209.	20.	573.	1.	890.	19.	573.
AUG	1149.	0.	4831.	846.	1042.	853.	898.	204.	20.	526.	1.	846.	19.	526.
SEP	1207.	0.	3058.	669.	838.	690.	588.	301.	26.	333.	6.	669.	20.	333.
OCT	1419.	1963.	1113.	1061.	818.	711.	349.	408.	51.	127.	25.	522.	44.	127.
NOV	1557.	4893.	0.	1792.	1194.	1095.	677.	735.	92.	15.	56.	448.	76.	15.
DEC	1775.	7745.	0.	2645.	1752.	1652.	1066.	1102.	133.	25.	87.	518.	108.	25.
ANNUAL	17708.	39674.	21552.	18289.	14400.	12843.	8872.	7084.	838.	2474.	465.	7393.	699.	2474.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 13.9 M3 PANEL= 13.1 M2	3500.	2560.	1599.	710.	335.	1267.	638.	10610.
5	FULL ACES, BIN= 75.7 M3 PANEL= 1.7 M2	3500.	5888.	962.	710.	335.	1267.	638.	13300.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.20	914.	856.28	REF.	REF.	15918.	20141.	29841.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.52	2162.	674.19	182.09	131.	12533.	18134.	25772.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.71	2468.	601.31	254.97	691.	11178.	17645.	24457.
4	MIN. ACES, BIN= 13.9 M3 PANEL= 13.1 M2	2.47	2432.	415.40	440.88	7302.	7722.	20764.	25470.
5	FULL ACES, BIN= 75.7 M3 PANEL= 1.7 M2	3.10	2432.	331.70	524.59	9992.	6166.	21898.	25656.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.06	889.	424.68	431.60	581.	11935.	16713.	19501.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.59	914.	899.23	-42.95	1037.	20400.	25659.	26798.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.36	960.	373.33	482.95	821.	10309.	15398.	17940.

ELKINS, WEST VIRGINIA

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 12165.
DESIGN COOLING LOAD (WATTS) = 4175.

EL. ($/KWHR) = 0.0470, 0.0850
GAS ($/THERM) = 0.3685, 0.8150
OIL ($/GAL.) = 1.1900, 1.4600

PWF = 18.59, 16.48
PWF = 31.67, 16.48
PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -16 C 29 C
TOTAL/SENSIBLE COOLING = 1.12

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1905.	11062.	0.	3602.	2630.	2587.	1461.	1461.	177.	35.	122.	564.	144.	35.
FEB	1738.	8530.	0.	2852.	2006.	1955.	1167.	1174.	142.	27.	95.	510.	116.	27.
MAR	1868.	7591.	0.	2603.	1720.	1661.	1059.	1078.	131.	24.	84.	543.	108.	24.
APR	1693.	3681.	0.	1493.	1099.	998.	606.	616.	78.	12.	43.	482.	66.	12.
MAY	1594.	1789.	1471.	1100.	894.	768.	392.	392.	52.	166.	22.	609.	45.	166.
JUN	1405.	671.	2684.	869.	869.	721.	275.	275.	33.	295.	10.	685.	30.	295.
JUL	1353.	0.	3584.	766.	935.	770.	326.	209.	26.	390.	4.	766.	23.	390.
AUG	1331.	0.	3137.	712.	873.	720.	602.	200.	27.	342.	5.	712.	22.	342.
SEP	1343.	1216.	1978.	927.	821.	694.	402.	308.	40.	219.	16.	593.	35.	219.
OCT	1512.	3742.	0.	1460.	1035.	938.	528.	545.	76.	12.	44.	432.	63.	12.
NOV	1609.	6621.	0.	2287.	1549.	1488.	838.	875.	115.	21.	75.	468.	94.	21.
DEC	1809.	10136.	0.	3318.	2352.	2302.	1311.	1322.	164.	32.	112.	535.	133.	32.
ANNUAL	19160.	54951.	12854.	21989.	16781.	15602.	8967.	8455.	1061.	1574.	631.	6897.	879.	1574.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 16.1 M3 PANEL= 22.3 M2	3500.	2799.	2114.	710.	335.	1267.	638.	11363.
5	FULL ACES, BIN= 35.0 M3 PANEL= 14.7 M2	3500.	3969.	1689.	710.	335.	1267.	638.	12109.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	745.	1129.	26.	376.	270.	811.	532.	3889.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.10	914.	1034.12	REF.	REF.	19224.	23447.	35024.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.44	2162.	789.23	244.89	131.	14672.	20273.	29108.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.55	2468.	733.77	300.35	691.	13641.	20108.	28322.
4	MIN. ACES, BIN= 16.1 M3 PANEL= 22.3 M2	2.69	2432.	421.73	612.39	8055.	7840.	21635.	26356.
5	FULL ACES, BIN= 35.0 M3 PANEL= 14.7 M2	2.86	2432.	397.62	636.50	8801.	7392.	21933.	26384.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.02	889.	464.96	569.16	581.	13757.	18535.	21232.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.56	914.	1075.55	-41.43	1037.	24997.	30257.	30109.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.38	960.	397.84	636.29	821.	11631.	16720.	19096.

