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Performance and Economics of the ACES and Alternative Residential Heating and Air Conditioning Systems in 115 U.S. Cities

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Department of Energy
Office of Buildings and Community Systems

OPERATED BY
UNION CARBIDE CORPORATION
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

ORNL/CON-52

Contract No. W-7405-eng-26

Energy Division

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Date Published: March 1981

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
UNION CARBIDE CORPORATION
for the
DEPARTMENT OF ENERGY

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CONTENTS

Page

LIST OF FIGURES ....

LIST OF TABLES ....

ABSTRACT 1

1. INTRODUCTION 1
   1.1 Purpose of the Study 1
   1.2 Study Method 1

2. ANNUAL CYCLE ENERGY SYSTEM 3
   2.1 ACES Concept 3
   2.2 Energy Conservation Advantages 5
   2.3 Alternative ACES Designs 5
      2.3.1 Ice formation methods 5
      2.3.2 Ambient heat collection 5
      2.3.3 Ice bin storage capacity 6

3. DESCRIPTIONS OF HVAC SYSTEMS 7
   3.1 Reference Single-Family House 7
   3.2 HVAC Systems Configurations 8
      3.2.1 System 1—electric furnace, central air conditioner, and electric resistance water heater 8
      3.2.2 System 2—high-performance air-to-air heat pump with electric resistance water heater 9
      3.2.3 System 3—high-performance air-to-air heat pump with desuperheater water heater 10
      3.2.4 System 4—minimum ACES of the brine-chiller type 11
      3.2.5 System 5—full ACES of the brine-chiller type 11

4. SIZES AND COSTS OF HVAC SYSTEMS 15
   4.1 Cost of System 1 for the Reference House at Knoxville, Tennessee 15
      4.1.1 Equipment costs for system 1 15
      4.1.2 Installation costs for system 1 18
      4.1.3 Total initial costs of system 1 19
      4.1.4 Schedule of annual maintenance costs for system 1 19
   4.2 Cost of System 2 for the Reference House at Knoxville, Tennessee 19
      4.2.1 Equipment costs for system 2 19
      4.2.2 Installation costs for system 2 22
      4.2.3 Total initial cost of system 2 22

4.2.4 Schedule of annual maintenance costs for system 2 22
4.3 Cost of System 3 for the Reference House at Knoxville, Tennessee 23
4.3.1 Equipment costs for system 3 23
4.3.2 Installation costs for system 3 24
4.3.3 Total initial cost of system 3 24
4.3.4 Schedule of annual maintenance costs for system 3 24
4.4 Costs of the Annual Cycle Energy Systems 25
4.4.1 ACES equipment costs 25
4.4.2 ACES installation costs 29
4.4.3 ACES total initial cost 30
4.4.4 ACES annual maintenance cost schedule 30
4.5 Costs of ACES for the Reference House at Knoxville, Tennessee 31
4.5.1 Cost of minimum ACES, system 4 31
4.5.2 Cost of full ACES, system 5 32
5. ECONOMIC ANALYSIS 35
5.1 Life-Cycle Cost Analysis 35
5.1.1 Estimation of annual cash flows 37
5.1.2 Life-cycle cost equation 38
5.2 Payback Analysis 40
5.3 Selection of Economic Parameters 40
6. RESULTS OF SYSTEMS EVALUATIONS 45
6.1 Description of Computer Output Tables 45
6.1.1 Systems design and performance 45
6.1.2 Systems first costs 47
6.1.3 Comparative systems costs 47
6.2 Systems Evaluation Results for the Reference House in Knoxville, Tennessee 47
6.2.1 Annual coefficients of performance 47
6.2.2 Systems first costs 48
6.2.3 First-year power costs 48
6.2.3 Life-cycle costs 48
6.3 National View of the Systems Evaluation Results 50
6.3.1 Regional variations in systems efficiencies 51
6.3.2 Regional variations in systems first costs 51
6.3.3 Regional variations in first-year power costs 62
6.3.4 Regional variations in life-cycle costs 62
7. PERFORMANCE AND ECONOMICS OF OTHER HVAC SYSTEMS 73
7.1 Assumptions of the Analysis 74
7.1.1 Systems performance characteristics 74
7.1.2 Systems costs 75
7.2 Results of the Analysis 76
8. CONCLUSIONS 81
8.1 Present-Day Best Systems 81
8.1.1 Energy conservation 81
8.1.2 Systems economics 81
8.2 Future Best Systems 81

REFERENCES 83
APPENDIX A—EQUIPMENT COST DATA FOR 1979 85
APPENDIX B—1979 POWER COST DATA FOR 115 U.S. CITIES 93
APPENDIX C—AIR-TO-AIR HEAT PUMP SEASONAL PERFORMANCE FACTORS (HEATING) FOR 115 U.S. CITIES 99
APPENDIX D—COMPUTER OUTPUT TABLES OF SYSTEMS EVALUATIONS 105

LIST OF FIGURES

Figure		Page
1	Principal heat flows of the ACES	4
2	Schematic of system 1—electric furnace, central air conditioner, and electric resistance water heater	9
3	Schematic of system 2—high-performance, air-to-air heat pump with electric resistance water heater	10
4	Schematic of system 3—high-performance, air-to-air heat pump with desuperheater water heater	11
5	Schematic of a brine-chiller type of ACES	12
6	Ice bin volume required for a minimum ACES	12
7	Collector panel area required for a minimum ACES	13
8	Ice bin volume required for a full ACES	14
9	Collector panel area required for a full ACES	14
10	ACES ice storage bin and heat exchanger	27
11	ACES collector panel	28
12	Present worth factor vs true rate of return available on an alternative investment opportunity	42
13	Nomogram for determining investor's perception of the time value of money	43
14	Life-cycle cost of HVAC systems at Knoxville, Tennessee	50
15	Annual coefficients of performance map for system 1—electric furnace, central air conditioner, and electric resistance water heater	52
16	Annual coefficients of performance map for system 2—high-performance, air-to-air heat pump with electric resistance water heater	53
17	Annual coefficients of performance map for system 3—high-performance, air-to-air heat pump with desuperheater water heater	54
18	Annual coefficients of performance map for system 4—brine-chiller minimum ACES	55
19	Annual coefficients of performance map for system 5—brine-chiller full ACES	56
20	Total initial costs map of system 1—electric furnace, central air conditioner, and electric resistance water heater	57
21	Total initial costs map of system 2—high-performance, air-to-air heat pump with electric resistance water heater	58
22	Total initial costs map of system 3—high-performance, air-to-air heat pump with desuperheater water heater	59
23	Total initial costs map of system 4—brine-chiller minimum ACES	60
24	Total initial costs map of system 5—brine-chiller full ACES	61

25 First-year power costs for system 1—electric furnace, central air conditioner, and electric resistance water heater 63
26 First-year power costs map for system 2—high-performance, air-to-air heat pump with electric resistance water heater 64
27 First-year power costs map for system 3—high-performance, air-to-air heat pump with desuperheater water heater 65
28 First-year power costs map for system 4—brine-chiller minimum ACES. (Costs are in $.) 66
29 First-year power costs map for system 5—brine-chiller full ACES. (Costs are in $.) 67
30 Life-cycle costs map for system 1—electric furnace, central air conditioner, and electric resistance water heater 68
31 Life-cycle costs map for system 2—high-performance, air-to-air heat pump with electric resistance water heater. 69
32 Life-cycle costs map for system 3—high-performance, air-to-air heat pump with desuperheater water heater 70
33 Life-cycle costs map for system 4—brine-chiller minimum ACES. (Costs are in K$.) 71
34 Life-cycle costs map for system 5—brine-chiller full ACES. (Costs are in K$.) 72
35 Knoxville systems comparisons, 1980 77
36 Knoxville systems comparisons, 1990 78
37 Knoxville solar systems comparisons, 1980 79
38 Knoxville solar systems comparisons, 1990 80

LIST OF TABLES

Table		Page
1	Description of single-family reference house	7
2	Assumed building and occupancy characteristics	8
3	Cost of fan units	16
4	Sears Best series air conditioning systems	16
5	Estimated cost of refrigerant lines	17
6	Estimated cost of electrical services wiring	17
7	Duct system costs as a function of HVAC system capacity	18
8	Installation costs of a split-system air conditioner	18
9	Total installed cost of system 1	19
10	Schedule of annual maintenance costs for system 1	20
11	Sears split-system heat pumps with an indoor coil and housing for use with fan unit and an outdoor coil, compressor, and fan unit	20
12	Components of the heat pump control system	21
13	Costs of refrigerant lines for an air-to-air heat pump	21
14	Total initial cost of system 2	22
15	Schedule of annual maintenance costs for system 2	23
16	Total initial cost of system 3	24
17	Schedule of annual maintenance costs for system 3	25
18	Costs of ACES mechanical packages	26
19	Ice bin on-site construction costs	27
20	Cost of brine lines for ACES	29
21	Costs of ACES electrical services wiring	29
22	Installation costs for ACES mechanical packages	29
23	Estimation of total initial cost of ACES	30
24	Schedule of annual maintenance costs for the ACES	31
25	Costs of 13.5-m^3 ice bin, using integrated construction	32
26	Total installed cost of minimum ACES for the reference house at Knoxville, Tennessee	33
27	Cost of 76.5-m^3 ice bin, using integrated construction	33
28	Total installed cost of full ACES for the reference house at Knoxville, Tennessee	34
29	Economic assumptions and parameters used in the study	41
30	Sample computer output listing for systems evaluation	46
31	Life-cycle costs of HVAC systems located in Knoxville, Tennessee	48
32	Levelized annual maintenance costs of the HVAC systems	49
33	Engineering performance characteristics and costs of HVAC systems in 1980	75

34 Engineering performance characteristics and costs of HVAC systems in 1990..... 76
B.1 1979 Power cost data for 115 U.S. cities 95
C.1 Air-to-air heat pump seasonal performance factors (heating) for 115 U.S. cities 101

ABSTRACT

The efficiency and life-cycle costs of the ACES are compared with those of three conventional electric HVAC systems in 115 cities in the United States. The three conventional systems are (1) an electric furnace with a central air conditioner and an electric resistance water heater, (2) a high-performance air-to-air heat pump with an electric resistance water heater, and (3) a high-performance air-to-air heat pump with a desuperheater unit for producing domestic hot water. Based on average weather conditions for each locality, monthly requirements for space heating, water heating, and space cooling for a reference single-family house are calculated. The initial cost and annual energy consumption of the ACES and conventional systems, designed to deliver identical energy services to the reference house, are computed and compared. (Power and equipment costs for the year 1979 are used.) Results of the study show that, over most of the United States, the ACES consumes one-third to one-half of the electrical energy required by conventional HVAC systems and delivers the same annual loads at comparable life-cycle costs.

1. INTRODUCTION

1.1 Purpose of the Study

The purpose of this study is the evaluation and comparison of the performance and economics of five different systems to supply space heating, air conditioning, and water heating to a typical single-family residence located at different geographical sites throughout the United States. The heating, ventilating, and air conditioning (HVAC) systems that are evaluated in this study are the (1) electric furnace, electric air conditioning, and resistance water heating; (2) high-performance air-to-air heat pump with electric resistance water heating; (3) high-performance air-to-air heat pump with desuperheater water heating; (4) minimum annual cycle energy system (ACES) of the brine-chiller type; and (5) full ACES of the brine-chiller type. The brine-chiller type ACES freezes ice on a submerged brine-to-water heat exchanger. The first two systems are currently in widespread use; the third system is presently available but is not yet widely used; and the two ACES could be assembled today, but packaged components for the systems are not yet commercially available.

This study has concentrated on electrically driven systems. Recently, electric HVAC systems have become the preferred choice of alternatives for residences and are now used in more than 10% of all homes.[1] In some regions of the country, electrically driven HVAC plants account for 80% of the home heating and cooling systems in existing residences. For the country as a whole today, the market share of electric heating and cooling systems for newly constructed homes exceeds 50%. In addition to the five systems studied across the United States, 19 additional systems were evaluated in one city, Knoxville, Tennessee, to determine their current competitiveness and the probable situation in 1990. The expanded study also encompasses natural-gas-fired alternatives.

1.2 Study Method

The demands of a particular building for space heating, space cooling, and water heating depend on the prevailing weather conditions at the building site, the type of building construction, and the life-style of the building's occupants. For the purposes of this study, we have specified a typical single-family residence and family life-style in 115 different cities so that the monthly thermal demands of the building can be calculated for average-year weather conditions. The peak hourly and monthly thermal demands of the building are calculated for each reference house of 115 cities located throughout the United States and are used to size each of the five HVAC systems considered in this study. The initial cost and annual performance of each system are then calculated so that the present-value life-cycle costs of each system, delivering identical services to the building, can be obtained and compared.

Incorporated into the computer program MAD are analytical methods for calculating the thermal demands of the building and for determining the annual performance of each HVAC system, as reported elsewhere.[2] This computer program was developed for modeling the monthly power consumption and the delivered load of an ACES, conventional and state-of-the-art heat pump installations, and an electric resistance heating system with air conditioning—all of which were tested at the experimental facility in Knoxville over a three-year period. Thus, the methods used in the program have been tested against measured power consumptions and delivered loads for each of the above systems. The results have provided a good validation of the model for simulating system performances under Knoxville weather conditions. The program has since been extended to estimate the size, cost, and performance of each of the five HVAC systems of this study, using any given weather data base.

It is assumed in all cases that the systems are optimally installed in accordance with good engineering practices. Air ducts are located in conditioned spaces of the building and, for the ACES, provision is made for venting heat losses from the mechanical package to the outdoors during the summer. The electric furnace heating system and the ACES are sized to deliver the design-day peak hourly heating load of the building for the given locality; the air conditioner and heat pump systems are sized to deliver the design-day hourly cooling load. The cost data base of the HVAC systems is obtained from the summer 1979 Sears and Roebuck catalog, as are the technical performance specifications of systems components. Where ranges of equipment quality and prices are offered, high-performance components are selected. For the advanced heat pump with a desuperheater for water heating, which is not offered in the Sears catalog, it is assumed that the heat pump listed in the catalog can be modified by adding a desuperheater package obtained from an alternative commercial source.

The heat pump selected for this study is rated by Air-Conditioning and Refrigeration Institute (ARI) methods as delivering a steady-state heating coefficient of performance (COP) of 2.75 at +8.3°C and 1.8 at −8.3°C. The cooling mode COP is equal to 2.63, which corresponds to an energy efficiency ratio (EER) rating of 9.0. These ratings are typical of the high-performance heat pumps available today from various manufacturers. The volume of the hot water storage tank is selected to be 0.20 m^3 (52 gal) and 0.30 m^3 (82 gal) for the resistance water heating and heat pump water heating systems respectively. As before, the costs of the hot water storage tanks are obtained from the Sears catalog. Standard engineering methods are used to estimate installation costs and the costs of unconventional components of the ACES, such as the ice storage bin and solar panel. These estimation methods, together with construction cost data, are obtained from the literature.[3]

The method used to quantify the relative engineering performance of each system is the annual coefficient of performance (ACOP). The ACOP is defined as the energy delivered by a system divided by the energy purchased to deliver the energy demands for a complete annual cycle. The energy demands include space heating, space cooling, and water heating. The larger the numerical value of an ACOP, the more efficient the system.

2. ANNUAL CYCLE ENERGY SYSTEM

The ACES is the most energy conserving of all electrically driven HVAC systems known today and is applicable throughout most of the United States. Although some components of the system are not yet commercially available, they resemble equipment used in similar fields, such as heat pump applications, controls, and solar collection installations; therefore, reasonably accurate estimates can be made of their costs. The primary system component, the ice storage bin, can be costed using standard estimating techniques for building construction. For these reasons, even though the ACES is not widely deployed now, it is possible to derive good estimates of the probable mature cost of the system. Advanced ACES designs can achieve a significant cost reduction by eliminating the need for a solar panel, but these designs are not treated in this report.

The ACES concept has been fully demonstrated at a test facility near Knoxville, Tennessee, and the excellent results of the test runs of the system have been reported.[4-6] The test run showed that the ACES consumed 6447 kWh and supplied an annual building load of 71.4 GJ, as compared with annual consumption of 11,358 kWh by a state-of-the-art, air-to-air heat pump system with resistance water heating that supplied the same loads. The ACES demonstrated a test year ACOP of 3.08. The spectacular energy savings of the ACES result primarily from its energy storage capability, which makes it possible to utilize both the hot and cold outputs of the ACES mechanical package. Because the ACES is not yet widely used and its principles are unfamiliar to most people, this chapter presents a brief description of the system concept. For more detailed information, the reader should consult other sources in the literature.[7]

2.1 ACES Concept

In the ACES, energy transfer is by an electrically driven unidirectional heat pump, which obtains its heat from water stored in an insulated underground tank. As the heat is extracted during the heating season, most of the water is frozen, and the stored ice provides air conditioning in the summer. Thus, the heat of the fusion of water is available as a heat source in winter and a heat sink in summer. Both the heating and cooling outputs of the heat pump are used; therefore, the resulting ACOP is high.

The basic concept of the ACES can best be understood by considering the monthly heat flows into and out of the ice storage bin. The principal heat flows, shown in Fig. 1, are denoted by the following nomenclature.

Q_H = space heating load of the building
Q_C = space cooling load of the building
Q_{HW} = heat load for production of domestic hot water
Q_L = heat leakage into the ice storage bin from the earth
Q_{COL} = heat collection by the solar collector panel
Q_{WD} = heat withdrawal from the ice storage bin
Q_{DP} = heat deposited in the ice storage bin

During the annual cycle, the energy level of the bin varies continuously in response to the heating and cooling demands of the building. Each year the ice inventory in the bin grows from zero to maximum and then declines to zero. During the heating season, monthly withdrawals of heat from the ice bin are made by the heat pump to supply water heating and space heating to the building. As the sensible energy of the bin is extracted, the bin temperature declines from 7 to 0°C. Further energy withdrawals then result in the formation of ice. Heat leakage into the bin from the surroundings and heat from the collector panel partially replenish the bin energy, but continual heat withdrawals eventually

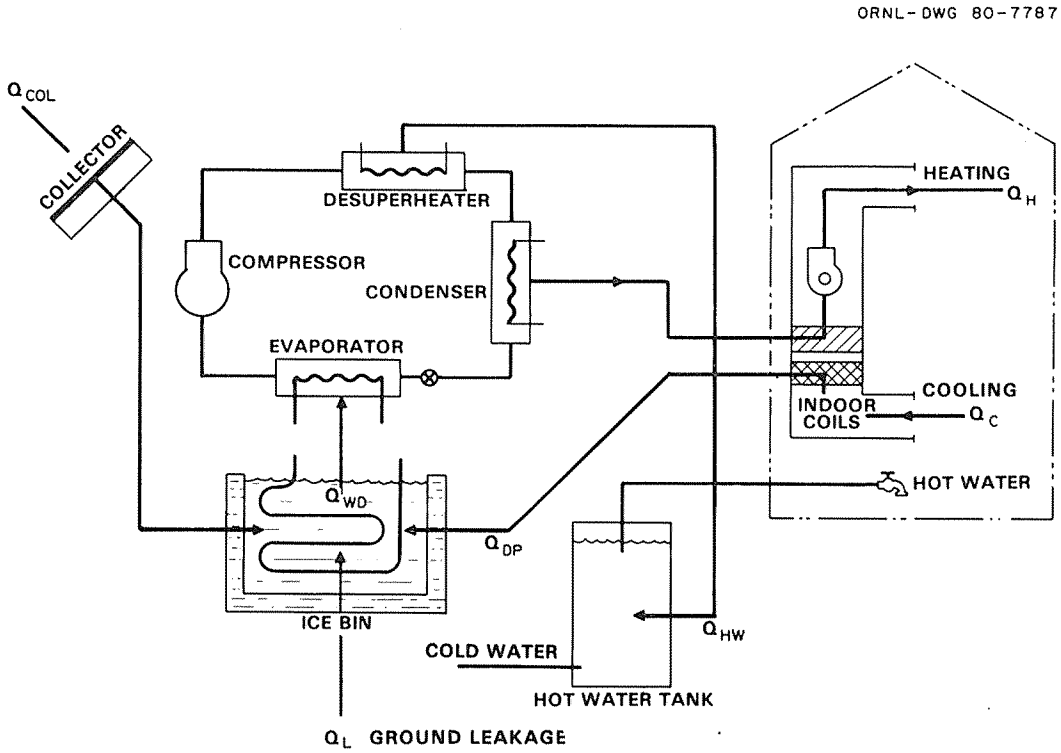

Fig. 1. Principal heat flows of the ACES.

cause the ice inventory to reach the bin storage capacity. Heat deliveries to the bin from the collector panel are controlled to cause the bin to attain full ice inventory at the end of the heating season. Collection panel operation is modulated during the late portion of the heating season to control the ice inventory.

At the beginning of the cooling season, the full inventory of winter-formed ice is available to provide air conditioning to the house. As the cooling season progresses, heat is extracted from the house by circulating chilled brine from the ice bin heat exchanger through use of an indoor fan coil. The house heat collected is delivered back to the ice bin. These energy deposits gradually melt out all of the ice in the bin and raise the bin temperature to 7°C, the maximum useful level for air conditioning purposes. If this bin temperature condition is reached at the end of the cooling season, the system is ready to begin a new annual cycle. However, if the winter-formed ice is depleted before the end of the cooling season, supplemental cooling will be needed to meet further air conditioning demands of the house.

Supplemental cooling is provided by operating the heat pump at night during the summer to remove heat from the storage bin. This heat removal causes the bin temperature to drop to a level that can be used to provide air conditioning during the following day. The heat extracted from the bin, together with the energy consumed by the heat pump, is rejected as waste heat to the outdoor environment. Supplemental cooling increases the electrical energy consumption of ACES by requiring summer heat pump operation and also imposes the need for a waste heat rejector. The rejector can be either an outdoor fan coil or, if properly sized, the same unglazed collector panel used for heat collection during the winter. This cooling mode operation provides the ACES with load management capability because the maximum electrical draw of the system occurs at off-peak hours.

2.2 Energy Conservation Advantages

The principal energy conservation advantages of the ACES are as follows:

1. During the heating season, the heat pump operates from a constant temperature heat source (the ice storage bin) and functions as a constant capacity heat pump. As a consequence, the heat pump does not suffer performance degradation at low outdoor temperatures.

2. During the cooling season, all, or a portion of the air conditioning needs of the building are supplied by winter-formed ice. The use of this ice, formed as a by-product during the heating season, results in a very high COP for summer air conditioning operations.

3. Supplemental summer cooling, required after the winter-formed ice has been depleted, can be supplied by off-peak operation of the compressor. This capability shifts the power demand of the system to low-load hours when electricity rates may be lower and when base-load utility plants of higher generation efficiency are used. In addition, the efficiency of the ACES heat pump is greater during the cool of the night than during the heat of the day.

4. Production of hot water by heat pump operation throughout the entire annual cycle is two to three times more efficient than production by resistance heating. During the summer, water heating also produces ice that may be used for air conditioning purposes.

2.3 Alternative ACES Designs

2.3.1 Ice Formation Methods

The ACES may employ either of two ice formation methods: (1) a water-to-brine heat exchanger submerged in the ice storage bin to freeze the water, or (2) a plate-type ice maker that freezes the water directly on the evaporator plates and periodically harvests the ice into the bin. The brine-chiller and the ice-maker types of ACES each offer certain advantages. The brine-chiller ACES (because of a higher ice packing density in the storage bin) uses bin volumes of approximately half the size necessary for an ice-maker ACES. The brine-chiller ACES also has simpler refrigeration circuitry, a lower refrigerant inventory, and provides a nonfreezing energy transfer fluid (the brine) for transporting heat into the storage bin from supplemental sources such as a solar collector panel. The ice-maker ACES eliminates the ice bin heat exchanger and its attendant costs and need for field crew installation and makes modularization of the system easier at the factory.

2.3.2 Ambient Heat Collection

Operation of the ACES to supply annual space and water heating needs will seldom, if ever, result in the production of the exact amount of ice needed for summer air conditioning. Even in the most favorable climates, where the average annual heating and cooling demands of the building result in an exact ice bin heat balance, variations in year-to-year weather, living patterns, and other factors will upset this balance. Consequently, the amount of ice produced will not be equal to the amount of ice needed for all years. To obtain an ice bin heat balance, the ACES must be designed with provisions both for melting excess ice and for supplying supplemental air conditioning when there is an ice deficit. These functions can be accomplished by collecting ambient heat from the environment during the heating season to melt surplus ice and by operating the heat pump at night during the cooling season to provide chilled water or ice for supplemental air conditioning.

The ACES may employ any of several methods for collecting ambient heat: (1) an unglazed, flat-plate solar/convector panel to collect solar energy and convective heat from the outside air; (2) a ground

heat exchanger to collect heat from the earth; or (3) an air coil used directly or indirectly through off-duty use of the heat pump in winter to collect heat from the ambient air for delivery to the ice storage bin. Each of these methods offers certain advantages, but only the first has been tested in a demonstration ACES. The solar collector panel is highly efficient because it collects both radiant and convective heat at relatively low temperatures—0° C and above. The ground source heat exchanger offers the advantage of a nearly constant temperature heat source that is free from fluctuations in winter weather conditions. Using the ACES heat pump to supply energy to the ice bin is attractive because it utilizes existing system equipment and it eliminates the need for costly collector panels or underground heat exchangers.

2.3.3 Ice Bin Storage Capacity

The ACES transfers energy between the seasons of the year by storing the heat that is removed from the house to provide summer air conditioning and then delivering the stored heat back to the house in the winter to provide space heating or water heating. The summer heat melts ice that is contained in the storage bin, and the water is refrozen in the winter as the heat pump extracts energy from the bin to meet the heating needs of the house. To achieve full interseasonal energy transfer, the ice storage bin must have the capacity to store all of the ice that can be produced during the heating season or all of the ice needed for summer air conditioning, whichever is smaller. A system with a bin of this size is defined as a *full* ACES.

Systems can be designed to have smaller bins than those of a full ACES. If this is done, the amount of ambient heat that must be collected from the environment to melt surplus ice, as well as the amount of supplemental cooling that must be provided, become greater. For practical reasons, the smallest bin that should be considered for an ACES should have a thermal capacity sufficient to allow at least two weeks of heat pump operation during the coldest month of the year without resort to ambient heat collection. A system with a bin of this size is defined as a *minimum* ACES. A two-week thermal capacity is thought to provide a sufficient integration period to allow averaging of cold weather and milder periods that allow energy collection. Abnormally cold weather occurs in three- or four-day cycles. The minimum ACES is a compromise to reduce the capital costs of the system, but its energy conservation potential is also reduced.

3. DESCRIPTIONS OF HVAC SYSTEMS

The five HVAC systems of this study are evaluated on a common basis by computation of their engineering performance and economics as they supply space heating, space cooling, and water heating to a typical modern home located in different cities of the United States. The amount of energy required by each system to maintain comfortable conditions in the house depends on the climate, type of building construction, and heat gains from internal sources. These heat gains arise from cooking, refrigeration, and the use of appliances such as television, stereos, and lighting. The heat emitted by these sources is dissipated within the thermal envelope of the house and reduces demands for space heating in winter and increases demands for space cooling in summer.

It is assumed in this study that the rate at which heat is supplied to the house by internal sources exclusive of the HVAC system is equal to 1040 W. The remainder of the electrical consumption of the home is by the space heating, space cooling, and water heating system to provide needed services, and it is this portion of the consumer's electricity bill that is analyzed in this report. For this purpose, the monthly thermal demands of a single-family residence are simulated for 115 cities of the country, and the energy requirements of each of five HVAC systems for supplying these calculated house thermal demands are estimated.

3.1 Reference Single-Family House

The house specified is a 167-m^2, single-family frame structure consisting of three bedrooms, two baths, a great room, a kitchen, a mechanical equipment room, and a crawl-space basement. The house is well insulated and has a thermal envelope of the type now commonly being built. The windows and glass doors are provided with double-pane insulated glass. Ceiling insulation that has a thermal resistance of 3.35 $m^2 \cdot °C/W$ is used over half of the roof area, and the other half uses insulation of 6.70 $m^2 \cdot °C/W$ thermal resistance. The side walls and floor are also insulated to a nominal thermal resistance of 3.35 $m^2 \cdot °C/W$. The exterior of the house is of painted wood, and the roof is of conventional brown asphalt shingles. The consumption rate of domestic hot water is defined to be 0.265 m^3/d (70 gpd), corresponding to that of a typical family of two adults and two children. House internal temperatures are maintained at 21°C during the heating season and 25.5°C during the cooling season. Natural ventilation is not used to satisfy any portion of the space cooling demand. Tables 1 and 2 give the major assumptions affecting the building's thermal loads estimation.

Table 1. Description of single-family reference house

Foundation (10.36 × 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), $m^2 \cdot °C/W$	3.35
Half ceiling area (nominal thermal resistance), $m^2 \cdot °C/W$	3.35
Half ceiling area (nominal thermal resistance), $m^2 \cdot °C/W$	6.70
Walls (nominal thermal resistance), $m^2 \cdot °C/W$	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 normalization,[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, kg (water)/d	2.27
Maximum indoor relative humidity, %	52

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

3.2 HVAC Systems Configurations

The space conditioning and water heating systems analyzed in this report are (1) electric heating with central air conditioning and electric resistance water heating, (2) air-to-air heat pump with electric resistance water heating, (3) air-to-air heat pump with desuperheater water heating, (4) minimum ACES of brine-chiller design, and (5) full ACES of brine-chiller design. Each system is described and a simplified schematic is given. The sizing methods used in this study will be discussed.

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

The all-electric home is rapidly becoming the most common type of residence because it offers low first cost and convenient, trouble-free operation. Space heating is provided by resistance elements that deliver heat to distribution ducts, which also accommodate central air conditioning. This type of home usually employs electric resistance water heating. The physical equipment for this HVAC system is comprised of an electric furnace with an indoor fan and an air conditioner with an indoor coil. The air conditioner is a conventional refrigeration system that rejects heat from the house to the outdoor air. In this report, the cooling performance of the air conditioner is assumed to be that of a high-performance, commercially available model.

The air distribution ducts are located within the thermal envelope of the house and are sized to deliver either the design-day heating or cooling load, whichever is limiting. The electric heating unit is sized to provide the design hourly heat load, and the air conditioner is sized to deliver the design hourly cooling load. Figure 2 depicts this conventional electric heating and cooling system. Baseboard electric heating is not evaluated in this study because such a system would not have central air conditioning and therefore would not be comparable. Because we wish to evaluate the systems with respect to identical services delivered, only central heating and cooling systems are considered in this study. Although

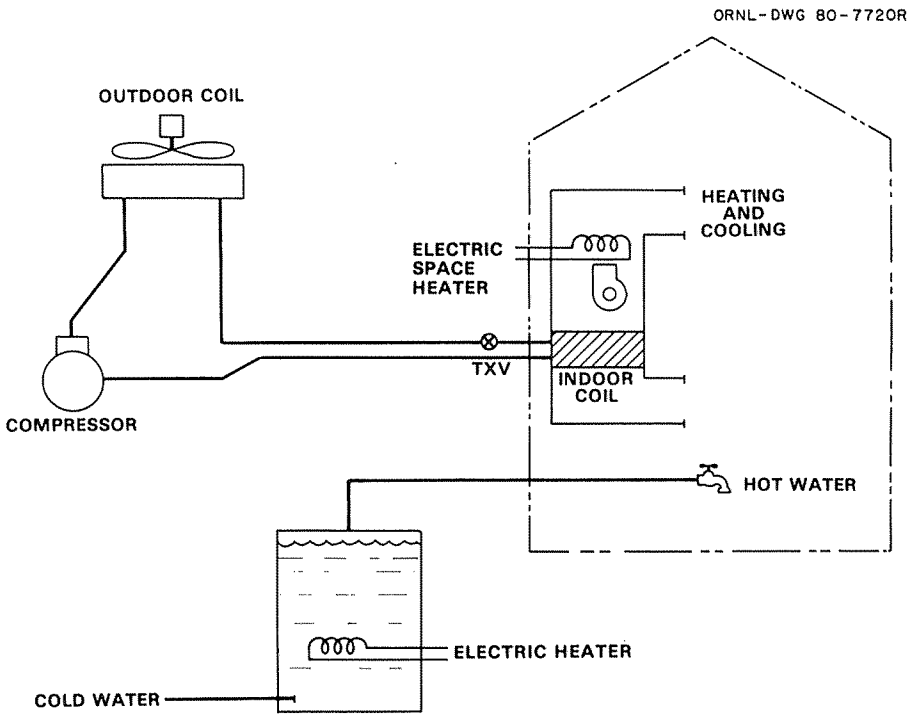

Fig. 2. Schematic of system 1—electric furnace, central air conditioner, and electric resistance water heater.

baseboard heaters could be used in combination with window air conditioners, such a system generally would not be capable of delivering the same heating and cooling loads as a central system.

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

Today, the fastest growing segment of the residential HVAC system market is the air-to-air heat pump. The desire of homeowners to have central air conditioning has led to a significant portion of the newly constructed houses being provided with heat pumps rather than fossil-fuel-fired systems. Basically, the air-to-air heat pump is a reversible air conditioner. The operating principles of the heat pump will not be discussed here, but detailed descriptions of the concept can be found in the literature. The characteristics of the heat pump selected for this study are typical of high-performance, single-speed heat pumps currently available from commercial sources.

Heat pumps are rated by standardized methods developed by the ARI. The heat pump selected for this study has an ARI steady-state heating COP equal to 1.8 at −8.3°C and 2.75 at +8.3°C. A heat pump performance model has been used in this study to estimate the average seasonal performance factor (SPF) of the unit over each season. The annual COP of the heat pump depends on the climate of the location where it is employed and allows for degradations in performance caused by cycling, frosting, and auxiliary resistance heating. Validation of the heat pump performance model has been obtained by comparing the simulated results with the actual results observed at two heat pump test facilities located at Knoxville, Tennessee. The accuracy of the simulation model has been confirmed by experimental data from these and other test facilities. Figure 3 is a simplified schematic of the heat pump system and its major functional components. At the present time, electric resistance water heaters are employed in most homes that are equipped with heat pump systems.

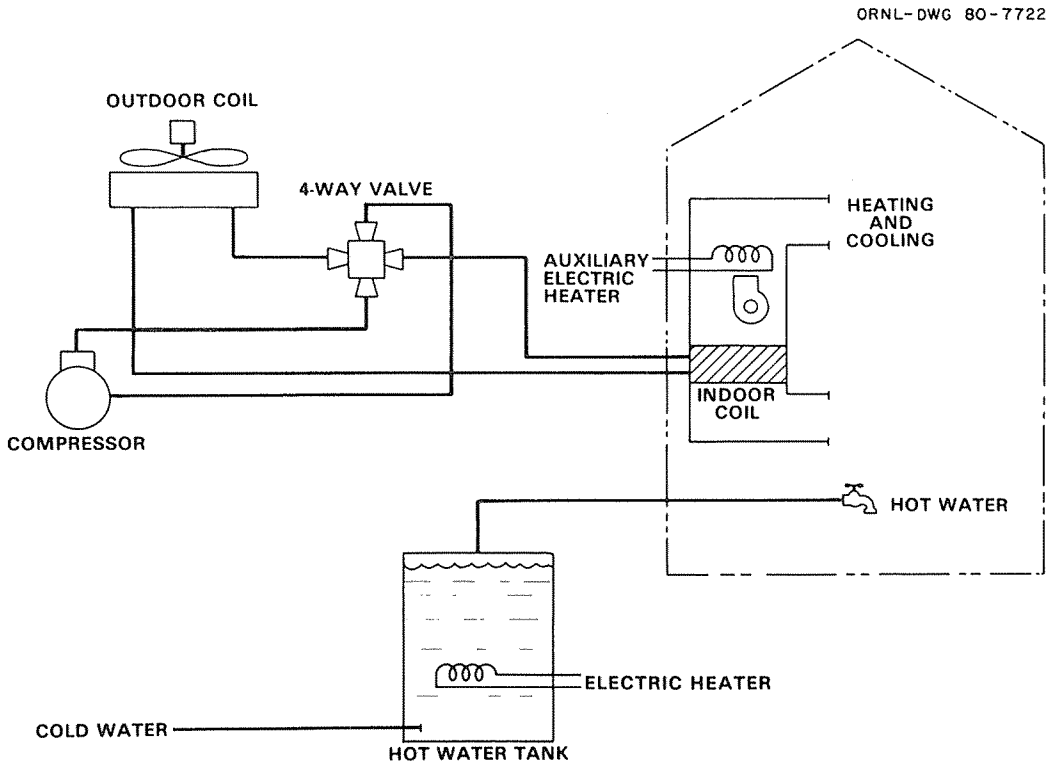

Fig. 3. Schematic of system 2—high-performance, air-to-air heat pump with electric resistance water heater.

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

Domestic hot water, at temperatures between 48 and 60°C, can be produced by use of the high-temperature energy in the refrigerant circuit of the heat pump. An analysis of the refrigerant cycle of a modern heat pump shows that between 11 and 18% of the total pumped energy is available for this purpose. In this study, we have assumed that 15% of the pumped energy can be used for producing domestic hot water. During the heating season, this energy can be extracted for water heating at the same SPF that applies for space heating. During the cooling season the heat pump is rejecting energy outdoors. This energy is available if it is delivered to the hot water storage tank. The domestic hot water production system requires a water pump to circulate water between the desuperheater and the storage tank. Electric power consumption by this component amounts to about 5% of the heat energy delivered to the storage tank; that is, the COP of the hot water delivery system is equal to about 20.

In Fig. 4, we see the arrangement of the primary components of this HVAC and water heating system. The heat pump performance characteristics are the same as described in Sect. 3.2.3. The hot water tank for the desuperheater system must be larger than tanks conventionally selected because the temperature recovery time is longer for this system than for electric resistance water heating systems. The larger tank is necessary to ensure that hot water will be available when needed. Heat pumps with desuperheaters are becoming available today, and it is hoped that, eventually, every major heat pump manufacturer will offer such units. Retrofitting heat pumps with desuperheaters requires cutting into the refrigerant system to install the heat exchanger. No major manufacturers are presently offering this accessory, and many are voiding the warranty of their heat pumps if they are retrofitted with another manufacturer's desuperheater.

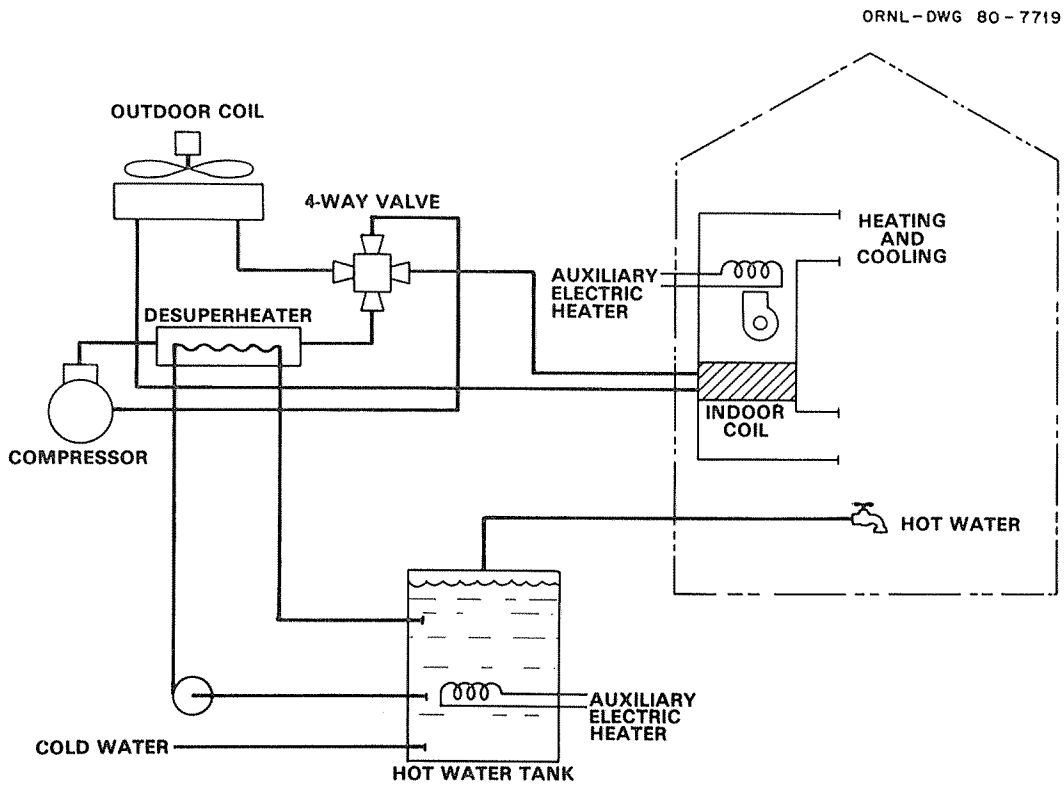

Fig. 4. Schematic of system 3—high-performance, air-to-air heat pump with desuperheater water heater.

3.2.4 System 4—Minimum ACES of the Brine-Chiller Type

The ACES mechanical package consists of a compressor, a hot water desuperheater, a hot water condenser, an evaporator, an accumulator, and a control logic package. An air coil heat rejector or a convector panel heat rejector is used during summer supplemental cooling operations.

The configuration of the minimum ACES is shown in Fig. 5; the three pumps shown clustered around the storage bin are actually a single pump providing multiple services through the cold-brine circuits. The minimum ACES has a bin capacity sufficient to supply only the heat needed for two weeks of house thermal demands during the peak heating season. The solar collector panel is selected to supply the bin with the energy shortfall occurring over the heating season. In the minimum ACES, the size of the ice storage bin has been made small to reduce capital costs, even though such a system exhibits a lower ACOP than would a full ACES (see Sect. 2.3.3). For the single-family residence specified in this study, Fig. 6 shows the storage bin sizes for the minimum ACES, and Fig. 7 shows the required area of unglazed solar collector panel that must accompany the given bin volume. It is noted that the size of an unglazed solar collector panel may, in some northern areas of the country, exceed a size practical to employ on the house. Alternative supplement heat collectors must then be provided.

3.2.5 System 5—Full ACES of the Brine-Chiller Type

The full brine-chiller ACES achieves maximum energy conservation at a given location by interseasonally transferring all of the cooling that can be utilized in an average year. The use of winter ice to provide summer cooling requires an ice bin volume that generally is larger than that of a minimum

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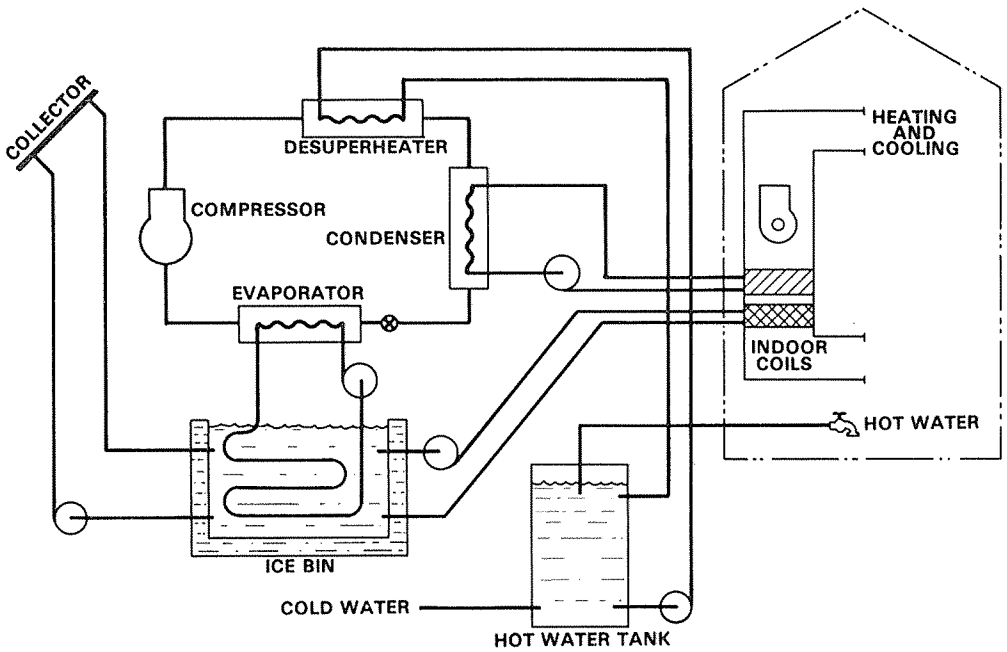

Fig. 5. Schematic of a brine-chiller type of ACES.

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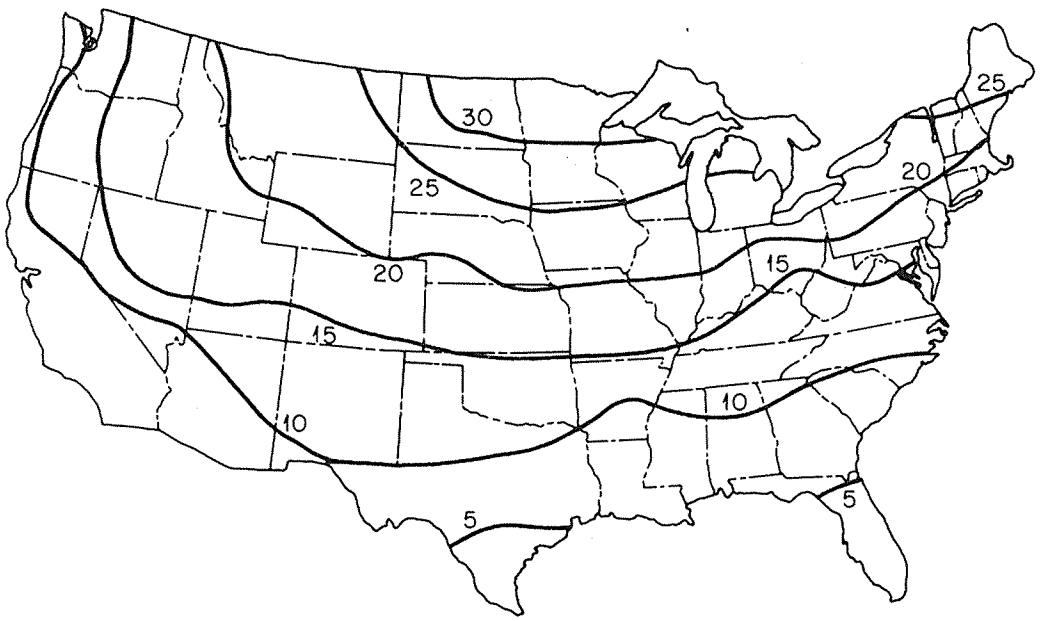

Fig. 6. Ice bin volume required for a minimum ACES (m^3).

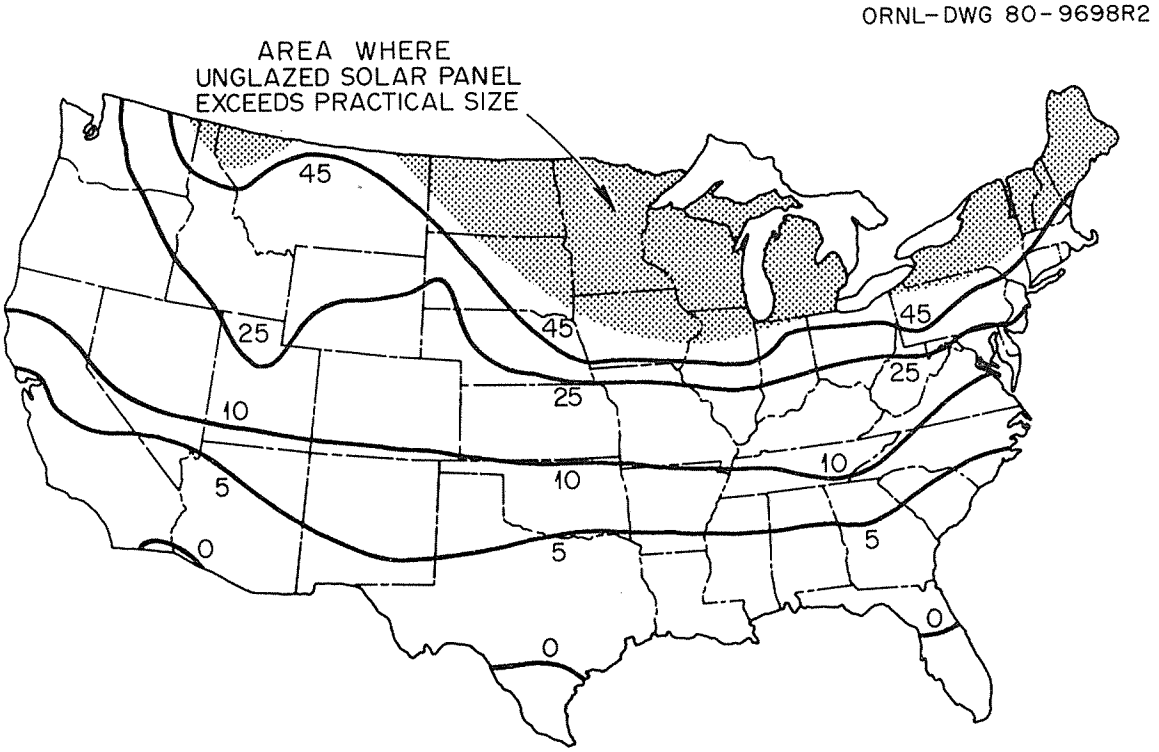

Fig. 7. Collector panel area required for a minimum ACES (m^2).

ACES. Otherwise, the configuration of a full ACES design is identical to that shown in Fig. 5 for a minimum ACES. For the single-family residence specified in this study, the required sizes of storage bins for a full ACES located in different regions of the country are shown in Fig. 8. The areas of unglazed solar collector panel that must accompany the full ACES ice storage bins are depicted in Fig. 9. From the figures, it is seen that the full ACES bin volumes are generally much larger than those of a minimum ACES. In addition, it is seen that the full ACES does not require a collection panel in many areas of the southern United States. Thus, we see that the ACES design is highly specific to building type, climate, and life-style. All ACES designs are based on average weather year predictions. Each system is capable of accommodating weather that is not average.

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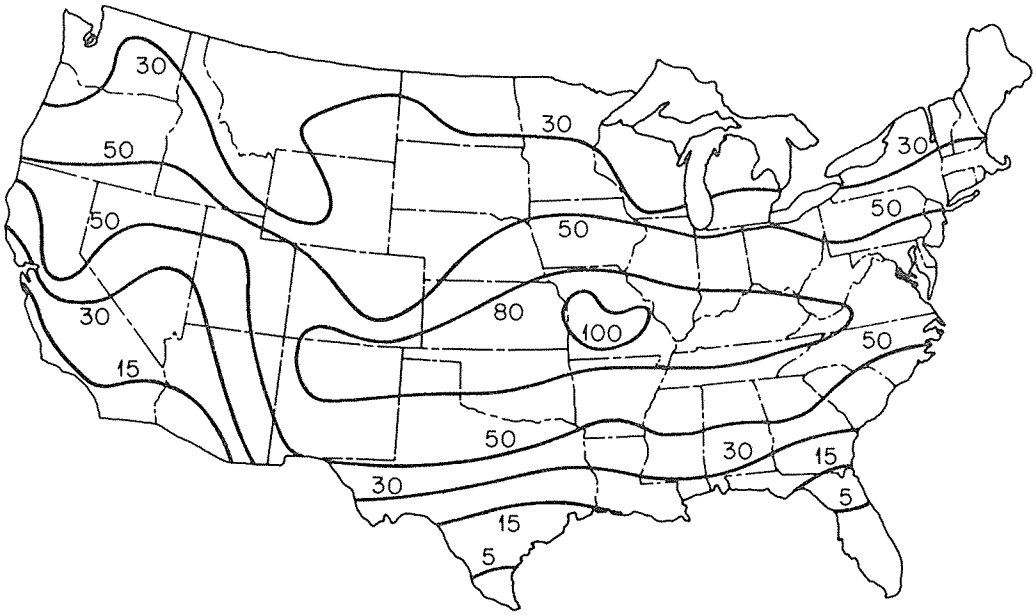

Fig. 8. Ice bin volume required for a full ACES (m^3).

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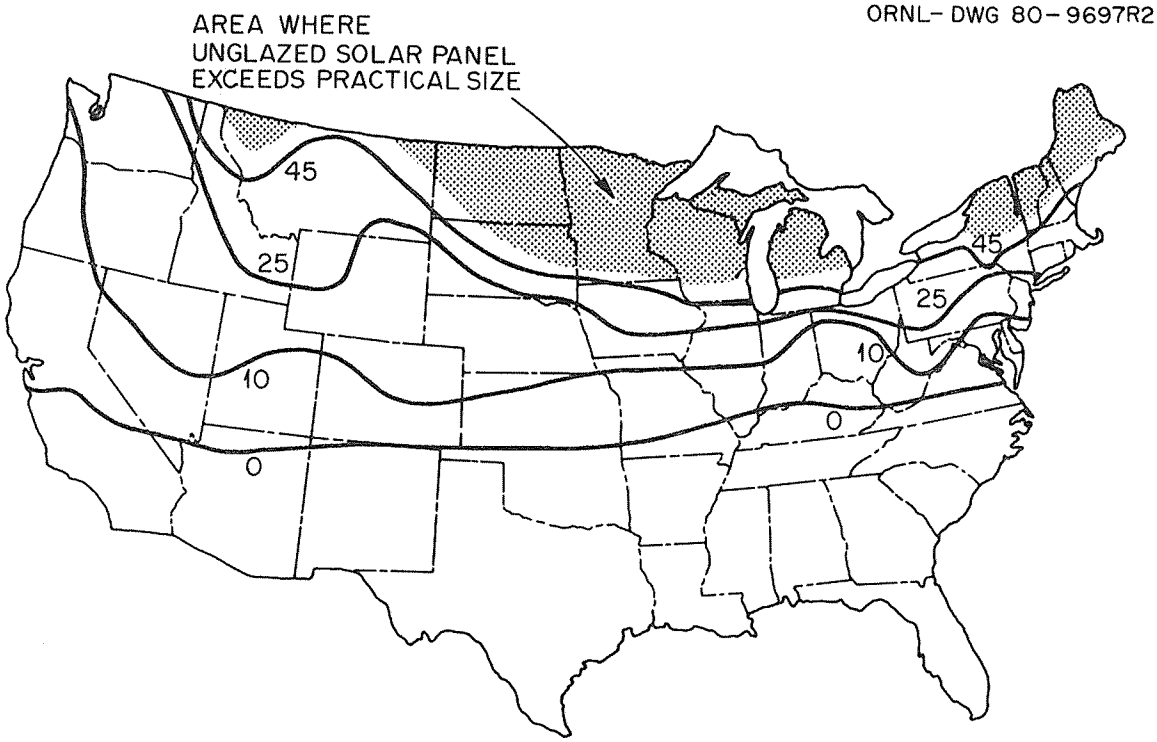

Fig. 9. Collector panel area required for a full ACES (m^2).