GREEN BAY, WISCONSIN

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 15475.
DESIGN COOLING LOAD (WATTS) = 4683.

EL. ($/KWHR) = 0.0418, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3697, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1100, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -24 C 29 C
TOTAL/SENSIBLE COOLING = 1.14

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1811.	18314.	0.	5591.	4737.	4735.	2210.	2210.	269.	58.	200.	561.	217.	58.
FEB	1702.	14449.	0.	4487.	3631.	3621.	1776.	1777.	218.	46.	158.	519.	176.	46.
MAR	1929.	12518.	0.	4014.	2945.	2913.	1586.	1587.	198.	40.	139.	576.	160.	40.
APR	1864.	5999.	0.	2184.	1424.	1337.	862.	862.	113.	19.	70.	537.	92.	19.
MAY	1875.	3045.	799.	1454.	1038.	927.	550.	550.	74.	97.	38.	618.	62.	97.
JUN	1735.	848.	2404.	979.	941.	790.	328.	328.	41.	265.	13.	746.	37.	265.
JUL	1696.	0.	3438.	846.	1011.	818.	247.	247.	32.	375.	5.	846.	28.	375.
AUG	1615.	0.	3442.	824.	996.	815.	346.	350.	32.	375.	6.	824.	27.	375.
SEP	1522.	1655.	1373.	1032.	837.	726.	319.	320.	49.	155.	23.	578.	42.	155.
OCT	1578.	4359.	0.	1649.	1074.	985.	567.	567.	87.	14.	53.	452.	71.	14.
NOV	1576.	10161.	0.	3261.	2244.	2199.	1132.	1134.	162.	32.	114.	470.	130.	32.
DEC	1714.	15332.	0.	4735.	3722.	3712.	1819.	1820.	230.	49.	168.	525.	185.	49.
ANNUAL	20617.	86680.	11455.	31055.	24602.	23578.	11741.	11752.	1505.	1522.	987.	7250.	1226.	1522.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	350.	1129.	48.	305.	275.	811.	482.	3400.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	350.	1199.	77.	305.	275.	843.	482.	3531.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	350.	1199.	77.	705.	335.	843.	582.	4091.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 25.0 M3 PANEL=132.5 M2*	4000.	3573.	8286.	830.	335.	1520.	638.	19182.*
5	FULL ACES, BIN= 27.0 M3 PANEL=123.6 M2*	4000.	3699.	7785.	830.	335.	1520.	638.	18806.*
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	720.	1129.	26.	632.	275.	811.	782.	4375.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.06	914.	1297.81	REF.	REF.	24126.	28440.	47817.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.34	2162.	1028.14	269.67	131.	19113.	24806.	40156.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.40	2468.	985.32	312.48	691.	18317.	24876.	39587.
4	MIN. ACES, BIN= 25.0 M3 PANEL=132.5 M2	2.81	2432.	490.67	807.14	15782.	9122.	30735.*	38061.
5	FULL ACES, BIN= 27.0 M3 PANEL=123.6 M2	2.81	2432.	491.11	806.70	15406.	9130.	30368.*	37700.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.03	889.	619.98	677.83	519.	18802.	23611.	27153.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.59	914.	1398.06	-100.25	975.	33283.	38572.	39182.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.44	960.	516.99	780.82	729.	15541.	20630.	23693.