4. SIZES AND COSTS OF HVAC SYSTEMS

It is necessary to cost each of the alternative HVAC systems in this study to evaluate the relative economics. In effect, this means that component sizes, purchase prices, and installation costs must be determined for 575 (5 × 115) separate systems. Regional differences in equipment costs are minimized by using the Sears, Roebuck and Co. summer 1979 catalog as the primary source of equipment availability and cost information for conventional equipment. For the ACES, mature systems costs are derived from information obtained from manufacturers of equipment known to be similar to the components of the ACES.

The ACES costs are based on data obtained from equipment manufacturers and on standard construction estimating practices for both labor and materials. The anticipated costs of ACES components, which are not yet commercially available (such as the heat pump mechanical package), are based on industry estimates; refrigeration manufacturers were consulted about the mechanical package and swimming pool manufacturers were consulted about the ice storage bin. In every case, the costs presented are considered to be realistic and are predicated upon the existence of a mature industry. The components of the ACES also include many presently available components, such as compressors, heat exchangers, pumps, insulation materials, concrete, convector panels, plastic tubing, and others. The costs of these components and materials are obtained directly from the Sears catalog and other sources.

The ACES does not require any completely new types of equipment, but the system will be engineered and assembled from existing equipment. This report assumes that the ice storage bin will be constructed on site and that it will be located underground and insulated on all surfaces to a thermal resistance of 7.04 $m^2 \cdot °C/W$ (R-40). Details of the ACES design and sizing procedures, which are too complex to be described fully in this report, should be obtained from ref. 7.

The cost of each HVAC system for each reference house of the study depends on the thermal requirements of the building, as affected by the climate of the city where it is located. In this study, the selection of equipment for each system is performed by algorithms contained in the computer program. The computer program estimates the peak hourly and the average monthly thermal demands of the building, sizes each system to meet these demands, and, using tabulated cost data, estimates the total installed cost of the system. The sizing and costing algorithms employed in the computer program are given in the following sections; also developed and presented are the complete costs of the five HVAC systems for the reference house located in Knoxville, Tennessee. (The peak design hourly loads of the reference house at this location are 9529 W for heating and 6783 W for cooling.)

4.1 Cost of System 1 for the Reference House at Knoxville, Tennessee

4.1.1 Equipment Costs for System 1

This HVAC system is comprised of a fan unit, air conditioner, hot water tank, air distribution system, controls, and auxiliary equipment. The initial installed cost of the system includes all expenditures for components, materials, and installation. 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 both materials and labor. The costs of the components of this system are estimated in the following manner.

Fan Unit. The fan unit contains the electrical resistance heating elements as well as the indoor fan, control relays, and filter assemblies. These units are sold as a separate item by Sears (see Table 3), for use

with heating-only systems, heating and air conditioning systems, or with heat pump systems. There are no cost differentials for use with any of the above systems. For the reference house located in Knoxville, the capacity of the smallest fan unit available, 10,334 W, exceeds the building's design hourly heating load of 9529 W. Therefore, this unit is selected for the system.

Table 3. Costs of fan units

Heating capacity (W)	Cost ($)
10,334	250
15,416	280
20,445	310
24,688	350
28,363	380
33,970	410

Air Conditioner. The air conditioner, which supplies all of the cooling demands of the house, is comprised of an indoor air coil and an outdoor unit. The refrigerant lines and controls that must be provided for the air conditioner are discussed in Sect. 4.2.1. The size of the air conditioner selected is based on the design-day cooling load of the house. Table 4 shows the air conditioner units available from the Sears catalog.

Table 4. Sears Best series air conditioning systems

Cooling capacity (W)	Power draw (W)	EER DOE (35°C)	EER DOE (28°C)	Unit cost ($)
6,741	2,450	9.4	10.2	930
7,913	2,950	9.2	10.0	970
9,818	3,550	9.4	10.3	1050
12,016	5,100	8.0	8.7	1080
13,482	5,800	7.9	8.6	1130
15,533	7,000	7.6	8.3	1170

In Knoxville, the reference house requires a cooling system capable of delivering at least 6783 W of cooling. The smallest air conditioner unit listed that is capable of doing this is the 7913-W cooling capacity unit at a cost of $970.

Controls. The basic control system for the electric resistance heating system with an air conditioner is a heating and cooling thermostat. This thermostat is used with all capacity systems and is listed in the catalog at a cost of $40. The control system wiring is included with other electrical costs, to be described later.

Auxiliaries. The auxiliary equipment includes the refrigerant tubes 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. Even though refrigerant lines are available in several sizes and lengths, for costing

purposes we have selected one average length. Table 5 shows the cost of providing refrigerant lines, as assumed in this study.

Table 5. Estimated cost of refrigerant lines

Cooling capacity (W)	Length of lines (m)	Cost of lines ($)
5,155 to 11,723	13	101
11,723 to 16,412	15	119

Table 6 presents data obtained from the Sears catalog for the costs of the wiring and the associated hardware required to supply electrical services to the system. It is assumed that, on the average, 15 m of wiring is needed for running lines from the main switch box to the powered components of the system. From the data presented in Tables 5 and 6, it is estimated that the electric resistance heating and electric air conditioning system for the reference house in Knoxville will require $59 worth of electrical wiring and $101 of refrigerant tubing. Thus, the cost of system auxiliaries amounts to $160.

Table 6. Estimated cost of electrical services wiring

Heating capacity (W)	Electrical system cost ($)
10,334	59
15,416	72
20,445	112
24,688	180
28,363	180
33,970	180

Water Heater. The electric resistance water heater has a storage capacity of 0.2 m^3 (52 gal) and employs two 3800-W 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 catalog price of the water heater equipped with a pressure relief valve is $200.

Air Ducts. The duct system is assumed to be field fabricated from 2.54-cm duct board and includes all diffusers, boots, transitions, elbows, supports, and sealers required for a typical house. The base costs of these materials are obtained from data presented by R. S. Means Co.,[8] and the duct sizes are selected to provide heating or cooling delivery rates corresponding to the capacity of the HVAC system required for the reference house at each location. Table 7 lists the cost of completely installed duct systems for different capacity HVAC systems that have been used in this study. Duct system costs for other system capacities are obtained by linear interpolation between the data given in the table. Duct costs for the all-electric system, heat pump with resistance water heating system, and heat pump with desuperheater water heating are based on the cooling capacities of the HVAC plants; duct costs for the minimum and full ACES are based on the heating capacities of the ACES mechanical packages.

The air ducts for the electric resistance heating and electric air conditioning system for the reference house at Knoxville, Tennessee, are sized to accommodate the 7913-W cooling capacity of the air

Table 7. Duct system costs as a function of HVAC system capacity[a]

HVAC system capacity		Duct cost[b]
W	Btu/h	($)
2,930	10,000	435
3,662	12,500	500
7,764	26,500	750
11,720	40,000	1,000
15,675	53,500	1,200
19,484	66,500	1,375
23,440	80,000	1,500
29,300	100,000	1,650

[a]HVAC system cooling capacity used to size ducts for electric resistance heating with electric air conditioning systems, heat pump systems with electric resistance water heating, and heat pump systems with desuperheater water heating. HVAC system heating capacity used to size ducts for minimum and full ACES.

[b]Total installed costs include ducts, insulation, diffusers, boots, elbows, plenums, transitions, and supports.

conditioner. The heating capacity of the electric furnace is not used as the duct design criterion for this system because the resistance heating elements are able to supply higher exit air temperatures than a heat pump. The installed cost of the ducts for the reference house located at Knoxville is obtained by linear interpolation from Table 7 and is found to be $759.

4.1.2 Installation Costs for System 1

The installation cost of each item of equipment in the system must be determined and included in the total installation cost of the system. For system 1, these component installation costs are estimated using the methods of refs. 3 and 8. Adjustments to 1979 costs were made by using 1979 labor rates and inflation adjustments, if required.

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. According to the data of ref. 8, these installation activities average about $140 for each hot water tank, independent of its storage capacity.

Air Conditioner. From ref. 3 the average cost of installing a split-system air conditioner, including its fan unit and controls system, depends on the cooling capacity of the unit. Table 8 shows the cost relationship recommended by ref. 3 and used in this study.

Table 8. Installation costs of a split-system air conditioner

Cooling capacity (W)	Time for installation (man-hours)	Installation cost[a] ($)
2,931 to 6,360	12	252
6,360 to 9,818	14	294
9,818 to 16,120	18	378

[a]Labor rate equals $21/man-hour.

4.1.3 Total Initial Cost of System 1

The total installed cost of an electric resistance heating system with electric central air conditioning and sized to meet the thermal demands of the reference house located at Knoxville, Tennessee, is given in Table 9.

Table 9. Total installed cost of system 1 (resistance heating system with central air conditioning)

Item	Cost ($)
Equipment	
Fan unit	250
Air conditioner	970
Controls	40
Air ducts	759
Water heater tank	200
Auxiliaries	
Refrigerant lines	101
Electrical wiring	59
Installation	
HVAC components	294
Hot water tank	140
Total	2813

4.1.4 Schedule of Annual Maintenance Costs for System 1

It is assumed in this report that system maintenance costs depend on the type rather than the size of the system and that the owner will provide routine preventive maintenance services needed to keep the system in good operating condition. Maintenance falls into four main categories: routine service, refrigerant system repairs, electrical components replacement, and replacement of the hot water storage tank. Routine servicing is assumed to cost an average of $10 per year for filter changes and equipment inspection, except for the sixth, twelfth, and eighteenth year, when cleaning both the indoor and outdoor heat exchanger coils is required at double price. The air conditioner should be inspected and its refrigerant charge adjusted every six years, at a cost assumed to be $50 in 1979. Replacement of contactors, starting capacitors, and fan motors, at a cost of about $100 in 1979 dollars, 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. The installed cost of the new tank is assumed to be $250. Table 10 shows the maintenance cost schedule assumed in this study for the electric resistance heating and electric air conditioning system.

4.2 Cost of System 2 for the Reference House at Knoxville, Tennessee

4.2.1 Equipment Costs for System 2

This HVAC system is comprised of a high-performance air-to-air heat pump, fan unit, air distribution system, water heater, controls, and auxiliary equipment. The initial installed cost of this HVAC system includes all expenditures for components, materials, and installation. The fan unit containing the electrical resistance heating elements for auxiliary heating is the same unit used with the

Table 10. Schedule of annual maintenance costs for system 1[a]

Year	Routine service ($)	Refrigerant system ($)	Electrical system ($)	Water tank ($)	Total maintenance ($)
1	10				10
2	10				10
3	10				10
4	10				10
5	10				10
6	20	50			70
7	10				10
8	10				10
9	10			250	260
10	10		100		110
11	10				10
12	20	50			70
13	10				10
14	10				10
15	10				10
16	10				10
17	10				10
18	20	50		250	320
19	10				10
20	10				10

[a]Annual costs given in terms of constant dollars.

previous HVAC system and is sized by procedures that have been described. Consequently, the fan unit for this HVAC system is selected with a heating capacity of 10,334 W, which costs $250 for the heat pump system for this reference house.

Heat Pump. The refrigeration package is a typical split system in which the indoor coil is mounted in the fan unit. The models available for selection are listed in Table 11 and have an average heating COP of 2.75. The size of the heat pump is conventionally selected on the basis of the design cooling load of the building, and auxiliary resistance heating capacity is provided as needed to meet high heating demands. For the reference house at Knoxville, the cooling demands are satisfied by the installation of the smallest capacity heat pump listed in Table 11, at a cost of $1080.

Table 11. Sears split-system heat pumps with an indoor coil and housing for use with fan unit and an outdoor coil, compressor, and fan unit

Cooling capacity (W)	Heating capacity (W)	Heating COP at +8.3 °C	Price of unit ($)
7,181	7,181	2.8	1,080
8,499	8,792	2.8	1,180
10,111	10,551	2.9	1,280
11,723	12,309	2.7	1,410
14,068	14,361	2.6	1,640
16,999	18,757	2.7	1,980
		Average 2.75	

Controls. The control system thermostats used with the heat pump are similar to those used with the previously described system. The indoor thermostat must have two heating stages and a cooling stage and, in addition, an emergency heat switch that activates electric heat if the compressor should fail. An outdoor thermostat is also required to activate supplemental heaters, thus improving system performance. This feature is assumed to be present in all of the heat pump systems studied in this report. Table 12 lists the control system components and costs assumed in the study. The air-to-air heat pump system for the reference house at Knoxville requires only the indoor thermostat, obtainable at a cost of $29.

Table 12. Components of the heat pump control system

Item	Cost ($)
Indoor thermostat (all heat pump systems), two stage heating/cooling	29.00
Outdoor thermostat	
Capacity of fan unit, W	
0 to 10,334	0
10,334 to 20,445	29.00
20,445 to 33,970	58.00

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 cost of the electrical services is given in Table 6, and the costs of refrigerant tubing for the system are given in Table 13. The costs of auxiliaries for the air-to-air heat pump system in the reference house at Knoxville are $59 for electrical services and $119 for refrigerant lines, a total of $178.

Table 13. Costs of refrigerant lines for an air-to-air heat pump

Cooling capacity (W)	Line length (m)	Line cost ($)
0 to 10,111	16	119
10,111 to 16,999	16	148

Water Heater. The water heater conventionally used with the air-to-air heat pump is an electric-resistance-heated storage tank. The unit selected in this study consists of a tank having a storage capacity of 0.2 m^3 (52 gal), which is heated by two 3800-W heating elements. The Sears catalog price of this unit, equipped with a pressure relief valve, is $200.

Air Ducts. The duct system capacity is selected to accommodate the cooling capacity of the heat pump, and its cost is estimated using the data presented in Table 7. For the heat pump system in this reference house, the cost of ducts required for delivering 7181 W of cooling is found to be $714.

4.2.2 Installation Costs for System 2

The installation cost of the air-to-air heat pump with an electric water heater is assumed to be identical to that of a split air conditioner system and, therefore, is costed according to the data listed in Table 8. For the heat pump system in the reference house at Knoxville, installation of the heat pump and fan unit costs $294; installation of the water heater is estimated to cost $140.

4.2.3 Total Initial Cost of System 2

The total installed cost of an air-to-air heat pump with electric resistance water heating, sized to meet the thermal demands of the reference house, is given in Table 14.

Table 14. Total initial cost of system 2 (electric resistance water heating)

Item	Cost ($)
Equipment	
Fan unit	250
Split-system heat pump	1080
Controls	29
Air ducts	714
Water heater tank	200
Auxiliaries	
Refrigerant lines	119
Electrical wiring	59
Installation	
Heat pump	294
Hot water tank	140
Total	2885

4.2.4 Schedule of Annual Maintenance Costs for System 2

The maintenance requirements of the air-to-air heat pump system are similar in many respects to those of the electric resistance heating with air conditioning system discussed earlier. The types of maintenance required are routine service, refrigerant system repairs, and replacement (as needed) of electrical components, compressor, and hot water storage tank. Routine servicing for this system consists of filter changes, equipment inspection, and indoor coil brushing. The estimated cost is about $20 per year and is higher than for the system discussed earlier because of the added complexity of the heat pump and the need to clean its heat exchanger coils periodically. Maintenance of the refrigerant system is assumed to cost about $50 every six years, and replacement of electrical components, including contactors, fan motors, and starting capacitors, is assumed to cost $120 in the thirteenth year. The replacement of the hot water tank is assumed to be required every nine years, at a cost of $250. These costs are in 1979 dollars and represent estimated present-day costs. In computing the actual cash outlays for maintenance at the time of repair, these costs are converted into "then-current" dollars by considering inflation and maintenance cost escalation.

Compressor Maintenance. Documented studies of heat pump compressor failures have been performed by American Electric Power Company and by Alabama Power. These studies have been summarized and reported by Collie.[9] The American Electric Power Company study revealed that split

and packaged heat pumps experience a compressor failure rate during the warranty period of between 3.6 and 23.8% per year, with an average of 8.2% per year. The Alabama Power study showed that split heat pump systems experience a failure rate of between 4.1 and 10.5% per year, with an overall average of 6.1% per year. Stated differently, these two studies indicate that the average time to compressor failure is between 6.1 and 8.2 years. In this study, it is assumed that the heat pump compressor will fail and must be replaced every eight years. The maintenance cost schedule used in this study for the air-to-air heat pump systems is given in Table 15.

Table 15. Schedule of annual maintenance costs for system 2 (air-to-air heat pump with resistance water heater)[a]

Year	Routine service ($)	Refrigerant system ($)	Electrical system ($)	Compressor replaced ($)	Water tank ($)	Total maintenance ($)
1	20					20
2	20					20
3	20					20
4	50					50
5	20					20
6	20	50				70
7	20					20
8	20			650		670
9	20				250	270
10	20					20
11	20					20
12	20	50				70
13	20		120			140
14	20					20
15	20					20
16	50			650		700
17	20					20
18	20	50			250	320
19	20					20
20	20					20

[a]Annual costs given in terms of constant dollars.

4.3 Cost of System 3 for the Reference House at Knoxville, Tennessee

4.3.1 Equipment Costs for System 3

Except for the addition of an extra heat exchanger and circulating pump for producing domestic hot water, this system is identical to the conventional heat pump system discussed in the preceding section. The minor differences in the costing procedures for this system over that of the conventional heat pump are discussed in the following.

Desuperheater Package. The cost of a typical 2.0-kW desuperheater package is estimated on the basis of information received from several independent manufacturers who are now offering this component as an accessory. The average price for the desuperheater and pump package is $400, excluding installation costs.

Hot Water Tank. The lower temperature recovery rate characteristic of desuperheater systems requires the installation of a larger hot water tank than is normally used. The hot water tank required for

a desuperheater water heating system should have a capacity of at least 0.3 m^3 (82 gal) to ensure a sufficient supply of hot water for domestic needs. The Sears catalog price for this size tank is $240.

4.3.2 Installation Costs for System 3

The installation of the desuperheater hot water system requires additional piping and additional electric wiring for system control. The materials and labor cost for installing the desuperheater system is estimated as $100 above the cost of the components.

4.3.3 Total Initial Cost of System 3

The total installed cost of this system, sized to meet the thermal demands of the reference house located at Knoxville, Tennessee, is given in Table 16.

Table 16. Total initial cost of system 3 (heat pump with desuperheater water heater)

Item	Cost ($)
Equipment	
Fan unit	250
Split-system heat pump	1080
Controls	29
Air ducts	714
Water heater tank (82-gal)	240
Auxiliaries	
Refrigerant lines	119
Electrical wiring	59
Desuperheater and pump package	400
Installation	
Heat pump	294
Hot water tank	140
Desuperheater package	100
Total	3425

4.3.4 Schedule of Annual Maintenance Costs for System 3

The maintenance requirements of a heat pump with desuperheater system differ slightly from those of conventional heat pump systems because of the need to descale and clean the desuperheater heat exchanger periodically throughout its life. In addition, the hot water circulating pump will probably need to be replaced or rebuilt at about ten-year intervals. The larger and more expensive hot water tank required by this sytem also adds to its maintenance cost because the tank will need to be replaced about every nine years. Table 17 shows the maintenance schedule and current maintenance costs assumed in this study for the heat pump with desuperheater HVAC system. Here it is assumed that the desuperheater is chemically cleaned and flushed every six years and that the installation labor cost of the hot water replacement tank amounts to $60.

Table 17. Schedule of annual maintenance costs for system 3 (air-to-air heat pump with desuperheater water heater)[a]

Year	Routine service ($)	Refrigerant system ($)	Electrical system ($)	Replace compressor ($)	Replace hot water tank ($)	Clean desuperheater ($)	Total maintenance ($)
1	20						20
2	20						20
3	20						20
4	50						50
5	20						20
6	20	50				60	130
7	20						20
8	20			650			670
9	20				300		320
10	20		50				70
11	20						20
12	20	50				60	130
13	20		120				140
14	20						20
15	20						20
16	50			650			700
17	20						20
18	50				300	60	410
19	20						20
20	20						20

[a]Annual costs given in terms of constant dollars.

4.4 Costs of the Annual Cycle Energy Systems

4.4.1 ACES Equipment Costs

This section provides information on the costs of components for a minimum and a full ACES of the brine-chiller type. The major components of the ACES are the mechanical package, ice bin, collector panel, and conventional equipment such as air ducts, hot water tank, and thermostats. It is not possible today to order from any commercial source the packaged components required for constructing an ACES. Instead, the major ACES components must be assembled from subcomponents such as heat exchangers, pumps, compressors, and other equipment that is currently in quantity production and for which mature costs are available. Some of the ACES components, such as the solar collector panel and the ice storage bin, must be built on site. The costs of these components are based on estimated costs of materials and labor. The costs of other components, such as the mechanical package and the controller, are derived from estimates provided by some manufacturers as to how much the component would probably cost if it were in full-scale production today.

Mechanical Package. The ACES mechanical package contains a water-to-water heat pump, consisting of an indoor fan unit, outdoor fan unit, compressor, heat exchanger, and pumps for circulating brine and hot water. The indoor unit consists 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. All of the components of the ACES mechanical package are presently in quantity production but are sold for other applications.

The costs of fully assembled ACES mechanical packages, as estimated by a limited number of heat pump and refrigeration equipment manufacturers, are given in Table 18. These costs, which vary with the heating capacity of the unit, are used in this study to determine the overall cost of the ACES.

Table 18. Costs of ACES mechanical packages

Capacity (W)	Heating COP	Cost ($)
7,180	2.55	2,500
9,964	2.55	2,650
13,189	2.55	2,950
17,584	2.55	3,350
21,981	2.55	3,750

Ice Bin. The ice bin is usually the largest and most costly component of the ACES. The office of Irwin G. Cantor performed a study in 1977 to determine the costs of 11 different types of bins considered to be suitable for ACES installations,[10] and these costing methods are used here. The most economical method of fabrication was found to be a proprietary construction technique using "foam forms." The foam-form ice bin can be built either as a free-standing tank or as an integrated tank that makes use of the building structure. Of these two possibilities, integrated tank construction is the least expensive and is the method assumed in this report. The Cantor study investigated the costs of factory-fabricated bins as well as bins constructed at the building site. The Cantor report considered some bins that have since been found to be impractical for ACES applications.

Figure 10 shows the type of ice bin construction that offers the lowest cost and provides the necessary thermal characteristics for the ACES. The ice bin should be below ground and insulated on all surfaces to a thermal resistance value of 7.05 $m^2 \cdot °C/W$ (R-40). The ice bin is constructed from conventional building materials, such as sand, gravel, cement, reinforcing rods, and liner fabric. The insulation is a closed-cell plastic material that is suitable for use in wet environments. Polypropylene ropes are used to form the coil support structure, and the coils are of heat-set plastic tubing. The fasteners for attaching the coils to the support structure are of a corrosion-resistant metal. This type of ice bin construction is believed to offer long, trouble-free service with the ACES.

Table 19 lists the unit costs that are used to price the ice bin. The data are taken from ref. 7 and represent construction costs prevailing for materials and labor. Based on these unit costs, the total installed costs of both integrated and free-standing bins can be obtained by use of the methods of ref. 10. In computing the installed cost of the bin, it is assumed that the bin is located beneath the garage floor, which serves as the top slab of the bin. Additionally, in the case of integrated tank construction, it is assumed that the floor and two walls of the basement can serve as an integral part of the bin structure. The installed costs of the less expensive integrated bins are calculated and used in this report to determine the total installed costs of ACES.

Solar Collector Panel. The ACES designs evaluated in this report use an unglazed collector panel to collect ambient heat for melting excess ice in the bin. Ambient heat is collected by this type of panel only when outdoor air temperatures exceed 0° C (32° F). The heat from solar radiation absorbed on the panel surface and heat obtained by convection from the ambient air is delivered to the ice bin by a brine heat-transfer fluid. The panel may have either the finned-tube configuration shown in Fig. 11, or it may be a continuous flat sheet having flow channels for the brine to circulate through it. Both types of panels are currently available from commercial sources and are usually sold for the heating of swimming pools.

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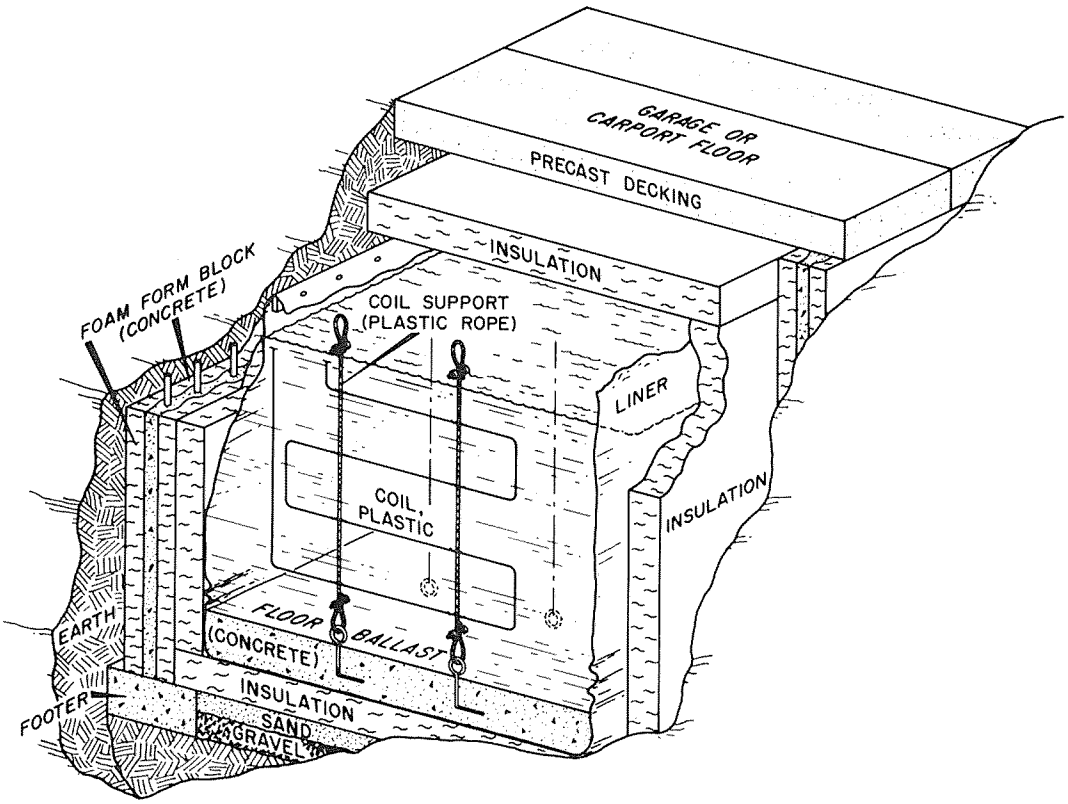

Fig. 10. ACES ice storage bin and heat exchanger.

Table 19. Ice bin on-site construction costs[a]

(all values are in $/m^2$ unless otherwise indicated)

	Free standing construction	Integrated construction
Excavation, $/m^3	1.63	
Footers, $/m	5.68	5.68
Floor slab	10.44	
Floor insulation	18.08	18.08
Walls, foam-form	22.71	22.71
Walls, bare block upgrade		3.12
Walls, supplemental insulation	12.05	12.05
Top slab		
Top insulation	18.08	18.08
Liner	4.84	4.84
Bin heat exchanger coil, $/m	3.28	3.28

[a]R. S. Means data; all costs include materials and installation.

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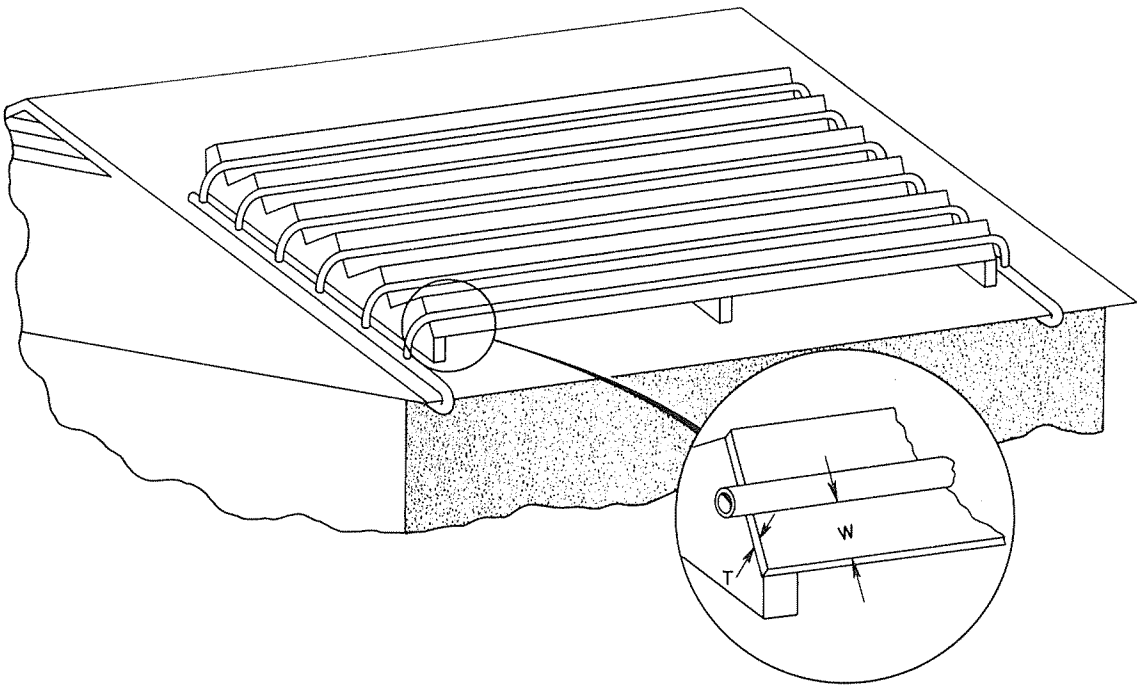

Fig. 11. ACES collector panel.

Several manufacturers offer unglazed collectors at prices ranging from \$30 to \$37/m^2 for the uninstalled panel. In this study, it is assumed that the collector panel cost is \$32.28/m^2, exclusive of installation.

Installing the solar panel requires that a support structure be provided for mounting the panel securely to the roof of the building. Also the panel must be connected to the ice bin heat exchanger by insulated piping to allow the heat transfer fluid to circulate through the panel and bin heat exchanger. The cost of rooftop installation of an unglazed panel is assumed to be \$6.46/m^2 of panel area, and the cost of installing brine lines from the panel to the ice bin is assumed to be a fixed charge of \$700 for each ACES. The total installed cost of the solar collector panel is expressed by

$$P_{cost} = 700 + 6.46A + 32.28A \,, \tag{1}$$

where P_{cost} is the installed cost in dollars, and A is the panel area in square meters.

Auxiliaries. Auxiliary equipment required for the ACES includes the controller with associated sensors and thermostats, insulated plastic tubing for the brine circuits, and wiring and electrical hardware for providing electrical service.

Controls. The ACES controller actuates system components according to programmed logic instructions that regulate the ice inventory and the delivery of heating and cooling loads to the building. The cost of this item of equipment, which is not yet commercially available, has been estimated by a major controls manufacturer to be about \$320, when produced in small-lot quantities. This cost includes the costs of the integrated circuit controller and all the sensors and thermostats needed for the control system.

Brine Lines. The brine lines for connecting the compressor and pump package to the convector panel and ice bin coils 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 costs of the brine lines assumed in this study are shown in Table 20.

Table 20. Costs of brine lines for ACES

System heating capacity (W)	Cost ($)
0 to 13,335	100
13,335 to 21,981	120

Electrical Services. The estimated costs of wiring, circuit breakers, switch boxes, and miscellaneous hardware for providing electrical services to the ACES are given in Table 21.

Table 21. Costs of ACES electrical services wiring

System heating capacity (W)	Cost ($)
0 to 10,258	60
10,258 to 17,585	110
17,585 to 21,981	180

Hot Water Tank. The 0.3-m^3 (82-gal) tank used with the ACES costs $240. This cost is obtained from the Sears 1979 catalog.

Ducts. Air duct sizes are based on the system capacity, and the cost of the ducting system is obtained from Table 7.

4.4.2 ACES Installation Costs

Mechanical Package. Installation of the ACES mechanical package consists of setting the indoor unit, outdoor unit, and compressor pump package and connecting the unit to the rest of the system. This job is estimated to be similar in complexity to the installation of a conventional heat pump. Table 22 lists the mechanical package installation costs assumed in this study.

Table 22. Installation costs for ACES mechanical packages

Heating capacity (W)	Man-hours	Cost ($21/h)
0 to 7,180	12	252
7,180 to 10,111	14	294
10,111 to 21,981	18	378

Hot Water Tank. As with conventional systems, the cost of installing the ACES hot water tank is assumed in this study to be $140.

4.4.3 ACES Total Initial Cost

The total installed cost of the ACES includes costs for fabricating or purchasing all components of the system and for installing each item of equipment. In the preceding sections, total installed costs have been presented for the ice bin, solar collector panel, and duct work. Installation and components costs have been presented separately for the mechanical package and the hot water tank of the ACES. This section summarizes costs and cost sources needed for determining the total installed cost of any ACES of specified size. Table 23 lists this information for a brine-chiller system.

Table 23. Estimation of total initial cost of ACES

Item	Cost
Equipment	
Mechanical package[a]	(from Table 18)
Air ducts[a]	(from Table 7)
Hot water tank	$240.00
Ice bin[b]	(from Table 19)
Solar collector panel[c]	Eq. (1)
Auxiliaries	
Controller and sensors	$320.00
Brine lines[a]	(from Table 20)
Electrical services wiring[a]	(from Table 21)
Installation	
Mechanical package[a]	(from Table 22)
Hot water tank	$140.00

[a] Depends on heating capacity of the system.
[b] Depends on linear dimensions of the ice bin.
[c] Depends on area of the collector panel.

4.4.4 ACES Annual Maintenance Cost Schedule

The ACES maintenance requirements include routine servicing, heat exchanger cleaning, refrigerant system servicing, electronic component replacement, pump repair and servicing, ice bin servicing, and hot water tank replacement. The complexity of the system increases maintenance needs over those of conventional systems, even though many of the maintenance needs are the same.

Routine servicing costs of about $20/year are required for filter changes, equipment inspection, and annual water treatment. The ACES brine-to-refrigerant and hot water heat exchangers should be cleaned at about 4-year intervals to maintain system performance. Heat exchanger cleaning costs are expected to average about $110 for each servicing. The refrigerant system of an ACES is similar to that of a conventional refrigerator, and the service life is expected to exceed 20 years. Nevertheless, it is recommended that the refrigerant charge be checked and adjusted every sixth year. This service is estimated to be $50. With the increased complexity of the control system and its use of microelectronic circuitry, it is prudent to assume that the controller may require replacement every 10 years. Complete replacement of the controller is estimated to cost $200. The pumps for circulating brine and hot water are assumed to require replacement or rebuilding every 7 years at a cost of $150. Ice bin maintenance

consists of draining the bin, tightening all manifold connectors, and inspecting structural elements every 5 years. The cost of this bin maintenance and service is estimated to be $100 for each servicing. The hot water tank for the ACES is the same as that used with a conventional heat pump desuperheater system. Tank replacement is estimated to cost $240 for a new tank and $60 for its installation. Table 24 summarizes these assumed maintenance costs and schedules for the ACES.

Table 24. Schedule of annual maintenance costs for the ACES (in constant dollars)

Year	Routine service	Clean heat exchangers	Refrigeration system maintenance	Electrical and electronics components replacements	Pump rebuild	Ice bin service	Hot water tank	Total
1	20							20
2	20							20
3	20							20
4	20	110						130
5	20					100		120
6	20		50					70
7	20				150			170
8	20	110						130
9	20						300	320
10	20			200				220
11	20					100		120
12	20	110	50					180
13	20							20
14	20				150			170
15	20							20
16	20	110				100		230
17	20							20
18	20		50				300	370
19	20							20
20	20							20

4.5 Costs of ACES for the Reference House at Knoxville, Tennessee

This section states the estimation of costs for minimum and full ACES of the brine-chiller type for the reference house at Knoxville, Tennessee. The design-day heating and cooling loads of the house at this location are calculated to be 9529 and 6783 W respectively. Design calculations show that the minimum ACES requires an ice bin with a storage capacity of 13.52 m^3 (2.44 × 2.35 × 2.35 m), an ice bin heat exchanger with an active tubing length of 130.7 m, and a solar collector panel with 14.63 m^2 of collection surface. The full ACES requires an ice bin with a storage capacity of 76.5 m^3 (2.44 × 5.60 × 5.69 m) and an ice bin heat exchanger with an active tubing length of 161.3 m. The full ACES does not require a solar panel because all of the ice produced during the heating season is saved to provide air conditioning during the cooling season. Both the minimum and full ACES require a mechanical package, controller, sensors, electrical service connections, brine lines, hot water tank, and an air duct system.

4.5.1 Cost of Minimum ACES, System 4

The total installed cost of the minimum ACES for the reference house is obtained using the methods outlined in Table 23. Listed items of equipment that depend on the design-day heating load of the house are the mechanical package, air duct system, brine lines, and electrical services.

Mechanical Package. The size and cost of the mechanical package is obtained from Table 18. The table shows that the smallest capacity unit capable of delivering the 9529-W design-day heating load costs $2650 and has a heating capacity of 9964 W. The installation cost of the mechanical package is obtained from Table 22 and is found to be $294.

Air Duct System. The installed cost of the air duct system required for the 9964-W mechanical package is obtained from the data listed in Table 7. Linear interpolation between these data yields

$$\text{DUCT COST} = 750 + \frac{9964 - 7764}{11720 - 7764}(1000 - 750) = \$889 .$$

Solar Collector Panel. The installed cost of the 14.63-m^2 solar collector panel for the minimum ACES is obtained from Eq. (1).

$$P_{cost} = 700 + 6.46(14.63) + 32.28(14.63) = \$1267 ,$$

where the first two terms of the equation represent installation costs, and the third term represents costs for materials. The cost of panel installation is $795, and the cost of the panel materials is $472.

Brine Lines. The installed cost of brine lines for the minimum ACES, obtained from Table 20, is $100.

Electrical Services. The cost of providing electrical service lines to the minimum ACES, obtained from Table 21, is $60.

Ice Bin. It is assumed that the ACES ice bin is located in the basement of the reference house and that the top deck, floor, and two walls of the bin serve as an integral part of the building structure. The incremental costs for constructing the remaining two walls of the bin and for installing the bin internal assemblies are derived from the data presented in Table 19. Itemized costs for the 13.52-m^3 minimum ACES bin are given in Table 25, where it is seen that the estimated cost of the ice bin is $1483.

Table 25. Costs of 13.5-m^3 ice bin, using integrated construction

Cost item	Unit cost	Quantity	Installed cost[a] ($)
Footers for 2 walls (2)	5.68 $/m	4.7 m	27
Floor insulation	18.08 $/$m^2$	5.52 m^2	100
Foam-form walls (2)	22.71 $/$m^2$	11.48 m^2	261
Upgraded block walls (2)	3.12 $/$m^2$	11.48 m^2	36
Wall supplemental insulation	12.05 $/$m^2$	22.96 m^2	277
Top deck insulation	18.08 $/$m^2$	5.52 m^2	100
Folded plastic sheet liner	4.84 $/$m^2$	52.30 m^2	253
Bin heat exchanger coil	3.28 $/m	130.7 m	429
Total installed cost			1483

[a]Includes costs for both materials and labor.

Total Cost of Minimum ACES. The total installed cost of the minimum ACES is given in Table 26.

4.5.2 Cost of Full ACES, System 5

The full ACES is identical to the minimum ACES except for the size of both the ice bin and the solar collector panel. The full ACES for the reference house does not require a collector panel because all of

Table 26. Total installed cost of minimum ACES for the reference house at Knoxville, Tennessee

Item ($)	Installed cost ($)
Equipment	
Mechanical package	2650
Air duct system	889
Hot water tank	240
Ice storage bin	1483
Solar collector panel	1267
Auxiliaries	
Controller and sensors	320
Brine lines	100
Electrical services	60
Installation	
Mechanical package	294
Hot water tank	140
Total	7443

the ice that can be produced in an average winter is saved to meet summer air conditioning demands of the house. Even this quantity of ice is not sufficient to satisfy all the cooling requirements, and supplemental-phase operation of the system is necessary in late summer. Table 27 lists itemized costs for the 76.5-m^3 ice storage bin required for the full ACES.

Table 27. Cost of 76.5-m^3 ice bin, using integrated construction

Cost item	Unit cost	Quantity	Installed cost[a] ($)
Footers for walls (2)	5.68 $/m	11.20 m	64
Floor insulation	18.08 $/$m^2$	31.35 m^2	567
Foam-form walls (2)	22.71 $/$m^2$	27.33 m^2	620
Upgraded block walls (2)	3.12 $/$m^2$	27.33 m^2	85
Supplemental wall insulation (4)	12.05 $/$m^2$	54.66 m^2	659
Top deck insulation	18.08 $/$m^2$	31.35 m^2	567
Folded plastic sheet liner	4.84 $/$m^2$	109.83 m^2	532
Bin heat exchanger coil	3.28 $/m	161.26 m	529
Total installed cost			3623

[a]Includes costs for both materials and labor.

Total Cost of Full ACES. The total installed cost of the full ACES for the reference house is given in Table 28.

Table 28. Total installed cost of full ACES for the reference house at Knoxville, Tennessee

Item	Installed cost[a] ($)
Equipment	
Mechanical package	2650
Air duct system	889
Hot water tank	240
Ice storage bin	3623
Solar collector panel	0
Auxiliaries	
Controller and sensors	320
Brine lines	100
Electrical services	60
Installation	
Mechanical package	294
Hot water tank	140
Total installed cost	8316

[a]Includes costs for both materials and labor.

5. ECONOMIC ANALYSIS

The five HVAC systems of this study are ranked according to their potential economic benefits on the basis of life-cycle costs and according to their economic risks on the basis of simple payback periods. The simple payback period of an HVAC system is the ratio of its incremental first cost, relative to a selected reference system, to its first-year savings in power costs. Simple payback analysis provides a rapid method for assessing the relative economic risks of different systems. As the simple payback period increases, there is a greater opportunity for events not to turn out as originally expected, and the risk is greater. It is important to the homeowner, who faces considerable uncertainties regarding future economic conditions, to obtain some idea of the relative risks associated with alternative investment decisions.

Although some people also use simple payback periods for ranking the potential economic benefits of different systems, this practice is not recommended because it does not take into account the different economic lifetimes of the systems, the possibility of power costs escalating, or the earnings from capital investments that are recovered and reinvested during the payback period. Life-cycle cost analysis takes these factors into account and is the method used in this study to assess the potential economic benefits of the systems. The life-cycle cost of a system is the amount of a hypothetical fund established at the start of the analysis period to pay all costs incurred by the system during its life cycle. Obviously, the most economical system is the one having the lowest life-cycle cost. The concepts of simple payback periods and life-cycle costs are discussed in more detail in the following.

5.1 Life-Cycle Cost Analysis

The overall cost of an HVAC system includes its initial price and costs for financing, delivery, and installation—together with all future costs for electrical power, property taxes, property insurance, and maintenance of the system over its lifetime or the period of analysis. If all the future costs can be estimated with reasonable accuracy, it is possible to compute the amount of a hypothetical fund, drawing interest at a stated rate, that would be required for paying all costs of the system at the time they occur. The initial amount of the fund, defined as the life-cycle cost of the system under consideration, is fixed at a level such that the remaining amount of the fund declines to zero at the end of the life cycle. Thus, in calculating life-cycle costs it is necessary to make assumptions concerning the rate of return on capital that the fund provides and the magnitudes of all future costs that will be incurred by the system during the period of analysis. Consideration of the following factors facilitates the making of these assumptions.

1. *Fund interest rate*—In this study the interest rate payable by the hypothetical fund from which all costs incurred by the system are disbursed is taken to be the after-tax rate of return on the best alternative investment available to the purchaser of the system, that is,

$$r_F = r_{AT} = (1 - T)r_{BT} , \tag{2}$$

where r_F is the fund interest rate, r_{AT} is the best after-tax rate of return available on opportunity investments, r_{BT} is the before-tax rate of return from the opportunity investment, and T is the incremental income tax rate of the investor. When discounted for inflation, denoted by r_i, the fund yields a true rate of return, r_t, that is given by the expression

$$(1 + r_t) = \frac{(1 + r_{AT})}{(1 + r_i)} . \tag{3}$$

2. *Period of analysis*—The selection of the economic evaluation period is based on considerations of the useful lifetime of the system and the maximum period of time for which relatively reliable estimates of future cash flows can be made. Although all the HVAC systems of this study have certain components that may be expected to provide useful service for 25 to 50 years, the prediction of operating costs for the systems so far into the future would be extremely unreliable. For this reason we have selected 20 years as the period of analysis even though this selection tends to penalize longer-lived systems. In this study, energy costs and savings accruing in more than 20 years are neglected for all the systems.

3. *Life-cycle cost*—In the most general terms the life-cycle cost of a system is simply the sum of the discounted cash flows required for acquiring the system and operating it over a length of time equal to the study period, that is,

$$LCC(N) = \sum_{k=0}^{N} \sum_{i=1}^{I} \frac{P_i(k)}{(1 + r_F)^k} , \tag{4}$$

where

$LCC(N)$ = life-cycle cost of system in dollars,
N = period of analysis in years,
I = number of different purposes of annual payments,
$P_i(k)$ = fund payment in year k for purpose i, in dollars,
r_F = annual interest rate of fund.

The principal task in life-cycle cost analysis is to obtain reasonable estimates of the annual cash flows associated with a system, based on knowledge of its initial cost and performance characteristics and on assumptions concerning probable future maintenance needs and economic conditions. The annual cash flows are met by payments from the fund, $P_i(k)$, for such expenses as down payment on the system; mortgage payments for borrowed capital (net of income tax rebates); and costs of electrical power, system maintenance, property insurance, and net property taxes. In the case of mortgage payments for borrowed capital, the summation in Eq. (4) must extend over the life of the loan even if it exceeds the study period. That is, the obligation to repay the loan is unaffected by the amount of time allotted for the study.[11]

4. *Present worth factor*—In special cases where $P_i(k)$ is constant over the study period, the evaluation of the summation terms in Eq. (4) can be facilitated by the use of present worth factors. The present worth factor is defined as

$$pwf(R, N) = R^1 + R^2 + R^3 + \cdots + R^N = \sum_{k=1}^{N} (R)^k . \tag{5}$$

It can be shown by elementary algebra that the present worth factor takes on the value N when R is equal to unity, and

$$pwf(R, N) = \frac{R(R^N - 1)}{(R - 1)} , \qquad \text{if } R \neq 1 . \tag{6}$$

5.1.1 Estimation of Annual Cash Flows

The following nomenclature is used for estimating annual cash flows and describing components of the life-cycle cost equation.

C = initial cost of installed system in dollars
f = fraction of system initial cost that is borrowed
L = life of the loan in years
N = period of analysis in years
P_I = levelized loan interest payment that is equivalent to the actual annual interest payments over the life of the loan
P_L = levelized annual payment on the loan
$P_E(k)$ = cost of electricity in year k in actual dollars
$P_m(k)$ = cost of maintenance in year k in constant dollars
$P_M(k)$ = cost of maintenance in year k in actual dollars
$P_P(k)$ = cost of property taxes in year k in actual dollars
$P_S(k)$ = cost of property insurance in year k in actual dollars
$pwf(R, N)$ = present worth factor
R = discount coefficient used in computing present worth factor
r_a = real annual escalation rate of system value, for computing annual property taxes and insurance premiums
r_{AT} = after-tax rate of return from best alternative investment opportunity
r_e = real annual escalation rate of electricity costs
r_F = annual rate of return of fund
r_i = annual rate of inflation
r_L = annual loan interest rate
r_m = real annual escalation rate of maintenance costs
r_P = annual property tax rate
r_S = annual property insurance rate
r_t = true annual rate of return of fund
T = incremental income tax rate of investor
$V_A(k)$ = value of system in year k in actual dollars

Factors affecting annual cash flows include the following.

1. *Mortgage and interest payments*—The levelized annual payment required for repaying a loan of fC dollars over a period of L years and at an annual interest rate of r_L is

$$P_L = \frac{fC}{pwf(R_1, L)}, \tag{7}$$

and the levelized annual interest payment on the loan is

$$P_I = P_L\left[1 - \frac{pwf(R_3, L)}{(1 + r_{AT})^{L+1} pwf(R_2, L)}\right] \tag{8}$$

The discount coefficients used in Eqs. (6) and (7) are

$$R_1 = \frac{1}{(1 + r_L)}, \tag{9}$$

$$R_2 = \frac{1}{(1 + r_{AT})}, \tag{10}$$

and

$$R_3 = \frac{(1 + r_{AT})}{(1 + r_L)}. \tag{11}$$

2. *System operating costs*—The annual costs of operating the system are assumed to be

$$P_M(k) = P_m(k)[(1 + r_m)(1 + r_i)]^k \quad \text{for maintenance and repair,} \tag{12}$$

$$P_E(k) = P_E(0)[(1 + r_e)(1 + r_i)]^k \quad \text{for power consumption,} \tag{13}$$

$$P_T(k) = r_P V_A(0)[(1 + r_a)(1 + r_i)]^k \quad \text{for property taxes,} \tag{14}$$

and

$$P_S(k) = r_S V_A(0)[(1 + r_a)(1 + r_i)]^k \quad \text{for property insurance premiums.} \tag{15}$$

The corresponding discount coefficients are

$$R_4 = \frac{(1 + r_m)(1 + r_i)}{(1 + r_{AT})} = \frac{(1 + r_m)}{(1 + r_t)}, \tag{16}$$

$$R_5 = \frac{(1 + r_e)(1 + r_i)}{(1 + r_{AT})} = \frac{(1 + r_e)}{(1 + r_t)}, \tag{17}$$

$$R_6 = \frac{(1 + r_a)(1 + r_i)}{(1 + r_{AT})} = \frac{(1 + r_a)}{(1 + r_t)}, \tag{18}$$

and

$$R_T = \frac{(1 + r_i)}{(1 + r_{AT})} = \frac{1}{(1 + r_t)}. \tag{19}$$

The discount coefficient, R_T, applies in the special cases where r_m, r_e, or r_a is assumed to be zero.

5.1.2 Life-Cycle Cost Equation

The life-cycle cost equation is obtained by inserting the expressions for the annual cash flows of the system into Eq. (2) and making use of the definition of present worth factors given by Eq. (5). The result

obtained is

$$LCC(N) = pwf(R_2, L)P_L + (1 - f)C + pwf(R_6, N)[V_A(0)(r_p + r_S)] + \sum_{k=1}^{N} P_m(k)(R_4)^k$$
$$+ pwf(R_5, N)P_P(0) - T[pwf(R_2, L)P_I + pwf(R_6, N)V_A(0)r_P] . \quad (20)$$

An inspection of Eq. (20) reveals that the life-cycle cost is made up of the following components:

1. present worth of the mortgage payments,
2. down payment on the system,
3. present worth of annual payments for property taxes and insurance,
4. present worth of annual expenditures for system maintenance,
5. present worth of annual expenditures for electrical power, and
6. credit for the present worth of income tax rebates received, for interest paid on the mortgage, and for property taxes.

It is convenient to regroup the terms of Eq. (20) to display as separate items the initial cost of the system and the present worths of financing costs, maintenance costs, power costs, property taxes, and insurance premiums. When this is done, the life-cycle cost equation becomes

$$LCC(N) = C + fC\left[\left(1 - T\frac{P_I}{P_L}\right)\frac{pwf(R_2, L)}{pwf(R_1, L)} - 1\right] + \sum_{k=1}^{N} P_m(k)(R_4)^k$$
$$+ pwf(R_5, N)P_P(0) + pwf(R_6, N)[r_P(1 - T) + r_S]V_A(0) . \quad (21)$$

Equation (21) is useful for examining the effects of simplifying assumptions that have been made in this study for estimating the life-cycle costs of the different HVAC systems.

Simplifying assumptions made in this study are as follows:

1. All systems are purchased entirely from equity funds, that is, $f = 0$.
2. Annual maintenance costs rise with the general rate of inflation, or $r_m = 0$.
3. Annual power costs rise with the general rate of inflation, or $r_e = 0$.
4. Annual property taxes and insurance premiums are the same for all systems.

The first three assumptions are made for the purpose of reducing the computations required for determining life-cycle costs. The last assumption states that, for purposes of taxation and insurance, the HVAC system is likely to be considered an integral part of the building. The annual property taxes will then be determined by the quality of the building, its living space, and the types of services provided by the HVAC system. Because all the systems considered in this study provide identical services—central heating and air conditioning and domestic hot water—it is believed that the annual property taxes and insurance premiums will be nearly the same for each system.

The result obtained by introducing the simplifying assumptions into Eq. (21) is

$$LCC(N) = C + \sum_{k=1}^{N} P_m(k)(R_T)^k + pwf(R_T, N)P_P(0) . \quad (22)$$

The present worth of annual payments for property taxes and insurance is neglected in Eq. (22) because it is assumed to be the same for all systems and thus does not affect relative life-cycle costs. This simplified life-cycle cost equation is considered to be suitable for use in a survey study, as in this report, and has been used to compute all life-cycle costs listed in Appendix D. For situations in

which the simplifying assumptions are not applicable because of local conditions, life-cycle costs should be recomputed using Eq. (20) or Eq. (21).

5.2 Payback Analysis

It is often of interest to compare an HVAC system with a reference system by computing the time it takes to recoup the incremental investment of each system through savings realized by lower annual operating costs. The computation of the payback period can be performed by varying the length of the study period in the life-cycle cost analysis to determine the time at which the life-cycle cost of the HVAC system becomes equal to that of the reference system. The discounted payback period determined in this manner takes into account the effects of escalating operating costs and the time value of money. Because of the labor required for computing discounted payback periods, however, the easily computed simple payback period is more often used for making a quick comparison of the risks associated with different systems. The simple payback period is defined to be the number of years required for the cumulative value of energy cost savings to equal the incremental first costs of the system without consideration of future fuel price increases or discount rates. The simple payback period, in years, is given by

$$SPB = \frac{IC - IC_R}{PC_R - PC}, \tag{23}$$

where IC and IC_R are the initial costs of the HVAC system and the reference system, respectively, and PC and PC_R are their first-year power costs. In this study, system 1—which has the lowest initial cost and the highest operating costs of the five systems considered—has been selected as the reference system. All simple payback periods listed in Appendix D have been computed according to Eq. (23).

Although the simple payback period provides an approximate measure of the relative economic risk associated with a given system, it is not a good measure of the system's potential economic benefits. For this purpose, the simple payback concept has two main deficiencies. One, the annual power cost savings are not properly discounted, and, furthermore, those costs occurring outside the limits of the simple payback period are completely neglected. Failure to include these discounted power cost savings introduces a bias against energy-conserving systems and distorts the true picture of their relative economic advantages. Two, the results of simple payback analysis depend on the choice of reference system. If a relatively advanced system is selected as the base and if short payback periods are required, it becomes difficult to introduce more advanced systems having higher initial costs and lower life-cycle costs.

5.3 Selection of Economic Parameters

The calculation of life-cycle costs requires specification of such future economic conditions as the anticipated annual rate of inflation and the true annual rate of return from alternative investment opportunities available to the purchaser of the system. Obviously, future economic conditions cannot be predicted with any high degree of certainty, and, as a result, the computed life-cycle costs may be incorrect. Nevertheless, life-cycle cost analysis provides the prospective buyer with a method for making a rational decision as to which system offers him the best economic returns, based on his own assessment of future economic conditions. Rightly so, the life-cycle cost of a system reflects not only the individual's current economic status and opportunities but also his subjective views of the future.

Consider, for example, two individuals who have different financial prospects and attitudes about the future. Individual A is free of debt and earns a high salary that places him in the 40% incremental income tax bracket. He has investment opportunities available that pay an annual rate of return to capital of 20% and believes, conservatively or wishfully, that inflation will be brought under control and will average 4% annually over the next 20 years. Individual B is also free of debt but earns a lower salary that places him in the 25% income tax bracket. He is able to realize only a 9% annual rate of return on his investments; he is also less optimistic about the likelihood of inflation being brought under control, believing that inflation will continue at an annual rate of 8% far into the future. For the purpose of illustration, and without in any way implying that these two individuals represent typical buyers of HVAC systems, we examine the effects of their differing views of the future on the computation of life-cycle costs.

The after-tax rate of return that applies for the hypothetical fund set up to pay the costs of the system is obtained from Eq. (2) and is found to be 12% for individual A and 6.75% for individual B. If both individuals believe that power costs and maintenance costs will rise at the rate of general inflation, the discount coefficient to be used in computing present worth factors is given by Eq. (19). Using the equation, R_T is found to be equal to 0.9286 for individual A and equal to 1.0117 for individual B. Inserting these values into Eq. (6) and evaluating the expression for an assumed study period of 20 years yields a present worth factor of 10.05 for individual A and 22.65 for individual B. The results show that A attaches far less importance to future operating costs than does B. The reaction of A might well be to purchase the cheapest available HVAC system and use his earnings from alternative investments to pay for any incremental operating costs.

The above example illustrates for a relatively trivial case the crucial importance of the values of the economic parameters used in life-cycle cost calculations. To obtain a valid comparison of the economic attractiveness of alternative HVAC systems, it is essential that life-cycle costs be calculated using parameters that appropriately reflect the buyer's personal financial situation and view of future economic conditions. Failure to properly account for such factors as use of borrowed capital, local property tax policies, insurance premiums, income tax rebates, and probable escalation rate of operating costs can lead to a life-cycle cost ranking of the systems that is invalid for a particular prospective buyer. We strongly urge careful examination of the assumptions and economic parameters used in this study to determine whether they are applicable to a particular situation.

Table 29 shows the assumptions and values of economic parameters used in this study in evaluating the life-cycle costs of five HVAC systems. As has been noted, other assumptions and

Table 29. Economic assumptions and parameters used in the study

Assumptions and parameters	Values
Fraction of system first cost that is borrowed, f	0
Period of analysis in years, N	20
Real annual escalation rate of maintenance costs, r_m	0
Real annual escalation rate of electricity costs, r_e	0
Annual property tax rate, r_P	0
Annual property insurance rate, r_S	0
Annual after-tax return rate on alternative investment, r_{AT} (%)	13
Incremental income tax rate, T (%)	30
Average annual rate of inflation, r_i (%)	7
True rate of return of alternative investment fund, r_i (%)	1.96
Present worth factor, pwf	16.41

values of economic parameters may be more appropriate for particular individuals. Such individuals should recompute the life-cycle costs of the systems by using the set of assumptions and parameters most applicable to their given situations. Figures 12 and 13 may be useful for preliminary scoping purposes. Figure 12 depicts the present worth factor as a function of the true annual rate of return from alternative investments available to the buyer and as a function of the length of the study period. Figure 13 is a nomogram from which the present worth factor and the true rate of return can be obtained from known assumptions about the rate of inflation and the after-tax rate of return from alternative investment opportunities.

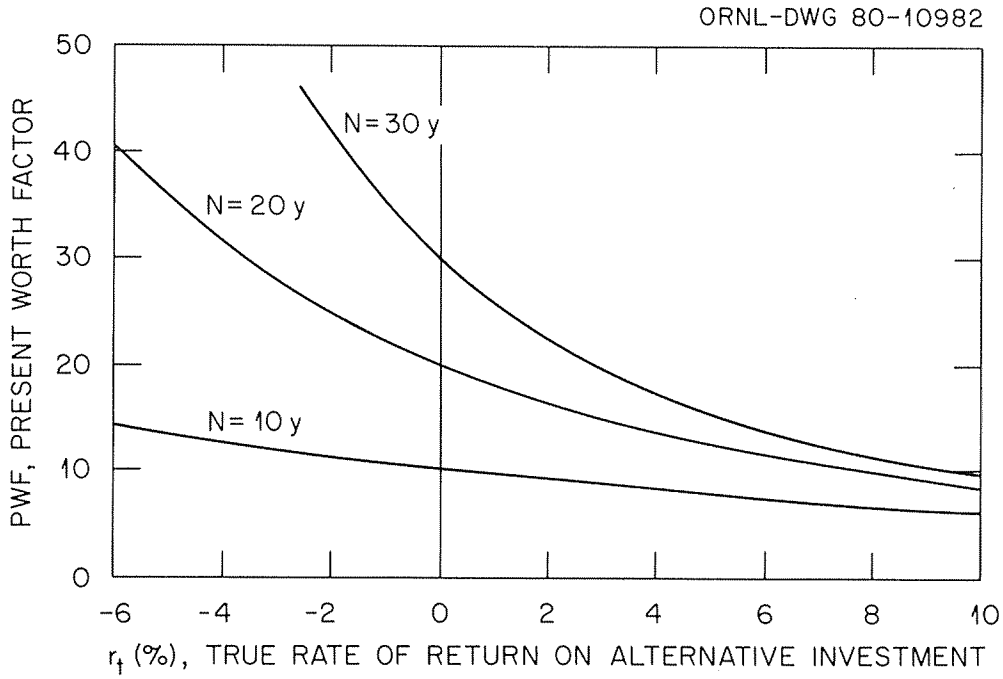

Fig. 12. Present worth factor vs true rate of return available on an alternative investment opportunity.

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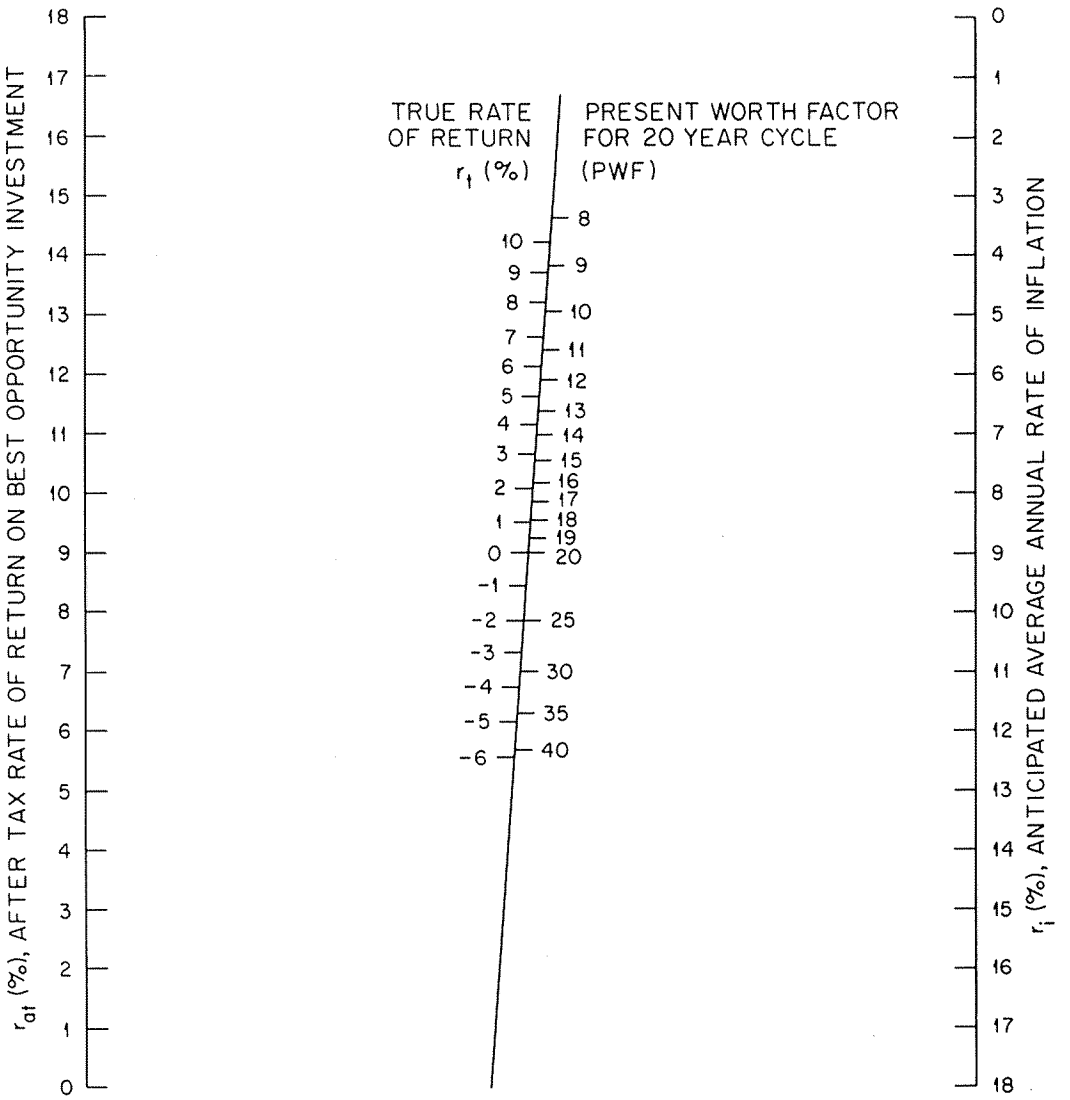

Fig. 13. Nomogram for determining investor's perception of the time value of money.

6. RESULTS OF SYSTEMS EVALUATIONS

6.1 Description of Computer Output Tables

The estimated costs and performances of the five HVAC systems for reference houses in 115 cities of the United States are listed in computer output tables in Appendix D. The format of these tables is illustrated in Table 30, which shows the results of the evaluation of the five heating and cooling systems in the reference house located in Knoxville, Tennessee. The heading of each table gives general information about the location of the building site, actual power costs prevailing at the location, size of the building, its indoor temperature regime, calculated design-day heating and cooling loads, and the design-day outdoor air temperatures for the particular city. The results of the systems evaluations are presented in three main subsections of the tables, "Systems Design and Performance," "Systems Costs," and "Comparative Systems Costs." The data listed in each of these subsections of the tables are described below.

6.1.1 Systems Design and Performance

This subsection of the computer output table lists three main categories of information: weather data, building parameters and loads, and system energy consumption. The data for each of these categories are presented on both a monthly and an annual basis; the data afford insight into the method of calculation and allow a relatively accurate estimate of the annual COP of each HVAC system considered in this study.

Weather Data. In addition to the weather data contained in the heading of the computer output tables, this section contains site-specific data on the monthly average outdoor air temperature, the average wind speeds, and the average inlet temperature of water heated for domestic consumption. The water inlet temperature is calculated based on the assumption that the feed line to the hot water tank is from an underground pipe and that the feedwater temperature is the same as that of its surroundings. The underground water supply line is assumed to be at a depth just below the frost line or at a minimum of 0.5 m, whichever is greater.

Building Parameters and Loads. The total heat loss coefficient of the building listed in this section represents heat losses (or gains) by conduction through the thermal envelope of the building and by infiltration of outside air. The conductive heat loss coefficient, listed in the heading of the computer output table, is a constant term that describes the thermal properties of the reference house design. The heat loss coefficient by air infiltration is calculated according to the Achenbach and Coblenz correlation and thus varies with the average monthly wind speed and the average monthly temperature difference across the building shell.

The monthly energy requirements of the building for space heating, water heating, and space cooling are calculated by using temperature bin weather data that describe the monthly average weather conditions prevailing at the particular site. The thermal loads that must be delivered by the HVAC system are calculated on the assumption that the duct system is located within the thermal envelope of the building so that duct heat losses or gains are negligible. The monthly water heating loads represent the amounts of energy that must be delivered to the hot water tank to raise the temperature of the supply water to 49°C and to compensate for heat losses from the tank.

System Energy Consumption. The calculated monthly and annual power consumption of the HVAC systems required for delivering the thermal needs of the building are listed in the computer output table. These data are used to compute the annual COP of each system; the COP of each system is defined as the ratio of the delivered energy to the purchased energy.

Table 30. Sample computer output listing for systems evaluation

KNOXVILLE, TENNESSEE

167 SQ M HOME, WELL INSULATED	DESIGN DAY LOADS (WATTS)		COND. LOSS COEF. (W/C) = 158.	AIR TEMP:	OUTDOOR	INDOOR
POWER COSTS ($/KWH) = 0.0304	HEATING = 9529.		COOLING (TOTAL/SEN.) = 1.26	WINTER =	-10 C	21 C
PRESENT WORTH FACTOR= 16.41	COOLING = 6782.		BLOWER CAPACITY (M3/H) = 2038.	SUMMER =	33 C	26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	2.20	14.48	5.34	267.81	1808.	9071.	0.	3022.	2069.	1930.	1220.	1185.
FEB	6.32	12.87	5.59	255.18	1625.	5345.	0.	1936.	1372.	1290.	801.	759.
MAR	8.42	17.70	8.26	260.24	1694.	4612.	0.	1752.	1188.	1117.	716.	687.
APR	15.76	12.87	12.57	233.74	1475.	1220.	1079.	933.	772.	727.	312.	309.
MAY	20.04	12.87	17.59	224.04	1327.	0.	2552.	805.	858.	695.	193.	193.
JUN	23.45	11.26	21.71	223.64	1128.	0.	4498.	1082.	1102.	814.	677.	215.
JUL	25.34	9.65	24.04	224.65	1074.	0.	6120.	1344.	1344.	1066.	1125.	245.
AUG	24.94	9.65	23.78	223.75	1084.	0.	6145.	1351.	1351.	1071.	1130.	469.
SEP	22.03	9.65	21.13	217.13	1150.	0.	3309.	885.	899.	687.	616.	619.
OCT	15.20	9.65	16.65	228.46	1364.	1192.	903.	864.	704.	663.	281.	273.
NOV	8.98	11.26	11.79	245.85	1505.	3658.	0.	1434.	985.	929.	541.	521.
DEC	3.94	9.65	7.58	254.01	1721.	7092.	0.	2448.	1651.	1542.	985.	960.
ANNUAL	14.72	11.80	14.67		16955.	32190.	24605.	17857.	14295.	12531.	8597.	6437.
ANNUAL COP								1.15	1.43	1.63	2.38	3.18

SYSTEMS FIRST COSTS

		COST, $						
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	434.	2885.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	534.	3425.
	ACES SYSTEMS, INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 14 P(M2)= 15	2650.	1483.	1267.	480.	240.	889.	434.	7442.
5	FULL,BR.CHILL, BIN(M3)= 76 P(M2)= 0	2650.	3623.	0.	480.	240.	889.	434.	8316.

COMPARATIVE SYSTEMS COSTS

		MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERIOD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	542.13	REF.	REF.	REF.	8898.	12487.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	434.00	108.13	0.7	1	7124.	12019.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	380.45	161.68	3.8	2	6245.	11927.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 14	1929.	261.01	281.12	16.5	4	4284.	13656.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 76	1929.	195.44	346.69	15.9	3	3208.	13453.	4

6.1.2 Systems First Costs

The computer printout table summarizes the installed costs of the HVAC systems obtained by the procedures described in Sect. 4 of this report. The costs listed in the tables are for systems having components that are properly sized to meet the design-day and annual loads of the reference house at the particular climatic location. The tables also list the required sizes of the ice storage bin and solar collector panel for the ACES. The total cost of each system is comprised of seven items that are specifically enumerated in the tables. In the case of components constructed on site—such as air ducts, ice bins, and solar collector panels—the listed costs include necessary expenditures for both materials and labor. The listed costs for factory-built components, such as water heaters, heat pumps, fan units, etc., are the purchase prices of the components. The cost of installing these components is estimated separately for each item and summed to obtain an overall installation cost.

6.1.3 Comparative Systems Costs

The computer printout tables also summarize the comparative costs of owning and operating each of the five HVAC systems of this study over a 20-year time period. For each system the table lists the present worth of the maintenance costs, first-year power costs, first-year power savings with respect to the reference system (system 1), simple payback period, simple payback ranking of the systems, present worth of power costs, life-cycle cost, and life-cycle ranking. The present value of the power costs over the 20-year study period is based on actual power costs for the particular city, which are discounted and summed as described in Sect. 5.1. A present worth factor of 16.41, corresponding to a true annual rate of return of 1.96%, is assumed for this purpose. The present worth of maintenance costs for each system is computed in a similar manner using the maintenance cost schedules presented in Sect. 4.

6.2 Systems Evaluation Results for the Reference House in Knoxville, Tennessee

The results of the evaluation of the five HVAC systems for the reference house located in Knoxville, Tennessee, are discussed here to illustrate the use and interpretation of data listed in the computer output tables of Appendix D. Because the primary objective of this report is to develop necessary information for assessing the relative efficiencies and costs of the different HVAC systems in different geographical locations, the computer output tables list four important parameters for characterizing each system. These parameters are the annual coefficient of performance, system first cost, first-year power cost, and life-cycle cost. The annual coefficient of performance characterizes the efficiency or the technological performance of the system. The system first cost, together with the first-year power cost, is used to estimate simple payback periods and life-cycle costs, indices commonly used to compare the economics of different systems.

6.2.1 Annual Coefficients of Performance

Table 30 shows that the reference house in Knoxville requires energy deliveries of 16,955, 32,190, and 24,605 MJ annually for water heating, space heating, and space cooling, respectively. This amounts to a total annual requirement of 73,750 MJ (20,486 kWh) for delivered energy services. The annual consumption of electricity by system 1, while providing these services to the house, is listed in the table as 17,857 kWh. Hence, for each purchased unit of electricity, system 1 is able to deliver 1.15 units of energy to the house. Stated differently, the annual COP of the electric resistance heating and central air conditioning system is 1.15. Computed in this manner, the annual coefficients of the five systems are found to be 1.15, 1.43, 1.63, 2.38, and 3.18. From an engineering

viewpoint, system 5 is the most efficient of the five systems, because it is able to deliver 3.18 kWh of energy services to the house for each kilowatt-hour of electricity consumed. Thus, the annual coefficient of performance concisely quantifies the efficiency or level of performance of a system.

6.2.2 Systems First Costs

Each of the five HVAC systems must be designed to have the capability of delivering the required annual and design-day heating and cooling loads to the reference house located in Knoxville. It is shown in Table 30 that the full ACES, which was found to be the most efficient system, is also the most expensive system in terms of first costs. The question then arises as to whether the savings in operating costs of the full ACES over its anticipated lifetime are sufficiently large to justify its incremental first costs. The answer to this question may be determined by calculating the life-cycle cost of the system based on its anticipated first-year power costs.

6.2.3 First-Year Power Costs

The first-year power cost of each system is obtained by multiplying its annual consumption of electricity by the electric power rate prevailing in the given location. For Knoxville, which has an average residential power rate of \$0.03/kWh, the first-year power costs of the five systems are found to be \$542.14, \$434.00, \$380.44, \$261.00, and \$195.43, respectively. The power costs of the systems for subsequent years are assumed to increase with the general rate of inflation. The first-year power costs are now used to compute the simple payback periods and life-cycle costs of the systems.

6.2.4 Life-Cycle Costs

The life-cycle costs of the five HVAC systems of this study, as designed to meet the needs of the reference house in Knoxville, Tennessee, are calculated by the methods described in Sect. 5 and are based on the assumptions and economic parameters listed in Table 29. The life-cycle cost relationship given in Eq. (22) can be rewritten as

$$LCC(N) = C + pwf(R_T, N)[M(R_T, N) + P_P(0)] , \tag{24}$$

where $M(R_T, N)$ represents the levelized annual maintenance cost of the system and the other variables and functions are as defined previously. Table 31 illustrates the computation of life-cycle costs for the HVAC systems at Knoxville, Tennessee.

Table 31. Life-cycle costs of HVAC systems located in Knoxville, Tennessee[a]

System No.	Initial cost, C (\$)	Levelized operating costs		Life-cycle cost, $LCC(N)$ (\$)
		Maintenance, $M(R_T, N)$ (\$)	Power, $P_P(0)$ (\$)	
1	2,813	47.27	542.14	12,487
2	2,885	122.43	434.00	12,018
3	3,425	137.53	380.44	11,927
4	7,442	117.56	261.00	13,656
5	8,316	117.56	195.43	13,453

[a]Assumed parameters: $N = 20$ years; $r_i = 1.96\%$; $pwf(N, R_T) = 16.413$.

The results listed in Table 31 show that, for an assumed value of $r_t = 1.96\%$, system 3 exhibits the lowest life-cycle cost of the five HVAC systems. It is of interest to determine how sensitive life-cycle costs are to the value selected for r_t. Varying r_t to reflect different economic positions of potential buyers will change the present worth factor and the levelized maintenance costs used in Eq. (24). The levelized annual maintenance costs are calculated from the relation

$$M(R_T, N) = \sum_{k=1}^{N} P_m(k)(R_T)^k / pwf(R_T, N) , \tag{25}$$

where $pwf(R_T, N)$ is given by Eq. (6), R_T by Eq. (19), and values of $P_m(k)$ are obtained from the maintenance cost schedules listed in Sect. 4. Table 32 lists the values of $M(R_T, N)$ and $pwf(R_T, N)$ obtained using different values of r_t.

Table 32. Levelized annual maintenance costs of the HVAC systems

r_t	$pwf(R_T, N)$	Levelized annual maintenance costs ($)				
		System 1	System 2	System 3	System 4	System 5
0.1943	5.0	31.60	81.88	91.89	89.82	89.82
0.0776	10.0	41.85	108.88	122.42	109.61	109.61
0.0291	15.0	46.41	120.37	135.23	116.48	116.48
0	20.0	49.00	126.50	142.00	119.50	119.50
−0.0204	25.0	50.72	130.32	146.20	121.07	121.07
−0.0359	30.0	51.94	132.87	148.97	121.90	121.90
−0.0483	35.0	52.85	134.63	150.89	122.32	122.32
−0.0673	40.0	53.50	135.75	152.09	122.36	122.36

The life-cycle costs of the five HVAC systems can be computed for different values of r_t by using Eq. (24) and the levelized annual maintenance costs listed in Table 32. When this is done for the Knoxville, Tennessee, example, the results shown in Fig. 14 are obtained. The figure illustrates the dependence of computed life-cycle costs on the present worth factor that is assumed applicable for a given buyer and shows how the selection of the optimal system will vary for individual buyers. As discussed in Sect. 5.3, each prospective buyer of an HVAC system should examine the alternative investment opportunities available to him and his own views of the economic future to determine the present worth factor that is applicable in his situation. The nomogram in Fig. 13 provides a rapid, convenient method of determining the true rate of return and present worth factor to be used for a given investor.

Consider, for example, a buyer who must pay a 40% income tax rate on earned interest and who has available investment opportunities paying an annual, before-tax rate of return to capital of 13%. If he believes that the annual long-term rate of inflation will average 10%, Eqs. (19) and (6) show that he is anticipating a true annual rate of return equal to −2% and a present worth factor of 24.89. Figure 14 shows that, under these conditions, system 5 would exhibit the lowest life-cycle cost of the five systems considered for the Knoxville, Tennessee, location. The true rate of return available to most small investors probably lies in the range of −2 to +2%. However, if opportunity investments paying a higher true rate of return are available or if the buyer plans to purchase the system using borrowed capital, he should select a correspondingly lower present worth factor for computing the life-cycle costs of the HVAC systems.

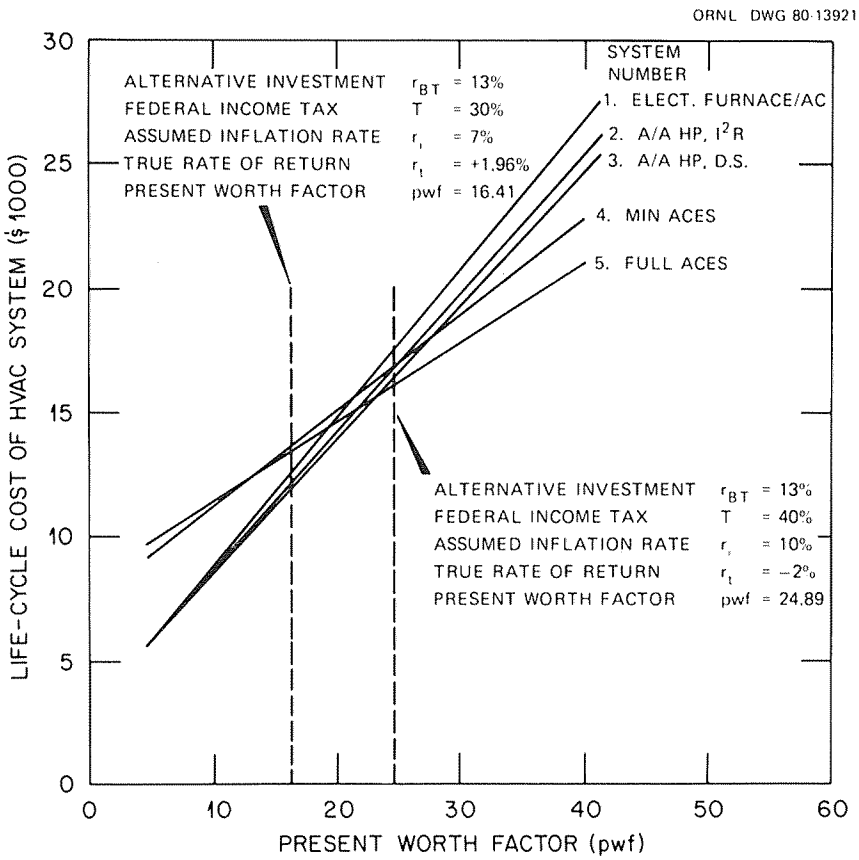

Fig. 14. Life-cycle cost of HVAC systems at Knoxville, Tennessee.

6.3 National View of the Systems Evaluation Results

This section presents the evaluation of the results for the comparison of five HVAC systems located in reference houses in 115 cities throughout the United States. For each system, the following characterization parameters are plotted on maps of the United States: annual coefficient of performance, system first cost, first-year power cost, and life-cycle cost. These maps provide a vantage point from which to discern and compare the technical-economic patterns of the HVAC systems involved. In each case, the annual coefficient of performance, or the system efficiency, is calculated for an HVAC installation that is properly designed and sized to deliver the heating and cooling loads required by the reference house in the climate of the particular location. Thus, for each city, the efficiencies of the five HVAC systems delivering identical monthly and annual loads are calculated to facilitate comparison of the systems.

The life-cycle costs of the various HVAC systems at different locations have been calculated by the procedures described in Sects. 4 and 5. The life-cycle costs presented for the energy-conserving systems 4 and 5, minimum and full ACES, are high for the following reasons:

1. The anticipated service lifetime of major components of the systems (ice storage bin and air ducts) exceeds the 20-year period of the study.
2. Finance charges, taxes, and unrecovered capital are assumed to have no impact on any system.
3. A true rate of return on alternative investments equal to + 2%, probably not achievable for many small investors, is used in determining the present worth of annual systems operating costs.

Using the methods described in this report, the reader may alter any or all of these assumptions, according to his judgment, to obtain new life-cycle costs.

6.3.1 Regional Variations in Systems Efficiencies

Annual coefficients of performance for five HVAC systems assumed to be operating in 115 U.S. cities are given in Figs. 15 through 19. The degree of efficiency or potential for energy conservation of systems 1 through 5 is seen to increase in that order. The conventional home heating and cooling plants, systems 1 and 2, are seen to be more efficient in the southern regions of the country than in the northern ones. The same is true for the air-to-air heat pump with a desuperheater for water heating (system 3). In the Deep South, the conventional air-to-air heat pump with electric resistance water heating (system 2) offers very little performance advantage over an electric resistance heating system that has a central air conditioner for cooling (system 1). System 3, however, which is now beginning to appear on the market, offers distinct performance advantages over the conventional systems 1 and 2.

System 5, the full ACES, exhibits the highest efficiencies in a broad area spanning the central United States, with slightly lower efficiencies in both northern and southern regions. The high efficiencies of the ACES in the central region occur because of the better balance between annual heating and cooling requirements of the reference house; this enables the system to effect interseasonal energy transfer to a greater degree. The full ACES offers significant performance advantages over all the other systems in reference houses throughout the country, with the exception of the Deep South. In the Deep South, annual cooling requirements of the building predominate over annual heating requirements so that the system is able to effect little or no interseasonal energy transfer.

6.3.2 Regional Variations in Systems First Costs

The installed costs of the five HVAC systems of this study are shown in Figs. 20 through 24 for 115 U.S. cities. It should be noted that the variation in the initial costs of the systems is caused by the different sizes of components required to match each system to the house energy needs, as affected by the climate of a given city. Regional variations in the costs of materials and labor needed for constructing the systems are not taken into account. It is apparent from Figs. 20, 21, and 22 that the initial costs of systems 1, 2, and 3 are relatively constant across the country. For these three systems, the increment in initial cost that is required to purchase the next most efficient system increases progressively. The initial cost of any of these three systems is seen to be substantially less than that of either a minimum or a full ACES.

The initial costs of the minimum and full ACES are shown in Figs. 23 and 24, respectively. Generally, it is seen that the initial cost of the ACES decreases with the latitude of the city in which it is located. In the minimum ACES design, an attempt is made to reduce initial costs even though some performance degradation results with respect to the full ACES. From Figs. 23 and 24 it is seen that in many regions of the country only minimal initial cost savings are achieved. In such regions the minimum ACES does not represent a viable option and only the full ACES should be considered. It should be noted that in the ACES initial costs maps (Figs. 23 and 24), several northern cities have been eliminated from the set of 115 cities considered previously. These cities represent areas where the minimum and full ACES designs are considered to be impractical because of the requirement for excessively large unglazed solar panels. Either glazed solar panels or an alternative supplementary heat source must be employed, if the ACES is to be used in these cities.

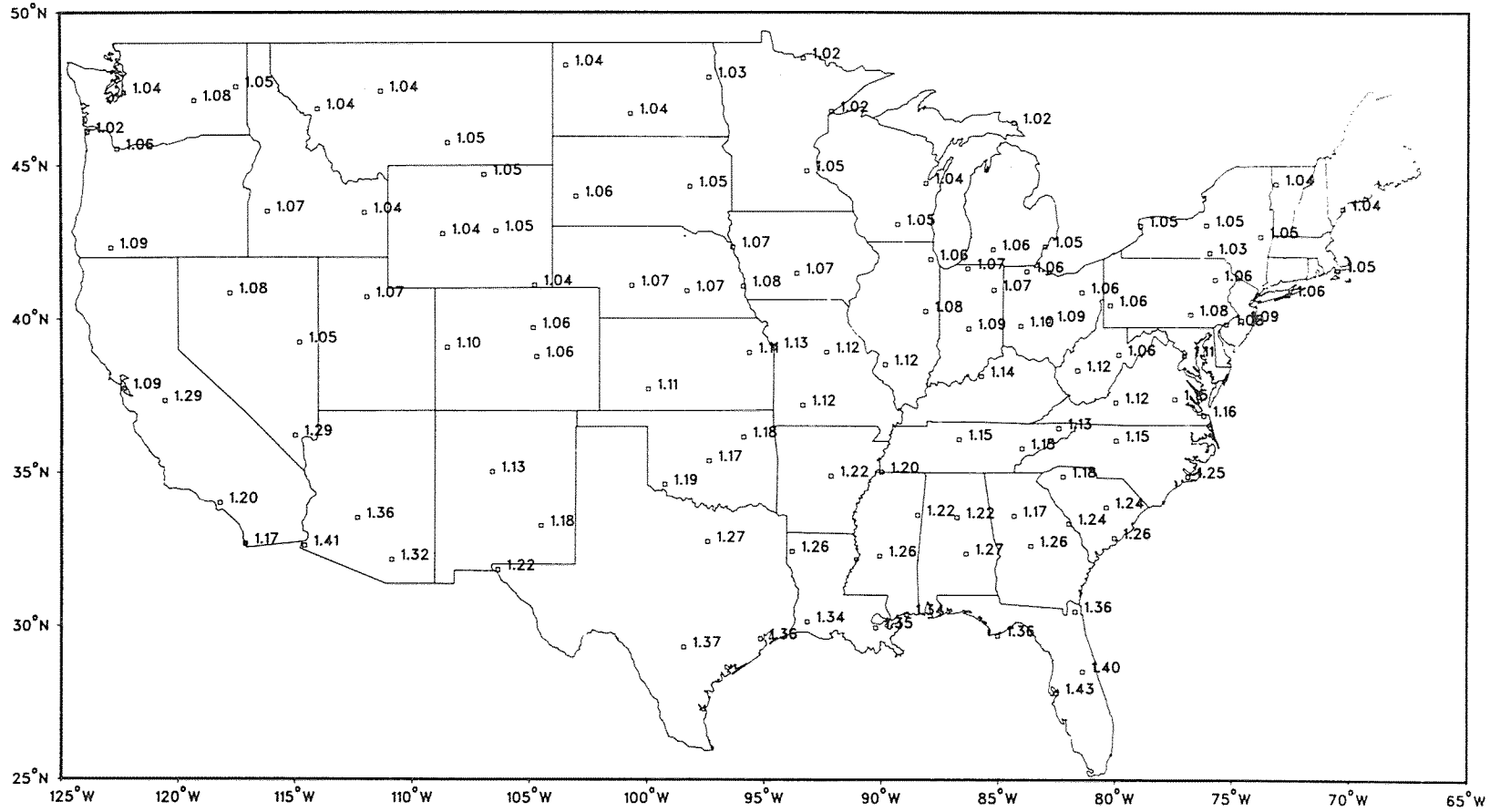

Fig. 15. Annual coefficients of performance map for system 1—electric furnace, central air conditioner, and electric resistance water heater.

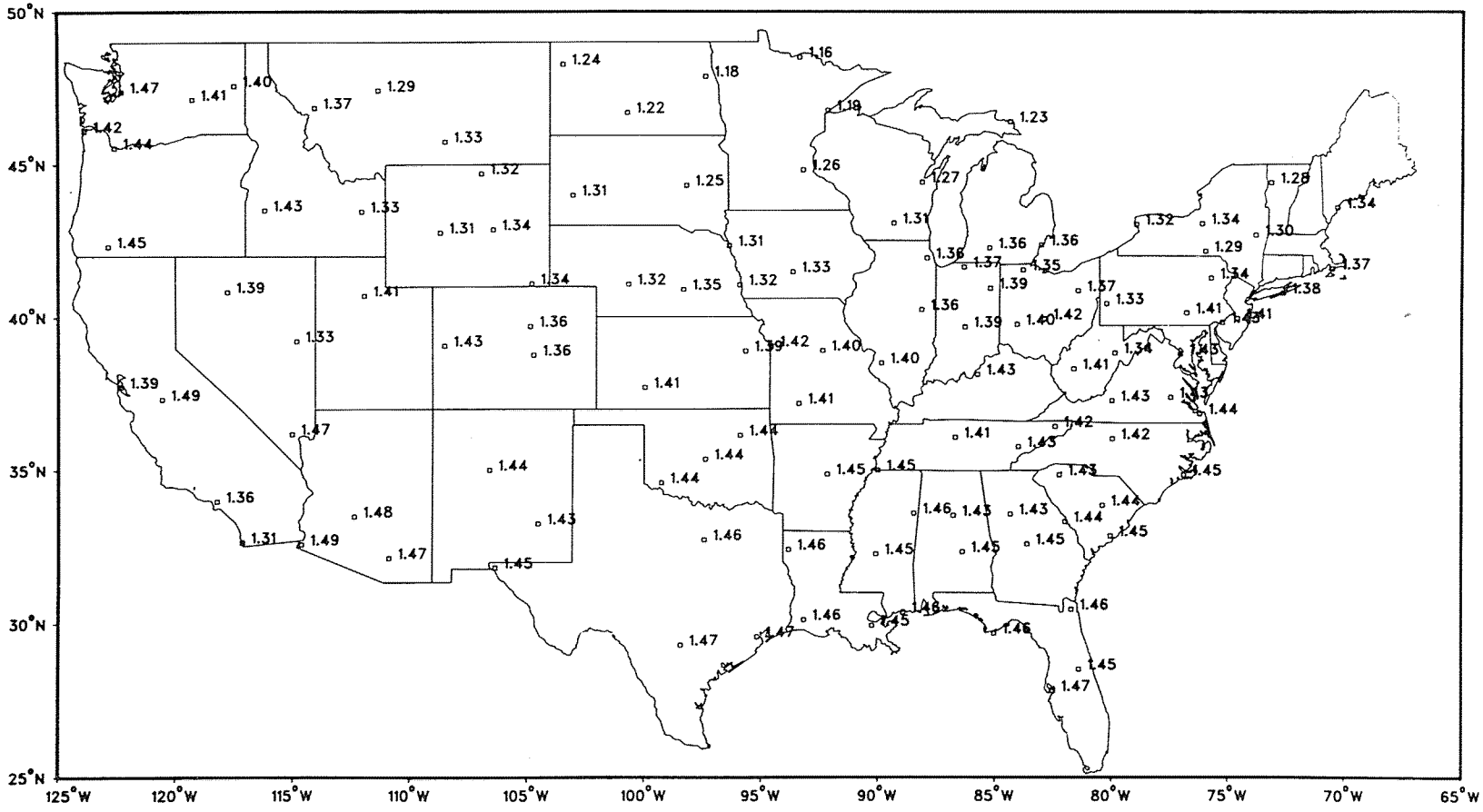

Fig. 16. Annual coefficients of performance map for system 2—high-performance, air-to-air heat pump with electric resistance water heater.

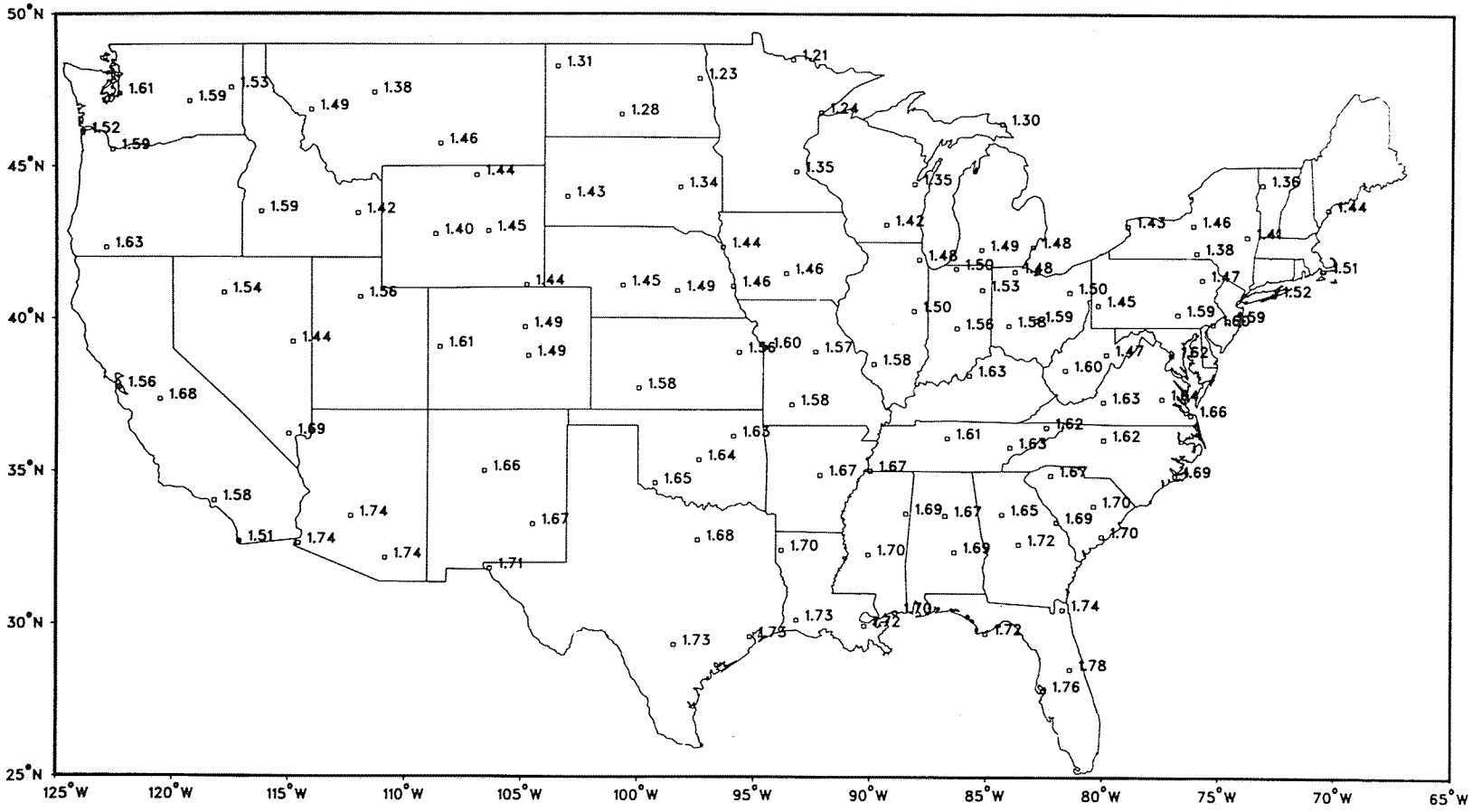

Fig. 17. Annual coefficients of performance map for system 3—high-performance, air-to-air heat pump with desuperheater water heater.

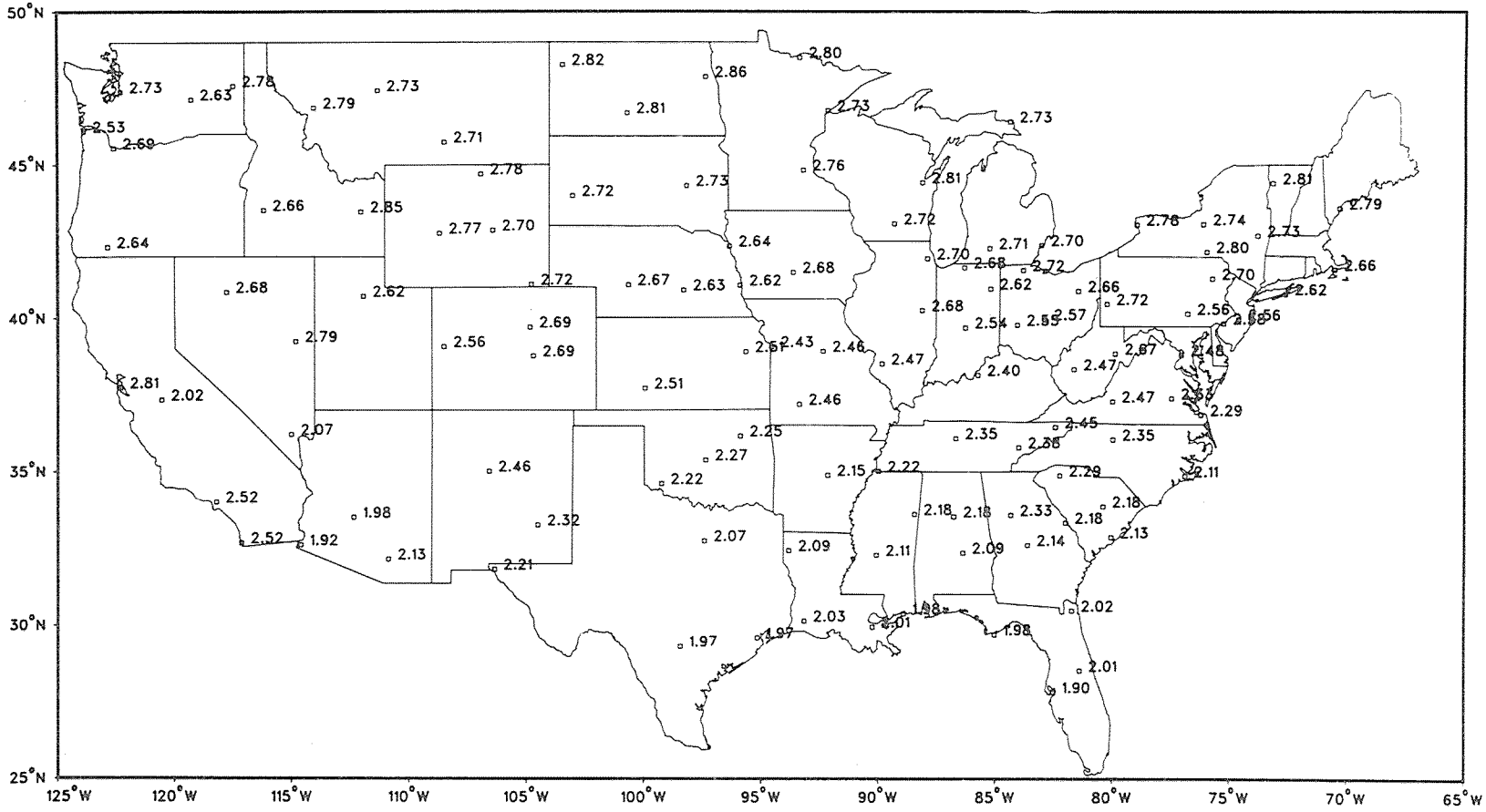

Fig. 18. Annual coefficients of performance map for system 4—brine-chiller minimum ACES.

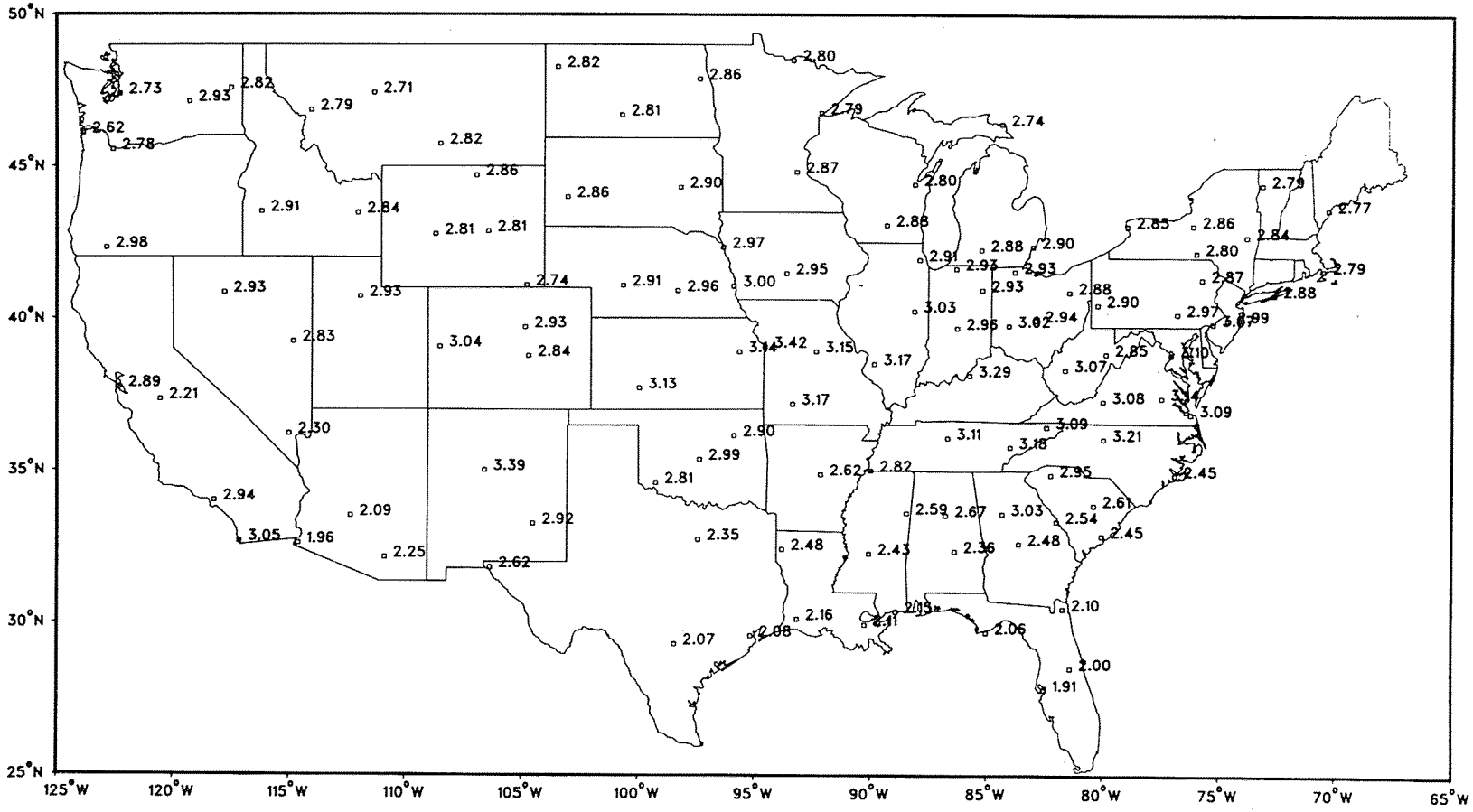

Fig. 19. Annual coefficients of performance map for system 5—brine-chiller full ACES.

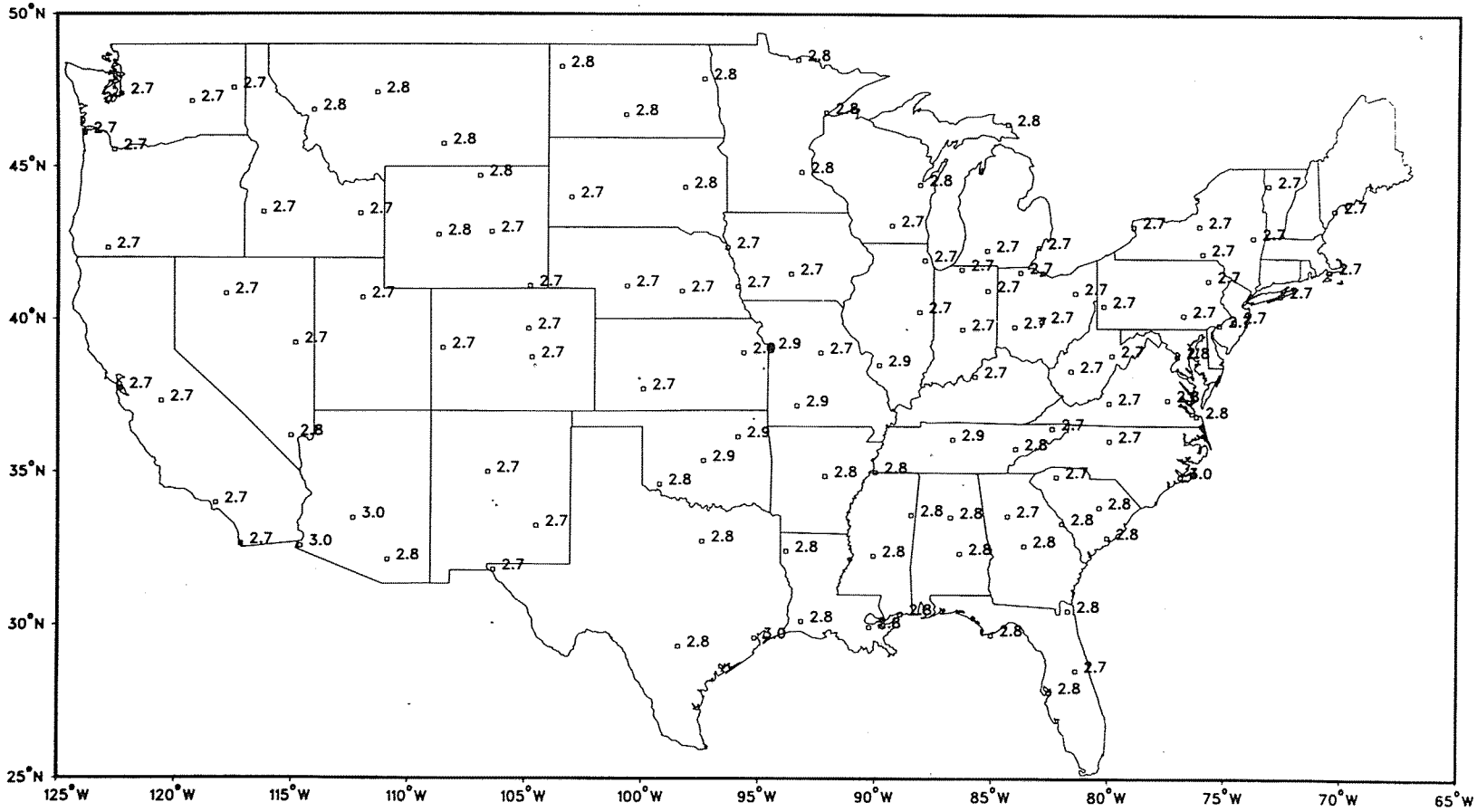

Fig. 20. Total initial costs map of system 1—electric furnace, central air conditioner, and electric resistance water heater. (Costs are in K$.)