*UNGLAZED PANEL EXCEEDS A PRACTICAL SIZE, AN ALTERNATIVE SUPPLEMENTARY HEAT SOURCE SHOULD BE USED IN THIS DESIGN.

MADISON, WISCONSIN

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 14973.
DESIGN COOLING LOAD (WATTS) = 5167.

EL. ($/KWHR) = 0.0415, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3697, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.1100, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -23 C 31 C
TOTAL/SENSIBLE COOLING = 1.16

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	ELEC. KWH	(7) OIL FURNACE: OIL GAL	ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	ELEC. KWH
JAN	1810.	17585.	0.	5388.	4297.	4268.	2134.	2134.	260.	56.	190.	558.	209.	56.
FEB	1703.	13379.	0.	4190.	3143.	3087.	1664.	1677.	204.	42.	145.	516.	165.	42.
MAR	1920.	11395.	0.	3699.	2516.	2418.	1466.	1475.	183.	36.	125.	569.	148.	36.
APR	1832.	5203.	0.	1954.	1295.	1177.	773.	777.	102.	16.	60.	525.	83.	16.
MAY	1812.	2183.	1236.	1244.	970.	848.	455.	455.	61.	142.	27.	645.	52.	142.
JUN	1648.	0.	2979.	782.	960.	793.	234.	234.	35.	324.	7.	782.	27.	324.
JUL	1588.	0.	4306.	910.	1095.	881.	247.	247.	29.	469.	2.	910.	26.	469.
AUG	1504.	0.	4056.	860.	1044.	846.	774.	233.	28.	442.	3.	860.	25.	442.
SEP	1425.	1218.	1824.	933.	819.	695.	384.	312.	41.	203.	16.	598.	36.	203.
OCT	1502.	3784.	0.	1468.	995.	891.	507.	512.	78.	12.	44.	429.	64.	12.
NOV	1530.	9087.	0.	2949.	1895.	1792.	1032.	1053.	148.	29.	101.	454.	118.	29.
DEC	1695.	14625.	0.	4534.	3296.	3234.	1751.	1754.	221.	46.	159.	517.	177.	46.
ANNUAL	19968.	78457.	14401.	28912.	22324.	20929.	11420.	10865.	1390.	1817.	880.	7365.	1132.	1817.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 24.1 M3 PANEL= 92.7 M2*	4000.	3488.	6055.	830.	335.	1520.	638.	16865.*
5	FULL ACES, BIN= 42.9 M3 PANEL= 57.5 M2	4000.	4561.	4087.	830.	335.	1520.	638.	15970.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.08	914.	1200.42	REF.	REF.	22316.	26538.	44722.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.40	2162.	926.88	273.54	131.	17231.	22832.	36872.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.50	2468.	868.99	331.43	691.	16154.	22621.	35785.
4	MIN. ACES, BIN= 24.1 M3 PANEL= 92.7 M2	2.74	2432.	474.14	726.27	13557.	8814.	28112.*	35294.
5	FULL ACES, BIN= 42.9 M3 PANEL= 57.5 M2	2.88	2432.	451.11	749.30	12662.	8386.	26788.*	33621.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.04	889.	589.32	611.10	611.	17677.	22485.	26023.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.62	914.	1283.08	-82.67	1037.	30361.	35621.	36760.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.43	960.	493.84	706.57	821.	14653.	19742.	22835.

*UNGLAZED PANEL EXCEEDS A PRACTICAL SIZE, AN ALTERNATIVE SUPPLEMENTARY HEAT SOURCE SHOULD BE USED IN THIS DESIGN.

CASPER, WYOMING

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 14957.
DESIGN COOLING LOAD (WATTS) = 4773.

EL. ($/KWHR) = 0.0343, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3478, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0400, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -23 C 32 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1835.	14530.	0.	4546.	3380.	3320.	1830.	1830.	222.	46.	158.	556.	179.	46.
FEB	1719.	12192.	0.	3864.	2845.	2786.	1558.	1558.	189.	39.	133.	516.	153.	39.
MAR	1925.	11116.	0.	3623.	2576.	2491.	1460.	1468.	179.	35.	122.	570.	145.	35.
APR	1827.	6658.	0.	2357.	1553.	1439.	950.	955.	120.	21.	75.	529.	98.	21.
MAY	1799.	3338.	1065.	1543.	1103.	966.	585.	587.	77.	127.	39.	626.	64.	127.
JUN	1632.	1103.	2744.	1059.	994.	827.	349.	349.	43.	302.	15.	756.	38.	302.
JUL	1575.	0.	4091.	883.	1084.	891.	242.	242.	31.	446.	5.	883.	26.	446.
AUG	1500.	0.	3720.	822.	1010.	836.	711.	228.	30.	405.	5.	822.	25.	405.
SEP	1432.	1977.	2023.	1168.	956.	815.	417.	363.	52.	227.	24.	625.	44.	227.
OCT	1520.	4948.	0.	1797.	1216.	1087.	640.	646.	93.	16.	56.	438.	76.	16.
NOV	1556.	10506.	0.	3351.	2319.	2235.	1266.	1274.	165.	33.	116.	465.	133.	33.
DEC	1724.	13571.	0.	4249.	3016.	2940.	1696.	1696.	208.	43.	148.	522.	167.	43.
ANNUAL	20043.	79938.	13642.	29261.	22050.	20632.	11706.	11197.	1411.	1739.	896.	7308.	1148.	1739.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 20.3 M3 PANEL= 23.2 M2	4000.	3244.	2165.	830.	335.	1520.	638.	12731.
5	FULL ACES, BIN= 35.1 M3 PANEL= 19.3 M2	4000.	4136.	1947.	830.	335.	1520.	638.	13406.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.08	914.	1003.37	REF.	REF.	18653.	22875.	45212.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.43	2162.	756.10	247.27	131.	14056.	19657.	36489.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.53	2468.	707.48	295.90	691.	13152.	19619.	35368.
4	MIN. ACES, BIN= 20.3 M3 PANEL= 23.2 M2	2.70	2432.	401.39	601.98	9422.	7462.	22625.	31560.
5	FULL ACES, BIN= 35.1 M3 PANEL= 19.3 M2	2.82	2432.	383.96	619.42	10097.	7138.	22975.	31523.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.03	889.	550.26	453.12	611.	16646.	21455.	26191.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.61	914.	1182.39	-179.02	1037.	28187.	33446.	37054.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.44	960.	458.93	544.44	821.	13754.	18843.	22945.

CHEYENNE, WYOMING

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 14479.
DESIGN COOLING LOAD (WATTS) = 4197.