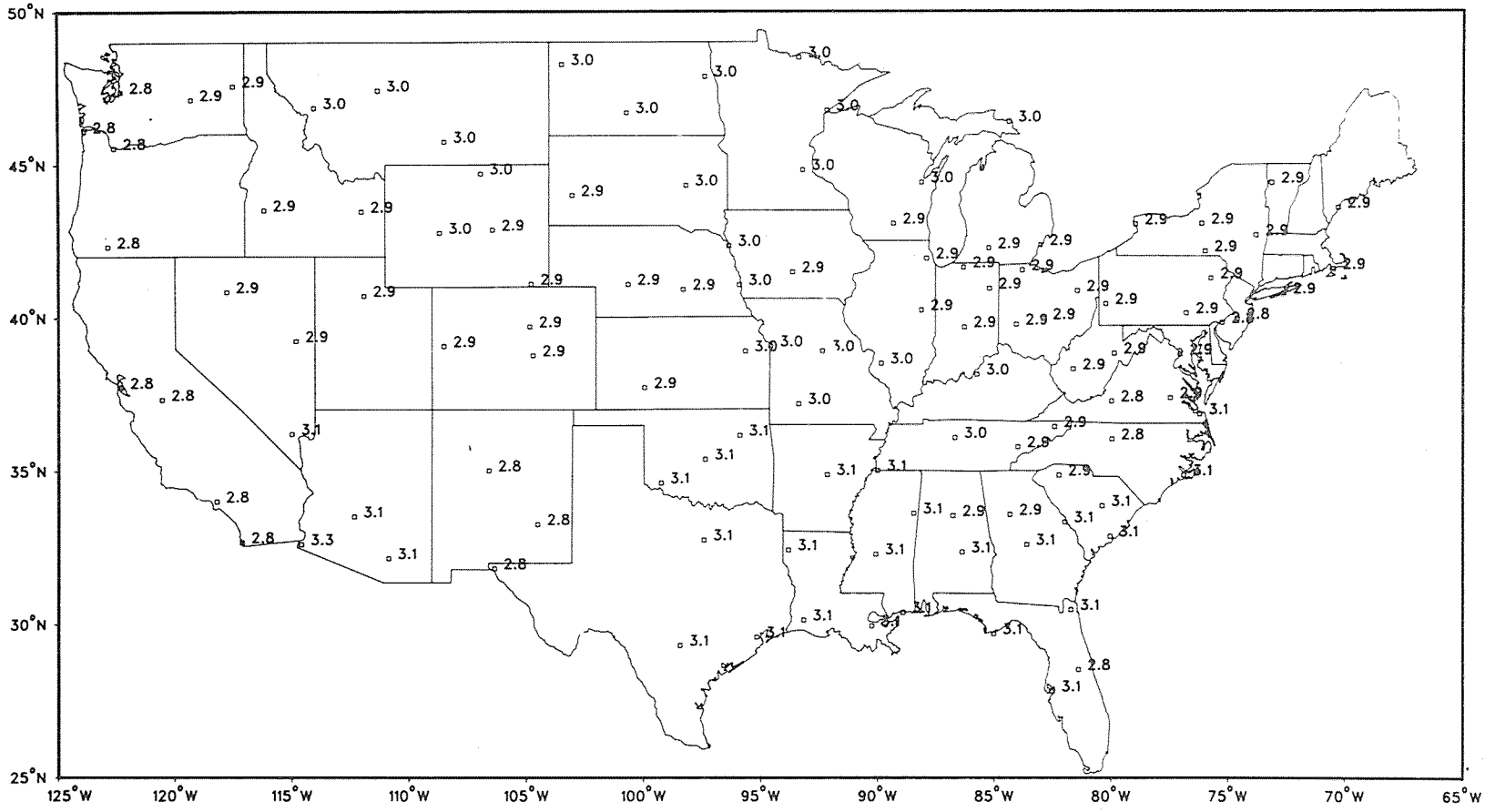

Fig. 21. Total initial costs map of system 2—high-performance, air-to-air heat pump with electric resistance water heater. (Costs are in KS.)

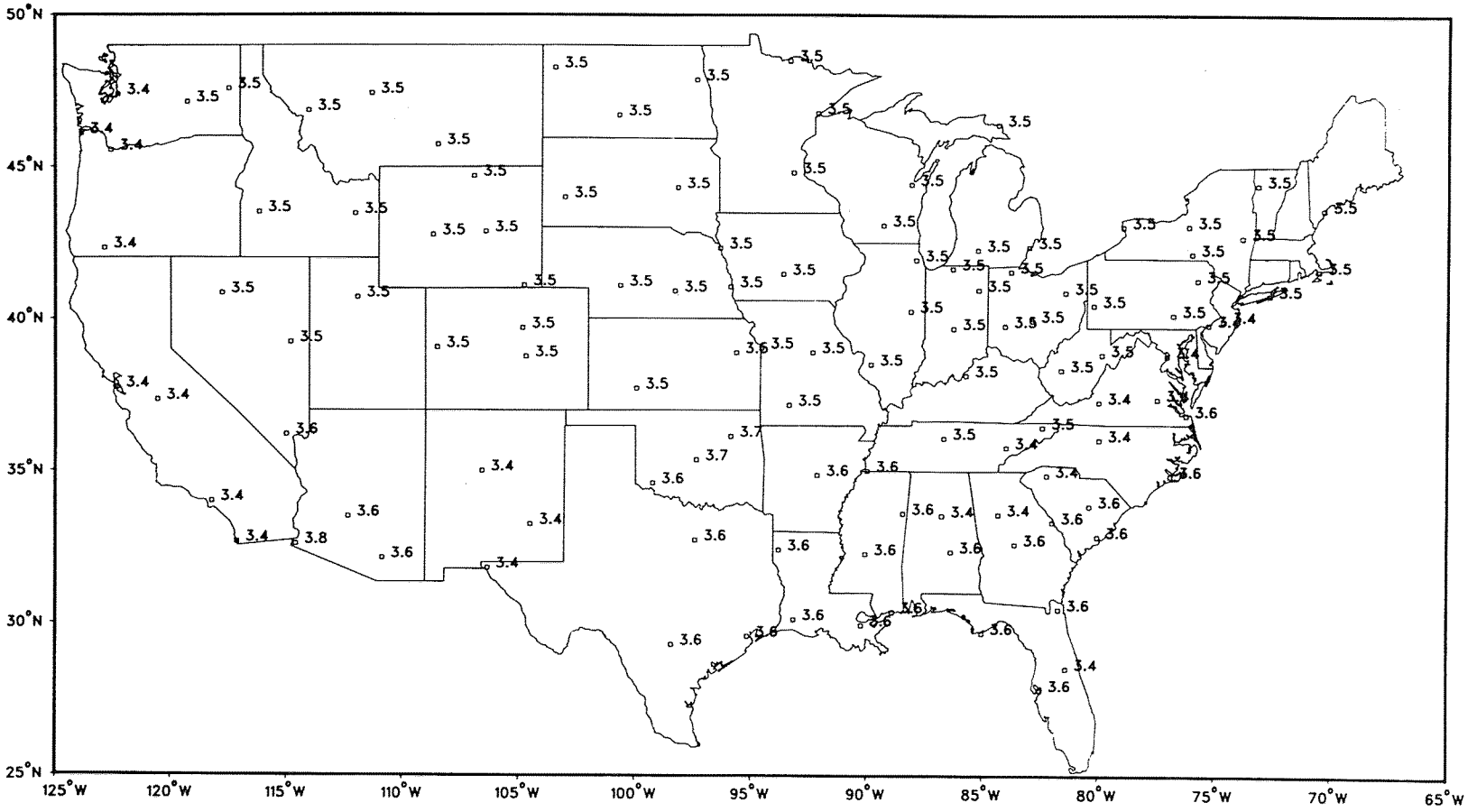

Fig. 22. Total initial costs map of system 3—high-performance, air-to-air heat pump with desuperheater water heater. (Costs are in K$.)

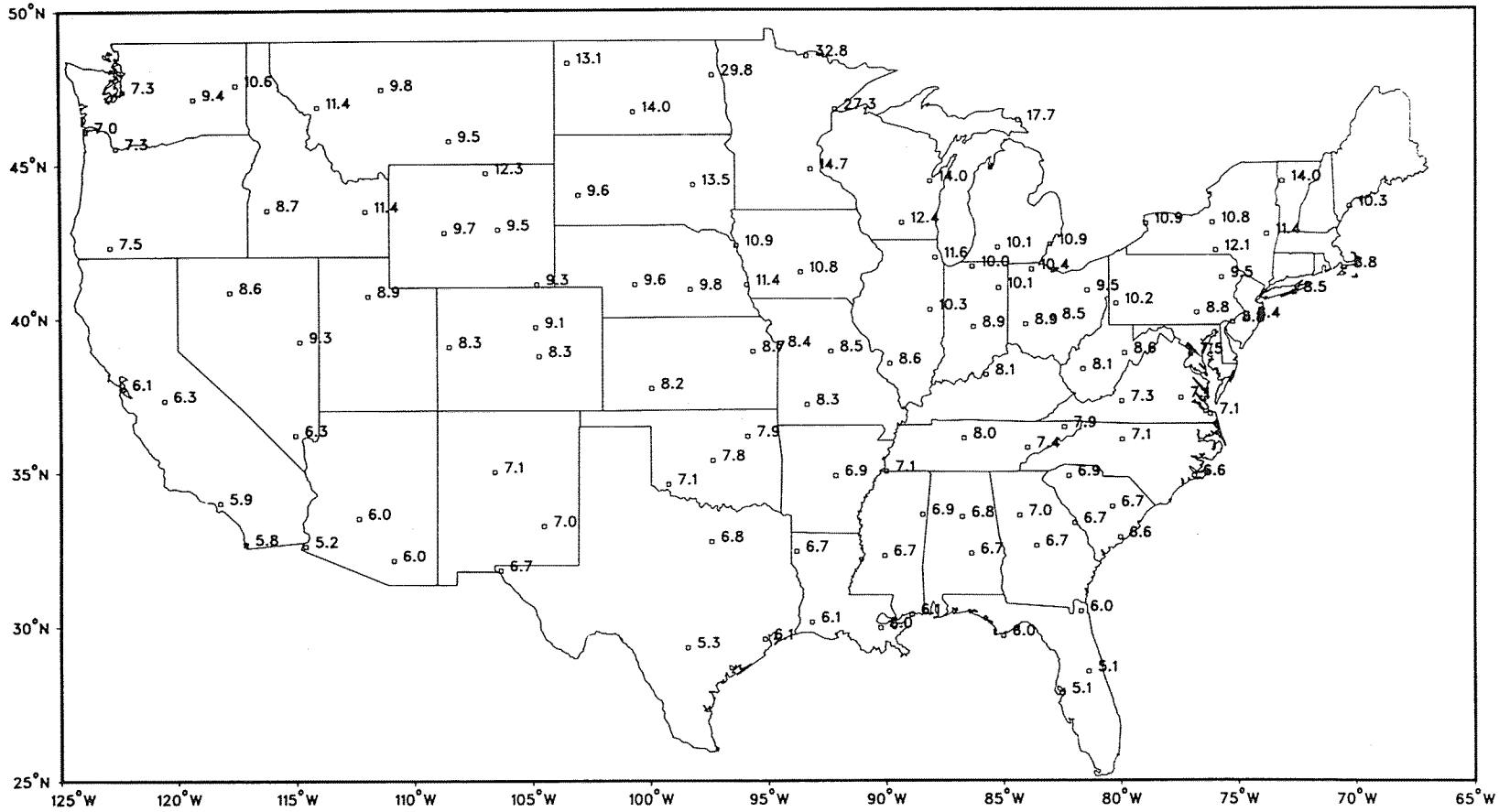

Fig. 23. Total initial costs map of system 4—brine-chiller minimum ACES. (Costs are in K$.)

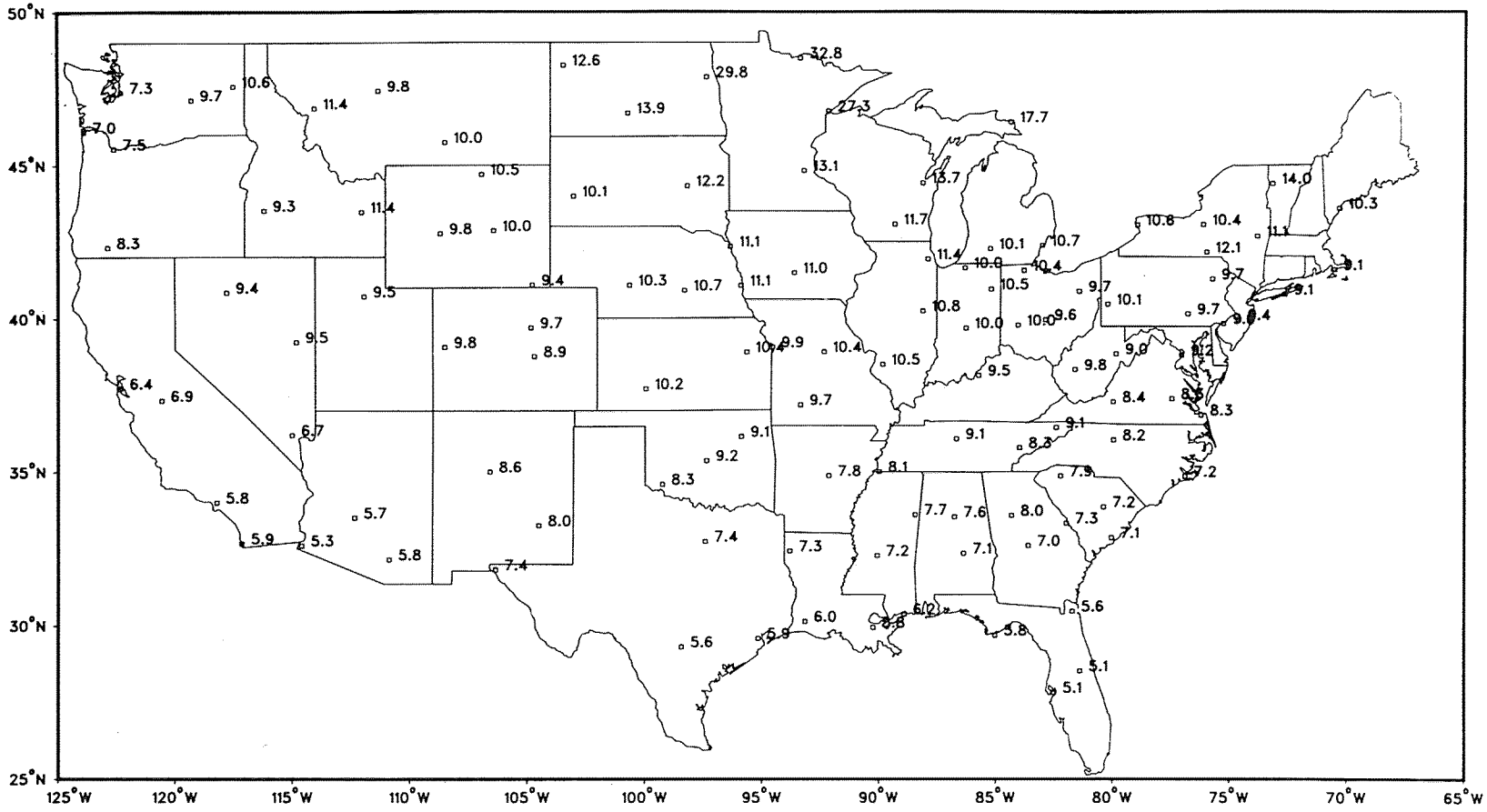

Fig. 24. Total initial costs map of system 5—brine-chiller full ACES. (Costs are in K$.)

6.3.3 Regional Variations in First-Year Power Costs

The first-year power costs of the five HVAC systems of this study are shown in Figs. 25 through 29 for 115 U.S. cities. The power costs are based on the computed annual electricity consumption of each HVAC system in a given city and the residential power rate prevailing in that city during January 1979. (Power rates and systems annual electricity consumptions for each of the 115 cities are listed in Appendix B.) The low annual power costs of systems located in the Tennessee Valley and the Pacific Northwest reflect the combined effects of mild climate and low power rates in these regions. Comparison of annual power costs for the full ACES (Fig. 29) with the annual power costs for the conventional HVAC systems shows that the ACES achieves substantial annual savings in the north-central portion of the United States. The relatively high annual power costs exhibited by all HVAC systems in this region arise from the harsher climate and higher power rates prevailing there.

6.3.4 Regional Variations in Systems Life-Cycle Costs

The life-cycle costs for the five HVAC systems in this study are shown in Figs. 30 through 34 for 115 U.S. cities. Two principal observations can be made about the results shown in the figures. First, the life-cycle costs of all systems are highest in the northern regions of the country. Second, the spread in life-cycle costs for the five HVAC systems in most cities amounts to only about 15%. That is, none of the electrically driven HVAC systems considered in this study offer a clear life-cycle economic advantage to the potential purchaser. Conversely, the results of the study also show that the ACES, with its high potential for energy conservation, does not exhibit a disadvantage in terms of life-cycle costs, even when life-cycle costs are calculated on the basis of the conservative assumptions used in the study. Using less conservative assumptions with respect to systems lifetimes, salvage values, and the present worth factor (applicable for the potential buyer) would show a clear-cut economic advantage as well as a performance advantage for ACES over the competing electrically driven systems.

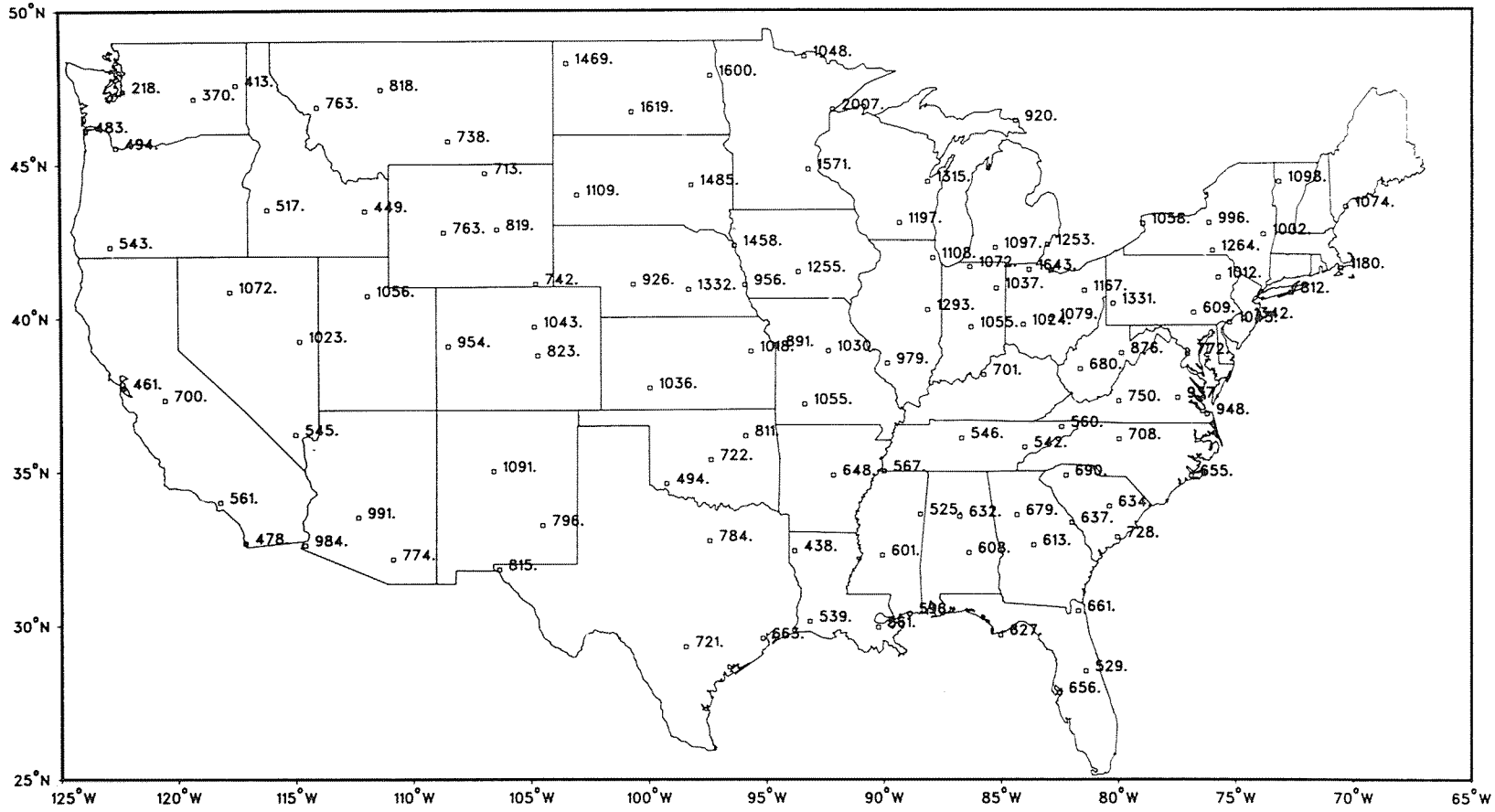

Fig. 25. First-year power costs for system 1—electric furnace, central air conditioner, and electric resistance water heater. (Costs are in $.)

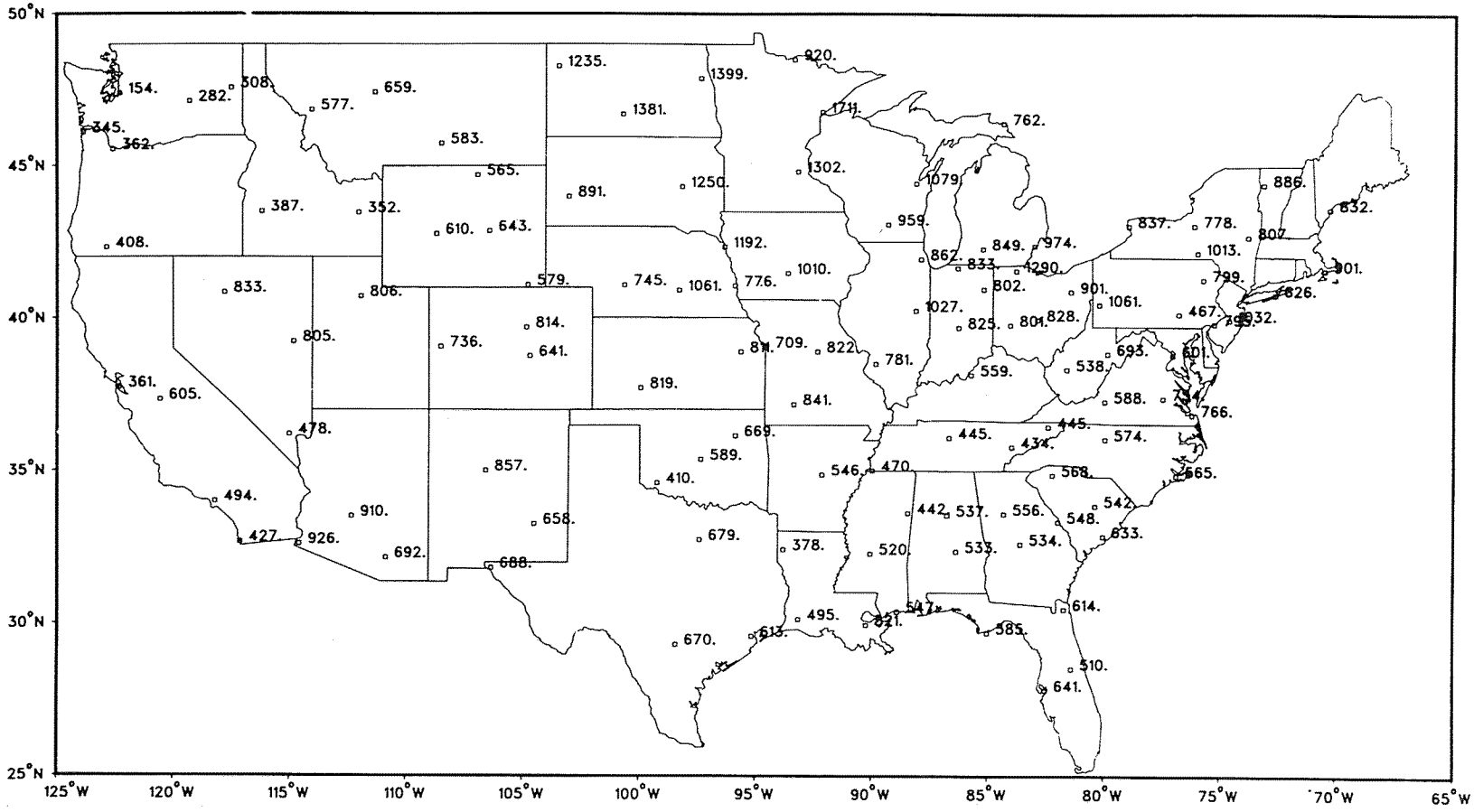

Fig. 26. First-year power costs map for system 2—high-performance, air-to-air heat pump with electric resistance water heater. (Costs are in $.)

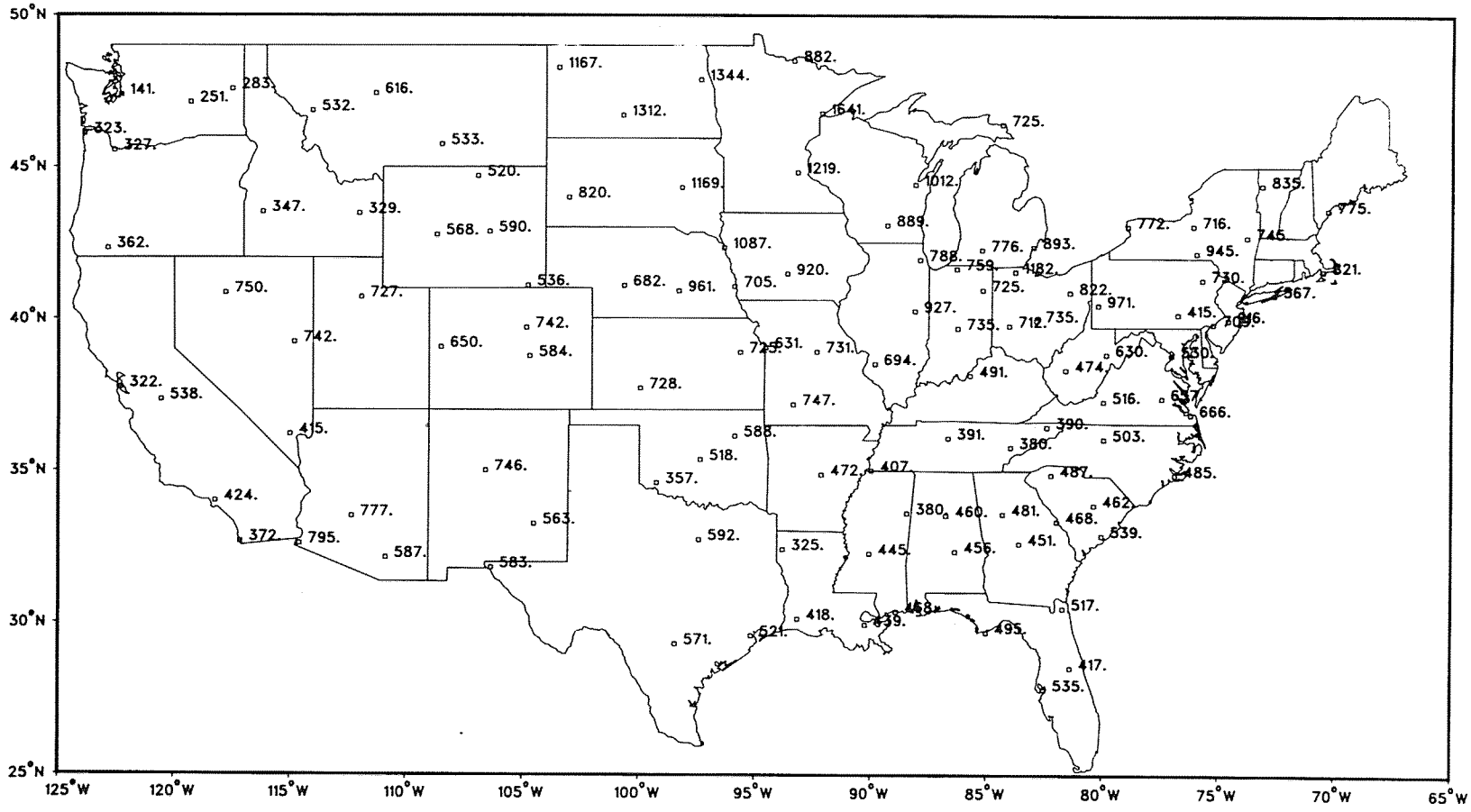

Fig. 27. First-year power costs map for system 3—high-performance, air-to-air heat pump with desuperheater water heater. (Costs are in $.)

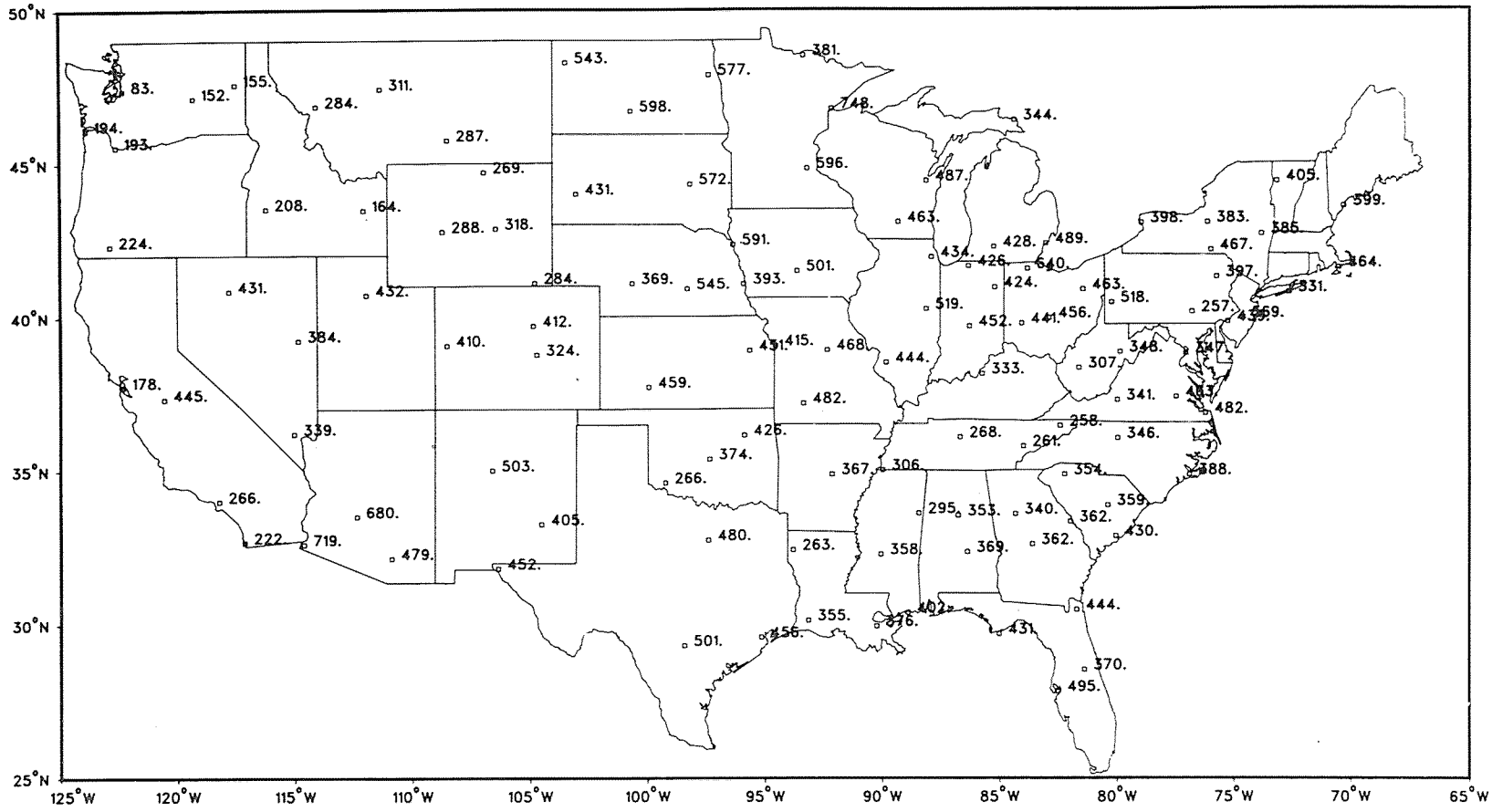

Fig. 28. First-year power costs map for system 4—brine-chiller minimum ACES. (Costs are in $.)

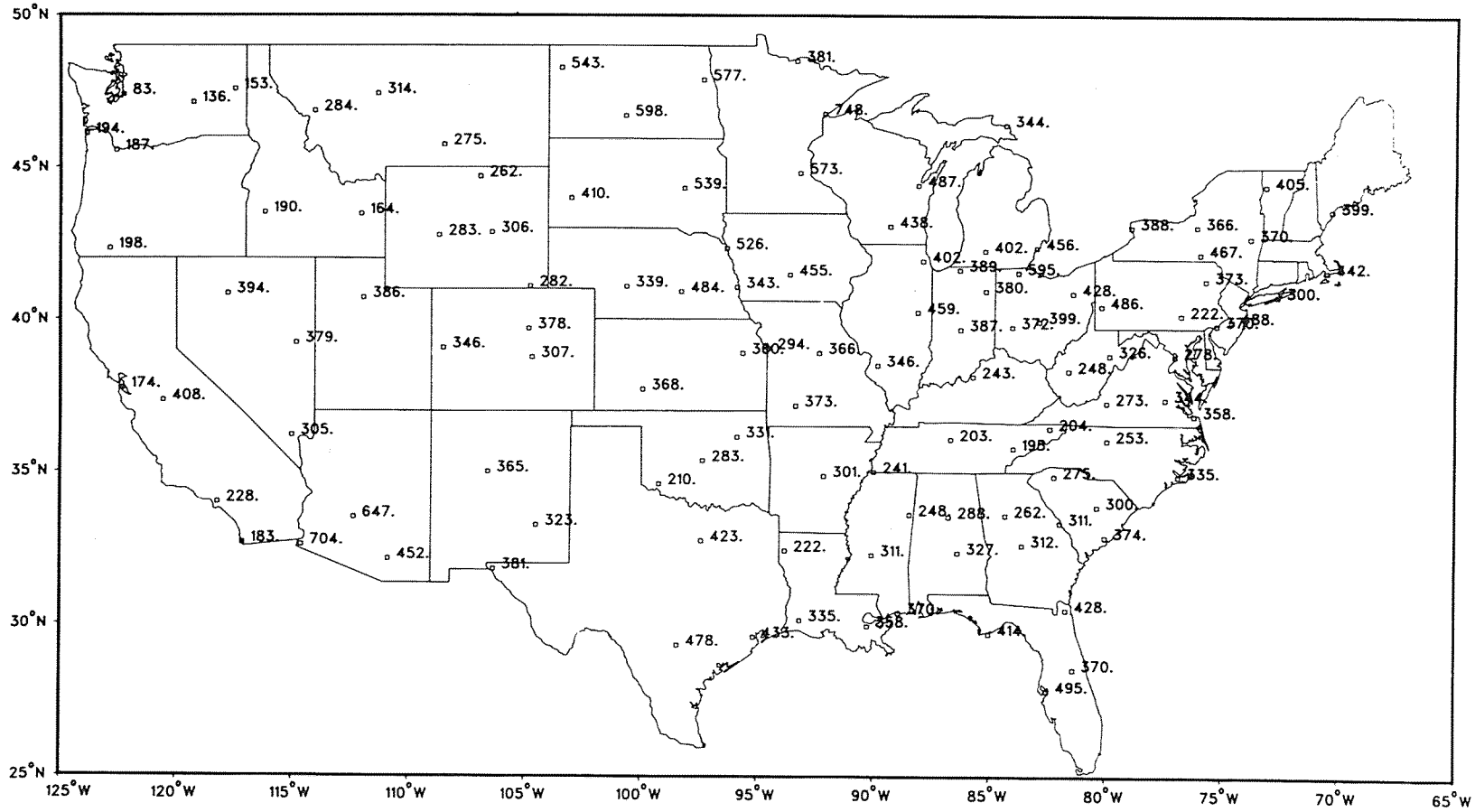

Fig. 29. First-year power costs map for system 5—brine-chiller full ACES. (Costs are in $.)

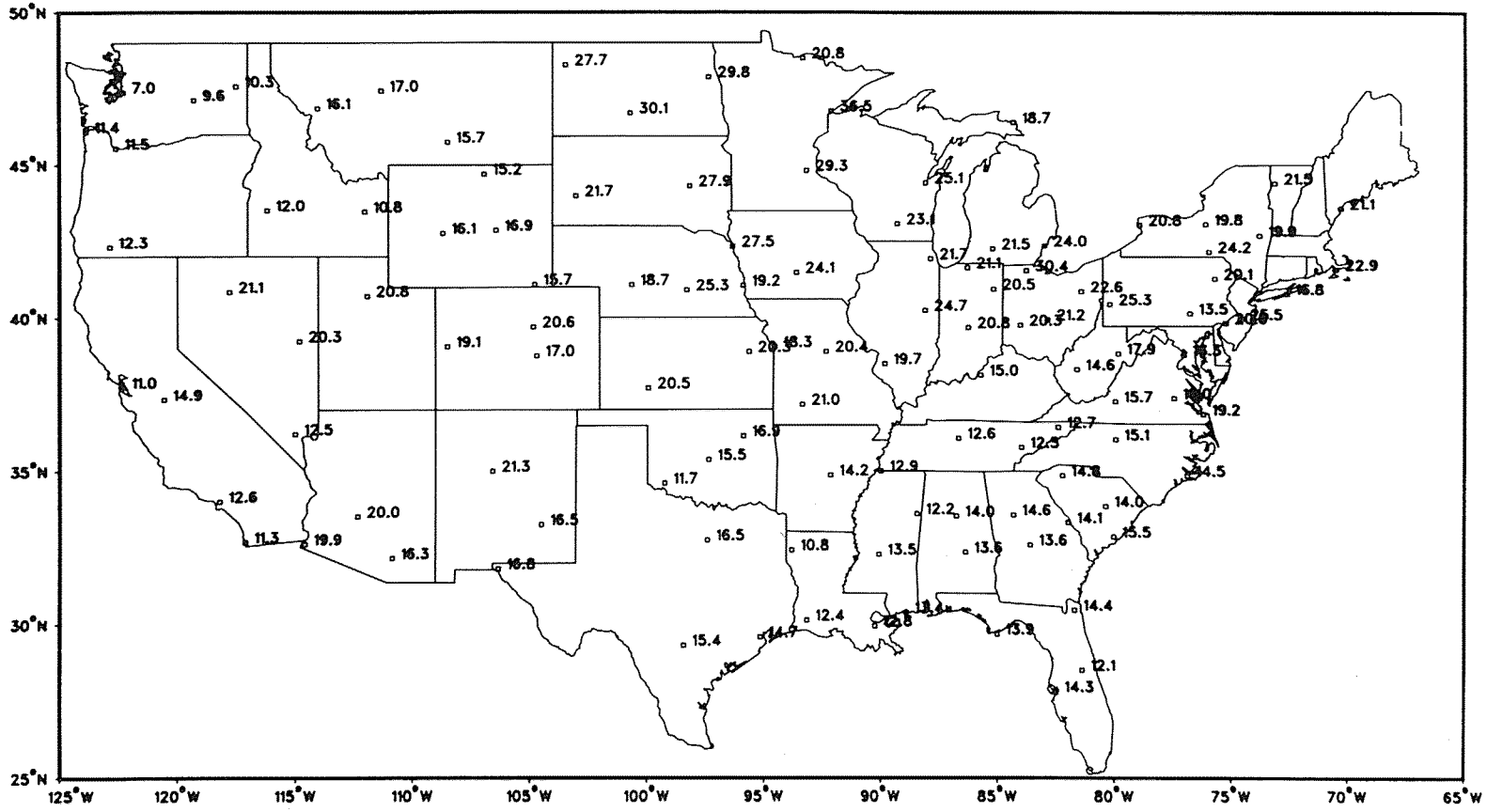

Fig. 30. Life-cycle costs map for system 1—electric furnace, central air conditioner, and electric resistance water heater. (Costs are in K$.)

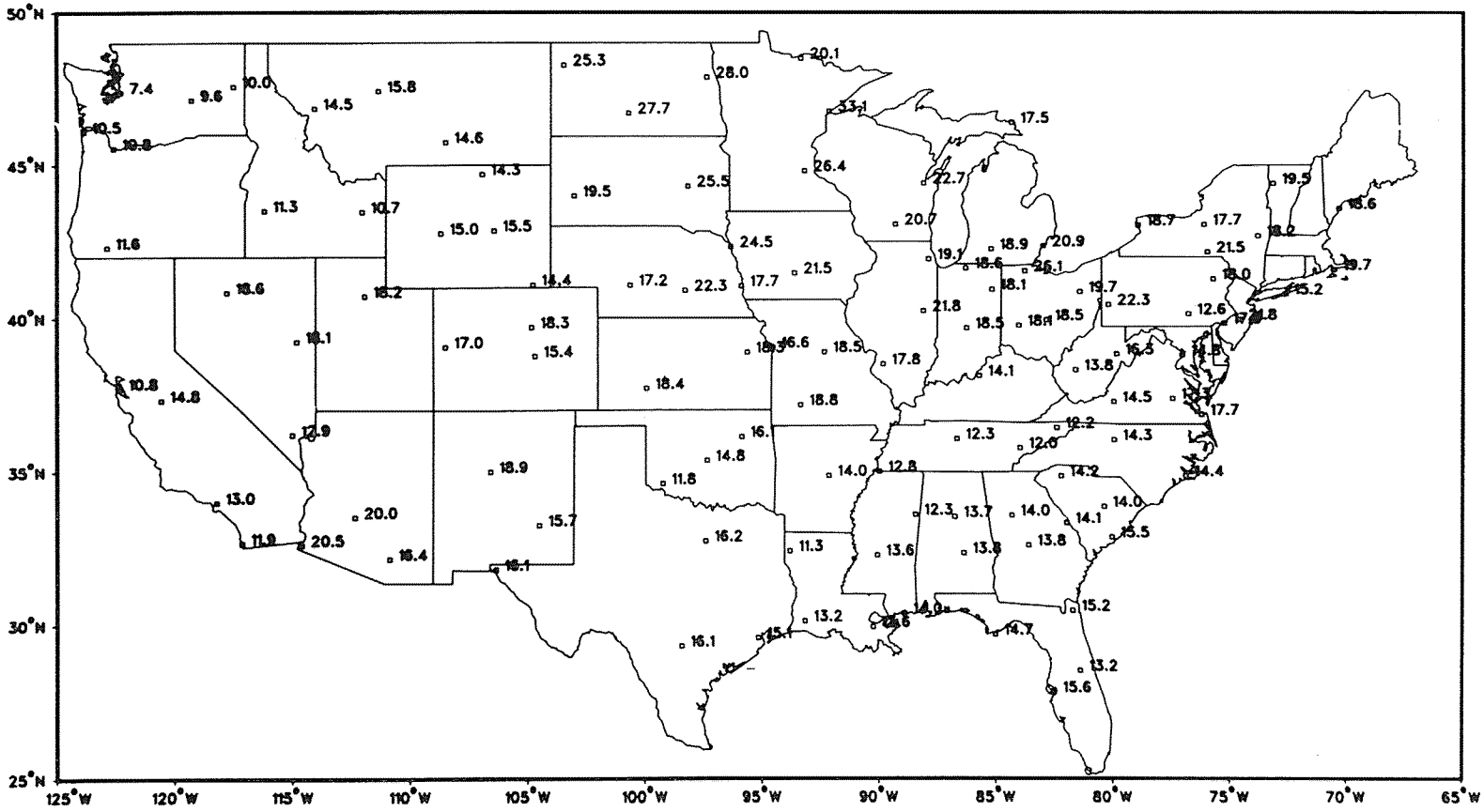

Fig. 31. Life-cycle costs map for system 2—high-performance, air-to-air heat pump with electric resistance water heater. (Costs are in K$.)

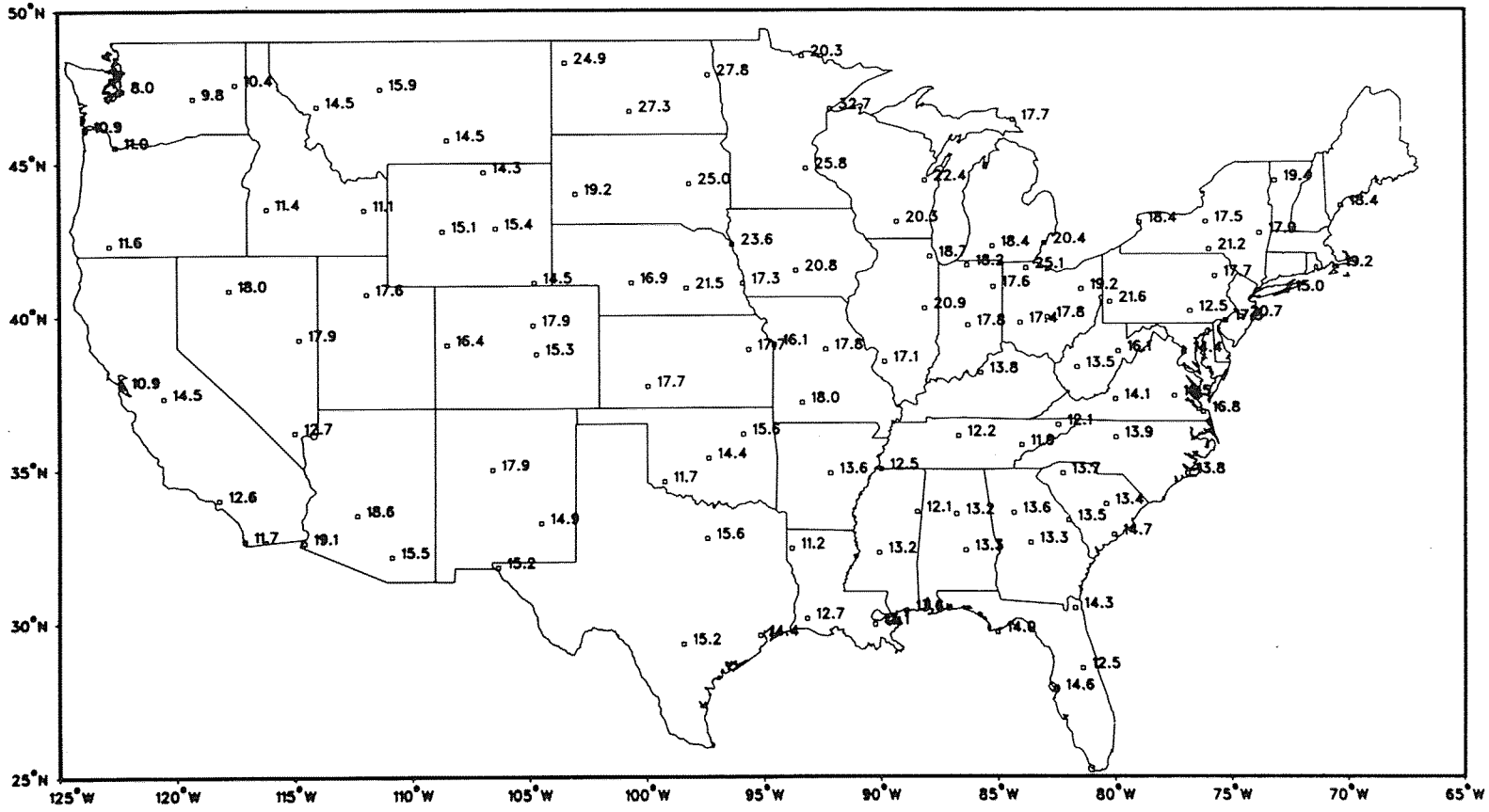

Fig. 32. Life-cycle costs map for system 3—high-performance, air-to-air heat pump with desuperheater water heater. (Costs are in KS.)

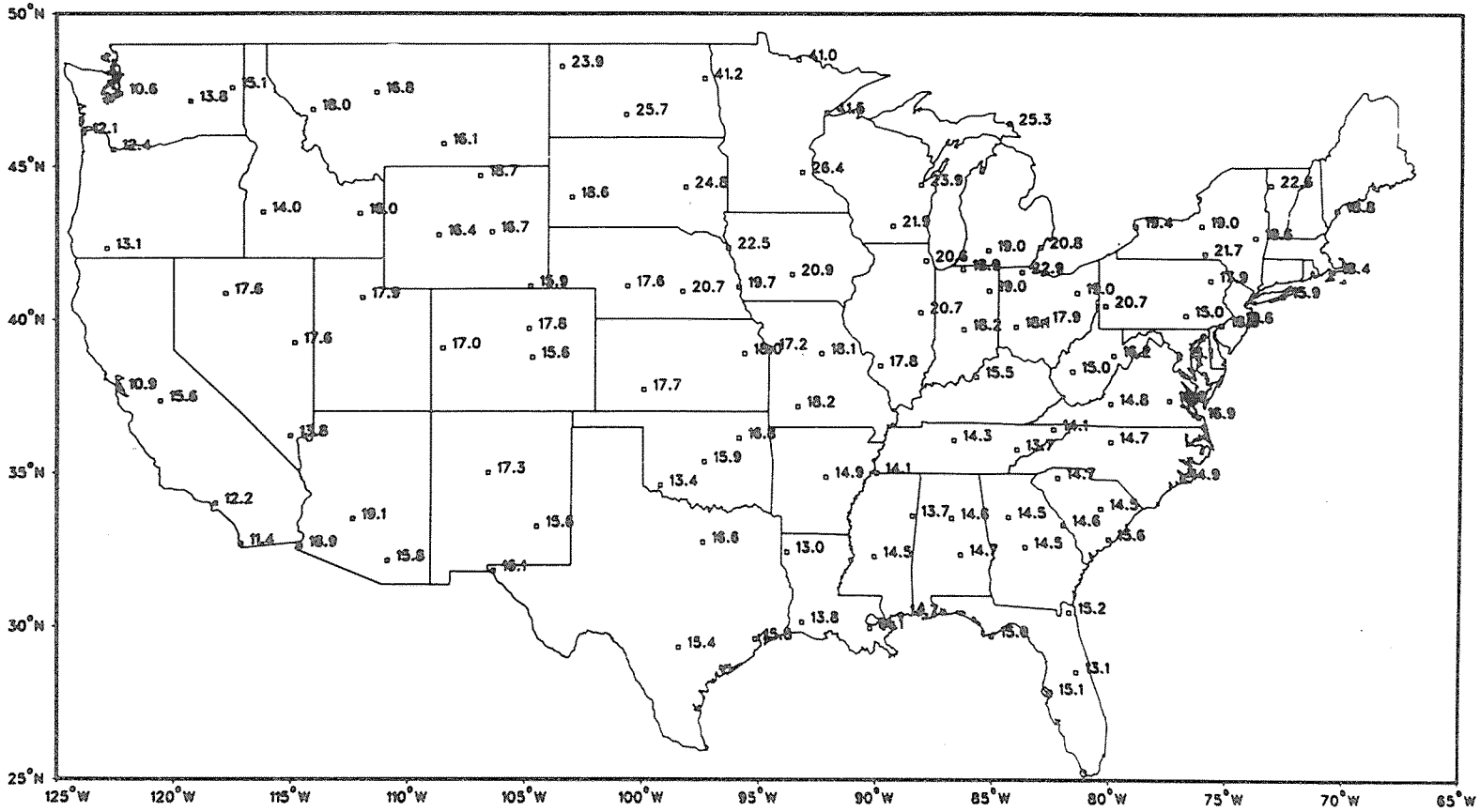

Fig. 33. Life-cycle costs map for system 4—brine-chiller minimum ACES. (Costs are in K$.)

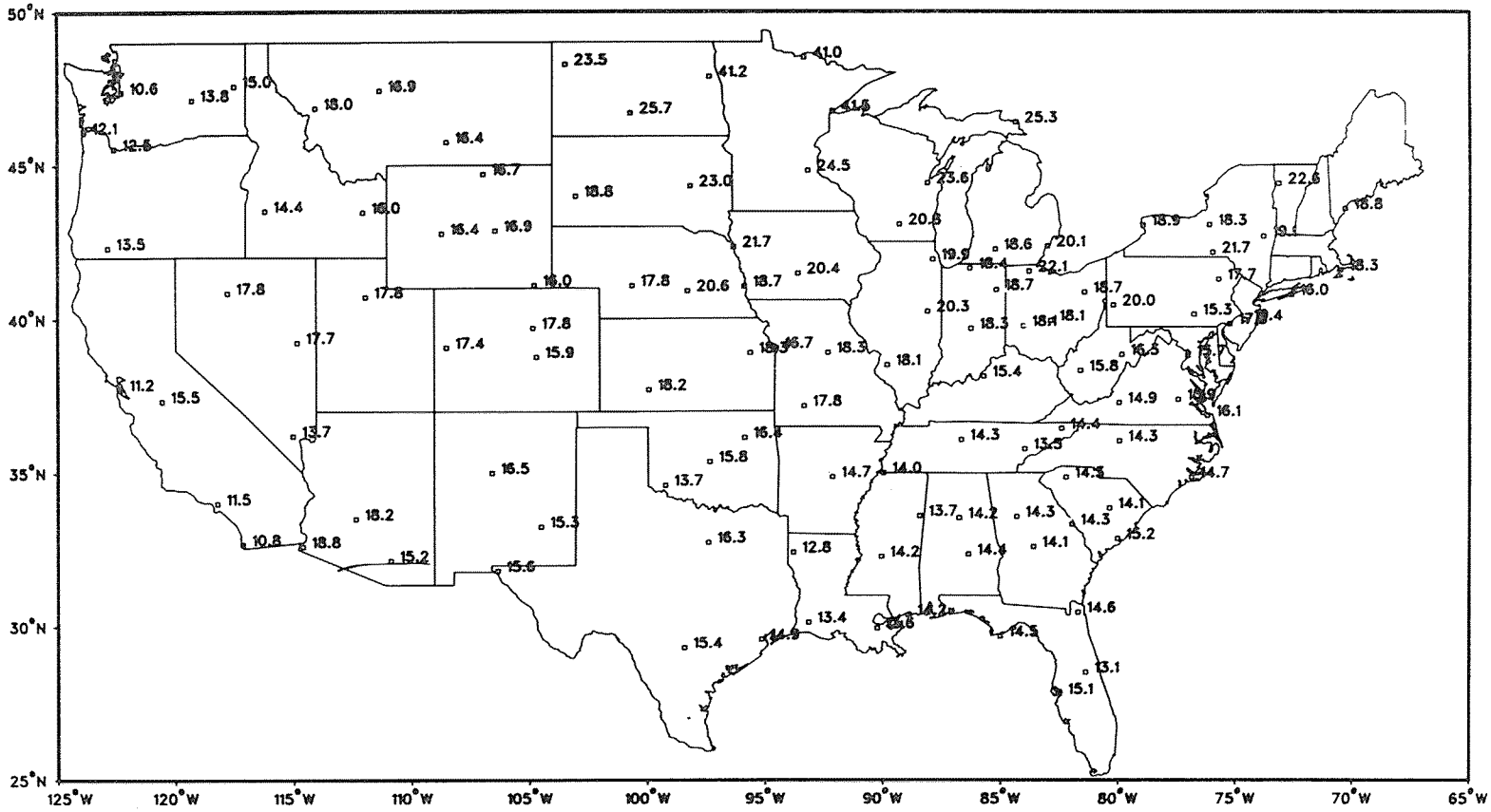

Fig. 34. Life-cycle costs map for system 5—brine-chiller full ACES. (Costs are in KS.)

7. PERFORMANCE AND ECONOMICS OF OTHER HVAC SYSTEMS

To gain a broader perspective of the efficiencies and life-cycle costs of other HVAC systems, this section considers an expanded set of systems that includes both current and future alternatives to the five systems that have been analyzed in detail in this study. The expanded set of HVAC systems includes: water-source systems, heat-actuated and absorption heat pumps, solar systems with sensible heat collection and photovoltaic energy conversion, and conventional and advanced gas furnaces with central air conditioners. The annual coefficients of performance and life-cycle costs of these systems—which supply identical annual loads of 32.19 GJ for space heating, 16.95 GJ for water heating, and 24.61 GJ for space cooling—have been estimated both for the current state of technology and for that expected by 1990. The following are brief descriptions of the HVAC systems that we have evaluated and compared:

1. electric resistance space heating and water heating system with central air conditioning,
2. air-to-air heat pump with a 2.75 ARI rating and an electric resistance water heater,
3. air-to-air heat pump with a desuperheater water heater,
4. minimum ACES—a brine-chiller type employing a small ice storage bin and solar-convector panel heat collection,
5. full ACES—a brine-chiller type with panel heat collection and a large ice storage bin to maximize interseasonal energy transfer,
6. water-source heat pump employing two wells for supply and reinjection and an electric resistance water heater,
7. water-source heat pump employing supply and reinjection wells and a desuperheater water heater,
8. water-source heat pump employing a ground heat exchanger and an electric resistance water heater,
9. water-source heat pump employing a ground heat exchanger and a desuperheater water heater,
10. multi-ACES—a brine-chiller type with diurnal hot and cold storage capability that employs the heat pump to melt excess ice,
11. conventional gas furnace with a central electric air conditioner and a gas water heater,
12. advanced gas furnace with a pulsed combustion boiler for space heating and water heating and a central electric air conditioner,
13. heat-actuated heat pump—an advanced gas-fired system employing the Stirling/Rankine cycle and a gas-fired water heater,
14. full ACES employing a Stirling/Rankine gas-fired heat pump as the prime mover,
15. absorption-type heat pump employing an organic working fluid (a gas-fired water heater is used for producing domestic hot water),
16. absorption-type heat pump employing an organic working fluid (a central electric air conditioner is used to provide space cooling, and a gas-fired water heater is used for producing domestic hot water),
17. solar—a hydronic system employing a flat-plate collector having an active area of 60 m^2 that is designed to supply 80% of the winter space- and water-heating needs of the building (the solar system is combined with a series-parallel heat pump),
18. solar—a hydronic system employing a flat-plate collector that is designed to supply 60% of the winter space- and water-heating needs of the building (the solar system is combined with a series-parallel heat pump),

19. solar—a rock storage system using air as the working fluid and employing a flat-plate collector having an area of 51 m^2 that is designed to supply 80% of the winter space- and water-heating needs of the building (the solar system is combined with a parallel heat pump),
20. solar—a rock storage system using air as the working fluid and employing a flat-plate collector having an area of 30 m^2 that is designed to supply 60% of the winter space- and water-heating needs of the building (the solar system is combined with a parallel heat pump to supply auxiliary heating needs),
21. solar—a hydronic system employing a flat-plate collector that is designed to supply 60% of the winter space- and water-heating needs of the building (the solar system is combined with a central electric air conditioner, an electric resistance water heater, and an electric resistance backup system for space heating),
22. solar—a hydronic system employing a flat-plate collector with an active area of 60 m^2 that supplies 80% of the winter space- and water-heating needs of the building (the solar system is combined with central electric air conditioning and electric resistance units for water heating and backup space heating),
23. solar—a hydronic system employing a flat-plate collector with an active area of 60 m^2 that supplies 80% of the winter space- and water-heating needs of the building (the solar system is combined with a series-parallel heat pump for backup space heating and with an absorption cooling unit for central air conditioning), and
24. solar—a photovoltaic energy conversion system having a peak collection capacity of 6 kW and a storage capacity of 140 kWh in lead-acid batteries (the annual power generation capacity of the system is sufficient to supply the total annual power needs of the system).

7.1 Assumptions of the Analysis

7.1.1 Systems Performance Characteristics

The estimated performance characteristics of the above HVAC systems, optimally designed to deliver the loads required by the reference house in a climate similar to that of Knoxville, Tennessee, are listed in Tables 33 and 34 for the years 1980 and 1990, respectively. The values of the seasonal performance factors for heating and cooling and the annual coefficients of performance of the systems as they deliver the required annual space-heating, water-heating, and space-cooling loads were obtained from the results of systems simulation runs made with the computer program MAD[2] and by manual calculation methods. The calculations were based on the following assumptions:

1. The ARI rating of air-to-air heat pumps will increase from 2.75 to 4.80 between 1980 and 1990 as a result of better heat exchangers, improvements in the efficiency of fan-motor combinations (from 20 to 40%), and improvements in compressor efficiency (from 58 to 64%).
2. Seasonal performance factors for space and water heating are 0.60 and 0.50, respectively, for conventional gas systems in 1980 and 1990.
3. Seasonal performance factors for space and water heating are 0.90 in 1980 and 0.93 in 1990 for pulsed-gas systems.
4. The use of high-efficiency equipment reduces parasitic power requirements for all systems by the year 1990. For gas-fired systems 11 through 16, the assumed annual parasitic electrical power requirements are 125, 125, 820, 680, 765, and 350 kWh, respectively.

Table 33. Engineering performance characteristics and costs of HVAC systems in 1980

System No.	System operating efficiencies			Energy use (kWh/year)	Present worth costs of system ($)			Life-cycle cost ($)
	SPFH	SPFC	ACOP		Initial	Maintenance	Energy	
				Electric systems				
1	1.00	1.63	1.15	17,857	2,813	776	11,723	15,300
2	1.66	1.63	1.43	14,295	2,885	2,010	9,385	14,300
3	1.66	1.63	1.64	12,351	3,425	2,257	8,227	13,900
4	2.55		2.38	8,597	7,442	1,929	5,644	15,000
5	2.55		3.18	6,437	8,316	1,929	4,226	14,500
6	2.50	2.00	1.75	11,705	7,292	2,030	7,685	17,000
7	2.50	2.00	2.09	9,800	7,542	2,050	6,434	16,000
8	2.30	1.90	1.68	12,192	4,732	2,030	8,004	14,800
9	2.30	1.90	1.99	10,293	4,982	2,050	6,758	13,800
10	2.30		2.34	8,753	6,175	1,929	5,747	13,900
				Gas hybrid systems				
11	0.60	1.63	0.72	24,323/4,443[a]	3,107	776	9,705	13,600
12	0.90	1.63	1.05	15,168/4,443	3,507	776	7,150	11,400
13								N.A.[b]
14								*b*
15								*b*
16								*b*
				Solar hybrid systems				
17	3.51	1.63	2.78	7,412	23,200	2,200	4,866	30,300
18	2.89	1.63	2.54	8,102	15,300	2,200	5,319	22,800
19	2.76	1.63	2.51	8,286	24,300	2,200	5,440	31,900
20	2.49	1.63	2.36	8,730	16,800	2,200	5,731	24,700
21	1.81	1.63	1.97	10,435	13,400	1,900	6,851	22,200
22	2.67	1.63	2.44	8,424	21,300	2,200	5,531	29,000
23								*b*
24			∞	0	72,000	24,800	0	96,800

[a]Annual energy consumption: gas/electric, kWh/year.
[b]Not available.

7.1.2 Systems Costs

1. *Initial cost*—Tables 33 and 34 list the initial installed costs of the above HVAC systems for the years 1980 and 1990, respectively. The initial cost of each system is based on current prices of equipment and has been estimated by the procedures described in Sect. 4. It is assumed that integrated construction is used in ACES ice bins and that the constant-dollar price of conventional equipment will not change over the ten-year period because of expanded production and improvements in manufacturing efficiency. The differences observed between the 1980 and 1990 initial costs of systems are caused by increased costs of improved equipment and by modifications in system design made possible by the availability of more efficient components in 1990, rather than by a change in the price base. For solar systems, however, it is assumed that the constant-dollar cost of collector panels will decline from $\$215/m^2$ in 1980 to $\$161/m^2$ in 1990 and that the cost of photovoltaic cells will decrease from \$10 to \$0.50 per peak watt over the same time period.

2. *Energy cost*—The energy prices used in the analysis represent national averages rather than prices expected to prevail in any given locality. The cost of electric power is taken to be \$0.04/kWh in 1980, and it is assumed that the real annual escalation rate of electric power costs over the

Table 34. Engineering performance characteristics and costs of HVAC systems in 1990

System No.	System operating efficiencies			Energy use (kWh/year)	Present worth costs of system ($)			Life-cycle cost ($)
	SPFH	SPFC	ACOP		Initial	Maintenance	Energy	
Electric systems								
1	1.00	3.04	1.29	15,881	3,440	945	12,709	17,100
2	3.09	3.04	2.08	9,849	4,232	2,450	7,882	14,600
3	3.09	3.04	2.62	7,819	4,770	2,751	6,258	13,800
4	5.00		4.81	4,259	8,036	2,351	3,408	13,800
5	5.00		6.08	3,369	9,216	2,351	2,696	14,300
6	3.60	2.88	2.14	9,573	8,032	2,475	7,661	18,200
7	3.60	2.88	2.67	7,673	8,282	2,499	6,141	16,900
8	3.38	2.70	2.07	9,897	5,472	2,475	7,921	15,900
9	3.38	2.70	2.56	8,002	5,722	2,499	6,404	14,600
10	3.80		4.00	5,122	6,715	2,351	4,099	13,200
Gas hybrid systems								
11	0.60	3.04	0.78	24,323/2,374[a]	3,307	945	12,956	17,200
12	0.93	3.04	1.21	14,679/2,374	3,707	945	8,572	13,200
13	1.20	1.24	1.16	16,890/820	5,092	2,550	8,334	16,000
14	1.20		1.46	13,273/680	9,192	2,550	6,578	18,300
15	1.10	0.50	0.64	31,220/765	4,792	2,450	14,804	22,100
16	1.10	3.04	1.37	12,411/2,598	6,128	2,450	7,721	16,300
Solar hybrid systems								
17	6.27	3.04	5.08	4,050	20,100	2,682	3,241	26,000
18	4.84	3.04	4.49	4,582	14,230	2,682	3,667	20,600
19	5.14	3.04	4.63	4,446	21,600	2,682	3,558	27,800
20	4.33	3.04	4.24	4,857	15,830	2,682	3,887	22,400
21	2.06	3.04	2.66	7,732	11,480	2,316	6,188	20,000
22	3.55	3.04	3.79	5,431	18,200	2,682	4,346	25,200
23	6.27	9.50	8.02	2,554	32,300	3,047	2,044	37,400
24				0	13,000	15,100	0	28,100

[a]Annual energy consumption: gas/electric, kWh/year.

ten-year period will amount to 2%. For the HVAC systems using natural gas as a fuel, it is assumed that the 1980 price of gas is $3.50/GJ and that the real annual escalation rate of natural gas prices will amount to 5%. Based on these assumptions, the 1990 price of electric power is $0.049/kWh and the 1990 price of natural gas is $5.70/GJ.

3. *Life-cycle cost*—Life-cycle costs are computed on the basis of a 20-year study period and an assumed real cost of money of 4% per year. In the analysis, it is assumed that all systems are purchased entirely from equity funds, that property taxes and insurance premiums are the same for all systems and can be neglected, and that the real annual escalation rate of maintenance costs is 2%. Based on these assumptions, and using the methods described in Sect. 5, the applicable present worth factors are 16.413 for computing present worth power costs and 22.148 for computing present worth natural gas costs.

7.2 Results of the Analysis

Tables 33 and 34 show the annual energy consumptions and life-cycle costs of the above HVAC systems for the years 1980 and 1990, respectively. For the purpose of comparing the engineering performances and economic attractiveness of the different HVAC systems, it is useful to plot these data in the form of bar graphs as shown in Figs. 35 and 36. These figures show the principal

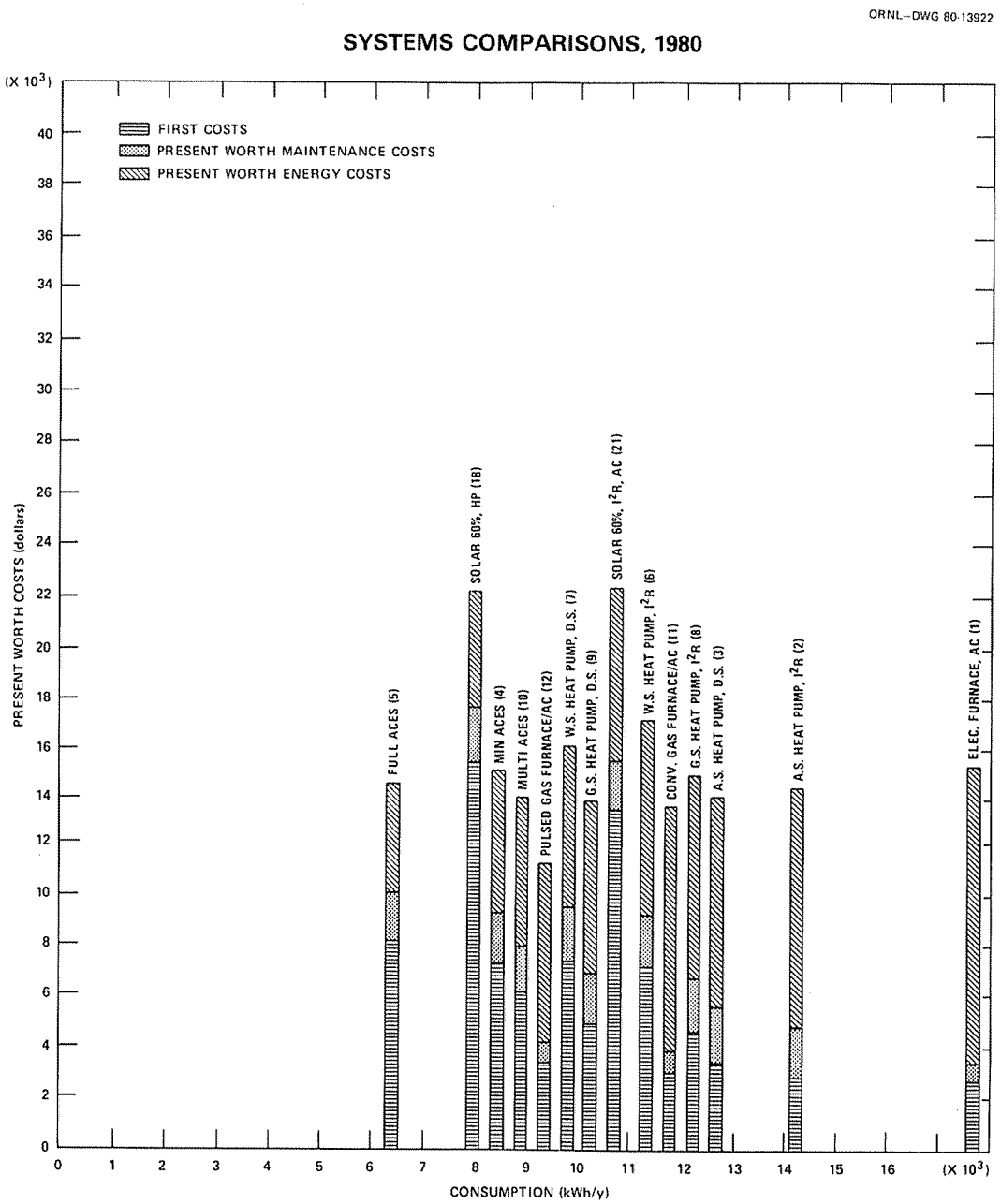

Fig. 35. Knoxville systems comparisons, 1980.

components of the life-cycle cost of each system and the current and future potential of the system for achieving energy conservation. The pulsed-gas furnace system is seen to be strongly competitive both in 1980 and 1990. Generally, the first cost of an energy-conserving system tends to be high, but rising costs of electric power and natural gas more than offset this disadvantage. Figures 37 and 38 display similar information for solar energy systems. These figures show that most solar energy systems are not competitive today and that significant improvements in design will be required before they can become so.

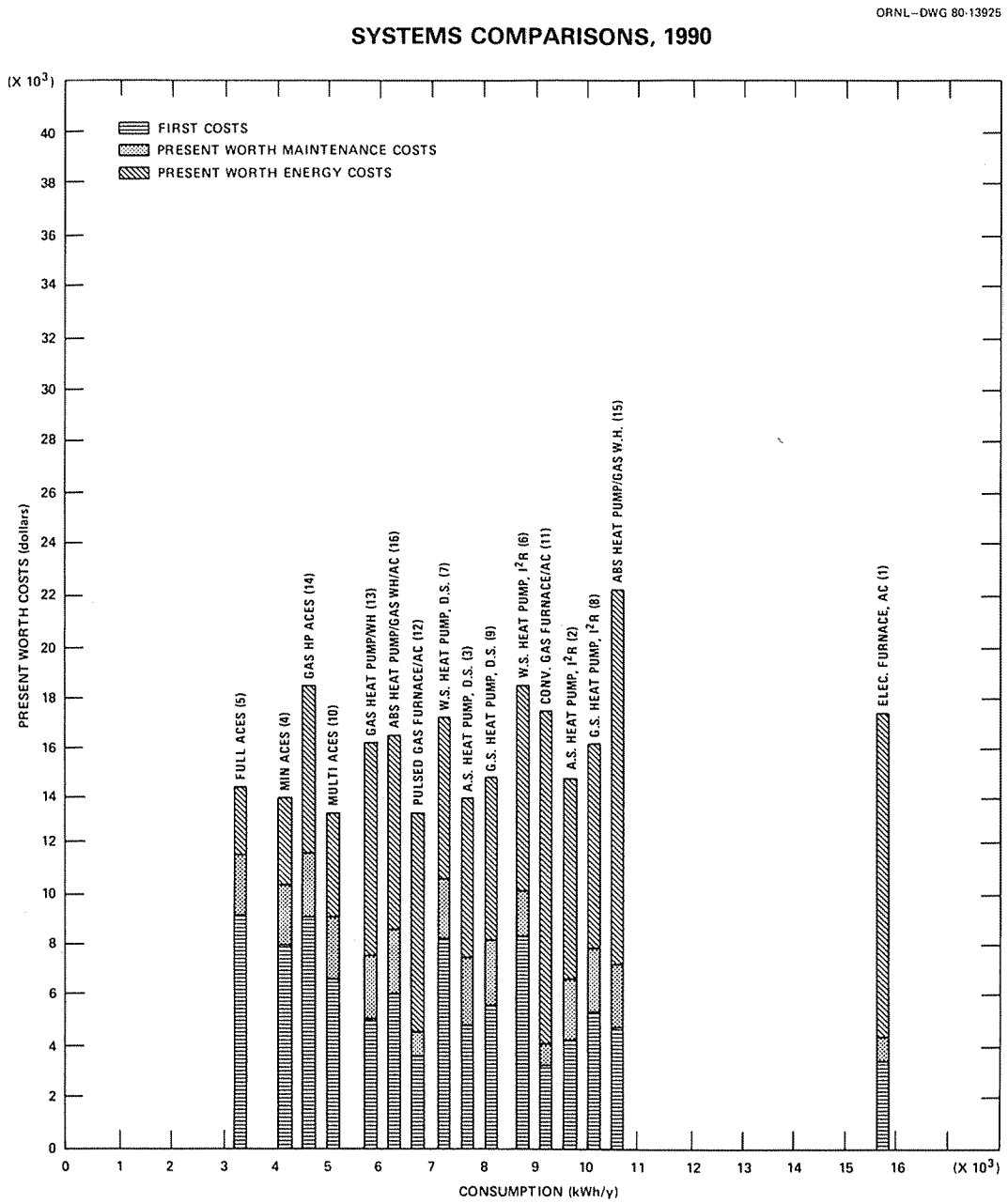

Fig. 36. Knoxville systems comparisons, 1990.

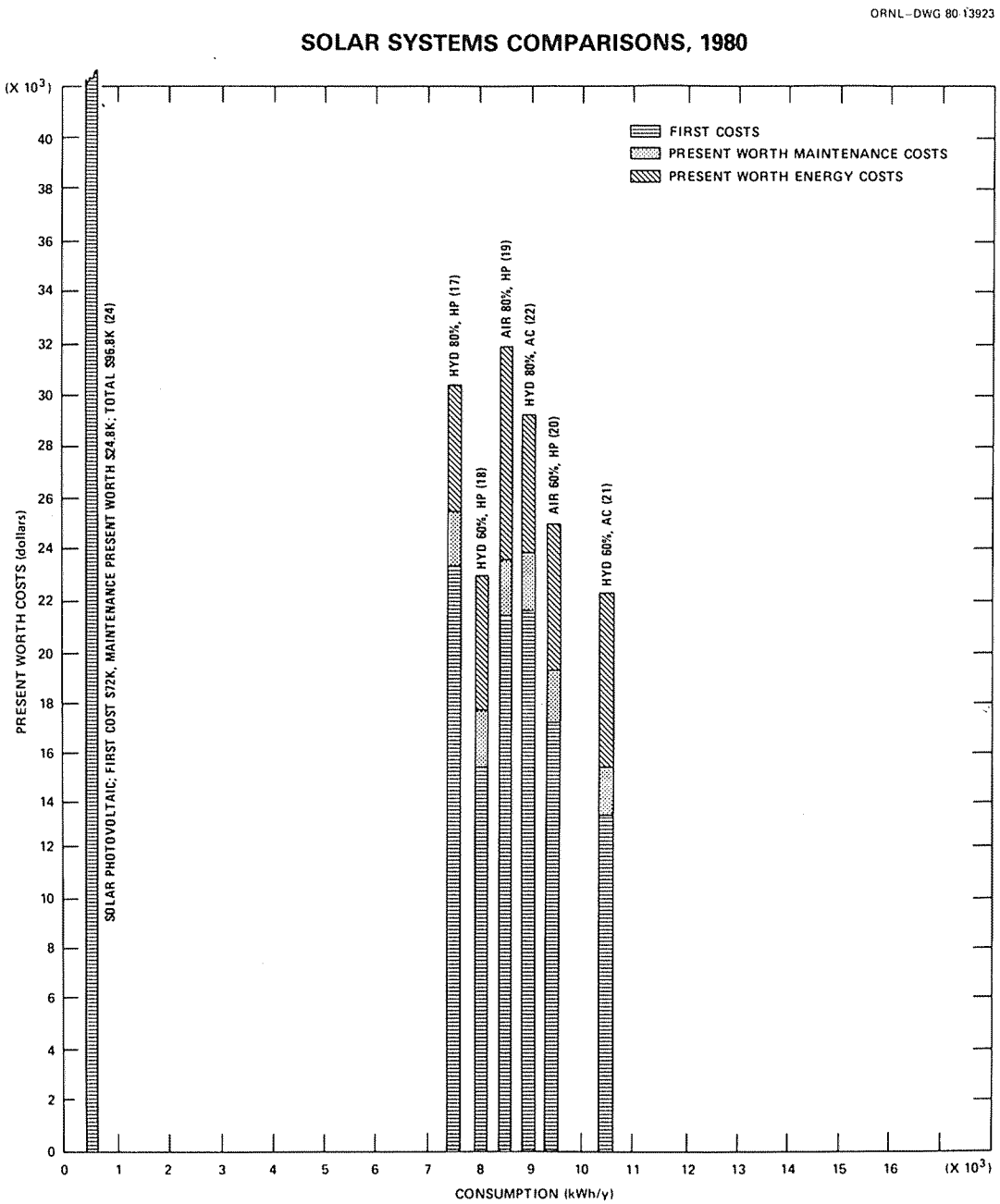

Fig. 37. Knoxville solar systems comparisons, 1980.

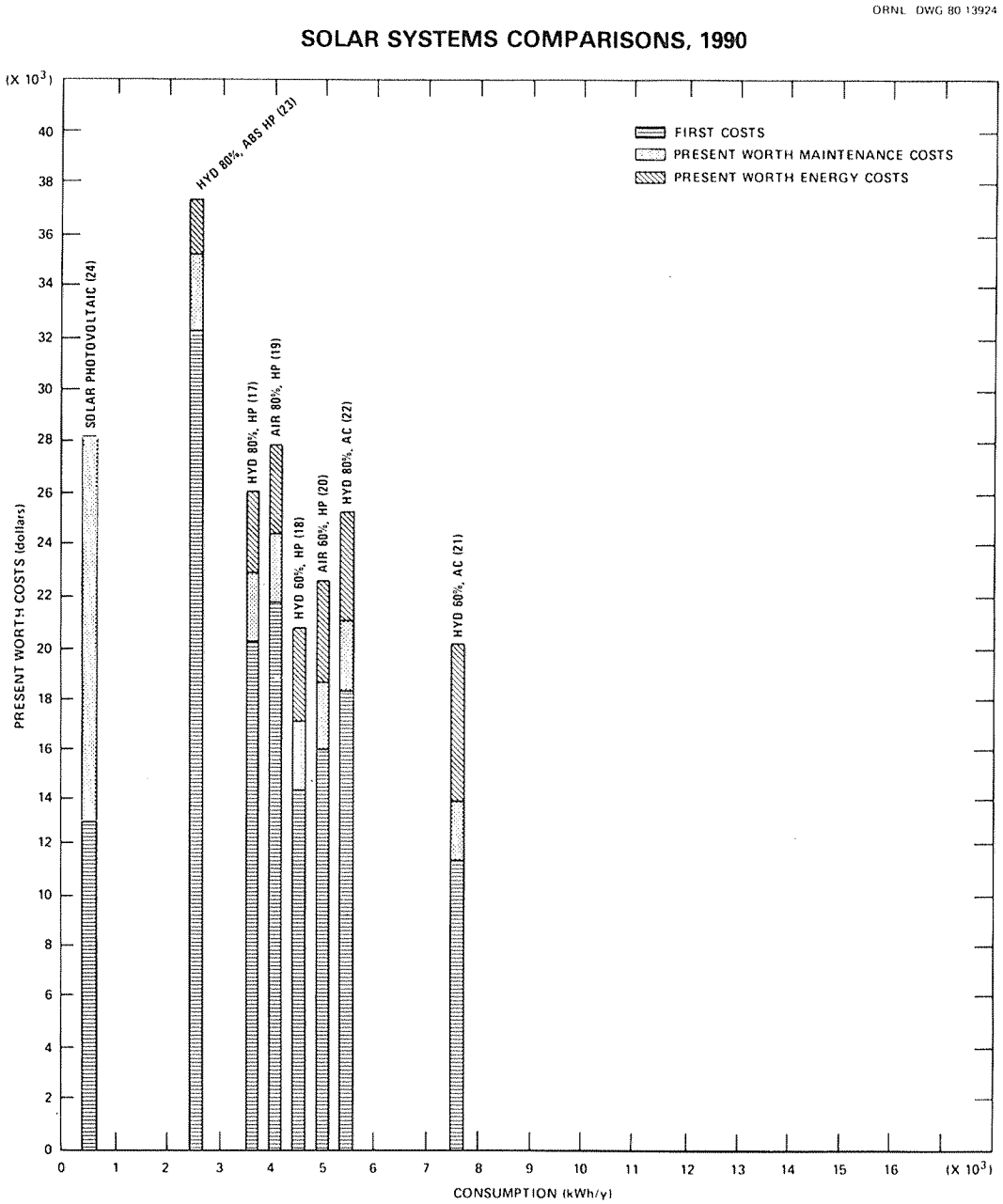

Fig. 38. Knoxville solar systems comparisons, 1990.

8. CONCLUSIONS

8.1 Present-Day Best Systems

The evaluations of the HVAC systems considered in this report are based on the use of actual 1979 power prices and installation prices and on the assumption of a 20-year system lifetime and an economic scenario that yields a present worth factor of 16.413. The principal conclusions of the study relate to the relative efficiencies and economic attractiveness of the different systems.

8.1.1 Energy Conservation

1. The ACES is the best of all the HVAC systems analyzed in this study for conserving electrical energy.
2. The air-to-air heat pump with an electric resistance water heater offers energy savings, with respect to an electric resistance heating system that has a central air conditioner, in most parts of the country.
3. The air-to-air heat pump with a desuperheater for heating domestic water represents an attractive modification to the conventional heat pump, and it should be commercialized as soon as possible.

8.1.2 Systems Economics

1. At today's power rates and systems prices, the ACES is economically competitive with all other electric HVAC systems throughout most of the United States. In terms of life-cycle costs, however, none of the five HVAC systems offers a clear-cut economic advantage over the other systems.
2. The air-to-air heat pump with a desuperheater for water heating represents a low first-cost system that would afford the buyer substantial savings in power costs and energy usage.
3. Although no single system is found to be the "best" throughout the entire United States, regional preferences are identifiable.
4. The HVAC systems with higher efficiencies also tend to have higher first costs. The annual savings in power costs, however, act to offset the incremental first costs and to shield the homeowner from rising costs caused by inflation and escalating energy prices.
5. All the energy-conserving systems in this study yield an internal rate of return to capital that exceeds the true rate of return available to most homeowners on alternative investments in the money market.

8.2 Future Best Systems

This study is primarily concerned with identifying the best electric HVAC system, with respect to life-cycle costs and performance, that is available today. It is also important to know whether the "best system" will change as technology advances and new concepts are introduced. Although this question cannot be answered definitively, an indication of the optimal HVAC system of the future can be obtained by postulating reasonable technological advances for current systems and evaluating the resulting improved systems under assumed future economic conditions. Such an analysis has been performed for a single location—Knoxville, Tennessee—using an extended set of systems that includes (1) the five improved electric systems of this study; (2) water-source, heat-actuated, and absorption heat pump systems; (3) solar energy systems employing sensible heat collection and photovoltaic energy conversion; and (4) conventional and advanced gas furnaces.

The results of the analysis are presented in Figs. 35 through 38 where the life-cycle costs and performances of the different systems are shown for the years 1980 and 1990. These figures show that, for current prices of natural gas, the conventional and advanced gas furnaces with central electric air conditioning offer lower first costs and life-cycle costs than any of the other competing systems. Except for the prohibitively expensive solar photovoltaic system, however, the full ACES provides the most energy conservation. Figures 37 and 38 show that the technological improvements anticipated by the year 1990 will greatly improve the efficiencies of all of the systems. Expected increases in the price of natural gas act to diminish greatly the attractiveness of the gas furnace systems. Surprisingly, it is the full ACES that is expected to show the most improvement by 1990 because of its more efficient mechanical equipment and the fact that this system utilizes both the heating and the cooling outputs of its heat pump. The solar photovoltaic system would be very attractive if means could be developed to reduce its high maintenance costs.

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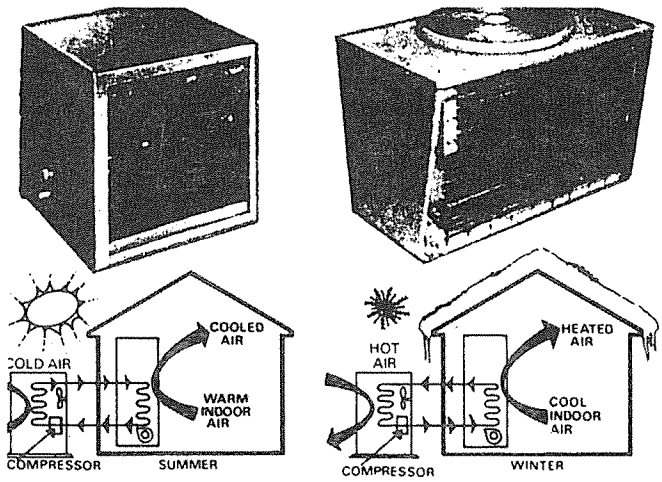
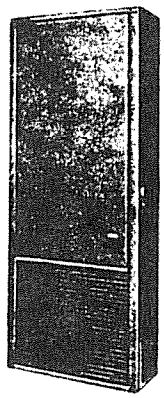
APPENDIX A*

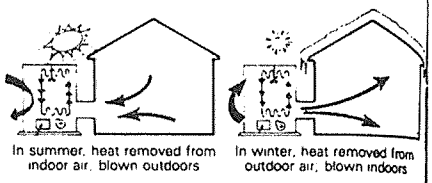
EQUIPMENT COST DATA FOR 1979

*Equipment cost data from Sears, Roebuck, and Co., *1979 Summer Catalog.*



Heat Pumps remove heat present in outdoor air to heat your home and remove heat from indoor air to cool your home . . . can draw heat from outside air at temperatures as low as 0 F.





Single-unit Heat Pumps

All components for heating and cooling in one compact cabinet . . . mounts on outside wall of home

19,000 Btuh cooling
18,500 Btuh heating

$1200.00 without basic control package

Sears single-unit heat pumps include compressor, coil and blower components needed for cooling and heating packaged all in one cabinet that mounts on outside wall of your home.

PACKAGE UNIT: Heating/cooling coil designed for low-cost operation. Sealed compressor with fast-acting overload protection, permanent lubrication. Reliable, efficient defrost system with temperature-pressure control; operates only when needed. Air circulation system has double-shaft motor with twin-centrifugal blowers.

CAPACITY: Provides up to 34,000 Btuh cooling and 36,000 Btuh heating with our largest capacity system. See chart below for capacity of other units.

HOUSING: Heavy-gauge galvanized steel cabinet with green enamel finish. AA units: 31⅛x12⁷/₁₆x72⅝ in. high. BB units: 31⅛x12⁷/₁₆x 78⅝ in. high.

INSTALLATION: Mounts on exterior masonry or frame walls outside of home. The unit operation can be free blowing or can have a duct-connected air distribution system with overhead duct, either exposed or concealed. May be mounted on wall at second story heights or on balcony. Ductwork connections at rear of cabinet for straight-line installation; electrical connections on side.

ELECTRICAL INFO: 208-230-v., 60-Hertz AC. UL listed. Factory wired with 24-v. control circuit. Thermostat not included, sold with basic control package below. Additional outdoor thermostats sold below.

ORDER INFO: Must order with basic control package, at least one 5.0 KW heater sold below. Order heat pumps and electric heaters from charts below. See Warranty (F) on page 624 and Important Note below.

Unit	Heating Btuh	Cooling Btuh	EER **	C O P *	Heaters	Duct Connections (in.) Supply	Duct Connections (in.) Return	Catalog Number	Wt. (lbs.)	Price
AA	18,500	19,000	7.0	2.3	5, 10 or	19¾x7¾	19¾x12⁹/₁₆	42A81201N	278	$1200.00
AA	21,000	22,000	6.9	2.3	13.5 KW	19¾x7¾	19¾x12⁹/₁₆	42A81202N	288	1250.00
BB	30,000	30,000	7.3	2.5	5, 10, 13.5	19¾x7¾	19¾x14	42A81203N	312	1420.00
BB	36,000	34,000	6.7	2.6	or 18 KW	19¾x7¾	19¾x14	42A81204N	322	1530.00

**Btuh per watt per Air Conditioning and Refrigeration Institute Std 210-76
*Coefficient of Performance at 47°F rated in accordance with Air Conditioning and Refrigeration Institute Std 240-76

Now at Sears . . . Split System Heat Pumps with two separate units . . . an indoor coil and housing for use with a Sears electric furnace and an outdoor coil, compressor and fan unit

24,500-Btuh heating
24,500-Btuh cooling **$1079.99** without electric furnace

Sears split system heat pumps include two basic units: one is located inside your home and connects to one of our electric furnaces. The other unit is installed outside on an elevated slab. When combined with the appropriate Sears electric furnace, these heat pumps use less electricity to heat your home than would be used by the electric furnace alone. It's done by transfering the heat from the outside air inside to heat your home. In summer the process is reversed; the heat is transfered from inside your home to outside, leaving your home comfortably cooled.

OUTDOOR UNIT: Large capacity accumulator. Demand defrost system. Crankcase heater. Lexan® plastic discharge grill. Components pre-charged with refrigerant at the factory. Upflow design directs air up and away from house and shrubbery.

INDOOR UNIT: Copper tube, aluminum-finned heat exchanger surface is factory installed in insulated coil cabinet. Install with Sears electric furnace for additional heat. For upflow, horizontal flow application; not suited for counterflow applications.

CAPACITY: Provides up to 58,000 Btuh cooling-64,000 Btuh heating with our largest capacity system. See chart below for capacity of other systems.

INSTALLATION: Outdoor unit rests on concrete slab (not incl.). Indoor unit mounts on one of the matching electric furnaces from table below. Refrigerant tubing connects to fittings on indoor, outdoor units. Complete instructions in Owner's Manual included.

ELECTRICAL INFORMATION: 208-230-volts, 60-Hertz AC. UL listed. Thermostat not included, sold separately below.

ORDER INFORMATION: Order thermostats below, and electric furnace p. 858. Must be used with correct Sears electric furnace, see chart below. See warranty (F), p. 624 and IMPORTANT NOTE below right.

Furnace	Heating Btuh	Cooling Btuh	Catalog No.	Wt. lbs	Price
(A)	24,500	24,500	42 A 82201N2	284	$1079.99
(B)	30,000	29,000	42 A 82202N2	316	1179.99
(C)	36,000	34,500	42 A 82203N2	331	1279.99
(D)	42,000	40,000	42 A 82204N2	336	1409.99
(E)	49,000	48,000	42 A 82205N2	426	1639.99
(F)	64,000	58,000	42 A 82206N2	462	1979.99

Electric Furnace match-up. (see page 858 for specifications)

Fur.	10KW	15KW	20KW	24KW	27.5KW	33.5KW	EER°	C.O.P.*
(A)	42A58711N	42A58712N	42A58713N	#	#	#	7.5	2.8
(B)	42A58711N	42A58712N	42A58713N	#	#	#	8.3	2.8
(C)	#	42A58712N	42A58713N	42A58714N	#	#	8.0	2.9
(D)	#	†	†	42A58714N	†	42A58716N	7.7	2.7
(E)	#	†	†	42A58714N	†	42A58716N	7.5	2.6
(F)	#	#	#	#	†	42A58716N	7.2	2.7

#No system match-up available. †Special furnace; consult Dept. 243 for specifications
°Btuh per watt per Air Conditioning and Refrigeration Institute Std 210-76.
*Coefficient of Performance at 47°F outdoor air temp. rated in accordance with Air Conditioning and Refrigeration Institute Standard 240-76

Indoor Thermostat Kit. Includes heating/cooling indoor thermostat and emergency heat switch (activates 100% of supplemental electric heat if compressor fails).

ORDERING INFORMATION: Shipping weight 2 pounds.
42 A 82141 .....Kit $29.00

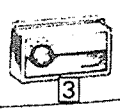
Outdoor Thermostat Kit. Activates supplemental heaters. For 10KW furnace, no outdoor thermostats are required. For 15 and 20 KW furnaces, order 42 A 82142. For furnaces over 20 KW, order 42 A 82142, 42 A 82143. See Note below right. Mount in mounting box outdoors.

ORDERING INFORMATION: Shipping weight 2 pounds.
42 A 82142—For furnaces 15 or 20 KW .....Kit $29.00
42 A 82143—For furnaces over 20 KW .....Kit 29.00

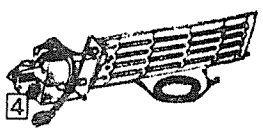
(1 and 2) Refrigerant Tubing Kits for Sears Split-System Heat Pumps

Pre-charged at factory. Copper suction (insulated) and liquid lines. Measure tubing path from indoor coil to outdoor unit, allowing 1 additional foot for every 90° turn. Order from chart at right.

Length	Catalog No.	Shpg. wt.	Price, kit
(1) For 24,500 to 34,500 Cooling Btuh			
15 feet	42 A 82131N	9 lbs.	$54.00
25 feet	42 A 82132N	15 lbs.	74.00
35 feet	42 A 82133N	24 lbs.	94.00
50 feet	42 A 82134N	36 lbs.	119.00
(2) For 40,000 to 58,000 Cooling Btuh			
15 feet	42 A 82136N	16 lbs.	$69.00
25 feet	42 A 82137N	20 lbs.	89.00
35 feet	42 A 82138N	30 lbs.	114.00
50 feet	42 A 82139N	46 lbs.	148.00



Accessories for single unit Pumps



Basic Control Package
Needed for each single-unit heat pump. Incl. heating/cooling thermostat, relay kit. Switches on electric heaters.
ORDER INFO: Wt. 5 lbs.
42 A 81274 .....$65.00

(3) Outdoor Thermostat
Activate supplem. heaters. Not needed for 5KW heaters; order 1 for 10KW, 2 for 13.5 and 18.0KW heaters. Mount on heat pump unit control box.
ORDER INFO: Wt. 1 lb.
42 A 81273 .....$16.00

Overload Protector. For heaters indicated at right.
ORDER INFORMATION:
For 13.5 KW heaters.
42A81271N–Wt. 16 lbs. $55.00
For 18.0KW heaters.
42A81272N–Wt. 17 lbs. $65.00

(4) Electric Heaters. Provide extra heat when outdoor temp. is extremely low. See chart for max. no. required.

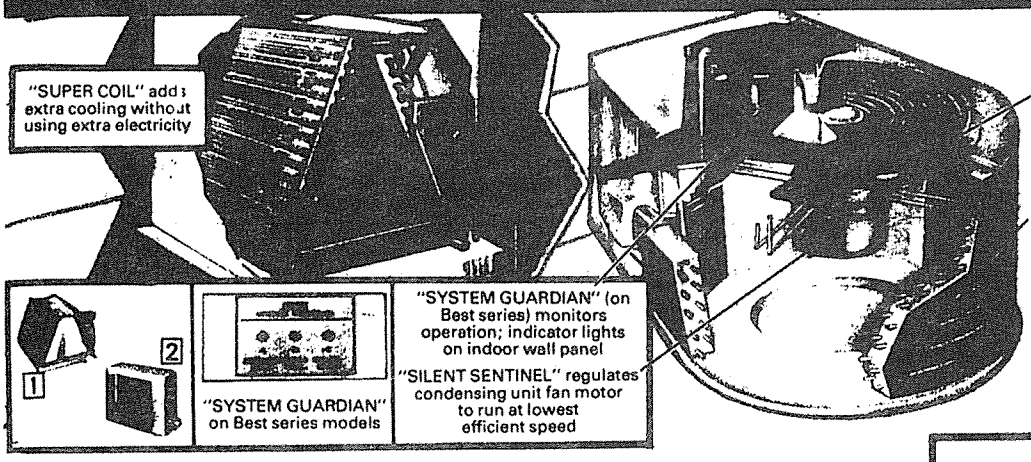
INSTALL: Space provided in unit for mounting, line and low voltage connections.

ORDER INFO: Order 42A81273 at left. Order heaters indicated for heat pump AA or BB. Each heat pump needs at least one 5.0 KW heater.

KW	Btuh	Volts	Catalog Number	Wt. (lbs.)	Price
For use with Heat Pump "AA"					
5.0	17,065	240	42 A 81211N	8	$97.00
10.0	34,130	240	42 A 81212N	11	142.00
13.5	46,075		Contact Dept. 243, address on cover		
For use with Heat Pump "BB"					
5.0	17,065	240	42 A 81214N	8	$100.00
10.0	34,130	240	42 A 81215N	11	145.00
13.5	46,075	240	42 A 81217N	15	180.00
18.0	61,434	240	42 A 81218N	22	195.00

NOTE: The Heat Pump is a complex product. It can only provide satisfactory service if sized and installed properly. Not for do-it-yourself installation. Stop in at your nearest Sears Catalog Store, for assistance or write Sears, Dept. 243, at the address on cover. Sears Engineering Dept. will review all orders.

Best series Air Conditioning Systems listed in top charts below have the highest efficiency ratings of any system we offer and feature exclusive "Silent Sentinel" electronic control



Best series Air Conditioning System

23,000 Btuh with "A" coil **$929.99** without tubing or thermostat

Cooling Capacity Btuh	Watts	EER† DOE 95°	EER† DOE 82°	Seasonal Energy Eff. Ratio†	System Components‡ Condenser Number	System Components‡ Coil Number	Minimum Furnace Specifications: Furnace width inches	Blower, in. Width	Blower, in. Inlet Diam.	HP	Supply ducts 6-in	Supply ducts 8-in	Cover (not incl.) size	Indoor coil size, inches (WxDxH) approximate	Catalog Number	Shpg wt. lbs	Price
Best series WITH "A" COIL (1) for counterflow or upflow furnaces																	
23,000	2450	9.4	10.2	8.9	81791	81521	16	9¼	7¾	¼	7	4	B	16½x19¼x14	42A82771N2	259	$929.99
27,000	2950	9.2	10.0	8.7	81792	81522	16	9¾	8¾	⅓	8	4	B	16½x19¼x18	42A82772N2	263	999.99
33,500	3550	9.4	10.3	8.9	81793	81524	18	10½	8¾	½*	10	5	B	21¼x25⅝x17⅞	42A82774N2	268	1049.99
41,000	5100	8.0	8.7	7.6	81795	81355	20	13⅛	8¾	½	12	6	B	21¼x25⅝x17⅞	42A82776N2	301	1079.99
46,000	5800	7.9	8.6	7.5	81796	81355	20	12¼	10⅜	½	14	7	B	21¼x25⅝x17⅞	42A82776N2	311	1129.99
53,000	7000	7.6	8.3	7.2	81797	81356	24	12¼	10⅜	¾**	16	8	B	21¼x25⅝x21¼	42A82777N2	335	1169.99
Best series WITH FLAT COIL (2) for horizontal furnaces																	
23,500	2450	9.6	10.4	9.1	81791	81531	16	9¼	7¾	¼	7	4	B	30½x10³/₆₄x22³/₃₂	42A82781N2	278	$929.99
27,500	2950	9.3	10.2	8.8	81792	81532	18	9¾	8¾	⅓*	9	5	B	16½x19¼x18	42A82782N2	282	999.99
[redacted]																	
33,500	3600	9.3	10.3	8.9	81793	81534	18	10½	8¾	½*	10	5	B	36½x10³/₆₄x22⅛	42A82784N2	296	1049.99
41,000	5100	8.0	8.7	7.6	81795	81348	20	13⅛	8¾	½	12	6	B	36½x10³/₆₄x22³/₃₂	42A82786N2	311	1099.99
46,000	5800	7.9	8.6	7.5	81796	81348	20	12¼	10⅜	½	14	7	B	36½x10³/₆₄x22³/₃₂	42A82788N2	321	1129.99
53,000	7200	7.4	8.1	7.1	81797	81349	24	12¼	10⅜	¾**	16	8	B	36½x10³/₆₄x27⅛	42A82787N2	358	1169.00

Better series Central Air Conditioning System

22,000 Btuh with "A" coil, relay transformer **$599.99** without tubing or thermostat

Cooling Capacity Btuh	Watts	EER† DOE 95°	EER† DOE 82°	Seasonal Energy Eff. Ratio	System Components‡ Condenser Number	System Components‡ Coil Number	Minimum Furnace Specifications: Furnace width inches	Blower, in. Width	Blower, in. Inlet Diam.	HP	Supply ducts 6-in	Supply ducts 8-in	Cover (not incl.) size	Indoor coil size, inches (WxDxH) approximate	Catalog Number	Shpg wt. lbs	Price
Better series WITH "A" COIL (1) for counterflow or upflow furnaces																	
22,000	2950	7.5	7.8	6.8	81681	81327	16	9¼	7¾	¼	6	3	A	16½x19¼x15¼	42A82541N3	211	$599.99
25,000	3250	7.7	7.9	6.9	81682	81327	16	9¾	8¾	¼	7	4	A	16½x19¼x15¼	42A82542N3	215	634.99
27,500	3700	7.4	8.0	7.1	81683	81327	16*	9¾	8¾	⅓	8	4	A	16½x19¼x15¼	42A82543N3	218	684.99
31,500	4150	7.6	8.2	7.2	81684	81323	18	9¾	8¾	½*	9	4	A	16½x19¼x17⅜	42A82548N3	236	764.99
36,500	4500	7.7	8.1	7.1	81685	81323	18	9¾	8¾	½*	10	5	A	16½x19¼x17⅜	42A82545N3	231	824.99
40,000	5200	7.7	8.7	7.5	81686	81324	20	13⅛	9¾	½	12	6	A	21¼x25⅝x17⅜	42A82546N3	278	924.99
46,000	6100	7.5	8.4	7.4	81687	81324	20	12¼	10⅜	½	14	7	B	21¼x25⅝x17⅜	42A82547N3	311	1034.99
Better series WITH FLAT COIL (2) for horizontal furnaces																	
21,500	2850	7.5	7.9	6.9	81681	81341	16	9¼	7¾	¼	6	3	A	30½x10³/₆₄x22³/₃₂	42A82551N3	230	$649.99
25,000	3250	7.7	7.9	7.0	81682	81341	16	9¾	8¾	¼	7	4	A	30½x10³/₆₄x22³/₃₂	42A82552N3	234	674.99
27,500	3650	7.5	8.3	7.3	81683	81342	16*	9¾	8¾	⅓	8	4	A	30½x10³/₆₄x22³/₃₂	42A82553N3	242	714.99
31,500	4150	7.6	8.2	7.2	81684	81343	18	9¾	8¾	½*	9	4	A	30½x10³/₆₄x22³/₃₂	42A82554N3	257	814.99
34,000	4350	7.8	8.3	7.3	81685	81343	18	9¾	8¾	½*	10	5	A	30½x10³/₆₄x22³/₃₂	42A82555N3	252	854.99
40,000	5200	7.7	8.7	7.5	81686	81344	20	13⅛	8¾	½	12	6	A	36½x10³/₆₄x22³/₃₂	42A82556N3	288	944.99
46,000	6100	7.5	8.4	7.4	81687	81344	20	12¼	10⅜	½	14	7	B	36½x10³/₆₄x22³/₃₂	42A82557N3	321	1054.99

‡System as rated by U.S. Dept. of Energy test procedures. ▲60% of return air should be located in ceiling or high wall.
**Can use ½-HP direct-drive blower. *If furnace is 18 in. wide or input is larger than 120,000 Btuh, ¾-H.P. motor may be used. †See EER Note below.

NOTE ON CONDENSING UNIT: Do you already have central air conditioning? At Sears you can buy a replacement condensing unit for any brand system to add on to your present system. Call Sears or stop in at your nearest Sears Store for more details.

In most localities
WE CAN ARRANGE CENTRAL AIR CONDITIONING INSTALLATION
See page 621 for details

Best series and Better series Systems feature:

CONDENSING UNIT-COIL: These units feature the "Silent Sentinel", an electronic control that senses outdoor temperature and automatically regulates condensing unit fan motor to run at lowest efficient speed for quiet operation. "Super Coil" also aids cooling by using cold condensate water from the coil drain pan without using more power. Low-resistance design of cooling coils. Both the "A" coil and the flat coil connect to present forced warm-air system with existing ductwork, registers and blowers. Better series units also include relay transformer. (See minimum specifications in chart at left.) Components are pre-charged at factory. Spring-mounted compressor housed in insulated compartment. Rubber grommets also help absorb sound.

HOUSING: Air drawn through sides of unit, exhausts at top. Lexan® plastic grille. Galvanized rust-resistant cabinet of heavy-gauge steel. Green acrylic enamel finish.

INSTALLATION: Installation instructions and Owner's Manual included.

ELECTRICAL INFORMATION: Thermostat not included, order separately on page 858. 208-230-volt, 60-Hz. AC motor. UL listed.

ORDERING INFORMATION: Order "A" coil (1) for counterflow or upflow furnace, flat coil (2) for horizontal furnace. Order refrigerant tubing and condensing unit cover on page 856. See Warranty (F) on page 624. EER Note, below left. *State catalog number, shipping weight and price only when ordering.*

EER NOTE: The Seasonal Energy Efficiency Ratio (SEER) and Energy Efficiency Ratio (EER) at 95° and 82° outdoor temperatures indicate the efficiency with which an air conditioner works. The numbers are shown for three different conditions at which the ratings are stated. These ratings were established by laboratory testing using Department of Energy statistical test procedures. They are comparative and a higher rating means a lower operating cost. Each set of three ratings for each Sears air conditioner system; ie, matched condensing unit and evaporator coil, is stated in the following order:

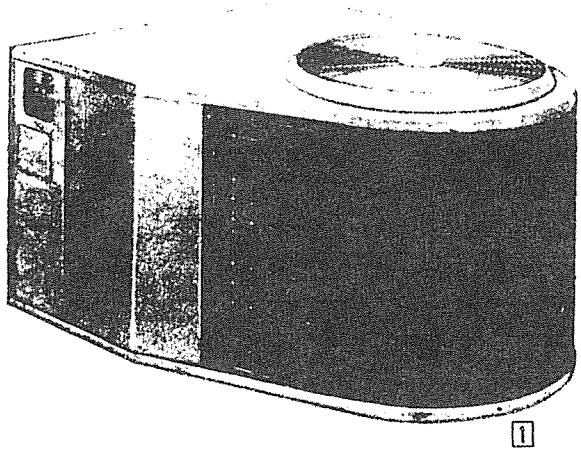
EER	EER	SEER			
95°	82°	e.g.	8.5	8.1	8.1.