EL. ($/KWHR) = 0.0267, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3478, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0400, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -22 C 30 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1846.	14071.	0.	4422.	3337.	3278.	1780.	1780.	216.	45.	153.	557.	174.	45.
FEB	1724.	11267.	0.	3609.	2646.	2580.	1465.	1465.	177.	36.	123.	515.	143.	36.
MAR	1926.	11256.	0.	3662.	2589.	2512.	1484.	1486.	181.	36.	123.	571.	147.	36.
APR	1827.	6994.	0.	2450.	1625.	1514.	993.	994.	125.	22.	78.	530.	102.	22.
MAY	1801.	3585.	835.	1587.	1104.	974.	615.	615.	80.	102.	42.	603.	66.	102.
JUN	1640.	1279.	2241.	1055.	944.	792.	362.	362.	46.	248.	17.	704.	40.	248.
JUL	1590.	0.	3174.	788.	967.	797.	230.	230.	34.	346.	7.	788.	26.	346.
AUG	1521.	0.	3051.	755.	938.	774.	409.	318.	33.	332.	8.	755.	25.	332.
SEP	1457.	2190.	1796.	1209.	956.	815.	372.	372.	55.	203.	27.	607.	47.	203.
OCT	1546.	4822.	0.	1769.	1199.	1071.	640.	642.	92.	15.	55.	445.	75.	15.
NOV	1579.	9371.	0.	3042.	2050.	1965.	1156.	1159.	151.	30.	103.	468.	122.	30.
DEC	1742.	11676.	0.	3728.	2588.	2503.	1498.	1498.	184.	37.	128.	521.	148.	37.
ANNUAL	20198.	76512.	11097.	28075.	20943.	19576.	11006.	10923.	1375.	1451.	866.	7062.	1116.	1451.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	310.	1129.	48.	253.	275.	811.	482.	3308.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	310.	1199.	77.	253.	275.	843.	482.	3439.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	310.	1199.	77.	653.	335.	843.	582.	3999.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 19.8 M3 PANEL= 18.6 M2	4000.	3180.	1907.	830.	335.	1520.	638.	12410.
5	FULL ACES, BIN= 23.0 M3 PANEL= 17.9 M2	4000.	3393.	1868.	830.	335.	1520.	638.	12583.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	690.	1129.	26.	632.	275.	811.	782.	4345.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.07	914.	749.61	REF.	REF.	13935.	18158.	43550.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.43	2162.	559.18	190.43	131.	10395.	15996.	34938.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.53	2468.	522.69	226.92	691.	9717.	16184.	33889.
4	MIN. ACES, BIN= 19.8 M3 PANEL= 18.6 M2	2.72	2432.	293.85	455.76	9102.	5463.	20305.	30259.
5	FULL ACES, BIN= 23.0 M3 PANEL= 17.9 M2	2.74	2432.	291.64	457.97	9275.	5422.	20437.	30316.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.01	889.	516.96	232.65	611.	15865.	20674.	25309.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.58	914.	1089.06	-339.45	1037.	26243.	31502.	35986.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.42	960.	426.79	322.82	821.	13010.	18099.	22107.

LANDER, WYOMING

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 16184.
DESIGN COOLING LOAD (WATTS) = 4672.