Unsure of your home's air conditioning requirement's? **Order our FREE Central Air Conditioning Sketch Blank 39 A 6726.** Write Sears at address on back cover or ask for a copy at any Sears Catalog Sales Store.

there's a big selection of Air Conditioning units and Supplies in our **1979 Mobile Home Catalog**... see page 594 for more details and how you can get your FREE copy

SEARS HAS IT

Central Air Conditioning System (1) for conventional homes features all necessary cooling components in one cabinet for simple installation . . . just attach air duct to your present system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(1) Multi-speed condensing unit fan blows hot air away from house and shrubbery

Low as **$779.99** 23,200 Btuh

- All necessary cooling components in one cabinet
- Automatic multi-speed air circulation fan
- Simple installation . . . just connect to present furnace duct-work, add drain line, [redacted]
- Five year warranty on compressor

Install this unit yourself . . . [redacted] instructions included.

CONDENSER, COIL: All necessary cooling components in one cabinet. Multi-speed condensing unit fan. All refrigerant connections made at factory.

HOUSING: Hot air vented away from top, away from house, shrubbery. Galvanized steel cabinet enameled to resist rust, corrosion. Foliage green color.

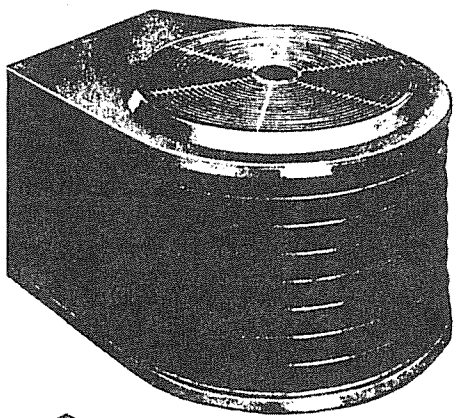
ELECTRICAL INFORMATION: 208–230-volt, 60-Hertz AC. Order thermostat separately, page 854.

INSTALLATION: Connect to existing furnace supply ductwork [redacted] Drain line is only plumbing required.

ORDERING INFORMATION: Order from chart below. See Warranty (F), page 624, EER story, page 855.

Cooling Btuh	Watts	82° EER*	95° EER*	SEER*	Dimensions (H x W x D) in.	Duct conn. (diam.) Supply	Duct conn. (diam.) Return	Catalog Number	Wt. lbs	Price
23,200	2850	8.1	8.6	7.5	20 x 38 x 41½	12-in.	12-in.	42A81055N‡	320	$779.99
29,000	4000	7.3	8.3	7.2	20 x 38 x 41½	12-in.	12-in.	42A81056N‡	320	849.99
34,400	4850	7.1	7.8	6.8	20 x 38 x 41½	12-in.	12-in.	42A81057N	325	919.99
42,000	6200	6.8	7.5	6.5	22¾ x 42 x 50	12-in.	Two 12-in.	42A81058N	370	1009.99
47,000	6900	6.8	7.6	6.6	22¾ x 42 x 50	12-in.	Two 12-in.	42A81059N	395	1129.99

‡Should not be used in mobile homes. *See EER note on page 855.



Our VERY LOW PRICED Good Central Air Conditioning System connects to upflow, counterflow furnaces

Low as **$599.99** 24,500 Btuh with "A" coil without tubing kit

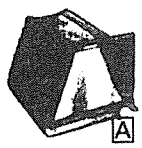
CONDENSER-COIL. Upflow design. Single-speed motor. Coil connects to your present forced warm-air upflow or counterflow furnace if adequate, using existing ductwork, registers, blowers. (See minimum specifications in chart below). Pre-charged at factory.

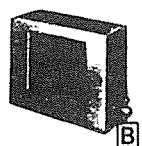
HOUSING: Air is drawn through sides of condensing unit and exhausts out top. Steel cabinet with avocado-green enamel finish.

ELECTRICAL INFO: 208–230-v., 60-Hz. AC motor helps provide operation under high or low voltage conditions. UL listed. Thermostat not incl., sold on page 857

INSTALLATION: 60% of return air should be located in ceiling or high wall. Installation instructions and Owner's Manual are included.

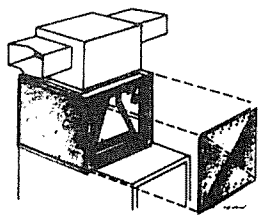
ORDERING INFORMATION: Order from chart below. Order tubing kit and condenser cover below. Order "A" coil for counterflow or upflow furnaces. Order flat coil (B) for horizontal furnaces. See Warranty (F) on page 624. EER story, pg. 855. *State catalog number, shpg. wt. and price only when ordering.*


A


B

Cooling BTUH (000's)	Watts	82° EER*	95° EER*	SEER*	System Components‡ Condenser Number	System Components‡ Coil Number	Minimum Furnace Specifications: Furnace width inches	Blower, in. Width	Blower, in. Inlet Diam.	HP	Supply duct 6-in.	Supply duct 8-in.	Cover (not incl.) size	Indoor coil size (WxDxH inches)	Catalog Number	Shpg. wt. lbs.	Price
Unit WITH "A" COIL (A) for counterflow or upflow furnaces																	
24,500	3450	7.1	8.1	7.0	81381	81327	16	9¼	7¾	¼	7	3	C	17¾ x 19¼ x 9 5/16	42A82171N2	212	$599.99
33,000	4650	7.1	7.7	6.7	81384	81323	16*	9¾	8¾	⅓	8	4	C	17¾ x 19¼ x 13⅛	42A82174N2	231	699.99
40,000	5600	7.1	8.1	7.1	81385	81324	16*	9¾	8¾	⅓	9	4	C	17¾ x 19¼ x 15¼	42A82175N2	275	829.99
53,000	7000	7.6	8.3	7.2	81387	81356	18	10½	8¾	½*	10	5	D	17¾ x 19¼ x 17 7/16	42A82177N2	335	1039.99
Unit WITH FLAT COIL (B) for horizontal furnaces																	
24,500	3450	7.1	8.1	7.1	81381	81341	16	9¼	7¾	¼*	7	3	C	26½ x 9 x 21⅜	42A82181N2	231	599.99
33,000	4650	7.1	7.7	6.7	81384	81343	16*	9¾	8¾	⅓	9	4	C	26½ x 9 x 21⅜	42A82184N2	249	699.99
40,000	5600	7.1	8.1	7.1	81385	81344	18	10½	8¾	⅓*	10	5	D	26½ x 9 x 21⅜	42A82185N2	285	829.99
53,000	7200	7.4	8.1	7.1	81387	81349	20	13⅛	8¾	½	12	6	D	34⅝ x 8¾ x 23¾	42A82187N2	358	1039.99

*See note, p. 855. ‡System as rated by U.S. Department of Energy test procedures.
*If furnace is 18 in. wide or input is larger than 120,000 BTUH, ¼-H.P. motor may be used.



Air Conditioning Supply Plenum Kits for "do-it-yourself" installation

For adapting plenums that are too small for "A" coil.

KIT INCLUDES: Supply plenum, top and bottom plates, set of "A" coil support rails and access panel.

ORDERING INFORMATION:

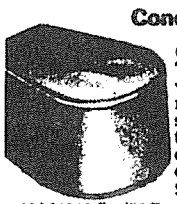
Complete installation instructions included. For "A" coils through 36,500 Btuh. Plenum is 20x20x24 in. high. Wt. 24 lbs.

42 A 78661C $41.39

For "A" coils 37,000 through 60,000 Btuh. Plenum is 21 7/16 x 26½ x 33 in. Shipping weight 33 lbs.

42 A 78662L..... $44.89

Condenser Cover



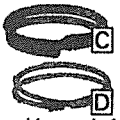
CONSTRUCTION: Tough, durable green vinyl-laminated material. Waterproof, can survive subfreezing temperatures without cracking. With Velcro® closure tabs.

SIZES, ORDER INFO:

42A81912 fits '79 Residential, Mobile Home single units; 1978 High Eff. models.

Cover size	Dimensions (LxWxH), in.	Catalog Number	Wt. lbs.	Wt. oz.	Price
For Best series and Better series Systems					
AA	29 x 37⅛ x 19 9/16	42 A 81916	1	8	$18.00
BB	29 x 37⅛ x 28 9/16	42 A 81917	2	2	19.00
For Good Systems					
CC	50¾ x 41 x 25¼	42 A 81912	2	6	34.00

Air Conditioning Accessories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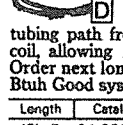
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Refrigerant Tubing Kits For Sears Best, Better and Good Systems. Pre-charged at factory. Copper suction (insulated) and liquid lines. Measure tubing path from indoor coil to outside coil, allowing 1 foot for every 90° turn. Order next longer length. 40,000–42,000 Btuh Good systems use tubing "C".

Length	Catalog No.	Shpg. wt.	Price, Kit
(C) For 21,000 to 36,500 BTUH Systems			
15 feet	42 A 81893N	9 lbs.	$49.00
20 feet	42 A 81894N	12 lbs.	56.00
25 feet	42 A 81895N	15 lbs.	68.00
35 feet	42 A 81896N	19 lbs.	84.00
45 feet	42 A 81897N	25 lbs.	101.00
(D) For 40,000 to 56,000 BTUH Systems			
15 feet	42 A 81888N	10 lbs.	57.00
25 feet	42 A 81832N	20 lbs.	87.00
40 feet	42 A 81833N	30 lbs.	119.00

Relay Transformer

$18.99

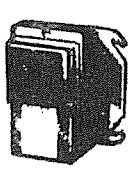


Plate mounted. For use with all split system air conditioning systems, when installing on other than Sears "15" gas furnaces. Provides automatic change of blower speed when needed in heating and cooling applications. Also provides wiring lead for power humidifier and electronic air cleaner (if applicable).

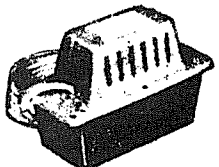
ORDERING INFORMATION:

Shipping weight 3 lbs.

42 A 9211 ..... $18.99

Condensate Pump

$55.00



Use when water condensed by indoor coil must be pumped either upward or over long distances to a drain. Safety floats cut off condenser preventing damaging overflow. Total lift 17 ft. Flanges for direct mounting on unit. 20-ft. plastic tubing.

ELECTRICAL INFO: UL listed. 120-volt, 60-Hertz AC. 60 watts.

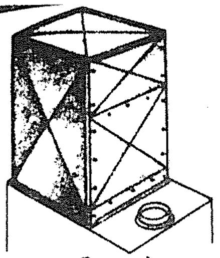
ORDERING INFORMATION:

Shipping weight 8 pounds.

42 A 81822 ..... $55.00

Same as above, but no safety float.

42 A 81823—Shpg. wt. 6 lbs. ..$45.00



Galvanized steel Plenum for Sears gas and oil furnaces

CONSTR: Rust-resistant ga vanized steel. Supply plenums for space-saver ; ıd basement models include rails for installing air conditioning "A" coil and screw-on front panel (provides easy access to coil). Assembly and installation instr. incl. Space-saver and basement furnace plenums accommodate Sears air conditioning coils through 36,000-Btuh cooling.**
ORDER INFO: For plenums tnat take larger coils or for more info about plenums, write Sears Engineering, Dept. 243, address on cover. Order flue pipe, elbows from Home Improvement Book. See "N" suffix note, p. 616.

For space-saver furnace. Order supply plenum below and return-air drop package you require below right. Includes return-air adapter.

Supply Plenum only, for space-saver furnaces located in basement
For gas furnaces. 39 inches high. 55,000, 80,000, 105,000 Btuh.
42 A 78622L—Shipping weight 31 lbs. . $44.89
For gas 130,000, 150,000, 175,000 Btuh.
42 A 78623L—Shipping weight 33 lbs. . . 47.19
For oil 105,000, 140,000 Btuh. 33 in. high.
42 A 78685L—Shipping weight 30 lbs. . $44.89

Supply Plenum for furnaces located in closet or utility room
For gas furnaces. 69 inches high.
55,000, 80,000, 105,000 Btuh.
42 A 78616N—Shipping weight 43 lbs. $59.79
130,000, 150,000, 175,000 Btuh.
42 A 78617N—Shipping weight 49 lbs. . . 62.09
For oil 105,000, 140,000 Btuh. 60 inches high.
42 A 78684N—Shipping weight 45 lbs. $58.69

Supply and Return-air Plenum for basement furnaces
One of each. 44 inches high.
For oil 105,000 Btuh.
42 A 78686N—Shipping weight 53 lbs. $72.49
For oil 140,000 Btuh.
42 A 78687N—Shipping weight 54 lbs. . . 75.89
For oil 175,000 Btuh, **gas** 150,000, 175,000 Btuh.
42 A 78682N—Shpg. wt. 58 lbs. $60.99
For oil and gas 210,000 Btuh**
42 A 78683N—Shpg. wt. 75 lbs. 72.49
**Plenum 42 A 78683N has 42,000 to 60,000-Btuh cooling capacity.

Supply Plenum only, for gas basement furnace up to 130,000 Btuh. 39 in. high.
80,000, 105,000 Btuh.
42 A 78622L—Shpg. wt. 31 lbs. $44.89
130,000 Btuh.
42 A 78623L—Shpg. wt. 33 lbs. 47.19

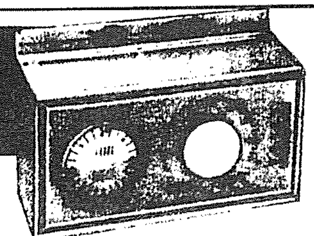
Return-air Plenum for gas basement furnaces up to 130,000 Btuh§
80,000, 105,000 Btuh.
42 A 78633C—Shpg. wt. 21 lbs. $31.09
130,000 Btuh.
42 A 78634L—Shpg. wt. 22 lbs. 32.19
§NOTE: To add Sears electronic air cleaner to gas basement furnace up to and including 130,000 Btuh, order 42 A 78635C below instead of those above. Adapter included
42 A 78635C—Shpg. wt. 20 lbs. $39.09

Supply and Return-air Plenum for counterflow furnaces
One of each. For heating only.
42 A 78701N—Shpg. wt. 38 lbs. $44.89

Supply and Return-air Plenum for horizontal furnaces. One of each. For heating only.
For gas 80,000, 100,000 Btuh.
42 A 78707N—Shpg. wt. 38 lbs. $42.59
For all oil; gas 120,000 through 160,000 Btuh.
42 A 78706N—Shpg. wt. 47 lbs. $50.59

Multipurpose Plenum. (Not shown.) 27x24x30 inches wide. Can be cut to smaller size. Use as a supply plenum on all Sears electronic air cleaners or as a straight supply or return-air grille plenum on all Sears horizontal furnaces.
ORDERING INFORMATION:
42 A 78655N—Shpg. wt. 28 lbs. $35.69

Thrif-T Thermostat helps reduce heating, cooling costs by turning down furnace, air conditioner



The Thrif-T thermostat reduces your fuel consumption by turning your furnace down or air conditioner up during the day and/or night as you desire. The chart at right gives an approximation of the savings you can realize with a single setback heating thermostat. Double setback units can help reduce your heating and cooling usage even more. No special tools needed; no need to disturb furnace wiring.
CONSTR: Beige color housing. Timer powered by long-life nickel-cadmium battery which is recharged automatically during the off cycle of the heating or cooling system. Temperature range from 50° to 90°F.
ELECTRICAL INFORMATION: 24 volts, 60-Hertz AC.
INSTALLATION: For 24-volt gas, oil or electric systems. Ideal for do-it-yourselfers . . . no special tools required; no need to disturb present furnace wiring. Identify and remove existing wire, reconnect to terminals of Thrif-T. For new installations, use 5-wire cable for heating/cooling or 2-wire cable for heating only model. Built-in level bubble. Complete installation instructions included.
ORDER INFORMATION: Thermostat cable sold separately below.

Possible Fuel Savings with night set-back heating▲

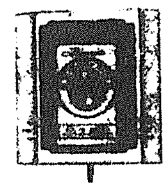
CITY	5° Setback	10° Setback
Atlanta	11%	15%
Boston	7%	11%
Chicago	7%	11%
Cleveland	8%	12%
Dallas	11%	15%
Kansas City	8%	12%
Los Angeles	12%	16%
Minneapolis	5%	9%
Philadelphia	8%	12%
Portland	9%	13%

Heating only Model. (Not shown.) Measures 6x3¼ inches. Single setback reduces furnace operation during nighttime hours when least needed. Double setback has both day and night setbacks which allow you to use less heat at night and during the day when homeowner is away. Shipping weight 1 pound 4 ounces.
42 A 9149—Single setback . . . . $44.99 42 A 9146—Double setback $49.99

Heating and Cooling Model. (Shown above.) Measures 6x3¾ inches. Single setback reduces furnace operation at nighttime during winter and reduces air conditioner use during summer at times you select. Double setback changes temperature 4 times in 24 hours: in winter months lowers heat at night and during day when homeowner is away; in summer months raises air conditioning temperature at night and when home is unoccupied. Shipping weight 1 pound 4 ounces.
42 A 9150—Single setback . . . . $54.99 42 A 9147—Double setback $59.99

▲The percentage of fuel savings was calculated for a 75°F day temperature setting and a night setback of eight hours (10 P.M. to 6 A.M.). These figures were published in the August 1973 issue of the American Society of Heating, Refrigeration and Air Conditioning Engineer's Journal. The amount you can actually save depends on many variables, such as highest and lowest temperature you select, local climate, size of your home and local energy costs. The chart is based on a computer study. It shows the approximate per cent of energy savings which can be realized for a one story home of 900 square feet with four persons in the household.

Thermostats for gas, oil or electric systems



CONSTRUCTION: 60° to 90° F. range. Dustproof mercury switch. Manual switch for constant or intermittent fan. Beige and gold-color housing. 4½x4½ inches.
INSTALLATION: For 24-volt gas, oil or single-stage electric systems. Requires 5-wire cable. Complete installation instructions included.
ORDERING INFORMATION: Order thermostat, below, cable at right below.
Heating, Cooling Model.
42 A 9295—Shipping weight 10 ounces . . $21.99
Cooling only Model.
Requires 3-wire cable sold at right.
42 A 9283—Shipping weight 9 ounces . . . $16.99
For heating only. No manual switch. Order 2-wire cable at right. Shipping weight 8 ounces.
42 A 9235—24-volt gas, oil systems $13.99
42 A 9237—Gas milli-volt systems 13.99

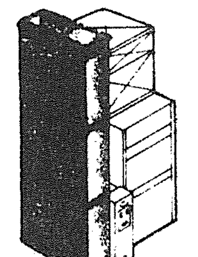
Thermostat Cable. 35-ft. coil.

Number wire	Catalog Number	Shpg wt.	Coil
2	42 A 9151	10 oz.	$3.29
3	42 A 9153	14 oz.	4.29
5	42 A 9155	1 lb. 8 oz.	6.29

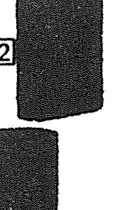
See our selection of Ductwork, Registers and Grilles in our Home Improvement Catalog; see p. 594

(1) Return-air Drop Packages for Sears furnaces, air cleaners
CONSTRUCTION: Rust-resistant galvanized steel. Measures 92 in. high (can be cut to fit). Includes duct and fittings (sizes listed in chart below), starting collar, two 30-in. long ducts, one 32-in. long duct with two turning vanes, screws and installation instructions.
CAPACITY, ORDERING INFORMATION: See chart below for capacity rating. See "N" suffix note on page 616.

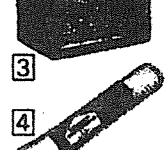
For furnaces up to and including		Duct and fittings	Catalog Number	Shpg wt. lbs.	Price
Heating Cap	Air cond. Cap.				
105,000 Btuh	24,000 Btuh	24x8-in.	42 A 78656N	48	$87.39
175 000 Btuh	42,000 Btuh	24x12-in.	42 A 78657N	54	96.59


1

(2 and 3) Filter Racks for gas forced-air horizontal furnaces
CONSTRUCTION: Steel racks, enamel finish. Attach to return-air side of furnace. Permanent washable-type air filter. For Sears "Ten" and "Fifteen" gas horizontal furnaces.
SIZES AND ORDERING INFO: Order from chart below. See "N" suffix note, page 616.


2

Key	For furnace (Btuh)	Includes	Catalog Number	Shipping weight pounds	Price
(2)	80,000	one 16x20-in. filter	42 A 78002	10	$16.99
(2)	100,000	one 20x20-in. filter	42 A 78003C	10	18.99
(3)	120,000	two 15x20-in. filters	42 A 78004N	22	45.99
(3)	140,000	two 16x25-in. filters	42 A 78005N	22	47.99
(3)	160,000	two 16x25-in. filters	42 A 78006N	22	49.99

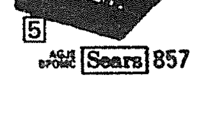

3

(4) One-inch thick multipurpose Fiber Glass Material
For use in furnaces not using frame-type filters. Many other uses around your home, too. Can be cut to fit your particular furnace's size requirements.
SIZES AND ORDERING INFORMATION:
42 A 8349C–240x30-inch Roll (shown at right). Shipping weight 2 pounds $5.99
42 A 8347L—30x31½-inch Pad (not shown). Shipping weight 1 pound* 1.29
*If mailed takes 15-lb. rate, see page 618

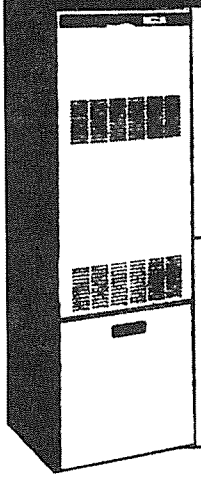
4

(5) Big Trapper Furnace Filters still have more glass fibers than any we've ever sold
Change filters regularly to help furnace produce maximum airflow.
CONSTRUCTION: One-piece, 1-inch thick compressed fiber glass furnace filters. Non-reusable. UL listed. Replace filter after 1 month of use to help maximize furnace's airflow.
ORDERING INFORMATION: Sold only in package of 6.

Size, in	Catalog No	Shpg wt	Pkg	Size, in	Catalog Number	Shpg wt.	Pkg
10x20x1	42 A 8350	1 lb. 6 oz.	$2.99	12x25x1	42 A 8360C	1 lb. 14 oz.	$2.99
14x20x1	42 A 8351	1 lb. 12 oz.	2.99	14x25x1	42 A 8361C	2 lbs. 2 oz.	2.99
15x20x1	42 A 8352	1 lb. 14 oz.	2.99	16x25x1	42 A 8362C	2 lbs. 6 oz.	2.99
16x20x1	42 A 8353	1 lb. 14 oz.	2.99	18x25x1	42 A 8363C	2 lbs. 6 oz.	2.99
20x20x1	42 A 8354C	2 lbs. 2 oz.	2.99	20x25x1	42 A 8364C	2 lbs. 6 oz.	2.99
12x24x1	42 A 8355	1 lb. 14 oz.	2.99	. . . . . .	. . . . . .	. . . . . .	. . . .

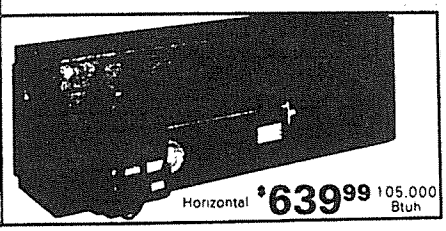

5

Sears Oil Furnaces . . . built for fuel economy with LIFE-CLAD heat exchanger warranted 10 years



Space-Saver **$539.99** 105,000 Btuh

- Fiberfrax® ceramic fiber-lined combustion chamber for clean firing and quick heating
- Summer switch for continuous operation without heat
- Die-cast aluminum burner designed for clean, efficient combustion
- Insulated jacket reduces heat loss through cabinet



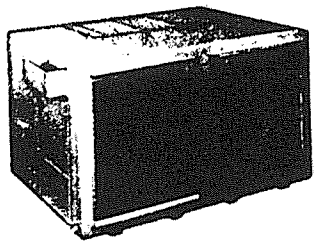
Horizontal **$639.99** 105,000 Btuh

HEAT EXCHANGER: LIFE-CLAD® ceramic-coated steel. Warranted 10 years.
BURNER: Die-cast aluminum. Combustion chamber lined with Fiberfrax® ceramic fiber, (horizontals with stainless steel combustion chamber). Cadmium cell safety control senses light from flame, automatically shuts off furnace if oil fails to ignite or if flame goes out during operation. Safety-limit control shuts off burner to prevent overheating. Includes oil filter.
BLOWER: Powerful, multi-speed direct-drive blower motor (except where noted in chart below) provides extra capacity needed to handle central air conditioning. Summer switch (not available on horizontals). Draft regulator and furnace air filter included (except where noted in chart below.
CABINET: Steel. Rust-resistant finish inside and out. Enameled green exterior. Avocado door.
ELEC. INFO: Factory assembled, pre-wired. 110–120-volt, 60-Hertz AC. UL listed.
ORDERING INFORMATION: See Warranty (B), page 624. Order thermostat separately, pg. 857. Order sub-base, if needed, for counterflow installation on combustible floor, pg. 859. Owner's Manual included. Not for mobile home use.

Btuh Input	Flue size	Motor HP	Watts used	Air Cond Cap. Btuh	Length x Width x Height in inches	Catalog Number	Wt lbs	Price
SPACE-SAVER UPFLOW FURNACE								
105,000	6 in	½	715	36,000	28x19x58	AG42 A 74111N	225	$539.99
140,000	7 in	½	755	42,000	28x20x58	AG42 A 74112N	242	569.99
BASEMENT UPFLOW FURNACE								
105,000	6 in	½	715	37,000	43x20x40	AG42 A 74121N	244	569.99
140,000	7 in	½	715	37,000	46x20x40	AG42 A 74122N	260	609.99
175,000	8 in	½▲▲	785	48,000	56x21½x50	AG42 A 74123N	393	759.99
210,000	8 in	½▲▲	805	48,000	61x24x52½	AG42 A 74124N	450	829.99
COUNTERFLOW (DOWNFLOW) FURNACE . . . order sub-base on facing page								
105,000	6 in	½	705	36,000	20x28x60	AG42 A 74133N	235	589.99
140,000	7 in	½	780	36,000	20x30x60	AG42 A 74134N	264	629.99
HORIZONTAL FURNACE . . . not for use in attic								
105,000	7 in	⅓	655	33,000	71x17x23½	AG42 A 74896N2	303	639.99
140,000	7 in	½	665	48,000	71x20x23½	AG42 A 74897N2	338	689.99
175,000•	8 in	½▲▲	855	37,000	66x23x23½	AG42 A 74898N2	370	739.99

•Air filter not incl. order filters, filter rack p. 857, filter grille from Home Improvement Book
▲▲Belt drive

NOTE: Memphis and Jacksonville customers "AG" items such as AG42A74111N are shipped from Atlanta. Allow time for delivery. Pay shipping charges from your Distribution Center. C.O.D.'s accepted only for shipment to a Sears store



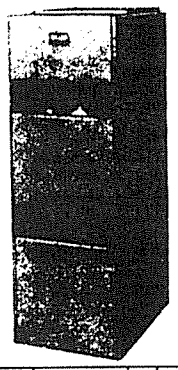
Combination Central Heating, Cooling Unit. Aluminized, steel heat exchanger, burner. Galv. steel cabinet. Direct-spark ignition. Power-vented. Direct-drive, multi-speed fan.
INSTALL: Install on ground or roof. Platform required to mount on flat or pitched roof (not incl.). Concrete slab required to mount on ground (not included).
ELEC. INFO: 230-v., 60-Hertz AC. Instructions included.
CAPACITY, ORD INFO: Warranty (D), p. 624. Wind, location won't affect combustion.

Heating Capacity (Btuh)	Cooling Capacity (Btuh)	Watts	Fan HP	Size (WxD) inches	Wt lbs	Natural Gas† Catalog Number	L.P Gas† Catalog Number	Price
80,000	23,000	4000	¼	45¾x55¾x24¾	500	42 A 81621N	42 A 81631N	$1169.99
80,000	29,000	4500	¼	45¾x55¾x24¾	510	42 A 81622N	42 A 81632N	1319.99
100,000	37,000	6000	½	45¾x55¾x24¾	565	42 A 81624N	42 A 81634N	1399.99
100,000	41,500	6600	½	45¾x58¾x24¾	590	42 A 81625N	42 A 81635N	1469.99
125,000	47,000	8000	¾	53¾x78¾x29¾	660	42 A 81626N	42 A 81636N	1669.99
150,000	57,500	9200	1	55¾x78¾x29¾	700	42 A 81627N	42 A 81637N	1819.99

†American Gas Association design certified

Heating and cooling capacities, watts are estimated. Contact Dept. 243 at address on cover or a Sears store for results of test procedures which were not available at the time of printing

Our lowest priced Oil Furnace has steel heat exchanger warranted 5 years



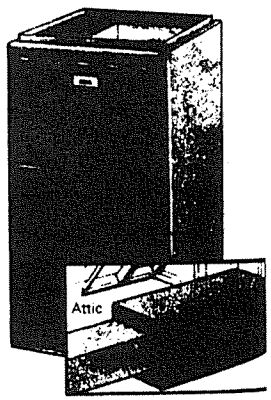
HEAT EXCHANGER: Steel. Warranted 5 yrs.
BURNER: Die-cast aluminum burner designed for clean, efficient combustion and economical fuel use. Combustion chamber lined with ceramic fiber (exc. horizontals have stainless steel chamber). Safety-limit control shuts off burner to prevent overheating. Oil filter not included.
BLOWER: Direct-drive, multi-speed blower motor. Draft regulator, air filter included.
CABINET: Steel. Olive-green enameled finish.
ELECTRICAL INFORMATION: 110–120-volt, 60-Hertz AC. UL listed.
ORDERING INFORMATION: Thermostat not included, order separately on page 857. See Warranty (B) on page 624. Not for mobile home use.

Furnace use and type	Btuh Input	Spds	Flue in	HP	Wattage	Air Cond Cap. Btuh	Size in (LxWxH)	Catalog Number	Wt lbs	Price
Space-Saver Upflow	105,000	2	6	⅓	410	25,000	28x20x58	42A74051N	217	$469.99
	140,000	3	7	¼	590	36,000	30x20x58	42A74052N	245	509.99
Basement Upflow	105,000	2	6	⅓	410	25,000	43x20x40	42A74061N	250	499.99
	140,000	3	7	¼	470	36,000	46x20x40	42A74062N	259	539.99
Counterflow§	105,000	4	6	¼	350	30,000	28x20x60	42A74041N	230	519.99
Horizontal•	105,000	3	7	⅓	435	24,000	71x17x23½	42A74891N2	295	569.99
	140,000	3	7	¼	425	37,000	71x20x23½	42A74892N2	320	619.99

•Not for use in attics §Sub-bases for counterflow models sold on p. 859

Electric Furnaces with insulated blower compartment to muffle noise, reduce heat loss

Low as **$249.99** 35,260 Btuh



HEATING ELEMENT: Each 5.0 KW (kilowatt) element has thermal cutoff which protects unit from overheating. Use with 24-volt thermostat sold below.
BLOWER: Direct-drive, multi-speed blower designed for effective air circulation and air conditioning. Unit can be installed either upright, upside down, or on its side for desired direction of air flow.
CABINET: Olive-green steel warm air compartment lined with fiber glass insulation. 10.3 KW, 15.4 KW and 20.4 KW models measure 20x20½x36 in. high. Others are 21½x20x48 in.
ELECTRICAL INFO: 240-volt, 60-Hertz AC. UL listed.
ORDERING INFO: For counterflow use on combustible floors (blows downward), order sub-base below. Order plenum chamber below. Order equal or slightly higher KW rating than present electric furnace or write Sears, Dept. 243, address on cover, for correct rating. See Warranty (C), pg. 624. Not for mobile home use.

Btuh output▲	KW	Motor HP	Heating Elements	Air Conditioning Capacity Btuh	Rated amps	Catalog Number	Wt lbs	Price
35,260	10.3	¼	2	22,000–36,000	46.7	42 A 58711N†	96	$249.99
52,695	15.4	¼	3	24,000–42,000	66.0	42 A 58712N†	96	279.99
69,760	20.4	¼	4	24,000–42,000	86.8	42 A 58713N††	96	309.99
84,235	24.6	½	5	29,000–48,000	105.0	42 A 58714N•	130	349.99
96,775	28.3	½	5	42,000–58,000	121.0	42 A 58715N•	140	379.99
115,905	33.8	½	6	42,000–58,000	143.9	42 A 58716N•	141	409.99

▲Furnace rating incl. motor. Btuh rating ††Must use multi-stage thermostat 42 A 9297 below.
†May use 42 A 9295 or 42 A 9235 thermostat •Recommend thermostat 42 A 9297 below

Sub-base. (Not shown). For 42A58711N, 42A58712N, 42A58713N above.
42 A 58764C—Needs floor opening of 20¼x20¾ in. Wt. 2 lbs. $9.99
For furnaces 42 A 58714N, 42 A 58715N and 42 A 58716N sold above.
42 A 58763C—Needs floor opening of 22¾x20⅞ in. Wt. 2 lbs. . . . $11.99

Plenum Chambers. (Not shown). See "N" note, p. 616. For upflow use. Incl. 1 supply plenum, 1 return-air adapter. Order return-air drop package, if needed, on p. 857. Max. cooling capacity is 36,000 Btuh. For plenums with larger capacity, write Sears, Dept. 243, address on cover.
42 A 78617N—Shipping weight 49 pounds $62.09
For counterflow use with 42 A 58711N, 42 A 58712N and 42 A 58713N.
42 A 78614L—Incl. supply, return-air plenums. Wt. 36 lbs. $47.19
For counterflow use with 42 A 58714N, 42 A 58715N and 42 A 58716N.
42 A 78702N—Incl. supply, return-air plenums. Wt. 44 lbs. $47.19
For horizontal use with all electric furnaces above.
42 A 78706N—Incl. supply, return-air plenums. Wt. 47 lbs. $50.59

Multi-stage Thermostat for electric furnaces. For heating and cooling with electric furnace above. Must be used with furnace 42 A 58713N. Turns furnace elements on or off as needed. For 24-volt systems.

CONSTRUCTION: Beige, gold-color housing. 3x5¾ in.
ORDER INFO: Needs 5-wire cable, p. 857; use two 3-wire cables if for separate heating/cooling.
42 A 9297—Shpg. wt. 1 lb. 6 oz. $39.99

APPENDIX B

1979 POWER COST DATA FOR 115 U.S. CITIES

Table B.1. 1979 Power cost data for 115 U.S. cities

Locations		Typical residential electric bills for 1000 kWh as of Jan. 1, 1979 ($)
States	Cities	
Alabama	Birmingham	38.01
	Montgomery	38.01
Arizona	Tucson	50.09
	Phoenix	60.63
	Yuma	60.63
Arkansas	Little Rock	36.85
California	Los Angeles	54.91
	Merced	38.68
	Oakland	38.68
	San Diego	52.46
Colorado	Colorado Springs	32.58
	Denver	41.99
	Grand Junction	41.99
District of Columbia	Washington, D.C.	37.04
Florida	Apalachicola	41.11
	Jacksonville	43.38
	Orlando	36.81
Georgia	Atlanta	38.87
	Augusta	38.87
	Macon	38.87
Idaho	Boise	21.85
	Idaho Falls	14.94
Illinois	Chicago	40.56
	E. St. Louis	42.84
	Urbana	47.65
Indiana	Fort Wayne	40.09
	Indianapolis	43.58
	South Bend	40.09
Iowa	Des Moines	44.39
	Sioux City	49.76
Kansas	Dodge City	44.66
	Topeka	41.94
Kentucky	Louisville	33.80
Louisiana	Lake Charles	34.48
	New Orleans	37.60
	Shreveport	25.89
Maine	Portland	38.86
Massachusetts	Falmouth	49.58
Michigan	Battle Creek	41.14
	Detroit	45.21
	Sault Ste. Marie	26.19
Minnesota	Duluth	51.82
	International Falls	26.30
	Minneapolis	49.18
Mississippi	Biloxi	37.66
	Columbus	29.32
	Jackson	36.46

Table B.1 (continued)

Locations		Typical residential electric bills for 1000 kWh as of Jan. 1, 1979 ($)
States	Cities	
Missouri	Columbia	45.03
	Kansas City	39.72
	Springfield	46.70
Montana	Billings	26.90
	Great Falls	26.90
	Missoula	26.90
Nebraska	Grand Island	47.67
	Lincoln	34.90
	North Platte	33.18
Nevada	Ely	33.68
	Las Vegas	31.33
	Winnemucca	42.27
New Jersey	Trenton	60.26
New Mexico	Albuquerque	56.96
	Roswell	43.98
New York	Albany	37.01
	Binghamton	43.13
	Niagara Falls	37.01
	Syracuse	37.01
	Westhampton Beach	53.94
North Carolina	Newbern	39.64
	Greensboro	39.42
North Dakota	Bismarck	45.27
	Grand Forks	40.73
	Williston	45.27
Ohio	Akron	45.34
	Columbus	47.70
	Dayton	43.81
	Toledo	59.54
Oklahoma	Altus	25.32
	Oklahoma City	35.49
	Tulsa	40.48
Oregon	Astoria	28.02
	Medford	28.02
	Portland	27.77
Pennsylvania	Middletown	26.10
	Philadelphia	47.49
	Pittsburgh	53.03
	Wilkes-Barre	41.59
South Carolina	Charleston	44.94
	Greenville	41.76
	Sumter	40.11
South Dakota	Huron	44.26
	Rapid City	39.46
Tennessee	Bristol	30.27
	Knoxville	30.36
	Memphis	30.27
	Nashville	28.46

Table B.1 (continued)

Locations		Typical residential electric bills for 1000 kWh as of Jan. 1, 1979 ($)
States	Cities	
Texas	El Paso	49.27
	Fort Worth	43.83
	Houston	40.52
	San Antonio	45.76
Utah	Salt Lake City	44.53
Vermont	Burlington	35.35
Virginia	Norfolk	51.55
	Richmond	51.55
	Roanoke	39.15
Washington	Moses Lake	16.00
	Seattle	11.28
	Spokane	15.83
West Virginia	Charleston	34.63
	Elkins	38.45
Wisconsin	Green Bay	41.40
	Madison	40.18
Wyoming	Casper	27.21
	Cheyenne	25.81
	Lander	27.21
	Sheridan	24.70

Source: U.S. Department of Energy, Energy Information Administration, *Typical Electric Bills, 1979*, DOE/EIA-0040(79).

APPENDIX C

AIR-TO-AIR HEAT PUMP SEASONAL PERFORMANCE FACTORS (HEATING) FOR 115 U.S. CITIES

Table C.1. Air-to-air heat pump[a] seasonal performance factors (heating) for 115 U.S. cities

Locations		Seasonal performance factors (heating)[b]
States	Cities	
Alabama	Birmingham	1.62
	Montgomery	1.68
Arizona	Tucson	1.82
	Phoenix	1.77
	Yuma	1.83
Arkansas	Little Rock	1.64
California	Los Angeles	1.90
	Merced	1.77
	San Diego	1.79
	Oakland	1.90
Colorado	Colorado Springs	1.47
	Denver	1.47
	Grand Junction	1.59
District of Columbia	Washington	1.61
Florida	Apalachicola	1.70
	Jacksonville	1.75
	Orlando	1.67
Georgia	Atlanta	1.63
	Augusta	1.66
	Macon	1.70
Idaho	Boise	1.60
	Idaho Falls	1.41
Illinois	Chicago	1.45
	E. St. Louis	1.52
	Urbana	1.43
Indiana	Fort Wayne	1.50
	Indianapolis	1.51
	South Bend	1.47
Iowa	Des Moines	1.39
	Sioux City	1.35
Kansas	Dodge City	1.52
	Topeka	1.49
Kentucky	Louisville	1.60
Louisiana	Lake Charles	1.68
	New Orleans	1.66
	Shreveport	1.68
Maine	Portland	1.44
Massachusetts	Falmouth	1.51
Michigan	Battle Creek	1.47
	Detroit	1.45
	Sault Ste. Marie	1.28
Minnesota	Duluth	1.23
	International Falls	1.18
	Minneapolis	1.30
Mississippi	Biloxi	1.65
	Columbus	1.67
	Jackson	1.68

Table C.1 (continued)

Locations		Seasonal performance factors (heating)[b]
States	Cities	
Missouri	Columbia	1.51
	Kansas City	1.55
	Springfield	1.53
Montana	Billings	1.42
	Great Falls	1.35
	Missoula	1.50
Nebraska	Grand Island	1.42
	Lincoln	1.38
	North Platte	1.39
Nevada	Ely	1.41
	Las Vegas	1.65
	Winnemucca	1.50
New Jersey	Trenton	1.58
New Mexico	Albuquerque	1.67
	Roswell	1.60
New York	Albany	1.37
	Binghamton	1.36
	Niagara Falls	1.39
	Syracuse	1.44
	Westhampton Beach	1.53
North Carolina	Newbern	1.69
	Greensboro	1.61
North Dakota	Bismarck	1.24
	Grand Forks	1.20
	Williston	1.27
Ohio	Akron	1.48
	Columbus	1.58
	Dayton	1.53
	Toledo	1.44
Oklahoma	Altus	1.58
	Oklahoma City	1.58
	Tulsa	1.57
Oregon	Astoria	1.73
	Medford	1.71
	Portland	1.75
Pennsylvania	Middletown	1.56
	Philadelphia	1.61
	Pittsburgh	1.41
	Wilkes-Barre	1.44
South Carolina	Charleston	1.67
	Greenville	1.66
	Sumter	1.71
South Dakota	Huron	1.27
	Rapid City	1.38
Tennessee	Bristol	1.62
	Knoxville	1.66
	Memphis	1.63
	Nashville	1.57
Texas	El Paso	1.69
	Fort Worth	1.66
	Houston	1.66
	San Antonio	1.77

Table C.1 (continued)

Locations		Seasonal performance factors (heating)[b]
States	Cities	
Utah	Salt Lake City	1.56
Vermont	Burlington	1.34
Virginia	Norfolk	1.66
	Richmond	1.65
	Roanoke	1.64
Washington	Moses Lake	1.58
	Seattle	1.79
	Spokane	1.55
West Virginia	Charleston	1.59
	Elkins	1.45
Wisconsin	Green Bay	1.31
	Madison	1.37
Wyoming	Casper	1.41
	Cheyenne	1.42
	Lander	1.38
	Sheridan	1.40

[a]Air-Conditioning and Refrigeration Institute (ARI) system, 2.75 ARI at +8.3°C.
[b]Cooling seasonal performance factors (SPFs) are 1.63 for all cities.

APPENDIX D

COMPUTER OUTPUT TABLES OF SYSTEMS EVALUATIONS

BIRMINGHAM, ALABAMA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0380
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 8666.
COOLING = 7005.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.26
BLOWER CAPACITY (M3/H) = 1868.

AIR TEMP: OUTDOOR INDOOR
WINTER = -7 C 21 C
SUMMER = 34 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	5.69	14.48	8.40	259.88	1688.	6143.	0.	2175.	1514.	1416.	914.	853.
FEB	9.08	16.09	8.64	255.46	1516.	3968.	0.	1524.	1118.	1053.	660.	597.
MAR	11.73	16.09	11.10	249.44	1582.	3068.	691.	1410.	1026.	960.	557.	522.
APR	17.34	14.48	15.04	233.45	1381.	1087.	1939.	1017.	873.	706.	304.	304.
MAY	21.95	12.87	19.63	223.52	1247.	0.	3868.	1007.	1045.	798.	592.	214.
JUN	25.13	11.26	23.38	227.45	1065.	0.	5758.	1280.	1283.	1006.	1059.	236.
JUL	26.55	9.65	25.49	227.40	1017.	0.	7323.	1534.	1534.	1276.	1342.	1076.
AUG	26.50	9.65	25.24	227.28	1027.	0.	7195.	1514.	1515.	1254.	1319.	1323.
SEP	23.68	11.26	22.80	224.15	1086.	0.	4776.	1118.	1128.	842.	881.	884.
OCT	17.31	11.26	18.70	226.96	1284.	1027.	2162.	1011.	875.	696.	411.	414.
NOV	11.16	12.87	14.26	244.19	1411.	3021.	0.	1231.	958.	905.	499.	447.
DEC	7.52	12.87	10.43	252.44	1609.	4856.	0.	1796.	1256.	1178.	752.	704.
ANNUAL	16.97	12.74	16.93		15914.	23169.	33712.	16617.	14124.	12090.	9292.	7575.
ANNUAL COP								1.22	1.43	1.67	2.18	2.67

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST, $ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	434.	2885.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	534.	3425.
	ACES SYSTEMS, INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN., BR.CHILL, BIN(M3)= 10 P(M2)= 5	2650.	1261.	887.	480.	240.	889.	434.	6841.
5	FULL, BR.CHILL, BIN(M3)= 53 P(M2)= 0	2650.	2898.	0.	480.	240.	889.	434.	7591.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	631.63	REF.	REF.	REF.	10367.	13956.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	536.86	94.77	0.8	1	8812.	13707.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	459.54	172.09	3.6	2	7543.	13225.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 10	1929.	353.17	278.46	14.5	4	5797.	14567.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 53	1929.	287.93	343.70	13.9	3	4726.	14246.	4

MONTGOMERY, ALABAMA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0380
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 7853.
COOLING = 7726.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.31
BLOWER CAPACITY (M3/H) = 1698.

AIR TEMP: OUTDOOR INDOOR
WINTER = -5 C 21 C
SUMMER = 36 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	7.55	12.87	10.16	252.38	1619.	4847.	0.	1796.	1262.	1181.	767.	704.
FEB	10.47	12.87	10.39	245.74	1454.	3092.	0.	1263.	964.	909.	559.	495.
MAR	13.25	14.48	12.73	242.73	1518.	2262.	862.	1197.	903.	843.	458.	431.
APR	18.90	11.26	16.48	223.34	1327.	593.	2459.	954.	872.	692.	256.	256.
MAY	23.50	9.65	20.85	220.46	1199.	0.	4708.	1138.	1153.	852.	870.	227.
JUN	26.05	9.65	24.42	226.26	1025.	0.	6725.	1434.	1434.	1172.	1234.	991.
JUL	26.97	9.65	26.44	228.34	980.	0.	8147.	1664.	1664.	1419.	1492.	1494.
AUG	27.41	8.05	26.20	226.07	989.	0.	8184.	1673.	1673.	1426.	1498.	1501.
SEP	24.70	9.65	23.88	223.19	1045.	0.	5689.	1262.	1266.	994.	1046.	1049.
OCT	18.68	9.65	19.97	220.58	1234.	598.	2685.	968.	887.	692.	505.	507.
NOV	13.29	11.26	15.75	236.07	1355.	2071.	984.	1120.	854.	794.	382.	353.
DEC	9.11	11.26	12.09	245.57	1543.	3916.	0.	1517.	1083.	1017.	645.	587.
ANNUAL	18.32	10.86	18.28		15289.	17379.	40444.	15985.	14016.	11990.	9712.	8595.
ANNUAL COP								1.27	1.45	1.69	2.09	2.36

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 8 P(M2)= 4	2650.	1138.	847.	480.	240.	889.	434.	6678.
5	FULL,BR.CHILL, BIN(M3)= 38 P(M2)= 0	2650.	2369.	0.	480.	240.	889.	434.	7062.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	607.60	REF.	REF.	REF.	9973.	13562.	2
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	532.73	74.87	3.4	1	8744.	13821.	3
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	455.73	151.88	5.2	2	7480.	13345.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 8	1929.	369.14	238.46	16.2	4	6059.	14666.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 38	1929.	326.70	280.90	15.1	3	5362.	14354.	4

TUCSON, ARIZONA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0501
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 6321.
COOLING = 7214.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.02
BLOWER CAPACITY (M3/H) = 1613.

AIR TEMP: OUTDOOR INDOOR
WINTER = -1 C 21 C
SUMMER = 39 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	10.80	11.26	12.07	241.73	1544.	3187.	667.	1428.	1021.	950.	599.	530.
FEB	11.80	11.26	12.07	239.46	1395.	2579.	842.	1248.	917.	851.	518.	451.
MAR	14.46	12.87	14.21	236.69	1460.	1984.	1833.	1270.	1008.	925.	415.	415.
APR	19.43	12.87	17.87	225.43	1274.	694.	3198.	1093.	998.	766.	440.	278.
MAY	23.93	12.87	22.27	228.01	1144.	0.	4838.	1144.	1172.	871.	893.	726.
JUN	28.96	12.87	25.98	239.41	966.	0.	6878.	1443.	1445.	1200.	1261.	1262.
JUL	29.97	12.87	28.21	241.71	910.	0.	7711.	1570.	1570.	1343.	1411.	1412.
AUG	28.29	11.26	28.21	234.62	910.	0.	7241.	1490.	1490.	1262.	1326.	1327.
SEP	27.16	11.26	26.08	232.06	962.	0.	6023.	1296.	1297.	1050.	1106.	1107.
OCT	21.49	12.87	22.27	222.47	1143.	0.	3830.	972.	1010.	766.	710.	711.
NOV	14.15	12.87	18.02	237.40	1268.	1861.	1620.	1146.	900.	825.	343.	329.
DEC	11.58	11.26	14.22	239.95	1460.	2857.	931.	1358.	985.	912.	544.	474.
ANNUAL	20.17	12.20	20.12		14435.	13161.	45612.	15459.	13814.	11721.	9566.	9024.
ANNUAL COP								1.32	1.47	1.74	2.13	2.25

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 6 P(M2)= 1	2500.	967.	746.	480.	240.	714.	392.	6039.
5	FULL,BR.CHILL, BIN(M3)= 16 P(M2)= 0	2500.	1501.	0.	480.	240.	714.	392.	5827.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	774.36	REF.	REF.	REF.	12710.	16299.	4
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	691.92	82.44	3.1	1	11357.	16434.	5
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	587.13	187.23	4.2	2	9637.	15501.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 6	1929.	479.17	295.19	10.9	4	7865.	15834.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 16	1929.	452.00	322.36	9.3	3	7419.	15175.	1

PHOENIX, ARIZONA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0606
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 5769.
COOLING = 8235.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.03
BLOWER CAPACITY (M3/H) = 1868.

AIR TEMP: OUTDOOR INDOOR
WINTER = 0 C 21 C
SUMMER = 42 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	10.88	6.44	12.35	231.72	1533.	2989.	746.	1384.	1002.	935.	585.	509.
FEB	12.83	8.05	12.44	230.57	1382.	2090.	1073.	1148.	875.	814.	468.	402.
MAR	15.72	9.65	14.96	227.29	1431.	1507.	2159.	1185.	983.	785.	367.	367.
APR	20.72	9.65	19.17	215.93	1224.	0.	3566.	949.	1010.	782.	663.	320.
MAY	25.51	9.65	24.18	225.04	1068.	0.	5589.	1252.	1265.	987.	1028.	1029.
JUN	30.96	9.65	28.37	237.40	875.	0.	8032.	1615.	1616.	1400.	1469.	1470.
JUL	33.61	9.65	30.84	243.41	807.	0.	10093.	1949.	1949.	1758.	1843.	1844.
AUG	31.84	9.65	30.75	239.39	810.	0.	9775.	1895.	1895.	1703.	1785.	1786.
SEP	29.00	8.05	28.25	229.67	879.	0.	7090.	1456.	1456.	1236.	1299.	1300.
OCT	22.33	8.05	23.86	214.54	1081.	0.	4307.	1036.	1063.	788.	796.	797.
NOV	14.79	8.05	19.01	226.12	1230.	1597.	1945.	1118.	906.	718.	372.	373.
DEC	11.33	6.44	14.73	230.69	1440.	2853.	940.	1353.	984.	914.	546.	472.
ANNUAL	21.63	8.58	21.58		13760.	11037.	55317.	16340.	15005.	12820.	11221.	10668.
ANNUAL COP								1.36	1.48	1.74	1.98	2.09

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	1050.	40.	160.	200.	880.	434.	3014.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 6 P(M2)= 1	2500.	945.	742.	480.	240.	714.	392.	6014.
5	FULL,BR.CHILL, BIN(M3)= 14 P(M2)= 0	2500.	1375.	0.	480.	240.	714.	392.	5701.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	990.70	REF.	REF.	REF.	16261.	20050.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	909.74	80.96	0.7	1	14932.	20009.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	777.30	213.39	2.8	2	12758.	18623.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 6	1929.	680.33	310.37	9.7	4	11167.	19110.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 14	1929.	646.79	343.91	7.8	3	10616.	18247.	1

YUMA, ARIZONA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0606
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 5025.
COOLING = 8564.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.03
BLOWER CAPACITY (M3/H) = 1868.

AIR TEMP: OUTDOOR INDOOR
WINTER = 2 C 21 C
SUMMER = 43 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	12.90	11.26	14.78	236.95	1438.	2284.	967.	1199.	897.	832.	522.	427.
FEB	14.97	11.26	14.62	232.26	1304.	1506.	1493.	1036.	834.	768.	339.	339.
MAR	18.05	12.87	16.71	228.56	1362.	919.	2839.	1119.	993.	775.	422.	365.
APR	22.38	14.48	20.46	227.77	1175.	0.	4078.	1023.	1061.	800.	755.	755.
MAY	25.56	14.48	25.08	234.98	1033.	0.	5370.	1204.	1216.	947.	988.	988.
JUN	30.92	14.48	29.06	247.15	849.	0.	8111.	1621.	1622.	1414.	1483.	1483.
JUL	34.03	16.09	31.56	257.48	778.	0.	11044.	2103.	2103.	1924.	2015.	2015.
AUG	33.20	14.48	31.74	252.31	771.	0.	10958.	2087.	2087.	1909.	1999.	1999.
SEP	30.83	11.26	29.66	240.38	826.	0.	8189.	1629.	1629.	1427.	1497.	1497.
OCT	24.76	11.26	25.75	226.61	1007.	0.	4981.	1131.	1142.	879.	917.	917.
NOV	17.53	11.26	21.28	226.44	1144.	805.	2370.	947.	836.	653.	447.	447.
DEC	13.32	11.26	17.20	236.01	1343.	2060.	1064.	1127.	851.	788.	480.	381.
ANNUAL	23.21	12.87	23.16		13030.	7574.	61465.	16225.	15271.	13116.	11863.	11614.
ANNUAL COP								1.41	1.49	1.74	1.92	1.96

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	1050.	40.	160.	200.	880.	434.	3014.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1280.	29.	178.	200.	898.	434.	3269.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1280.	29.	578.	240.	898.	534.	3809.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 5 P(M2)= 0	2500.	849.	0.	480.	240.	714.	392.	5175.
5	FULL,BR.CHILL, BIN(M3)= 6 P(M2)= 0	2500.	959.	0.	480.	240.	714.	392.	5285.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	983.75	REF.	REF.	REF.	16147.	19936.	4
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	925.88	57.86	4.4	2	15197.	20476.	5
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	795.24	188.51	4.2	1	13053.	19119.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 5	1929.	719.27	264.47	8.2	4	11806.	18910.	2
5	FULL ACES, BR.CHILL, BIN (M3)= 6	1929.	704.13	279.61	8.1	3	11557.	18772.	1

LITTLE ROCK, ARKANSAS

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0369
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 9076.
COOLING = 7613.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.30
BLOWER CAPACITY (M3/H) = 1953.

AIR TEMP: OUTDOOR INDOOR
WINTER = -8 C 21 C
SUMMER = 36 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	5.34	12.87	7.45	257.40	1725.	6414.	0.	2261.	1540.	1437.	947.	887.
FEB	7.82	14.48	7.68	255.05	1551.	4456.	0.	1669.	1160.	1088.	717.	654.
MAR	10.78	16.09	10.33	251.60	1613.	3435.	0.	1402.	1057.	998.	596.	550.
APR	17.03	16.09	14.62	237.42	1397.	1079.	1613.	964.	818.	672.	298.	298.
MAY	21.66	12.87	19.64	222.86	1247.	0.	3831.	1001.	1033.	788.	462.	213.
JUN	26.13	12.87	23.77	233.00	1050.	0.	6671.	1431.	1433.	1164.	1224.	255.
JUL	27.68	11.26	26.12	233.24	992.	0.	8616.	1748.	1748.	1501.	1577.	1259.
AUG	27.57	11.26	25.88	232.99	1002.	0.	8264.	1690.	1690.	1440.	1513.	1517.
SEP	23.68	11.26	23.25	224.15	1069.	0.	4812.	1119.	1127.	846.	888.	891.
OCT	17.10	11.26	18.78	227.43	1280.	1004.	2013.	979.	844.	676.	384.	387.
NOV	10.27	12.87	13.92	246.22	1424.	3426.	0.	1347.	1010.	951.	539.	490.
DEC	6.69	14.48	9.71	257.61	1637.	5515.	0.	1987.	1351.	1262.	819.	779.
ANNUAL	16.81	13.14	16.76		15987.	25329.	35820.	17598.	14812.	12822.	9963.	8180.
ANNUAL COP								1.22	1.45	1.67	2.15	2.62

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 10 P(M2)= 6	2650.	1297.	934.	480.	240.	889.	434.	6924.
5	FULL,BR.CHILL, BIN(M3)= 61 P(M2)= 0	2650.	3142.	0.	480.	240.	889.	434.	7835.

COMPARATIVE SYSTEMS COSTS

	NEW CONSTRUCTION ALTERNATIVES	MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERIOD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	648.48	REF.	REF.	REF.	10644.	14233.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	545.81	102.67	2.5	1	8959.	14036.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	472.49	175.99	4.5	2	7755.	13620.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 10	1929.	367.14	281.34	14.6	4	6026.	14879.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 61	1929.	301.41	347.07	14.5	3	4947.	14712.	4

LOS ANGELES, CALIFORNIA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0549
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 4935.
COOLING = 5048.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.06
BLOWER CAPACITY (M3/H) = 1104.

AIR TEMP: OUTDOOR INDOOR
WINTER = 3 C 21 C
SUMMER = 31 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	12.85	11.26	13.98	237.07	1469.	2040.	438.	1050.	771.	723.	455.	392.
FEB	13.46	11.26	13.46	235.68	1346.	1575.	408.	881.	664.	625.	389.	327.
MAR	14.07	11.26	13.73	234.30	1479.	1536.	657.	950.	736.	690.	412.	343.
APR	15.34	11.26	14.78	231.43	1391.	1000.	841.	808.	668.	626.	302.	272.
MAY	16.49	9.65	16.37	225.53	1375.	546.	1307.	757.	680.	575.	231.	231.
JUN	18.22	9.65	18.00	221.61	1269.	0.	1870.	672.	692.	572.	264.	172.
JUL	20.34	8.05	19.31	213.51	1260.	0.	3161.	890.	892.	689.	589.	298.
AUG	20.87	8.05	19.88	212.33	1237.	0.	3232.	896.	896.	689.	602.	603.
SEP	20.45	8.05	19.59	213.28	1208.	0.	3083.	863.	865.	668.	575.	576.
OCT	18.21	9.65	18.49	221.63	1292.	0.	1866.	678.	713.	594.	355.	356.
NOV	15.84	11.26	16.94	230.29	1309.	904.	1122.	806.	680.	573.	260.	245.
DEC	13.85	11.26	15.27	234.80	1418.	1659.	644.	965.	737.	689.	406.	333.
ANNUAL	16.67	10.06	16.65		16054.	9261.	18631.	10216.	8996.	7715.	4839.	4147.
ANNUAL COP								1.20	1.36	1.58	2.52	2.94

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	930.	40.	160.	200.	688.	392.	2660.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	392.	2843.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	492.	3383.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 4 P(M2)= 1	2500.	819.	739.	480.	240.	714.	392.	5884.
5	FULL,BR.CHILL, BIN(M3)= 17 P(M2)= 0	2500.	1474.	0.	480.	240.	714.	392.	5800.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	560.95	REF.	REF.	REF.	9207.	12643.	4
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	493.95	67.00	2.7	1	8107.	12960.	5
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	423.61	137.34	5.3	2	6953.	12593.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 4	1929.	265.72	295.23	10.9	4	4361.	12175.	2
5	FULL ACES, BR.CHILL, BIN (M3)= 17	1929.	227.71	333.24	9.4	3	3737.	11467.	1

MERCED, CALIFORNIA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0387
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 6398.
COOLING = 6293.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 1528.

AIR TEMP: OUTDOOR INDOOR
WINTER = -1 C 21 C
SUMMER = 37 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	6.95	9.65	7.51	247.19	1723.	4848.	0.	1825.	1223.	1141.	761.	716.
FEB	10.12	9.65	7.66	239.98	1551.	2927.	0.	1244.	881.	831.	525.	488.
MAR	12.34	11.26	10.76	238.23	1596.	2536.	688.	1265.	927.	866.	486.	465.
APR	15.86	11.26	15.91	230.23	1348.	1376.	1892.	1080.	893.	717.	338.	338.
MAY	18.66	12.87	22.00	227.18	1154.	694.	2935.	1015.	919.	703.	407.	259.
JUN	23.70	12.87	27.07	227.48	924.	0.	4713.	1062.	1086.	845.	868.	199.
JUL	53.91	11.26	30.04	292.75	838.	0.	26204.	4710.	4725.	4580.	4767.	4771.
AUG	25.32	9.65	29.89	224.61	844.	0.	5451.	1166.	1172.	955.	1001.	1005.
SEP	22.45	9.65	26.81	218.09	934.	0.	4171.	972.	991.	745.	770.	773.
OCT	17.80	8.05	21.45	219.29	1176.	676.	2528.	946.	853.	665.	476.	479.
NOV	11.09	8.05	15.55	234.51	1362.	2658.	0.	1117.	846.	797.	431.	406.
DEC	7.53	8.05	10.36	242.59	1611.	4456.	0.	1686.	1129.	1054.	684.	661.
ANNUAL	18.81	10.19	18.75		15062.	20173.	48581.	18089.	15644.	13900.	11513.	10559.
ANNUAL COP								1.29	1.49	1.68	2.02	2.21

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	930.	40.	160.	200.	688.	392.	2660.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	392.	2843.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	492.	3383.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 8 P(M2)= 6	2500.	1089.	915.	480.	240.	714.	392.	6331.
5	FULL,BR.CHILL, BIN(M3)= 46 P(M2)= 0	2500.	2550.	0.	480.	240.	714.	392.	6877.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	699.68	REF.	REF.	REF.	11484.	14920.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	605.09	94.59	1.9	1	9932.	14785.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	537.64	162.04	4.5	2	8825.	14465.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 8	1929.	445.32	254.36	14.4	3	7309.	15570.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 46	1929.	408.44	291.24	14.5	4	6704.	15510.	4

OAKLAND, CALIFORNIA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0389
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 4832.
COOLING = 3539.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 1019.

AIR TEMP: OUTDOOR INDOOR
WINTER = 3 C 21 C
SUMMER = 26 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	9.55	12.87	11.53	247.85	1565.	3508.	0.	1409.	945.	880.	597.	597.
FEB	11.74	11.26	11.20	239.60	1426.	2074.	0.	972.	701.	662.	422.	434.
MAR	12.49	14.48	11.59	244.46	1563.	2195.	0.	1044.	782.	738.	448.	472.
APR	13.41	14.48	12.62	242.36	1473.	1870.	593.	1030.	771.	719.	398.	410.
MAY	14.31	16.09	14.08	243.59	1465.	1623.	798.	994.	767.	713.	369.	376.
JUN	16.22	16.09	15.49	239.27	1364.	933.	1519.	898.	766.	632.	276.	276.
JUL	16.33	14.48	16.56	235.74	1368.	862.	1670.	905.	784.	643.	272.	272.
AUG	16.90	14.48	16.93	234.44	1353.	671.	1840.	877.	782.	638.	306.	254.
SEP	17.80	11.26	16.53	225.85	1325.	448.	1996.	834.	771.	625.	380.	230.
OCT	16.41	9.65	15.45	225.73	1412.	704.	1222.	797.	698.	592.	241.	242.
NOV	13.43	9.65	14.03	232.49	1420.	1502.	0.	812.	647.	616.	340.	358.
DEC	10.22	9.65	12.58	239.77	1524.	3042.	0.	1269.	864.	808.	529.	539.
ANNUAL	14.06	12.87	14.05		17258.	19431.	9639.	11839.	9278.	8268.	4577.	4460.
ANNUAL COP								1.09	1.39	1.56	2.81	2.89

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST, $ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	930.	40.	160.	200.	688.	392.	2660.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	392.	2843.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	492.	3383.
	ACES SYSTEMS, INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN., BR.CHILL, BIN(M3)= 6 P(M2)= 4	2500.	922.	839.	480.	240.	714.	392.	6087.
5	FULL, BR.CHILL, BIN(M3)= 14 P(M2)= 2	2500.	1310.	782.	480.	240.	714.	392.	6418.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	461.02	REF.	REF.	REF.	7567.	11002.	4
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	361.30	99.72	1.8	1	5930.	10783.	1
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	321.95	139.07	5.2	2	5284.	10925.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 6	1929.	178.24	282.78	12.1	3	2925.	10942.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 14	1929.	173.68	287.34	13.1	4	2851.	11199.	5

SAN DIEGO, CALIFORNIA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0525
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 3787.
COOLING = 5158.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.12
BLOWER CAPACITY (M3/H) = 1019.

AIR TEMP: OUTDOOR INDOOR
WINTER = 7 C 21 C
SUMMER = 31 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	13.00	9.65	14.13	233.45	1463.	1803.	0.	907.	705.	670.	424.	356.
FEB	13.63	9.65	13.62	232.03	1340.	1382.	0.	756.	608.	580.	362.	297.
MAR	14.35	11.26	13.90	233.67	1472.	1284.	390.	832.	653.	618.	358.	301.
APR	15.71	11.26	14.93	230.59	1385.	734.	660.	702.	598.	566.	261.	238.
MAY	16.72	12.87	16.50	231.57	1370.	369.	947.	645.	593.	518.	203.	203.
JUN	18.00	11.26	18.10	225.39	1265.	0.	1398.	590.	603.	514.	162.	162.
JUL	20.11	11.26	19.38	220.61	1257.	0.	2550.	785.	785.	622.	479.	186.
AUG	21.08	11.26	19.95	218.40	1235.	0.	3046.	864.	864.	669.	568.	382.
SEP	20.71	9.65	19.65	215.97	1206.	0.	2717.	799.	800.	626.	508.	509.
OCT	18.60	9.65	18.57	220.76	1289.	0.	1727.	653.	668.	558.	329.	331.
NOV	15.67	8.05	17.04	224.13	1305.	768.	872.	725.	618.	532.	203.	227.
DEC	13.81	8.05	15.40	228.33	1413.	1427.	366.	852.	653.	616.	381.	305.
ANNUAL	16.78	10.32	16.76		16001.	7767.	14673.	9110.	8148.	7087.	4237.	3497.
ANNUAL COP								1.17	1.31	1.51	2.52	3.05

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	930.	40.	160.	200.	688.	392.	2660.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	392.	2843.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	492.	3383.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 4 P(M2)= 2	2500.	749.	759.	480.	240.	714.	392.	5834.
5	FULL,BR.CHILL, BIN(M3)= 20 P(M2)= 0	2500.	1545.	0.	480.	240.	714.	392.	5871.

COMPARATIVE SYSTEMS COSTS

		MAINT.	1ST YEAR	1ST YEAR	SIMPLE	SIMPLE	POWER	LIFE	LIFE
	NEW CONSTRUCTION ALTERNATIVES	PRESENT WORTH	POWER COST	POWER SAVING	PAYBACK PERIOD	PAYBACK RANKING	PRESENT WORTH	CYCLE COST	CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	477.91	REF.	REF.	REF.	7844.	11280.	2
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	427.44	50.46	3.6	1	7016.	11869.	5
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	371.79	106.12	6.8	2	6102.	11743.	4
4	MIN. ACES, BR.CHILL, BIN (M3)= 4	1929.	222.28	255.63	12.4	4	3648.	11412.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 20	1929.	183.45	294.46	10.9	3	3011.	10811.	1

COLORADO SPRINGS, COLORADO

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0326
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 13069.
COOLING = 4481.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 2802.

AIR TEMP: OUTDOOR INDOOR
WINTER = -18 C 21 C
SUMMER = 31 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.4M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-2.29	16.09	3.85	281.26	1867.	11971.	0.	3844.	3053.	2887.	1557.	1557.
FEB	0.22	17.70	2.61	278.85	1730.	9310.	0.	3067.	2338.	2208.	1255.	1255.
MAR	1.97	19.31	3.04	278.16	1899.	9096.	0.	3054.	2238.	2111.	1251.	1264.
APR	7.88	20.92	5.14	268.02	1758.	5375.	0.	1982.	1452.	1373.	811.	821.
MAY	13.58	19.31	8.46	251.81	1686.	2631.	1414.	1441.	1096.	1028.	509.	511.
JUN	18.87	19.31	11.93	239.81	1500.	879.	2661.	1115.	994.	789.	309.	309.
JUL	21.36	16.09	14.80	228.73	1437.	0.	3613.	1017.	1052.	821.	340.	228.
AUG	20.70	14.48	16.17	225.82	1383.	0.	3339.	955.	994.	781.	624.	216.
SEP	16.53	16.09	15.70	238.55	1356.	1469.	2279.	1174.	978.	774.	434.	338.
OCT	10.43	16.09	13.49	252.40	1488.	3909.	945.	1661.	1174.	1099.	558.	567.
NOV	2.99	16.09	10.26	269.27	1563.	7844.	0.	2613.	1865.	1756.	974.	1002.
DEC	0.33	16.09	6.69	275.32	1756.	10206.	0.	3323.	2446.	2305.	1327.	1360.
ANNUAL	9.38	17.30	9.34		19423.	62688.	14251.	25246.	19681.	17932.	9943.	9428.
ANNUAL COP								1.06	1.36	1.49	2.69	2.84

SYSTEMS FIRST COSTS

		COST,$						
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 17 P(M2)= 13	2950.	1789.	1215.	530.	240.	1074.	518.	8316.
5	FULL,BR.CHILL, BIN(M3)= 36 P(M2)= 10	2950.	2518.	1086.	530.	240.	1074.	518.	8917.

COMPARATIVE SYSTEMS COSTS

		MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERIOD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	822.50	REF.	REF.	REF.	13500.	16979.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	641.21	181.30	1.2	1	10525.	15449.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	584.21	238.29	3.2	2	9589.	15302.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 17	1929.	324.11	498.39	11.3	3	5320.	15565.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 36	1929.	307.17	515.33	12.1	4	5042.	15883.	4

DENVER, COLORADO

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0420
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 13514.
COOLING = 4428.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 2887.

AIR TEMP: OUTDOOR INDOOR
WINTER = -20 C 21 C
SUMMER = 33 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.2M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-2.17	16.09	3.49	280.98	1881.	12208.	0.	3914.	3083.	2913.	1586.	1586.
FEB	-0.29	16.09	2.27	276.73	1742.	9722.	0.	3185.	2433.	2297.	1299.	1299.
MAR	1.93	17.70	2.95	274.97	1903.	9062.	0.	3046.	2246.	2119.	1242.	1262.
APR	8.33	17.70	5.44	260.44	1747.	4972.	0.	1866.	1362.	1288.	762.	774.
MAY	14.33	16.09	9.21	243.54	1656.	2245.	1348.	1314.	1018.	956.	461.	462.
JUN	19.58	16.09	13.06	231.63	1457.	636.	2691.	1041.	953.	756.	279.	279.
JUL	22.61	14.48	16.15	228.28	1384.	0.	3690.	1015.	1032.	796.	340.	224.
AUG	21.89	14.48	17.50	226.66	1331.	0.	3314.	936.	962.	750.	619.	210.
SEP	17.07	14.48	16.79	234.05	1315.	1273.	2228.	1100.	930.	737.	424.	316.
OCT	11.36	14.48	14.17	247.00	1462.	3423.	1014.	1530.	1097.	1026.	506.	246.
NOV	3.39	16.09	10.49	268.37	1554.	7738.	0.	2581.	1817.	1708.	966.	994.
DEC	0.49	16.09	6.53	274.97	1762.	10193.	0.	3321.	2456.	2313.	1330.	1347.
ANNUAL	9.88	15.82	9.84		19193.	61471.	14286.	24850.	19388.	17659.	9815.	9000.
ANNUAL COP								1.06	1.36	1.49	2.69	2.93

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 17 P(M2)= 16	3350.	1826.	1316.	550.	240.	1288.	518.	9088.
5	FULL,BR.CHILL, BIN(M3)= 38 P(M2)= 11	3350.	2617.	1133.	550.	240.	1288.	518.	9696.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1043.44	REF.	REF.	REF.	17127.	20605.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	814.11	229.33	0.9	1	13362.	18287.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	741.50	301.94	2.5	2	12171.	17883.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 17	1929.	412.14	631.30	10.1	3	6765.	17782.	1
5	FULL ACES, BR.CHILL, BIN (M3)= 38	1929.	377.92	665.52	10.5	4	6203.	17829.	2

GRAND JUNCTION, COLORADO

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0420
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 11941.
COOLING = 5415.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 2547.

AIR TEMP: OUTDOOR INDOOR
WINTER = -16 C 21 C
SUMMER = 34 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.1M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES ER.CHILL
JAN	-1.92	9.65	3.30	267.32	1889.	10858.	0.	3541.	2542.	2388.	1435.	1435.
FEB	0.85	11.26	2.49	264.30	1735.	7996.	0.	2703.	1910.	1796.	1100.	1109.
MAR	5.11	14.48	4.00	261.19	1861.	6343.	0.	2279.	1565.	1474.	924.	368.
APR	11.07	16.09	7.49	250.95	1669.	3329.	814.	1528.	1103.	1037.	576.	608.
MAY	16.77	16.09	12.20	238.02	1539.	1312.	2088.	1149.	972.	786.	348.	348.
JUN	23.37	17.70	16.61	236.56	1322.	0.	4315.	1104.	1133.	857.	374.	231.
JUL	25.95	16.09	19.80	239.15	1241.	0.	5437.	1274.	1275.	949.	1003.	248.
AUG	24.08	14.48	20.71	231.62	1205.	0.	4578.	1117.	1122.	830.	847.	225.
SEP	19.37	16.09	19.18	232.12	1224.	610.	3001.	1022.	939.	723.	562.	334.
OCT	12.48	14.48	15.53	244.47	1408.	2612.	1074.	1300.	959.	898.	415.	444.
NOV	3.72	11.26	10.95	257.80	1537.	6624.	0.	2267.	1521.	1427.	816.	887.
DEC	-1.58	9.65	6.42	266.54	1766.	10639.	0.	3446.	2478.	2327.	1353.	1400.
ANNUAL	11.61	13.94	11.56		18394.	50323.	21308.	22731.	17519.	15490.	9754.	8237.
ANNUAL COP								1.10	1.43	1.61	2.56	3.04

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST, $ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS, INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN., BR.CHILL, BIN(M3)= 16 P(M2)= 16	2950.	1690.	1322.	530.	240.	1074.	518.	8323.
5	FULL, BR.CHILL, BIN(M3)= 72 P(M2)= 4	2950.	3630.	866.	530.	240.	1074.	518.	9808.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	954.46	REF.	REF.	REF.	15666.	19145.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	735.60	218.86	1.0	1	12074.	16999.	3
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	650.44	304.02	2.5	2	10676.	16389.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 16	1929.	409.55	544.91	10.3	3	6722.	16975.	2
5	FULL ACES, BR.CHILL, BIN (M3)= 72	1929.	345.85	608.61	11.7	4	5677.	17414.	4

WASHINGTON, DISTRICT OF COLUMBIA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0370
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 9373.
COOLING = 6781.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.24
BLOWER CAPACITY (M3/H) = 2038.

AIR TEMP: OUTDOOR INDOOR
WINTER = -9 C 21 C
SUMMER = 35 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	0.64	17.70	3.14	277.90	1895.	10258.	0.	3376.	2386.	2232.	1366.	1366.
FEB	1.93	17.70	3.05	274.98	1715.	8147.	0.	2740.	1898.	1775.	1117.	1117.
MAR	5.77	19.31	5.55	269.53	1800.	6466.	0.	2296.	1572.	1474.	932.	962.
APR	12.53	17.70	9.92	250.90	1576.	2738.	784.	1332.	977.	917.	498.	554.
MAY	18.26	16.09	15.24	234.62	1420.	857.	2379.	1039.	921.	735.	293.	293.
JUN	22.40	14.48	19.78	227.82	1201.	0.	3976.	1013.	1033.	778.	474.	211.
JUL	24.47	14.48	22.58	232.51	1131.	0.	5712.	1290.	1291.	996.	1051.	242.
AUG	23.67	12.87	22.69	227.42	1127.	0.	5025.	1172.	1176.	880.	927.	227.
SEP	20.10	14.48	20.20	227.19	1185.	0.	3138.	865.	923.	722.	585.	291.
OCT	14.26	14.48	15.64	240.43	1404.	1900.	1188.	1121.	869.	812.	345.	372.
NOV	8.51	16.09	10.49	256.76	1554.	4328.	0.	1634.	1127.	1061.	601.	654.
DEC	2.23	16.09	5.84	271.02	1789.	8856.	0.	2957.	2053.	1920.	1169.	1209.
ANNUAL	12.90	15.96	12.84		17797.	43550.	22202.	20836.	16227.	14304.	9358.	7498.
ANNUAL COP								1.11	1.43	1.62	2.48	3.10

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	434.	2885.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	534.	3425.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 15 P(M2)= 14	2650.	1549.	1240.	480.	240.	889.	434.	7482.
5	FULL,BR.CHILL, BIN(M3)= 82 P(M2)= 2	2650.	3766.	771.	480.	240.	889.	434.	9229.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	771.76	REF.	REF.	REF.	12667.	16257.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	601.06	170.71	0.4	1	9866.	14760.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	529.82	241.94	2.5	2	8696.	14379.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 15	1929.	346.62	425.15	11.0	3	5689.	15101.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 82	1929.	277.73	494.04	13.0	4	4559.	15717.	4

APPALACHICOLA, FLORIDA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0411
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 6301.
COOLING = 7372.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.45
BLOWER CAPACITY (M3/H) = 1358.

AIR TEMP: OUTDOOR INDOOR
WINTER = -1 C 21 C
SUMMER = 33 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	11.19	14.48	13.53	247.41	1487.	2891.	0.	1216.	929.	876.	553.	477.
FEB	13.35	14.48	13.47	242.49	1345.	1811.	825.	1018.	782.	730.	420.	362.
MAR	15.65	14.48	15.19	237.28	1422.	1113.	1341.	933.	783.	653.	298.	298.
APR	19.89	14.48	18.19	227.66	1262.	0.	2991.	861.	890.	699.	377.	196.
MAY	23.94	12.87	21.85	228.02	1160.	0.	5773.	1309.	1311.	1008.	1062.	1063.
JUN	26.60	11.26	24.96	230.79	1004.	0.	7798.	1611.	1611.	1359.	1428.	1429.
JUL	27.69	11.26	26.89	233.26	962.	0.	9196.	1839.	1839.	1602.	1681.	1682.
AUG	27.63	11.26	26.96	233.12	959.	0.	9152.	1830.	1830.	1594.	1673.	1675.
SEP	25.94	12.87	25.25	232.56	993.	0.	7417.	1543.	1543.	1292.	1359.	1360.
OCT	21.48	12.87	22.12	222.43	1149.	0.	4165.	1031.	1053.	787.	771.	772.
NOV	16.64	12.87	18.58	231.74	1247.	907.	1953.	932.	810.	649.	372.	373.
DEC	12.82	12.87	15.38	240.43	1414.	2173.	797.	1133.	851.	794.	477.	390.
ANNUAL	20.23	13.01	20.20		14404.	8895.	51408.	15256.	14233.	12045.	10473.	10077.
ANNUAL COP								1.36	1.46	1.72	1.98	2.06

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 5 P(M2)= 1	2500.	925.	747.	480.	240.	714.	392.	5999.
5	FULL,BR.CHILL, BIN(M3)= 16 P(M2)= 0	2500.	1447.	0.	480.	240.	714.	392.	5773.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	627.18	REF.	REF.	REF.	10294.	13883.	1
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	585.14	42.04	6.0	2	9604.	14681.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	495.19	131.99	6.0	1	8128.	13992.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 5	1929.	430.55	196.63	16.2	4	7067.	14995.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 16	1929.	414.26	212.91	13.9	3	6800.	14502.	3

JACKSONVILLE, FLORIDA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0434
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 6117.
COOLING = 7683.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.40
BLOWER CAPACITY (M3/H) = 1273.

AIR TEMP: OUTDOOR INDOOR
WINTER = 0 C 21 C
SUMMER = 34 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	11.77	14.48	13.98	246.09	1469.	2825.	660.	1306.	948.	887.	564.	482.
FEB	14.91	16.09	14.11	242.23	1322.	1603.	1233.	1023.	816.	759.	369.	346.
MAR	16.44	16.09	15.91	238.76	1393.	1265.	1732.	1034.	868.	707.	320.	320.
APR	20.39	16.09	18.84	229.79	1237.	0.	2987.	854.	901.	710.	467.	285.
MAY	24.33	14.48	22.29	232.19	1143.	0.	5526.	1262.	1267.	969.	1017.	1018.
JUN	26.24	14.48	25.12	236.52	998.	0.	7172.	1503.	1503.	1250.	1314.	1315.
JUL	27.42	12.87	26.75	235.93	967.	0.	8854.	1781.	1781.	1543.	1619.	1620.
AUG	27.24	12.87	26.61	235.51	973.	0.	8761.	1767.	1767.	1526.	1603.	1603.
SEP	25.83	14.48	24.83	235.60	1009.	0.	7348.	1536.	1536.	1280.	1347.	1347.
OCT	21.08	14.48	21.77	224.95	1163.	0.	4070.	1019.	1055.	795.	754.	754.
NOV	16.52	12.87	18.44	232.02	1252.	1048.	1822.	950.	811.	653.	349.	350.
DEC	12.43	12.87	15.54	241.30	1408.	2508.	722.	1211.	894.	836.	514.	428.
ANNUAL	20.38	14.35	20.35		14335.	9248.	50887.	15246.	14148.	11915.	10237.	9868.
ANNUAL COP								1.36	1.46	1.74	2.02	2.10

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 5 P(M2)= 1	2500.	915.	739.	480.	240.	714.	392.	5980.
5	FULL,BR.CHILL, BIN(M3)= 12 P(M2)= 0	2500.	1289.	0.	480.	240.	714.	392.	5616.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	661.37	REF.	REF.	REF.	10855.	14445.	2
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	613.74	47.63	5.3	1	10074.	15151.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	516.87	144.50	5.5	2	8484.	14348.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 5	1929.	444.06	217.31	14.6	4	7289.	15193.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 12	1929.	428.09	233.28	12.0	3	7027.	14572.	3

ORLANDO, FLORIDA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0368
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 5195.
COOLING = 4999.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.39
BLOWER CAPACITY (M3/H) = 1104.

AIR TEMP: OUTDOOR INDOOR
WINTER = 2 C 21 C
SUMMER = 26 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	14.81	11.26	16.48	232.62	1371.	1484.	1415.	1035.	840.	785.	398.	331.
FEB	15.52	12.87	16.36	234.30	1242.	1235.	1412.	930.	766.	627.	294.	294.
MAR	17.94	12.87	17.56	228.80	1329.	703.	2351.	966.	871.	692.	357.	447.
APR	21.60	16.09	19.73	229.27	1203.	0.	3584.	947.	967.	738.	665.	665.
MAY	24.08	14.48	22.42	231.62	1137.	0.	5361.	1232.	1235.	937.	987.	987.
JUN	25.79	12.87	24.76	232.23	1012.	0.	7002.	1478.	1478.	1220.	1284.	1283.
JUL	26.65	12.87	26.24	234.18	987.	0.	8290.	1691.	1691.	1444.	1517.	1517.
AUG	26.57	12.87	26.38	234.00	982.	0.	8360.	1701.	1701.	1457.	1530.	1529.
SEP	25.78	9.65	25.19	225.64	996.	0.	7022.	1476.	1476.	1223.	1287.	1286.
OCT	23.00	11.26	22.92	222.62	1118.	0.	4845.	1138.	1146.	852.	893.	893.
NOV	19.00	14.48	20.31	229.68	1181.	0.	2760.	800.	864.	688.	516.	515.
DEC	15.86	11.26	17.92	230.24	1314.	1204.	1622.	977.	817.	666.	314.	313.
ANNUAL	21.38	12.74	21.36		13872.	4627.	54025.	14370.	13853.	11329.	10043.	10061.
ANNUAL COP								1.40	1.45	1.78	2.01	2.00

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	930.	40.	160.	200.	688.	392.	2660.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	392.	2843.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	492.	3383.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 4 P(M2)= 0	2500.	752.	0.	480.	240.	714.	392.	5078.
5	FULL,BR.CHILL, BIN(M3)= 4 P(M2)= 0	2500.	752.	0.	480.	240.	714.	392.	5078.

COMPARATIVE SYSTEMS COSTS

	NEW CONSTRUCTION ALTERNATIVES	MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERIOD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	528.95	REF.	REF.	REF.	8682.	12117.	1
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	509.92	19.03	9.7	2	8370.	13223.	5
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	417.04	111.91	6.5	1	6845.	12486.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 4	1929.	369.68	159.27	15.2	3	6068.	13076.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 4	1929.	369.68	159.27	15.2	4	6068.	13076.	4

ATLANTA, GEORGIA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0389
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 8704.
COOLING = 6635.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.26
BLOWER CAPACITY (M3/H) = 1868.

AIR TEMP: OUTDOOR INDOOR
WINTER = -7 C 21 C
SUMMER = 33 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	4.28	17.70	6.76	269.64	1753.	7370.	0.	2534.	1758.	1643.	1049.	994.
FEB	6.96	19.31	6.92	266.84	1578.	5149.	0.	1869.	1304.	1222.	790.	733.
MAR	9.46	19.31	9.34	261.16	1651.	4239.	0.	1636.	1171.	1102.	687.	642.
APR	15.68	17.70	13.31	243.76	1447.	1538.	1423.	1072.	869.	809.	358.	356.
MAY	20.92	14.48	17.98	225.31	1312.	0.	3244.	919.	964.	756.	207.	207.
JUN	23.76	12.87	21.84	227.61	1123.	0.	4909.	1151.	1154.	858.	905.	224.
JUL	25.01	12.87	24.07	230.46	1073.	0.	6191.	1356.	1356.	1079.	1138.	247.
AUG	25.13	12.87	23.90	230.72	1079.	0.	6257.	1369.	1369.	1090.	1150.	928.
SEP	21.99	12.87	21.49	223.60	1136.	0.	3953.	991.	1010.	757.	732.	736.
OCT	15.94	14.48	17.36	236.61	1336.	1345.	1606.	1019.	840.	684.	312.	315.
NOV	10.42	16.09	12.84	252.42	1465.	3436.	0.	1362.	1014.	956.	532.	495.
DEC	5.72	16.09	8.90	263.09	1669.	6206.	0.	2188.	1505.	1407.	889.	858.
ANNUAL	15.44	15.55	15.39		16622.	29283.	27584.	17466.	14313.	12364.	8748.	6733.
ANNUAL COP								1.17	1.43	1.65	2.33	3.03

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	930.	40.	160.	200.	688.	434.	2702.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	434.	2885.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	534.	3425.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 11 P(M2)= 6	2650.	1345.	941.	480.	240.	889.	434.	6979.
5	FULL,BR.CHILL, BIN(M3)= 68 P(M2)= 0	2650.	3346.	0.	480.	240.	889.	434.	8038.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	678.89	REF.	REF.	REF.	11143.	14620.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	556.34	122.56	1.5	1	9131.	14026.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	480.59	198.30	3.6	2	7888.	13571.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 11	1929.	340.05	338.84	12.6	3	5581.	14490.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 68	1929.	261.72	417.17	12.8	4	4296.	14264.	3

AUGUSTA, GEORGIA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0389
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 8070.
COOLING = 7412.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.30
BLOWER CAPACITY (M3/H) = 1698.

AIR TEMP: OUTDOOR INDOOR
WINTER = -6 C 21 C
SUMMER = 35 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	7.64	11.26	9.17	248.89	1658.	4879.	0.	1816.	1287.	1207.	776.	712.
FEB	10.00	12.87	9.49	246.81	1486.	3377.	0.	1351.	1011.	953.	590.	530.
MAR	12.21	12.87	11.91	241.80	1551.	2787.	848.	1350.	997.	931.	524.	491.
APR	17.56	12.87	15.69	229.66	1357.	1042.	2135.	1031.	892.	714.	301.	301.
MAY	22.05	12.87	20.04	223.73	1231.	0.	4206.	1061.	1097.	828.	639.	220.
JUN	25.44	9.65	23.54	224.88	1058.	0.	6182.	1350.	1354.	1080.	1136.	469.
JUL	26.83	9.65	25.45	228.03	1019.	0.	7785.	1613.	1613.	1356.	1426.	1429.
AUG	26.37	8.05	25.10	223.70	1032.	0.	7346.	1542.	1542.	1280.	1347.	1350.
SEP	23.40	9.65	22.71	220.23	1090.	0.	5060.	1167.	1177.	891.	933.	935.
OCT	16.97	8.05	18.77	221.17	1281.	1114.	2352.	1067.	921.	726.	446.	448.
NOV	11.45	9.65	14.57	236.98	1399.	2948.	832.	1350.	985.	916.	484.	451.
DEC	8.01	9.65	10.99	244.78	1587.	4533.	0.	1700.	1219.	1145.	709.	667.
ANNUAL	17.33	10.59	17.28		15749.	20680.	36746.	16398.	14096.	12029.	9310.	8002.
ANNUAL COP								1.24	1.44	1.69	2.18	2.54

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 8 P(M2)= 4	2650.	1151.	869.	480.	240.	889.	434.	6713.
5	FULL,BR.CHILL, BIN(M3)= 44 P(M2)= 0	2650.	2578.	0.	480.	240.	889.	434.	7271.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	637.41	REF.	REF.	REF.	10462.	14051.	2
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	547.90	89.51	2.8	1	8993.	14070.	3
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	467.58	169.83	4.7	2	7675.	13539.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 8	1929.	361.89	275.52	14.2	4	5940.	14582.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 44	1929.	311.03	326.38	13.7	3	5105.	14306.	4

MACON, GEORGIA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0389
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 7848.
COOLING = 7830.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.32
BLOWER CAPACITY (M3/H) = 1698.

AIR TEMP: OUTDOOR INDOOR
WINTER = -5 C 21 C
SUMMER = 36 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	7.85	14.48	10.55	254.98	1604.	4850.	0.	1793.	1238.	1156.	768.	703.
FEB	10.40	16.09	10.66	252.48	1445.	3222.	0.	1296.	962.	905.	571.	508.
MAR	12.94	16.09	12.76	246.69	1517.	2413.	778.	1225.	912.	851.	477.	445.
APR	18.44	16.09	16.22	234.22	1337.	753.	2164.	950.	848.	680.	268.	268.
MAY	23.20	12.87	20.32	226.34	1220.	0.	4585.	1122.	1144.	851.	848.	227.
JUN	25.59	12.87	23.72	231.78	1051.	0.	6313.	1371.	1371.	1100.	1159.	704.
JUL	26.34	12.87	25.71	233.47	1008.	0.	7769.	1608.	1608.	1354.	1423.	1426.
AUG	26.48	11.26	25.60	230.52	1013.	0.	7627.	1584.	1584.	1329.	1397.	1400.
SEP	23.65	12.87	23.51	227.37	1059.	0.	5303.	1200.	1209.	932.	976.	979.
OCT	18.01	11.26	19.91	225.36	1236.	790.	2393.	972.	865.	681.	452.	454.
NOV	15.95	12.87	15.94	233.31	1347.	1560.	1622.	1085.	885.	719.	309.	317.
DEC	8.98	12.87	12.46	249.15	1529.	4100.	0.	1564.	1109.	1038.	661.	584.
ANNUAL	18.15	13.54	18.11		15367.	17688.	38552.	15770.	13733.	11596.	9310.	9015.
ANNUAL COP								1.26	1.45	1.72	2.14	2.48

SYSTEMS FIRST COSTS

		COST,$						
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 8 P(M2)= 4	2650.	1137.	843.	480.	240.	889.	434.	6673.
5	FULL,BR.CHILL, BIN(M3)= 38 P(M2)= 0	2650.	2349.	0.	480.	240.	889.	434.	7042.

COMPARATIVE SYSTEMS COSTS

		MAINT.	1ST YEAR	1ST YEAR	SIMPLE	SIMPLE	POWER	LIFE	LIFE
	NEW CONSTRUCTION ALTERNATIVES	PRESENT WORTH	POWER COST	POWER SAVING	PAYBACK PERIOD	PAYBACK RANKING	PRESENT WORTH	CYCLE COST	CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	612.96	REF.	REF.	REF.	10061.	13650.	2
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	533.82	79.15	3.2	1	8762.	13839.	3
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	450.72	162.24	4.9	2	7398.	13262.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 8	1929.	361.89	251.08	15.4	4	5940.	14542.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 38	1929.	311.53	301.43	14.0	3	5113.	14085.	4

BOISE, IDAHO

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0219
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 11727.
COOLING = 5486.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 2547.

AIR TEMP: OUTDOOR INDOOR
WINTER = -15 C 21 C
SUMMER = 34 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.1M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-1.06	14.48	3.45	275.19	1883.	11513.	0.	3722.	2676.	2507.	1502.	1502.
FEB	1.43	16.09	2.62	272.81	1730.	8371.	0.	2806.	1928.	1805.	1132.	1150.
MAR	4.79	17.70	3.77	268.48	1870.	6851.	0.	2423.	1631.	1530.	973.	1002.
APR	9.33	16.09	6.64	254.90	1701.	4092.	0.	1609.	1162.	1099.	646.	664.
MAY	13.78	16.09	10.63	244.79	1601.	2375.	1318.	1330.	1017.	951.	466.	468.
JUN	19.05	14.48	14.45	229.55	1404.	811.	2847.	1102.	991.	777.	296.	296.
JUL	24.11	14.48	17.28	231.69	1340.	0.	4965.	1220.	1251.	934.	583.	247.
AUG	22.25	12.87	18.20	224.20	1303.	0.	4159.	1073.	1115.	849.	772.	226.
SEP	17.13	14.48	17.03	233.93	1306.	1225.	2361.	1107.	942.	743.	448.	312.
OCT	10.51	14.48	14.02	248.93	1468.	3509.	0.	1383.	1034.	977.	491.	519.
NOV	3.68	14.48	10.14	264.44	1568.	7187.	0.	2432.	1633.	1527.	873.	935.
DEC	-0.07	14.48	6.22	272.96	1774.	10675.	0.	3459.	2346.	2189.	1360.	1339.
ANNUAL	10.41	15.02	10.37		18947.	56610.	15651.	23664.	17728.	15888.	9541.	9712.
ANNUAL COP								1.07	1.43	1.59	2.66	2.91

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 17 P(M2)= 25	2950.	1712.	1656.	530.	240.	1074.	518.	8680.
5	FULL,BR.CHILL, BIN(M3)= 49 P(M2)= 11	2950.	2905.	1111.	530.	240.	1074.	518.	9328.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	517.06	REF.	REF.	REF.	8487.	11965.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	387.36	129.69	1.6	1	6358.	11283.	1
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	347.16	169.89	4.4	2	5698.	11411.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 17	1929.	208.47	308.59	19.4	3	3422.	14031.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 49	1929.	190.35	326.70	20.3	4	3124.	14382.	5

IDAHO FALLS, IDAHO

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0149
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 14999.
COOLING = 4397.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 3226.

AIR TEMP: OUTDOOR INDOOR
WINTER = -23 C 21 C
SUMMER = 31 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (2.9M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-6.73	9.65	4.87	278.22	1827.	15304.	0.	4759.	3967.	3813.	1892.	1892.
FEB	-3.72	11.26	3.28	274.69	1707.	11611.	0.	3700.	2882.	2733.	1472.	1472.
MAR	-0.63	14.48	2.36	274.21	1926.	10441.	0.	3435.	2488.	2350.	1363.	1363.
APR	6.88	16.09	2.54	260.46	1857.	5534.	0.	2053.	1440.	1365.	813.	813.
MAY	11.53	14.48	3.79	246.63	1869.	3358.	1032.	1629.	1200.	1134.	596.	596.
JUN	15.07	14.48	5.71	238.60	1736.	1894.	1800.	1316.	1063.	1000.	435.	435.
JUL	20.01	12.87	7.88	224.10	1709.	0.	3486.	1070.	1161.	938.	253.	253.
AUG	18.70	12.87	9.65	227.08	1639.	931.	3142.	1251.	1123.	885.	340.	340.
SEP	14.19	11.26	10.51	234.03	1554.	2235.	1958.	1387.	1095.	1024.	381.	399.
OCT	7.23	11.26	10.28	249.82	1614.	5233.	0.	1902.	1364.	1292.	655.	654.
NOV	0.58	9.65	9.05	261.64	1609.	8930.	0.	2928.	2097.	1980.	1013.	1012.
DEC	-5.94	9.65	7.05	276.45	1741.	14796.	0.	4594.	3681.	3535.	1765.	1765.
ANNUAL	6.43	12.34	6.41		20788.	80266.	11418.	30024.	23560.	22049.	10979.	10995.
ANNUAL COP								1.04	1.33	1.42	2.85	2.84

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 21 P(M2)= 70	3350.	2041.	3422.	550.	240.	1288.	518.	11408.
5	FULL,BR.CHILL, BIN(M3)= 21 P(M2)= 70	3350.	2041.	3422.	550.	240.	1288.	518.	11408.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	448.56	REF.	REF.	REF.	7362.	10841.	2
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	351.99	96.57	2.2	1	5777.	10702.	1
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	329.41	119.15	6.3	2	5407.	11119.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 21	1929.	164.03	284.53	30.6	3	2692.	16030.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 21	1929.	164.03	284.53	30.6	4	2692.	16030.	5

CHICAGO, ILLINOIS

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0406
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 14228.
COOLING = 5661.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.21
BLOWER CAPACITY (M3/H) = 3056.

AIR TEMP:	OUTDOOR	INDOOR
WINTER =	-21 C	21 C
SUMMER =	33 C	26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS					SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.7M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-4.07	17.70	4.27	288.58	1851.	14941.	0.	4665.	3640.	3475.	1837.	1837.
FEB	-2.43	17.70	2.64	284.87	1729.	12057.	0.	3830.	2879.	2720.	1522.	1529.
MAR	1.28	19.31	2.64	279.71	1915.	10203.	0.	3366.	2340.	2198.	1339.	1352.
APR	8.50	17.70	4.44	260.05	1784.	4856.	0.	1845.	1308.	1238.	731.	736.
MAY	14.55	17.70	7.66	246.34	1717.	2120.	1199.	1271.	990.	933.	446.	447.
JUN	20.55	14.48	11.25	226.15	1526.	0.	3249.	979.	1038.	830.	229.	229.
JUL	22.98	12.87	14.45	225.84	1451.	0.	4583.	1186.	1197.	904.	551.	251.
AUG	21.70	12.87	16.26	222.93	1380.	0.	3845.	1040.	1064.	818.	716.	227.
SEP	17.06	14.48	16.20	234.08	1337.	1050.	1656.	946.	805.	657.	320.	279.
OCT	11.91	14.48	14.30	245.76	1457.	2975.	0.	1231.	944.	898.	427.	434.
NOV	3.39	17.70	11.15	271.65	1529.	8299.	0.	2730.	1872.	1756.	964.	990.
DEC	-2.27	17.70	7.45	284.51	1726.	13455.	0.	4217.	3165.	3010.	1613.	1613.
ANNUAL	9.43	16.22	9.39		19401.	69956.	14532.	27307.	21241.	19438.	10697.	9923.
ANNUAL COP								1.06	1.36	1.48	2.70	2.91

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 21 P(M2)= 76	3350.	1994.	3658.	550.	240.	1288.	518.	11598.
5	FULL,BR.CHILL, BIN(M3)= 46 P(M2)= 46	3350.	2923.	2495.	550.	240.	1288.	518.	11364.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1107.55	REF.	REF.	REF.	18179.	21657.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	861.54	246.01	0.9	1	14141.	19066.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	788.40	319.15	2.4	2	12941.	18653.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 21	1929.	433.86	673.69	13.2	4	7121.	20649.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 46	1929.	402.49	705.06	12.3	3	6606.	19900.	3

EAST ST. LOUIS, ILLINOIS

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0428
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 12124.
COOLING = 6955.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.24
BLOWER CAPACITY (M3/H) = 2632.

AIR TEMP: OUTDOOR INDOOR
WINTER = -16 C 21 C
SUMMER = 35 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.6M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-1.65	16.09	2.51	279.81	1920.	12016.	0.	3871.	2938.	2767.	1563.	1563.
FEB	0.91	17.70	2.26	277.27	1743.	8986.	0.	2980.	2139.	2011.	1213.	1221.
MAR	5.12	19.31	4.75	271.00	1832.	6983.	0.	2449.	1701.	1600.	991.	1041.
APR	13.21	17.70	9.29	249.37	1600.	2494.	888.	1289.	966.	910.	473.	547.
MAY	19.17	16.09	14.90	232.56	1433.	655.	2698.	1041.	952.	754.	279.	279.
JUN	23.29	12.87	19.77	226.55	1201.	0.	4675.	1132.	1145.	846.	546.	227.
JUL	25.22	11.26	22.87	227.64	1120.	0.	6378.	1401.	1403.	1114.	1172.	256.
AUG	24.81	11.26	23.16	226.71	1109.	0.	6042.	1340.	1345.	1057.	1112.	247.
SEP	20.68	12.87	20.67	222.60	1167.	0.	3501.	922.	979.	755.	651.	198.
OCT	14.68	12.87	15.94	236.19	1392.	1812.	1326.	1117.	879.	822.	335.	344.
NOV	6.84	16.09	10.50	260.55	1554.	5458.	0.	1948.	1361.	1281.	710.	787.
DEC	0.55	16.09	5.51	274.82	1802.	10311.	0.	3365.	2423.	2277.	1329.	1375.
ANNUAL	12.74	15.02	12.68		17872.	48715.	25507.	22856.	18231.	16194.	10374.	8083.
ANNUAL COP								1.12	1.40	1.58	2.47	3.17

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST, $ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	970.	40.	173.	200.	759.	434.	2856.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	434.	2957.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	534.	3497.
	ACES SYSTEMS, INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN., BR.CHILL, BIN(M3)= 17 P(M2)= 21	2950.	1765.	1507.	530.	240.	1074.	518.	8584.
5	FULL, BR.CHILL, BIN(M3)= 99 P(M2)= 2	2950.	4389.	758.	530.	240.	1074.	518.	10459.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	979.16	REF.	REF.	REF.	16072.	19704.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	780.99	198.17	0.5	1	12819.	17786.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	693.77	285.39	2.2	2	11387.	17142.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 17	1929.	444.41	534.75	10.7	3	7294.	17808.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 99	1929.	346.28	632.88	12.0	4	5684.	18072.	4

URBANA, ILLINOIS

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0476
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 13299.
COOLING = 6208.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.19
BLOWER CAPACITY (M3/H) = 2887.

AIR TEMP: OUTDOOR INDOOR
WINTER = -19 C 21 C
SUMMER = 33 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-4.88	20.92	4.20	296.97	1853.	15610.	0.	4851.	3909.	3747.	1936.	1936.
FEB	-2.43	22.53	2.64	294.71	1729.	12078.	0.	3836.	2914.	2757.	1538.	1544.
MAR	2.34	24.13	2.99	287.14	1901.	9487.	0.	3164.	2211.	2080.	1262.	1290.
APR	10.42	22.53	5.31	265.53	1751.	3991.	0.	1595.	1182.	1123.	635.	647.
MAY	17.34	19.31	9.09	243.27	1661.	1221.	1966.	1137.	973.	799.	348.	348.
JUN	21.86	16.09	13.13	229.87	1454.	0.	3842.	1060.	1092.	847.	235.	235.
JUL	23.38	14.48	16.55	230.03	1368.	0.	5016.	1237.	1243.	923.	759.	252.
AUG	23.23	12.87	18.28	226.41	1300.	0.	4977.	1212.	1222.	904.	921.	244.
SEP	19.13	16.09	17.88	232.66	1274.	682.	2750.	1013.	920.	717.	517.	327.
OCT	12.93	17.70	15.44	250.01	1412.	2629.	897.	1276.	936.	881.	195.	205.
NOV	4.41	22.53	11.74	279.18	1507.	7682.	0.	2553.	1747.	1642.	907.	961.
DEC	-2.40	20.92	7.59	291.35	1720.	13383.	0.	4196.	3192.	3038.	1632.	1646.
ANNUAL	10.44	19.17	10.40		18931.	66764.	19447.	27129.	21543.	19458.	10885.	9635.
ANNUAL COP								1.08	1.36	1.50	2.68	3.03

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST, $ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 22 P(M2)= 43	3350.	2015.	2352.	530.	240.	1288.	518.	10293.
5	FULL,BR.CHILL, BIN(M3)= 66 P(M2)= 18	3350.	3521.	1403.	530.	240.	1288.	518.	10850.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1292.70	REF.	REF.	REF.	21218.	24696.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	1026.55	266.16	0.8	1	16849.	21774.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	927.17	365.53	2.1	2	15218.	20931.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 22	1929.	518.68	774.03	9.8	4	8513.	20736.	2
5	FULL ACES, BR.CHILL, BIN (M3)= 66	1929.	459.13	833.57	9.8	3	7536.	20315.	1

FORT WAYNE, INDIANA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0401
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 13292.
COOLING = 5651.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.16
BLOWER CAPACITY (M3/H) = 2887.

AIR TEMP: OUTDOOR INDOOR
WINTER = -19 C 21 C
SUMMER = 32 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.4M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-3.36	17.70	3.87	286.97	1866.	14016.	0.	4412.	3375.	3202.	1769.	1769.
FEB	-1.07	17.70	2.51	281.78	1734.	10623.	0.	3433.	2499.	2349.	1382.	1394.
MAR	2.08	19.31	3.06	277.91	1898.	9189.	0.	3080.	2150.	2020.	1232.	1264.
APR	9.85	19.31	5.52	260.27	1743.	4186.	0.	1647.	1216.	1152.	657.	672.
MAY	15.51	17.70	9.36	244.16	1651.	1741.	1472.	1194.	963.	904.	402.	402.
JUN	21.40	14.48	13.34	225.54	1446.	0.	3510.	1001.	1043.	818.	227.	227.
JUL	23.44	12.87	16.61	226.90	1366.	0.	4823.	1203.	1211.	903.	732.	247.
AUG	22.48	12.87	18.13	224.72	1306.	0.	4490.	1130.	1146.	859.	832.	234.
SEP	18.64	14.48	17.54	230.50	1287.	798.	2601.	1023.	916.	718.	491.	274.
OCT	11.77	14.48	14.95	246.09	1431.	3034.	701.	1360.	974.	915.	447.	461.
NOV	4.00	19.31	11.20	273.55	1527.	7808.	0.	2593.	1751.	1640.	938.	1008.
DEC	-1.02	17.70	7.10	281.67	1739.	11888.	0.	3786.	2761.	2597.	1480.	1517.
ANNUAL	10.31	16.49	10.27		18994.	63282.	17595.	25863.	20005.	18079.	10589.	9467.
ANNUAL COP								1.07	1.39	1.53	2.62	2.93

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 20 P(M2)= 40	3350.	1908.	2258.	530.	240.	1288.	518.	10092.
5	FULL,BR.CHILL, BIN(M3)= 58 P(M2)= 17	3350.	3244.	1356.	530.	240.	1288.	518.	10526.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1036.83	REF.	REF.	REF.	17018.	20497.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	801.99	234.84	0.9	1	13164.	19089.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	724.78	312.05	2.4	2	11896.	17609.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 20	1929.	424.49	612.34	12.1	4	6967.	18989.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 58	1929.	379.55	657.28	11.9	3	6230.	18685.	3

INDIANAPOLIS, INDIANA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0436
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 12814.
COOLING = 5980.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.22
BLOWER CAPACITY (M3/H) = 2717.