EL. ($/KWHR) = 0.0343, 0.0850 PWF = 18.59, 16.49
GAS ($/THERM) = 0.3478, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0400, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -26 C 31 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) ELEC. KWH
JAN	1818.	14107.	0.	4424.	3443.	3402.	1770.	1770.	216.	45.	156.	550.	174.	45.
FEB	1703.	10512.	0.	3393.	2524.	2476.	1367.	1370.	168.	33.	117.	506.	135.	33.
MAR	1923.	10074.	0.	3333.	2348.	2281.	1341.	1344.	166.	32.	113.	566.	135.	32.
APR	1852.	6014.	0.	2185.	1454.	1349.	881.	883.	113.	19.	69.	534.	92.	19.
MAY	1859.	3165.	798.	1483.	1062.	944.	572.	573.	75.	97.	40.	613.	63.	97.
JUN	1719.	1265.	2007.	1048.	933.	791.	366.	366.	47.	223.	18.	700.	41.	223.
JUL	1684.	0.	3412.	840.	1009.	831.	245.	245.	33.	372.	5.	840.	28.	372.
AUG	1610.	0.	3313.	808.	979.	805.	440.	235.	32.	361.	6.	808.	27.	361.
SEP	1529.	1753.	1746.	1100.	911.	781.	335.	335.	51.	196.	24.	619.	43.	196.
OCT	1586.	4447.	0.	1676.	1151.	1038.	597.	600.	88.	14.	53.	455.	72.	14.
NOV	1587.	9320.	0.	3030.	2143.	2077.	1075.	1079.	151.	30.	105.	470.	121.	30.
DEC	1726.	12798.	0.	4035.	2957.	2908.	1573.	1573.	198.	41.	142.	520.	159.	41.
ANNUAL	20590.	73854.	11277.	27354.	20913.	19684.	10561.	10373.	1337.	1461.	848.	7181.	1091.	1461.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	350.	1129.	48.	305.	275.	811.	3400.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	350.	1199.	77.	305.	275.	843.	3531.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	350.	1199.	77.	705.	335.	843.	4091.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 19.8 M3 PANEL= 27.6 M2	4000.	3274.	2412.	830.	335.	1520.	638.	13009.
5	FULL ACES, BIN= 23.9 M3 PANEL= 25.2 M2	4000.	3545.	2279.	830.	335.	1520.	638.	13147.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	720.	1129.	26.	632.	275.	811.	782.	4375.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.07	914.	937.98	REF.	REF.	17437.	21751.	42632.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.40	2162.	717.12	220.87	131.	13331.	19024.	34988.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.49	2468.	674.95	263.03	691.	12547.	19106.	34132.
4	MIN. ACES, BIN= 19.8 M3 PANEL= 27.6 M2	2.77	2432.	362.14	575.85	9608.	6732.	22173.	30234.
5	FULL ACES, BIN= 23.9 M3 PANEL= 25.2 M2	2.82	2432.	355.70	582.28	9747.	6613.	22191.	30110.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.02	889.	514.95	423.03	519.	15653.	20461.	24806.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.56	914.	1128.37	-190.39	975.	26851.	32141.	35757.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.41	960.	429.57	508.41	729.	12949.	18038.	21790.

SHERIDAN, WYOMING

167 SQ M HOME, WELL INSULATED
DESIGN HEATING LOAD (WATTS) = 15682.
DESIGN COOLING LOAD (WATTS) = 5031.

EL. ($/KWHR) = 0.0272, 0.0850 PWF = 18.59, 16.48
GAS ($/THERM) = 0.3478, 0.8150 PWF = 31.67, 16.48
OIL ($/GAL.) = 1.0400, 1.4600 PWF = 25.25, 16.48

DESIGN WEATHER: WINTER SUMMER
OUTDOOR TEMP. = -25 C 33 C
TOTAL/SENSIBLE COOLING = 1.00

DESIGN AND PERFORMANCE

MONTH	BUILDING LOADS: WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION: (1) ELEC. RES. KWH	(2) HEAT PUMP KWH	(3) HP DS KWH	(4) MIN. ACES KWH	(5) FULL ACES KWH	(6) GAS FURNACE: GAS THERMS	(6) GAS FURNACE: ELEC. KWH	(7) OIL FURNACE: OIL GAL	(7) OIL FURNACE: ELEC. KWH	(8) PULSE GAS FURN.: GAS THERMS	(8) PULSE GAS FURN.: ELEC. KWH
JAN	1833.	14075.	0.	4419.	3399.	3344.	1751.	1778.	216.	45.	155.	554.	174.	45.
FEB	1717.	11130.	0.	3569.	2653.	2595.	1412.	1435.	176.	35.	124.	512.	142.	35.
MAR	1926.	9751.	0.	3244.	2251.	2167.	1282.	1301.	162.	31.	110.	566.	131.	31.
APR	1833.	6004.	0.	2177.	1442.	1327.	861.	873.	112.	19.	69.	528.	92.	19.
MAY	1811.	2886.	1156.	1431.	1056.	923.	531.	535.	71.	135.	36.	638.	60.	135.
JUN	1650.	1007.	2484.	1009.	949.	792.	337.	337.	42.	274.	15.	732.	38.	274.
JUL	1597.	0.	4131.	894.	1090.	894.	245.	245.	31.	450.	5.	894.	27.	450.
AUG	1521.	0.	3799.	836.	1027.	849.	726.	232.	31.	414.	6.	836.	25.	414.
SEP	1450.	1961.	2018.	1168.	959.	819.	416.	363.	52.	226.	26.	629.	44.	226.
OCT	1533.	4891.	0.	1785.	1202.	1083.	617.	643.	93.	15.	58.	441.	75.	15.
NOV	1562.	9922.	0.	3190.	2200.	2119.	1109.	1178.	158.	31.	112.	465.	127.	31.
DEC	1725.	13735.	0.	4295.	3078.	3007.	1636.	1651.	210.	43.	152.	523.	169.	43.
ANNUAL	20159.	75364.	13589.	28017.	21306.	19920.	10922.	10572.	1354.	1719.	868.	7319.	1103.	1719.

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL ELECTRIC SYSTEMS	COMPONENTS COSTS, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL COST, $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	350.	1129.	48.	305.	275.	811.	482.	3400.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	350.	1199.	77.	305.	275.	843.	482.	3531.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	350.	1199.	77.	705.	335.	843.	582.	4091.
	ANNUAL CYCLE ENERGY SYSTEMS (ACES)	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
4	MIN. ACES, BIN= 19.8 M3 PANEL= 95.1 M2*	4000.	3245.	6192.	830.	335.	1520.	638.	16760.*
5	FULL ACES, BIN= 34.4 M3 PANEL= 32.6 M2	4000.	4142.	2693.	830.	335.	1520.	638.	14158.
	FOSSIL FUEL FIRED SYSTEMS	FURNACE	A/C	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	TOTAL, $
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	775.	1129.	26.	376.	270.	811.	532.	3919.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	720.	1129.	26.	632.	275.	811.	782.	4375.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	1125.	1129.	26.	236.	270.	811.	532.	4129.

SYSTEM COMPARISONS

NO.	NEW CONSTRUCTION ALTERNATIVES	SYSTEM EFFIC. (ACOP)	MAINT. PRESENT WORTH $	1ST YEAR ENERGY COST $	1ST YEAR ENERGY SAVING $	INCREM. FIRST COST $	ENERGY PRESENT WORTH $	LIFE CYCLE COST: AVERAGE $	LIFE CYCLE COST: MARGINAL $
1	EL. FURNACE AND WATER HEATER, CENTRAL AC	1.08	914.	762.62	REF.	REF.	14177.	18491.	43561.
2	HEAT PUMP WITH ELEC. RES. WATER HEATER	1.42	2162.	579.94	182.68	131.	10781.	16474.	35538.
3	HEAT PUMP, DESUPERHEATER WATER HEATER	1.52	2468.	542.22	220.40	691.	10080.	16639.	34463.
4	MIN. ACES, BIN= 19.8 M3 PANEL= 95.1 M2	2.78	2432.	297.29	465.34	13360.	5527.	24719.*	34491.
5	FULL ACES, BIN= 34.4 M3 PANEL= 32.6 M2	2.87	2432.	287.77	474.86	10757.	5350.	21939.*	31399.
6	GAS FURNACE, GAS HOT WATER, CENTRAL AC	2.03	889.	517.79	244.84	519.	15786.	20594.	25405.
7	OIL FURNACE, EL. HOT WATER, CENTRAL AC	1.58	914.	1102.22	-339.60	975.	26504.	31794.	36433.
8	PULSE GAS FURNACE, GAS HW, CENTRAL AC	2.43	960.	430.54	332.09	729.	13023.	18112.	22317.

*UNGLAZED PANEL EXCEEDS A PRACTICAL SIZE, AN ALTERNATIVE SUPPLEMENTARY HEAT SOURCE SHOULD BE USED IN THIS DESIGN.

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