AIR TEMP: OUTDOOR INDOOR
WINTER = -18 C 21 C
SUMMER = 32 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.9M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-1.95	19.31	3.00	287.06	1901.	12869.	0.	4103.	3073.	2893.	1655.	1655.
FEB	0.58	19.31	2.23	281.30	1744.	9577.	0.	3145.	2243.	2107.	1276.	1286.
MAR	3.69	20.92	3.80	277.53	1869.	8164.	0.	2787.	1930.	1813.	1123.	1169.
APR	11.29	20.92	7.34	260.28	1674.	3489.	0.	1434.	1104.	1049.	577.	605.
MAY	16.49	17.70	12.08	241.93	1544.	1351.	1653.	1087.	906.	747.	343.	343.
JUN	22.17	14.48	16.50	227.28	1326.	0.	4110.	1071.	1097.	834.	227.	227.
JUL	24.01	12.87	19.66	228.19	1246.	0.	5418.	1272.	1275.	948.	1000.	248.
AUG	23.17	12.87	20.52	226.28	1212.	0.	4993.	1190.	1197.	878.	922.	235.
SEP	19.71	14.48	18.93	228.07	1233.	0.	2932.	844.	919.	732.	548.	282.
OCT	12.74	16.09	15.23	247.16	1420.	2656.	916.	1289.	946.	887.	415.	436.
NOV	4.72	19.31	10.63	271.92	1549.	7173.	0.	2423.	1659.	1557.	883.	949.
DEC	-0.01	17.70	6.08	279.38	1779.	11076.	0.	3571.	2576.	2419.	1407.	1456.
ANNUAL	11.38	17.16	11.33		18497.	56356.	20023.	24215.	18926.	16863.	10377.	9891.
ANNUAL COP								1.09	1.39	1.56	2.54	2.96

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	COST, $ AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS, INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN., BR.CHILL, BIN(M3)= 18 P(M2)= 27	2950.	1841.	1728.	530.	240.	1074.	518.	8881.
5	FULL, BR.CHILL, BIN(M3)= 71 P(M2)= 8	2950.	3645.	1017.	530.	240.	1074.	518.	9974.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1055.31	REF.	REF.	REF.	17321.	20800.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	824.77	230.53	0.9	1	13538.	18462.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	734.87	320.43	2.3	2	12062.	17774.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 18	1929.	452.21	603.09	10.2	3	7422.	18233.	2
5	FULL ACES, BR.CHILL, BIN (M3)= 71	1929.	387.46	667.85	10.9	4	6360.	18263.	3

SOUTH BEND, INDIANA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0401
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 13078.
COOLING = 5472.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.16
BLOWER CAPACITY (M3/H) = 2802.

AIR TEMP: OUTDOOR INDOOR
WINTER = -18 C 21 C
SUMMER = 32 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BP.CHILL
JAN	-4.35	19.31	4.03	292.49	1860.	15081.	0.	4706.	3684.	3518.	1861.	1861.
FEB	-1.99	19.31	2.46	287.15	1736.	11394.	0.	3648.	2711.	2553.	1457.	1472.
MAR	1.39	20.92	2.66	282.75	1914.	9751.	0.	3241.	2278.	2142.	1288.	1307.
APR	9.05	19.31	4.74	262.09	1773.	4562.	0.	1760.	1269.	1203.	699.	709.
MAY	15.35	17.70	8.25	244.51	1694.	1861.	1481.	1241.	996.	937.	421.	421.
JUN	20.49	16.09	12.06	229.58	1495.	0.	3168.	957.	1020.	817.	224.	224.
JUL	22.47	12.87	15.35	224.69	1415.	0.	4359.	1138.	1150.	872.	526.	242.
AUG	22.23	12.87	17.09	224.14	1347.	0.	4342.	1116.	1134.	856.	806.	235.
SEP	18.13	16.09	16.84	234.92	1313.	899.	2347.	1016.	894.	708.	445.	230.
OCT	11.99	16.09	14.64	248.85	1443.	2925.	650.	1325.	948.	893.	434.	442.
NOV	4.22	19.31	11.22	273.06	1527.	7624.	0.	2542.	1703.	1597.	904.	937.
DEC	-1.86	19.31	7.29	286.85	1732.	12815.	0.	4041.	2985.	2827.	1569.	1574.
ANNUAL	9.76	17.43	9.72		19248.	66913.	16347.	26729.	20772.	18923.	10635.	9704.
ANNUAL COP								1.07	1.37	1.50	2.68	2.93

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST, $ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS, INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN., BR.CHILL, BIN(M3)= 21 P(M2)= 53	2950.	1955.	2747.	530.	240.	1074.	518.	10014.
5	FULL, BR.CHILL, BIN(M3)= 51 P(M2)= 26	2950.	3028.	1699.	530.	240.	1074.	518.	10039.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERICD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1071.56	REF.	REF.	REF.	17588.	21067.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	832.73	238.83	0.9	1	13668.	18593.	3
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	758.61	312.95	2.4	2	12452.	18164.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 21	1929.	426.36	645.21	11.3	4	6998.	18942.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 51	1929.	389.03	682.54	10.7	3	6385.	18354.	2

DES MOINES, IOWA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0444
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 14704.
COOLING = 6181.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.20
BLOWER CAPACITY (M3/H) = 3141.

AIR TEMP: OUTDOOR INDOOR
WINTER = -22 C 21 C
SUMMER = 33 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.8M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-6.79	19.31	4.56	298.03	1839.	16871.	0.	5198.	4364.	4212.	2065.	2065.
FEB	-3.55	20.92	2.72	293.97	1726.	12627.	0.	3987.	3139.	2989.	1592.	1602.
MAR	1.00	22.53	2.58	286.92	1917.	10346.	0.	3407.	2448.	2311.	1357.	1381.
APR	9.95	24.13	4.36	269.87	1788.	4358.	0.	1707.	1253.	1192.	679.	689.
MAY	16.63	19.31	7.68	244.88	1717.	1344.	1612.	1126.	945.	789.	360.	360.
JUN	21.81	17.70	11.47	233.02	1517.	0.	3668.	1048.	1077.	843.	237.	237.
JUL	24.26	16.09	14.93	235.32	1432.	0.	5253.	1295.	1300.	964.	618.	263.
AUG	23.58	14.48	16.96	230.49	1352.	0.	5094.	1246.	1255.	929.	943.	252.
SEP	18.11	16.09	17.05	234.97	1305.	830.	2072.	947.	833.	668.	395.	297.
OCT	12.52	17.70	15.16	250.93	1423.	2760.	780.	1295.	942.	889.	418.	426.
NOV	3.24	20.92	11.91	278.56	1500.	8230.	0.	2703.	1874.	1765.	952.	992.
DEC	-2.93	20.92	7.99	292.56	1704.	13785.	0.	4303.	3329.	3184.	1670.	1675.
ANNUAL	9.82	19.17	9.78		19220.	71152.	18479.	29263.	22760.	20734.	11286.	10239.
ANNUAL COP								1.07	1.33	1.46	2.68	2.95

SYSTEMS FIRST COSTS

		COST,$						
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 23 P(M2)= 51	3350.	2125.	2694.	550.	240.	1288.	518.	10765.
5	FULL,BR.CHILL, BIN(M3)= 60 P(M2)= 24	3350.	3405.	1637.	550.	240.	1288.	518.	10988.

COMPARATIVE SYSTEMS COSTS

	NEW CONSTRUCTION ALTERNATIVES	MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERIOD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1254.59	REF.	REF.	REF.	20592.	24071.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	1010.32	244.27	0.9	1	16583.	21508.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	920.39	334.20	2.3	2	15107.	20819.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 23	1929.	501.00	753.59	10.7	4	8223.	20917.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 60	1929.	454.53	800.06	10.4	3	7460.	20378.	1

SIOUX CITY, IOWA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0498
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 14960.
COOLING = 6496.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.16
BLOWER CAPACITY (M3/H) = 3226.

AIR TEMP: OUTDOOR INDOOR
WINTER = -23 C 21 C
SUMMER = 34 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (2.1M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-7.91	17.70	5.02	297.29	1821.	17503.	0.	5368.	4614.	4470.	2128.	2128.
FEB	-4.96	17.70	3.02	290.60	1716.	13175.	0.	4137.	3383.	3241.	1648.	1656.
MAR	0.28	20.92	2.49	285.28	1920.	10518.	0.	3456.	2523.	2389.	1374.	1398.
APR	9.54	20.92	3.80	264.24	1809.	4489.	0.	1750.	1304.	1242.	695.	706.
MAY	16.61	19.31	6.66	244.94	1757.	1465.	1789.	1201.	1004.	832.	381.	381.
JUN	22.40	17.70	10.15	234.37	1567.	0.	3890.	1100.	1133.	884.	248.	248.
JUL	24.42	14.48	13.53	232.40	1487.	0.	5577.	1366.	1373.	1016.	843.	276.
AUG	23.64	14.48	15.75	230.62	1400.	0.	5353.	1303.	1313.	971.	990.	262.
SEP	18.01	16.09	16.21	235.20	1337.	994.	2360.	1051.	916.	726.	448.	330.
OCT	11.53	16.09	14.81	249.90	1437.	3244.	781.	1434.	1026.	969.	466.	477.
NOV	2.31	19.31	12.00	277.37	1497.	8697.	0.	2832.	1999.	1888.	991.	1029.
DEC	-3.65	17.70	8.39	287.63	1689.	13819.	0.	4308.	3365.	3227.	1669.	1675.
ANNUAL	9.35	17.70	9.32		19436.	73905.	19751.	29305.	23953.	21854.	11882.	10565.
ANNUAL COP								1.07	1.31	1.44	2.64	2.97

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	434.	2745.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	434.	2957.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	534.	3497.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 24 P(M2)= 54	3350.	2187.	2781.	550.	240.	1288.	518.	10914.
5	FULL,BR.CHILL, BIN(M3)= 64 P(M2)= 24	3350.	3567.	1632.	550.	240.	1288.	518.	11145.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1458.22	REF.	REF.	REF.	23935.	27455.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	1191.88	266.34	0.8	1	19563.	24530.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	1087.46	370.76	2.0	2	17849.	23604.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 24	1929.	591.26	866.96	9.4	4	9705.	22548.	2
5	FULL ACES, BR.CHILL, BIN (M3)= 64	1929.	525.74	932.48	9.0	3	8629.	21703.	1

DODGE CITY, KANSAS

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0447
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 12350.
COOLING = 6176.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.03
BLOWER CAPACITY (M3/H) = 2632.

AIR TEMP: OUTDOOR INDOOR
WINTER = -17 C 21 C
SUMMER = 36 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.8M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-1.23	17.70	2.93	282.13	1903.	11270.	0.	3660.	2755.	2599.	1482.	1482.
FEB	1.26	17.70	2.31	276.49	1741.	8645.	0.	2885.	2116.	1997.	1132.	1132.
MAR	4.60	20.92	4.33	275.46	1848.	7507.	0.	2599.	1860.	1753.	1065.	1095.
APR	11.59	20.92	8.47	259.61	1631.	3474.	949.	1580.	1142.	1073.	593.	651.
MAY	17.41	19.31	13.84	243.13	1475.	1199.	2134.	1107.	945.	761.	330.	330.
JUN	24.15	17.70	18.72	238.33	1242.	0.	4527.	1118.	1137.	848.	380.	228.
JUL	26.09	14.48	22.05	236.17	1152.	0.	5800.	1311.	1312.	1012.	1068.	246.
AUG	25.85	16.09	22.75	238.91	1125.	0.	5687.	1284.	1287.	994.	1047.	241.
SEP	20.99	17.70	20.72	231.72	1166.	0.	3445.	912.	974.	754.	641.	196.
OCT	13.93	17.70	16.40	247.74	1374.	2309.	1543.	1287.	988.	922.	387.	396.
NOV	5.01	19.31	11.18	271.26	1528.	6649.	0.	2272.	1588.	1495.	835.	899.
DEC	0.91	17.70	6.18	277.29	1776.	9647.	0.	3173.	2234.	2101.	1257.	1300.
ANNUAL	12.54	18.10	12.49		17960.	50701.	24085.	23189.	18337.	16307.	10267.	9245.
ANNUAL COP								1.11	1.41	1.58	2.51	3.13

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 16 P(M2)= 12	2950.	1738.	1172.	530.	240.	1074.	518.	8221.
5	FULL,BR.CHILL, BIN(M3)= 88 P(M2)= 2	2950.	4100.	788.	530.	240.	1074.	518.	10200.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1035.64	REF.	REF.	REF.	16999.	20477.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	818.92	216.72	1.0	1	13441.	18366.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	728.26	307.38	2.4	2	11953.	17666.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 16	1929.	458.53	577.10	9.6	3	7526.	17677.	2
5	FULL ACES, BR.CHILL, BIN (M3)= 88	1929.	368.21	667.43	11.2	4	6044.	18173.	3

TOPEKA, KANSAS

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0419
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 12362.
COOLING = 6982.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.23
BLOWER CAPACITY (M3/H) = 2632.

AIR TEMP: OUTDOOR INDOOR
WINTER = -17 C 21 C
SUMMER = 36 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.9M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-3.11	17.70	3.11	286.40	1896.	13243.	0.	4206.	3261.	3093.	1687.	1687.
FEB	-0.16	17.70	2.24	279.71	1743.	9718.	0.	3184.	2310.	2180.	1289.	1293.
MAR	4.06	20.92	3.93	276.69	1864.	7927.	0.	2720.	1903.	1795.	1097.	1140.
APR	12.25	20.92	7.76	258.11	1658.	3038.	750.	1433.	1043.	986.	538.	582.
MAY	19.05	19.31	12.92	239.39	1511.	722.	2531.	1053.	953.	763.	291.	291.
JUN	22.89	17.70	17.74	235.47	1279.	0.	4588.	1139.	1151.	857.	387.	233.
JUL	25.70	14.48	21.20	235.30	1185.	0.	6580.	1454.	1455.	1148.	1210.	267.
AUG	25.28	16.09	22.16	237.62	1148.	0.	6246.	1386.	1390.	1093.	1149.	256.
SEP	20.24	17.70	20.46	233.43	1175.	0.	3118.	859.	924.	725.	582.	190.
OCT	14.71	17.70	16.45	245.97	1372.	1913.	1225.	1122.	870.	818.	341.	352.
NOV	5.96	19.31	11.44	269.11	1518.	6143.	0.	2128.	1472.	1388.	765.	845.
DEC	-0.31	17.70	6.49	280.05	1764.	11132.	0.	3583.	2601.	2452.	1407.	1455.
ANNUAL	12.21	18.10	12.16		18114.	53834.	25038.	24265.	19334.	17297.	10743.	8591.
ANNUAL COP								1.11	1.39	1.56	2.51	3.14

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	970.	40.	173.	200.	759.	434.	2856.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	434.	2957.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	534.	3497.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 19 P(M2)= 22	2950.	1837.	1563.	530.	240.	1074.	518.	8712.
5	FULL,BR.CHILL, BIN(M3)= 96 P(M2)= 3	2950.	4306.	931.	530.	240.	1074.	518.	10449.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERICD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1017.69	REF.	REF.	REF.	16704.	20336.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	810.85	206.85	0.5	1	13309.	18276.	3
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	725.44	292.25	2.2	2	11907.	17662.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 19	1929.	450.55	567.15	10.3	3	7395.	18037.	2
5	FULL ACES, BR.CHILL, BIN (M3)= 96	1929.	360.31	657.39	11.5	4	5914.	18292.	4

LOUISVILLE, KENTUCKY

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0338
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 11225.
COOLING = 6640.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.21
BLOWER CAPACITY (M3/H) = 2377.

AIR TEMP: OUTDOOR INDOOR
WINTER = -14 C 21 C
SUMMER = 34 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	0.90	16.09	3.60	274.04	1877.	9932.	0.	3281.	2347.	2199.	1341.	1287.
FEB	3.64	16.09	3.71	267.80	1691.	6955.	0.	2402.	1682.	1578.	993.	942.
MAR	6.56	17.70	6.45	264.45	1765.	5834.	0.	2111.	1473.	1384.	869.	828.
APR	13.89	16.09	11.01	244.54	1535.	2261.	1196.	1259.	967.	904.	447.	440.
MAY	19.08	12.87	16.42	226.22	1373.	704.	2910.	1074.	979.	765.	283.	283.
JUN	23.14	11.26	20.93	222.94	1158.	0.	4839.	1148.	1164.	859.	727.	226.
JUL	25.46	11.26	23.58	228.19	1092.	0.	6636.	1437.	1439.	1158.	1219.	258.
AUG	24.91	9.65	23.47	223.68	1097.	0.	6097.	1346.	1350.	1065.	1121.	247.
SEP	21.25	11.26	20.75	218.65	1164.	0.	3992.	1006.	1049.	794.	740.	610.
OCT	14.21	11.26	16.00	234.00	1390.	1941.	1417.	1167.	913.	850.	351.	344.
NOV	7.47	14.48	10.77	255.84	1544.	4847.	0.	1775.	1256.	1181.	663.	645.
DEC	2.96	14.48	6.15	266.07	1777.	8087.	0.	2740.	1904.	1783.	1104.	1075.
ANNUAL	13.62	13.54	13.57		17462.	40561.	27088.	20747.	16524.	14521.	9857.	7184.
ANNUAL COP								1.14	1.43	1.63	2.40	3.29

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	434.	2745.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	434.	2957.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	534.	3497.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 15 P(M2)= 12	2950.	1603.	1173.	530.	240.	1074.	518.	8088.
5	FULL,BR.CHILL, BIN(M3)= 93 P(M2)= 0	2950.	4179.	0.	530.	240.	1074.	518.	9491.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	701.26	REF.	REF.	REF.	11510.	15031.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	558.50	142.75	1.5	1	9167.	14134.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	490.81	210.45	3.6	2	8056.	13810.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 15	1929.	333.15	368.11	14.5	3	5468.	15485.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 93	1929.	242.82	458.44	14.7	4	3986.	15406.	4

LAKE CHARLES, LOUISIANA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0345
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 6680.
COOLING = 7571.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.43
BLOWER CAPACITY (M3/H) = 1443.

AIR TEMP: OUTDOOR INDOOR
WINTER = -2 C 21 C
SUMMER = 34 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	10.19	16.09	12.75	252.96	1517.	3590.	0.	1419.	1051.	990.	630.	556.
FEB	12.99	16.09	12.87	246.60	1366.	2147.	820.	1116.	838.	782.	452.	401.
MAR	15.61	16.09	14.84	240.65	1435.	1433.	1578.	1066.	876.	718.	339.	339.
APR	19.93	16.09	18.08	230.84	1266.	0.	3094.	880.	931.	733.	388.	199.
MAY	23.96	14.48	21.89	231.35	1158.	0.	5729.	1301.	1306.	1004.	1054.	853.
JUN	26.63	12.87	25.05	234.13	1001.	0.	7781.	1607.	1607.	1356.	1425.	1426.
JUL	27.65	9.65	26.88	229.90	962.	0.	8889.	1786.	1786.	1549.	1626.	1627.
AUG	27.38	9.65	26.75	229.28	967.	0.	8671.	1750.	1750.	1511.	1586.	1588.
SEP	25.66	11.26	24.80	228.64	1010.	0.	6796.	1442.	1442.	1185.	1247.	1248.
OCT	20.85	11.26	21.43	218.92	1176.	0.	3963.	1004.	1041.	788.	734.	736.
NOV	15.03	14.48	17.74	238.69	1279.	1537.	1557.	1048.	845.	685.	300.	303.
DEC	12.18	14.48	14.51	245.15	1448.	2570.	567.	1213.	883.	827.	519.	429.
ANNUAL	19.84	13.54	19.80		14587.	11277.	49446.	15634.	14357.	12126.	10301.	9706.
ANNUAL COP								1.34	1.46	1.73	2.03	2.16

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 6 P(M2)= 2	2500.	995.	769.	480.	240.	714.	392.	6090.
5	FULL,BR.CHILL, BIN(M3)= 20 P(M2)= 0	2500.	1631.	0.	480.	240.	714.	392.	5958.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	539.04	REF.	REF.	REF.	8848.	12437.	1
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	495.03	44.01	5.8	1	8125.	13202.	3
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	418.11	120.93	6.6	2	6863.	12727.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 6	1929.	355.17	183.87	17.8	4	5830.	13849.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 20	1929.	334.66	204.38	15.4	3	5493.	13380.	4

NEW ORLEANS, LOUISIANA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0376
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 6304.
COOLING = 7351.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.51
BLOWER CAPACITY (M3/H) = 1358.

AIR TEMP: OUTDOOR INDOOR
WINTER = -1 C 21 C
SUMMER = 33 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	11.42	14.48	13.58	246.96	1485.	2954.	0.	1233.	953.	900.	560.	484.
FEB	14.11	14.48	13.72	240.77	1336.	1681.	938.	998.	778.	726.	388.	349.
MAR	16.29	14.48	15.57	235.82	1407.	1161.	1632.	992.	837.	687.	308.	308.
APR	20.16	12.87	18.58	223.77	1247.	0.	3094.	875.	918.	720.	482.	197.
MAY	24.08	12.87	22.11	228.35	1150.	0.	5521.	1263.	1268.	968.	1016.	1018.
JUN	26.44	11.26	25.02	230.42	1002.	0.	7295.	1525.	1525.	1271.	1337.	1338.
JUL	27.26	9.65	26.69	229.01	970.	0.	9586.	1736.	1736.	1496.	1571.	1572.
AUG	27.16	9.65	26.54	228.77	976.	0.	8586.	1738.	1738.	1496.	1571.	1572.
SEP	25.73	11.26	24.71	228.81	1014.	0.	6878.	1457.	1457.	1198.	1261.	1262.
OCT	21.04	11.26	21.57	218.49	1171.	0.	3927.	996.	1026.	775.	728.	729.
NOV	15.62	12.87	18.15	234.06	1263.	1204.	1505.	942.	781.	637.	292.	293.
DEC	12.51	12.87	15.17	241.11	1422.	2359.	618.	1156.	853.	799.	495.	406.
ANNUAL	20.15	12.34	20.12		14442.	9359.	48581.	14912.	13869.	11672.	10010.	9527.
ANNUAL COP								1.35	1.45	1.72	2.01	2.11

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 6 P(M2)= 2	2500.	929.	763.	480.	240.	714.	392.	6018.
5	FULL,BR.CHILL, BIN(M3)= 16 P(M2)= 0	2500.	1470.	0.	480.	240.	714.	392.	5797.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	560.70	REF.	REF.	REF.	9203.	12792.	1
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	521.49	39.21	6.5	1	8560.	13637.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	438.86	121.84	6.5	2	7203.	13068.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 6	1929.	376.36	184.34	17.4	4	6177.	14125.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 16	1929.	358.21	202.49	14.7	3	5880.	13606.	3

SHREVEPORT, LOUISIANA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0259
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 8057.
COOLING = 7905.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.34
BLOWER CAPACITY (M3/H) = 1698.

AIR TEMP: OUTDOOR INDOOR
WINTER = -6 C 21 C
SUMMER = 36 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	6.83	14.48	9.46	257.29	1647.	5495.	0.	1984.	1395.	1305.	839.	778.
FEB	9.71	14.48	9.61	250.76	1482.	3518.	0.	1389.	1017.	957.	608.	545.
MAR	12.53	16.09	11.98	247.63	1548.	2710.	831.	1325.	978.	912.	513.	482.
APR	18.33	14.48	15.86	231.20	1350.	754.	2177.	956.	854.	685.	270.	270.
MAY	22.89	12.87	20.43	225.64	1216.	0.	4761.	1151.	1170.	865.	880.	230.
JUN	25.62	12.87	24.22	231.85	1032.	0.	6545.	1405.	1406.	1141.	1201.	489.
JUL	27.80	11.26	26.41	233.51	981.	0.	8815.	1778.	1778.	1536.	1613.	1616.
AUG	27.53	11.26	26.26	232.89	987.	0.	8356.	1702.	1702.	1456.	1530.	1533.
SEP	24.44	11.26	23.91	225.88	1044.	0.	5612.	1249.	1257.	985.	1032.	1035.
OCT	18.79	11.26	19.87	223.59	1238.	716.	2848.	1029.	933.	723.	535.	537.
NOV	12.54	12.87	15.44	241.05	1366.	2552.	937.	1249.	930.	865.	633.	405.
DEC	8.56	14.48	11.57	253.36	1564.	4488.	0.	1681.	1188.	1114.	706.	651.
ANNUAL	17.96	13.14	17.92		15454.	20233.	40883.	16899.	14607.	12543.	10165.	8569.
ANNUAL COP								1.26	1.46	1.70	2.09	2.48

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 9 P(M2)= 4	2650.	1192.	858.	480.	240.	889.	434.	6742.
5	FULL,BR.CHILL, BIN(M3)= 44 P(M2)= 0	2650.	2571.	0.	480.	240.	889.	434.	7264.

COMPARATIVE SYSTEMS COSTS

	NEW CONSTRUCTION ALTERNATIVES	MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERIOD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	437.52	REF.	REF.	REF.	7181.	10770.	1
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	378.18	59.34	4.3	1	6207.	11284.	3
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	324.74	112.78	7.0	2	5330.	11195.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 9	1929.	263.17	174.34	22.5	4	4320.	12991.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 44	1929.	221.86	215.66	20.6	3	3642.	12835.	4

PORTLAND, MAINE

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0389
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 13797.
COOLING = 4619.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.10
BLOWER CAPACITY (M3/H) = 2971.

AIR TEMP: OUTDOOR INDOOR
WINTER = -20 C 21 C
SUMMER = 30 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (2.3M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES ER.CHILL
JAN	-5.37	16.09	4.92	288.26	1825.	15276.	0.	4751.	3837.	3678.	1895.	1895.
FEB	-3.83	16.09	3.19	284.76	1710.	12308.	0.	3894.	3052.	2899.	1563.	1562.
MAR	-0.06	16.09	2.42	276.20	1923.	10185.	0.	3364.	2406.	2268.	1344.	1343.
APR	6.04	16.09	3.01	262.37	1839.	5782.	0.	2117.	1428.	1350.	844.	844.
MAY	11.81	14.48	4.84	246.00	1828.	2960.	656.	1442.	1054.	999.	543.	543.
JUN	16.86	12.87	7.32	231.26	1675.	1027.	1747.	1049.	907.	755.	324.	324.
JUL	19.71	12.87	9.92	224.78	1629.	0.	3041.	972.	1018.	823.	235.	235.
AUG	19.07	12.87	11.84	226.24	1553.	0.	2920.	930.	997.	810.	225.	306.
SEP	15.15	12.87	12.55	235.12	1476.	1518.	1399.	1071.	870.	818.	314.	314.
OCT	9.52	14.48	11.89	251.19	1551.	3845.	0.	1499.	1059.	1005.	527.	526.
NOV	4.00	14.48	10.09	263.70	1570.	7173.	0.	2429.	1620.	1523.	868.	867.
DEC	-3.11	14.48	7.52	279.86	1723.	13076.	0.	4111.	3160.	3008.	1598.	1598.
ANNUAL	7.48	14.48	7.46		20301.	73151.	9762.	27629.	21408.	19937.	10279.	10357.
ANNUAL COP								1.04	1.34	1.44	2.79	2.77

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 21 P(M2)= 43	3350.	1992.	2356.	550.	240.	1288.	518.	10293.
5	FULL,BR.CHILL, BIN(M3)= 21 P(M2)= 43	3350.	1992.	2356.	550.	240.	1288.	518.	10293.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1073.68	REF.	REF.	REF.	17623.	21101.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	831.91	241.76	0.9	1	13655.	18580.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	774.76	298.91	2.5	2	12717.	18429.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 21	1929.	399.46	674.22	11.3	3	6557.	18779.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 21	1929.	399.46	674.22	11.3	4	6557.	18779.	4

FALMOUTH, MASSACHUSETTS

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0496
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 11294.
COOLING = 4563.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.29
BLOWER CAPACITY (M3/H) = 2462.

AIR TEMP: OUTDOOR INDOOR
WINTER = -14 C 21 C
SUMMER = 28 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.1M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-1.45	19.31	3.63	285.92	1876.	12472.	0.	3986.	3049.	2859.	1604.	1604.
FEB	-1.18	22.53	2.26	291.86	1743.	11128.	0.	3575.	2702.	2533.	1441.	1441.
MAR	2.15	19.31	2.72	277.75	1912.	9023.	0.	3038.	2087.	1949.	1222.	1232.
APR	7.28	19.31	5.01	266.10	1763.	5177.	0.	1928.	1292.	1212.	772.	777.
MAY	12.80	24.13	8.64	263.41	1679.	2711.	0.	1220.	943.	897.	488.	491.
JUN	17.98	16.09	12.45	235.27	1480.	570.	1875.	890.	810.	668.	257.	257.
JUL	21.09	14.48	15.62	224.93	1405.	0.	3454.	980.	988.	767.	221.	221.
AUG	20.55	14.48	17.14	226.16	1345.	0.	3298.	937.	951.	741.	616.	212.
SEP	17.16	16.09	16.64	237.13	1321.	741.	1758.	873.	771.	629.	338.	251.
OCT	12.20	17.70	14.23	251.67	1459.	2505.	0.	1101.	823.	782.	393.	399.
NOV	7.25	17.70	10.69	262.90	1547.	5161.	0.	1864.	1242.	1164.	677.	691.
DEC	0.45	17.70	6.76	278.32	1753.	10542.	0.	3416.	2514.	2354.	1338.	1343.
ANNUAL	9.69	18.24	9.65		19281.	60031.	10384.	23807.	18173.	16553.	9367.	9918.
ANNUAL COP								1.05	1.37	1.51	2.66	2.79

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 18 P(M2)= 27	2950.	1774.	1751.	530.	240.	1074.	518.	9836.
5	FULL,BR.CHILL, BIN(M3)= 32 P(M2)= 21	2950.	2321.	1499.	530.	240.	1074.	518.	9133.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1180.36	REF.	REF.	REF.	19374.	22852.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	901.01	279.35	0.8	1	14789.	19714.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	820.69	359.67	2.1	2	13470.	19183.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 18	1929.	464.43	715.93	8.6	3	7623.	18389.	2
5	FULL ACES, BR.CHILL, BIN (M3)= 32	1929.	442.17	738.19	8.7	4	7258.	18320.	1

BATTLE CREEK, MICHIGAN

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0411
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 12208.
COOLING = 4888.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.12
BLOWER CAPACITY (M3/H) = 2632.

AIR TEMP: OUTDOOR INDOOR
WINTER = -16 C 21 C
SUMMER = 32 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.7M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-3.27	16.09	3.96	283.49	1863.	13804.	0.	4352.	3311.	3143.	1738.	1738.
FEB	-2.43	16.09	2.40	281.59	1738.	11449.	0.	3663.	2724.	2567.	1463.	1471.
MAR	1.05	16.09	2.46	273.69	1922.	9728.	0.	3236.	2345.	2210.	1287.	1298.
APR	7.21	14.48	4.28	256.44	1790.	5297.	0.	1969.	1385.	1310.	783.	789.
MAY	14.67	12.87	7.48	236.23	1725.	1894.	1274.	1223.	972.	918.	424.	424.
JUN	20.99	11.26	11.01	218.61	1534.	0.	3515.	1027.	1070.	845.	236.	236.
JUL	22.54	9.65	14.14	218.29	1463.	0.	4198.	1124.	1141.	872.	512.	243.
AUG	21.16	9.65	15.87	215.17	1395.	0.	3526.	990.	1020.	794.	658.	222.
SEP	16.21	11.26	15.75	229.45	1354.	1179.	1512.	962.	803.	660.	295.	289.
OCT	10.85	12.87	13.83	244.89	1475.	3334.	0.	1336.	1012.	961.	464.	471.
NOV	2.92	14.48	10.70	266.16	1546.	8189.	0.	2705.	1826.	1713.	963.	1006.
DEC	-2.53	14.48	7.05	278.54	1741.	12925.	0.	4074.	3024.	2866.	1579.	1593.
ANNUAL	9.11	13.27	9.08		19547.	67800.	14025.	26662.	20632.	18859.	10401.	9780.
ANNUAL COP								1.06	1.36	1.49	2.71	2.88

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 19 P(M2)= 57	2950.	1857.	2896.	530.	240.	1074.	519.	10065.
5	FULL,BR.CHILL, BIN(M3)= 43 P(M2)= 35	2950.	2727.	2054.	530.	240.	1074.	518.	10093.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1096.86	REF.	REF.	REF.	18003.	21482.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	848.81	248.04	0.9	1	13932.	18857.	3
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	775.87	320.98	2.3	2	12735.	18447.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 19	1929.	427.90	668.96	11.0	4	7023.	19018.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 43	1929.	402.35	694.51	10.6	3	6604.	18627.	2

DETROIT, MICHIGAN

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0452
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 11773.
COOLING = 5560.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.19
BLOWER CAPACITY (M3/H) = 2547.

AIR TEMP: OUTDOOR INDOOR
WINTER = -15 C 21 C
SUMMER = 32 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.8M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-5.03	17.70	4.52	290.77	1841.	15490.	0.	4814.	3809.	3646.	1911.	1911.
FEB	-4.01	17.70	2.67	288.45	1728.	12889.	0.	4061.	3156.	3000.	1615.	1619.
MAR	0.24	19.31	2.28	282.09	1929.	10643.	0.	3493.	2454.	2307.	1384.	1392.
APR	7.47	17.70	3.67	262.39	1814.	5224.	0.	1955.	1358.	1284.	773.	777.
MAY	14.29	16.09	6.53	243.64	1762.	2092.	1119.	1262.	986.	932.	446.	447.
JUN	19.35	14.48	9.95	228.88	1575.	560.	2684.	1052.	975.	781.	283.	283.
JUL	22.47	12.87	13.19	224.69	1500.	0.	4439.	1175.	1189.	906.	396.	253.
AUG	21.45	12.87	15.25	222.37	1419.	0.	3951.	1069.	1093.	840.	736.	234.
SEP	17.33	14.48	15.57	233.45	1361.	907.	1993.	971.	848.	685.	382.	277.
OCT	11.62	16.09	14.09	249.71	1465.	2912.	0.	1216.	924.	880.	419.	423.
NOV	4.45	19.31	11.28	272.53	1524.	7393.	0.	2477.	1647.	1545.	866.	881.
DEC	-2.48	17.70	7.75	284.97	1714.	13276.	0.	4164.	3097.	2943.	1595.	1597.
ANNUAL	8.93	16.36	8.90		19632.	71385.	14186.	27709.	21535.	19747.	10805.	10092.
ANNUAL COP								1.05	1.36	1.48	2.70	2.90

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 22 P(M2)= 75	2950.	1937.	3620.	530.	240.	1074.	518.	10870.
5	FULL,BR.CHILL, BIN(M3)= 43 P(M2)= 49	2950.	2726.	2615.	530.	240.	1074.	518.	10653.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1252.72	REF.	REF.	REF.	20562.	24040.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	973.60	279.12	0.8	1	15980.	20905.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	892.74	359.98	2.1	2	14653.	20366.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 22	1929.	488.50	764.21	10.7	4	8018.	20817.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 43	1929.	456.25	796.47	10.0	3	7489.	20071.	1

SAULT SAINTE MARIE, MICHIGAN

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0262
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 15759.
COOLING = 3703.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.06
BLOWER CAPACITY (M3/H) = 3396.

AIR TEMP: OUTDOOR INDOOR
WINTER = -25 C 21 C
SUMMER = 27 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (4.7M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-9.96	16.09	5.49	298.67	1803.	19580.	0.	5940.	5406.	5265.	2341.	2341.
FEB	-9.53	16.09	4.46	297.69	1665.	16916.	0.	5162.	4663.	4530.	2035.	2031.
MAR	-4.42	17.70	3.34	289.37	1887.	13985.	0.	4409.	3616.	3455.	1737.	1734.
APR	2.97	17.70	2.57	272.60	1855.	8005.	0.	2739.	1921.	1817.	1078.	1077.
MAY	9.93	17.70	2.32	256.81	1927.	4103.	0.	1675.	1251.	1193.	659.	659.
JUN	15.07	14.48	2.66	238.59	1852.	1783.	1471.	1261.	1022.	967.	419.	419.
JUL	18.32	12.87	3.52	227.93	1880.	741.	2560.	1165.	1063.	870.	332.	332.
AUG	17.55	12.87	4.67	229.69	1835.	823.	2162.	1108.	995.	824.	327.	327.
SEP	12.74	14.48	5.75	243.87	1735.	2332.	657.	1242.	937.	892.	399.	398.
OCT	8.00	16.09	6.53	257.91	1762.	4894.	0.	1849.	1273.	1208.	632.	630.
NOV	0.71	17.70	6.75	277.74	1696.	10400.	0.	3360.	2415.	2280.	1164.	1154.
DEC	-6.96	16.09	6.38	291.86	1768.	17032.	0.	5223.	4522.	4379.	1995.	1991.
ANNUAL	4.54	15.82	4.54		21665.	100594.	6851.	35134.	29082.	27680.	13118.	13091.
ANNUAL COP								1.02	1.23	1.30	2.73	2.74

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST, $ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	310.	930.	40.	213.	200.	688.	392.	2773.
2	HEAT PUMP WITH ELECTRIC HOT WATER	310.	1080.	58.	231.	200.	714.	392.	2985.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	310.	1080.	58.	631.	240.	714.	492.	3525.
	ACES SYSTEMS, INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN., BR.CHILL, BIN(M3)= 27 P(M2)= 226*	3350.	2284.	9461.	550.	240.	1288.	518.	17690.*
5	FULL, BR.CHILL, BIN(M3)= 27 P(M2)= 226*	3350.	2284.	9461.	550.	240.	1288.	518.	17690.*

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERICD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	920.17	REF.	REF.	REF.	15103.	18652.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	761.66	158.51	1.3	1	12502.	17497.	1
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	724.94	195.23	3.9	2	11899.	17681.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 27	1929.	343.56	576.61	25.9	3	5639.	25259.*	4
5	FULL ACES, BR.CHILL, BIN (M3)= 27	1929.	343.56	576.61	25.9	4	5639.	25259.*	5

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

DULUTH, MINNESOTA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0518
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 17514.
COOLING = 3661.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.03
BLOWER CAPACITY (M3/H) = 3736.

AIR TEMP: OUTDOOR INDOOR
WINTER = -28 C 21 C
SUMMER = 28 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (6.1M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-13.57	20.92	4.84	316.69	1828.	23689.	0.	7089.	6761.	6634.	2785.	2688.
FEB	-10.50	20.92	4.32	309.72	1670.	18333.	0.	5557.	5119.	4997.	2184.	2181.
MAR	-4.69	20.92	3.58	296.54	1878.	14760.	0.	4622.	3850.	3700.	1817.	1814.
APR	3.29	24.13	2.90	285.00	1843.	8497.	0.	2872.	2039.	1934.	1129.	1127.
MAY	9.77	22.53	2.42	267.02	1923.	4455.	0.	1772.	1296.	1237.	696.	695.
JUN	15.48	19.31	2.30	247.50	1866.	1694.	1370.	1223.	993.	945.	403.	408.
JUL	18.46	17.70	2.55	237.47	1918.	714.	2366.	1136.	1036.	856.	328.	328.
AUG	17.89	16.09	3.13	235.48	1896.	760.	2128.	1101.	996.	829.	326.	350.
SEP	12.24	19.31	3.84	254.85	1807.	2678.	582.	1345.	993.	949.	435.	435.
OCT	7.48	19.31	4.54	265.65	1840.	5461.	0.	2028.	1403.	1335.	689.	687.
NOV	-1.72	22.53	5.00	293.09	1763.	12649.	0.	4004.	3101.	2958.	1371.	1361.
DEC	-9.64	19.31	5.11	304.49	1817.	19704.	0.	5979.	5437.	5303.	2274.	2030.
ANNUAL	3.71	20.25	3.71		22049.	113392.	6447.	38728.	33024.	31676.	14442.	14105.
ANNUAL COP								1.02	1.19	1.24	2.73	2.79

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	310.	930.	40.	213.	200.	688.	392.	2773.
2	HEAT PUMP WITH ELECTRIC HOT WATER	310.	1080.	58.	231.	200.	714.	392.	2985.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	310.	1080.	58.	631.	240.	714.	492.	3525.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 32 P(M2)= 466*	3350.	2603.	18777.	550.	240.	1288.	518.	27326.*
5	FULL,BR.CHILL, BIN(M3)= 32 P(M2)= 466*	3350.	2603.	18777.	550.	240.	1288.	518.	27326.*

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	2006.87	REF.	REF.	REF.	32940.	36488.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	1711.31	295.57	0.7	1	28089.	33084.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	1641.47	365.40	2.1	2	26942.	32725.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 32	1929.	748.41	1258.47	19.5	3	12284.	41540.*	4
5	FULL ACES, BR.CHILL, BIN (M3)= 32	1929.	748.41	1258.47	19.5	4	12284.	41540.*	5

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

INTERNATIONAL FALLS, MINNESOTA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0263
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 19598.
COOLING = 3711.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.02
BLOWER CAPACITY (M3/H) = 4245.

AIR TEMP: OUTDOOR INDOOR
WINTER = -33 C 21 C
SUMMER = 28 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP	AVE WIND SPEED	INLET WATER TEMP	HEAT LOSS COEF.	WATER HEAT	SPACE HEAT	SPACE COOL	(1) ELEC. A/C	(2) HEAT PUMP	(3) HEAT PUMP	(4) MIN. ACES	(5) FULL ACES
	C	KM/H	C (8.2M)	W/C	MJ	MJ	MJ	I2R	I2R	D.S.	BR.CHILL	BR.CHILL
JAN	-16.12	14.48	3.57	309.37	1878.	24913.	0.	7443.	7235.	7118.	2822.	2822.
FEB	-12.72	14.48	3.54	301.65	1697.	19185.	0.	5801.	5467.	5354.	2280.	2277.
MAR	-5.18	14.48	3.34	284.55	1887.	14308.	0.	4499.	3802.	3662.	1768.	1766.
APR	2.91	17.70	3.03	272.75	1838.	8251.	0.	2803.	2047.	1951.	1101.	1100.
MAY	10.68	16.09	2.68	251.84	1913.	3819.	0.	1592.	1230.	1182.	626.	625.
JUN	16.44	14.48	2.40	235.49	1862.	1377.	1722.	1194.	1008.	844.	381.	381.
JUL	18.78	12.87	2.25	226.90	1930.	634.	2664.	1167.	1080.	884.	327.	327.
AUG	17.88	12.87	2.28	228.93	1929.	847.	2372.	1176.	1060.	875.	344.	374.
SEP	11.30	14.48	2.48	247.14	1859.	3043.	0.	1362.	1075.	1036.	462.	462.
OCT	6.69	16.09	2.80	260.89	1908.	5801.	0.	2142.	1504.	1436.	727.	726.
NOV	-3.47	17.70	3.14	287.22	1834.	13499.	0.	4260.	3433.	3296.	1454.	1448.
DEC	-12.29	14.48	3.43	300.67	1884.	21230.	0.	6421.	6026.	5900.	2184.	2178.
ANNUAL	2.91	15.02	2.91		22419.	116905.	6757.	39860.	34967.	33538.	14476.	14486.
ANNUAL COP								1.02	1.16	1.21	2.80	2.90

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	310.	930.	40.	213.	200.	688.	392.	2773.
2	HEAT PUMP WITH ELECTRIC HOT WATER	310.	1080.	58.	231.	200.	714.	392.	2985.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	310.	1080.	58.	631.	240.	714.	492.	3525.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 33 P(M2)= 588*	3750.	2693.	23501.	620.	240.	1454.	518.	32776.*
5	FULL,BR.CHILL, BIN(M3)= 33 P(M2)= 588*	3750.	2693.	23501.	620.	240.	1454.	518.	32776.*

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1048.30	REF.	REF.	REF.	17206.	20755.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	919.62	128.68	1.7	1	15094.	20089.	1
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	882.05	166.25	4.5	2	14478.	20260.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 33	1929.	380.71	667.60	44.9	3	6249.	40954.*	4
5	FULL ACES, BR.CHILL, BIN (M3)= 33	1929.	380.71	667.60	44.9	4	6249.	40954.*	5

*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
POWER COSTS ($/KWH) = 0.0492
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 16205.
COOLING = 5391.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.13
BLOWER CAPACITY (M3/H) = 3481.

AIR TEMP: OUTDOOR INDOOR
WINTER = -26 C 21 C
SUMMER = 32 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (2.9M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES ER.CHILL
JAN	-10.26	17.70	5.52	302.64	1802.	19753.	0.	5988.	5343.	5215.	2359.	2359.
FEB	-7.26	17.70	3.48	295.82	1700.	15044.	0.	4651.	3946.	3818.	1837.	1844.
MAR	-1.72	19.31	2.26	286.54	1929.	11892.	0.	3840.	2885.	2742.	1515.	1520.
APR	7.29	20.92	2.44	269.36	1860.	5614.	0.	2077.	1473.	1403.	819.	921.
MAY	14.83	19.31	3.97	248.97	1862.	2004.	1256.	1289.	1023.	974.	450.	450.
JUN	20.17	17.70	6.36	233.57	1712.	0.	2778.	950.	1009.	832.	238.	238.
JUL	22.54	14.48	9.09	228.12	1661.	0.	4305.	1197.	1210.	935.	266.	266.
AUG	22.17	14.48	11.35	227.29	1572.	0.	4150.	1146.	1163.	897.	774.	254.
SEP	15.88	16.09	12.49	240.02	1478.	1375.	1543.	1056.	871.	718.	302.	321.
OCT	10.49	17.70	12.27	255.54	1536.	3698.	0.	1454.	1062.	1015.	499.	502.
NOV	0.63	19.31	10.75	281.20	1544.	10289.	0.	3287.	2334.	2210.	1139.	1155.
DEC	-6.28	17.70	8.27	293.59	1693.	16365.	0.	5017.	4146.	4022.	1922.	1929.
ANNUAL	7.37	17.70	7.35		20352.	86035.	14031.	31952.	26465.	24780.	12120.	11660.
ANNUAL COP								1.05	1.26	1.35	2.76	2.87

SYSTEMS FIRST COSTS

		COST, $							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	310.	930.	40.	213.	200.	688.	392.	2773.
2	HEAT PUMP WITH ELECTRIC HOT WATER	310.	1080.	58.	231.	200.	714.	392.	2985.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	310.	1080.	58.	631.	240.	714.	492.	3525.
	ACES SYSTEMS, INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN., BR.CHILL, BIN(M3)= 27 P(M2)= 148*	3350.	2347.	6419.	550.	240.	1288.	518.	14712.*
5	FULL, BR.CHILL, BIN(M3)= 41 P(M2)= 94*	3350.	2854.	4344.	550.	240.	1288.	518.	13144.*

COMPARATIVE SYSTEMS COSTS

	NEW CONSTRUCTION ALTERNATIVES	MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERIOD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1571.39	REF.	REF.	REF.	25792.	29341.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	1301.54	269.85	0.8	1	21363.	26358.	3
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	1218.69	352.71	2.1	2	20003.	25786.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 27	1929.	596.06	975.33	12.2	4	9783.	26425.*	4
5	FULL ACES, BR.CHILL, BIN (M3)= 41	1929.	573.44	997.95	10.4	3	9412.	24486.*	1

*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
POWER COSTS ($/KWH) = 0.0377
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 6502.
COOLING = 7304.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.55
BLOWER CAPACITY (M3/H) = 1358.

AIR TEMP: OUTDOOR INDOOR
WINTER = -1 C 21 C
SUMMER = 33 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES ER.CHILL
JAN	9.99	19.31	12.47	259.96	1529.	3813.	0.	1484.	1055.	992.	654.	582.
FEB	12.36	19.31	12.63	254.59	1375.	2400.	509.	1136.	828.	776.	480.	422.
MAR	15.22	19.31	14.72	248.08	1440.	1420.	908.	950.	760.	714.	344.	324.
APR	20.40	17.70	18.13	233.06	1264.	0.	3261.	908.	948.	740.	405.	202.
MAY	24.67	16.09	22.13	236.23	1149.	0.	5947.	1335.	1341.	1041.	1094.	673.
JUN	26.96	14.48	25.42	238.15	987.	0.	8049.	1649.	1649.	1402.	1474.	1475.
JUL	28.03	12.87	27.31	237.30	946.	0.	9410.	1870.	1870.	1639.	1720.	1722.
AUG	27.71	12.87	27.14	236.57	952.	0.	9091.	1818.	1818.	1584.	1662.	1664.
SEP	25.82	14.48	25.06	235.56	1001.	0.	7185.	1506.	1506.	1252.	1317.	1319.
OCT	20.61	14.48	21.51	226.01	1173.	0.	3824.	979.	1020.	775.	709.	711.
NOV	15.47	17.70	17.64	244.23	1282.	1368.	1492.	991.	810.	660.	290.	292.
DEC	11.67	17.70	14.28	252.86	1458.	2875.	0.	1204.	908.	859.	536.	450.
ANNUAL	19.91	16.36	19.87		14555.	11877.	49675.	15830.	14513.	12435.	10687.	9836.
ANNUAL COP								1.34	1.46	1.70	1.98	2.15

SYSTEMS FIRST COSTS

		COST,$						
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 7 P(M2)= 2	2500.	1006.	786.	480.	240.	714.	392.	6118.
5	FULL,BR.CHILL, BIN(M3)= 26 P(M2)= 0	2500.	1884.	0.	480.	240.	714.	392.	6210.

COMPARATIVE SYSTEMS COSTS

		MAINT.	1ST YEAR	1ST YEAR	SIMPLE	SIMPLE	POWER	LIFE	LIFE
	NEW CONSTRUCTION ALTERNATIVES	PRESENT WORTH	POWER COST	POWER SAVING	PAYBACK PERICD	PAYBACK RANKING	PRESENT WORTH	CYCLE COST	CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	596.17	REF.	REF.	REF.	9785.	13374.	1
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	546.55	49.62	5.1	1	8971.	14048.	3
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	468.29	127.88	6.2	2	7686.	13551.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 7	1929.	402.46	193.71	17.1	4	6606.	14654.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 26	1929.	370.41	225.76	15.0	3	6080.	14219.	4

COLUMBUS, MISSISSIPPI

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0293
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 9067.
COOLING = 7713.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.32
BLOWER CAPACITY (M3/H) = 1953.

AIR TEMP: OUTDOOR INDOOR
WINTER = -8 C 21 C
SUMMER = 35 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	5.85	19.31	8.14	269.36	1699.	6580.	0.	2300.	1607.	1503.	965.	902.
FEB	8.61	19.31	8.49	263.08	1522.	4383.	0.	1640.	1172.	1100.	703.	643.
MAR	12.14	19.31	11.13	255.08	1581.	3103.	727.	1425.	1038.	971.	558.	526.
APR	17.67	17.70	15.25	239.25	1373.	998.	1913.	986.	852.	690.	293.	293.
MAY	22.26	16.09	19.98	230.77	1234.	0.	4331.	1083.	1122.	845.	657.	223.
JUN	25.84	14.48	23.78	235.62	1049.	0.	6553.	1411.	1413.	1143.	1203.	252.
JUL	26.83	12.87	25.85	234.59	1003.	0.	7953.	1637.	1637.	1386.	1457.	1461.
AUG	26.59	12.87	25.47	234.04	1018.	0.	7834.	1621.	1621.	1365.	1435.	1439.
SEP	23.38	14.48	22.85	230.02	1084.	0.	5188.	1188.	1207.	923.	956.	959.
OCT	17.28	14.48	18.57	233.58	1289.	1204.	2395.	1102.	942.	741.	454.	457.
NOV	11.52	17.70	14.00	253.21	1421.	3142.	676.	1383.	991.	924.	500.	469.
DEC	6.21	17.70	10.11	265.27	1621.	6041.	0.	2129.	1460.	1364.	872.	835.
ANNUAL	17.01	16.36	16.97		15894.	25451.	37570.	17905.	15061.	12955.	10053.	8458.
ANNUAL COP								1.22	1.46	1.69	2.18	2.59

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 10 P(M2)= 5	2650.	1305.	908.	480.	240.	889.	434.	6907.
5	FULL,BR.CHILL, BIN(M3)= 56 P(M2)= 0	2650.	2980.	0.	480.	240.	889.	434.	7672.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	524.97	REF.	REF.	REF.	8617.	12206.	2
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	441.59	83.38	3.0	1	7248.	12325.	3
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	379.84	145.13	5.5	2	6234.	12099.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 10	1929.	294.75	230.22	17.8	4	4838.	13674.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 56	1929.	247.99	276.98	17.5	3	4070.	13672.	4

JACKSON, MISSISSIPPI

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0365
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 7860.
COOLING = 7725.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.33
BLOWER CAPACITY (M3/H) = 1698.

AIR TEMP: OUTDOOR INDOOR
WINTER = -5 C 21 C
SUMMER = 36 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	7.42	14.48	9.90	255.95	1629.	5225.	0.	1904.	1336.	1250.	809.	747.
FEB	10.74	16.09	10.13	251.69	1463.	3242.	0.	1307.	982.	925.	574.	513.
MAR	13.10	16.09	12.46	246.35	1529.	2516.	879.	1274.	952.	888.	488.	460.
APR	18.19	14.48	16.19	231.50	1338.	844.	2214.	984.	871.	696.	279.	279.
MAY	22.66	12.87	20.53	225.12	1212.	0.	4535.	1111.	1136.	846.	839.	225.
JUN	25.81	11.26	24.07	228.99	1038.	0.	6503.	1400.	1401.	1134.	1194.	723.
JUL	27.18	11.26	26.05	232.10	995.	0.	8348.	1703.	1703.	1454.	1528.	1531.
AUG	26.81	11.26	25.80	231.25	1005.	0.	7813.	1614.	1614.	1362.	1431.	1434.
SEP	24.33	12.87	23.49	228.92	1060.	0.	5592.	1250.	1257.	981.	1029.	1031.
OCT	18.57	12.87	19.61	227.36	1248.	807.	2751.	1041.	933.	725.	517.	520.
NOV	12.22	14.48	15.42	245.06	1367.	2712.	822.	1274.	932.	866.	459.	424.
DEC	8.94	14.48	11.80	252.51	1555.	4276.	0.	1620.	1147.	1075.	683.	635.
ANNUAL	18.00	13.54	17.96		15438.	19623.	39456.	16481.	14263.	12202.	9829.	8522.
ANNUAL COP								1.26	1.45	1.70	2.11	2.43

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 9 P(M2)= 4	2650.	1165.	854.	480.	240.	889.	434.	6711.
5	FULL,BR.CHILL, BIN(M3)= 43 P(M2)= 0	2650.	2512.	0.	480.	240.	989.	434.	7205.

COMPARATIVE SYSTEMS COSTS

	NEW CONSTRUCTION ALTERNATIVES	MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERIOD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	600.91	REF.	REF.	REF.	9863.	13452.	2
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	520.03	80.88	3.1	1	8536.	13613.	3
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	444.88	156.03	5.1	2	7302.	13167.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 9	1929.	358.38	242.54	16.1	4	5882.	14523.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 43	1929.	310.70	290.22	15.1	3	5100.	14234.	4

COLUMBIA, MISSOURI

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0450
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 12563.
COOLING = 6447.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.17
BLOWER CAPACITY (M3/H) = 2717.

AIR TEMP: OUTDOOR INDOOR
WINTER = -17 C 21 C
SUMMER = 34 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.6M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-1.74	17.70	2.55	283.29	1918.	12084.	0.	3890.	2963.	2791.	1570.	1570.
FEB	1.44	17.70	2.23	276.07	1744.	8577.	0.	2867.	2079.	1957.	1172.	1179.
MAR	4.96	20.92	4.64	274.65	1836.	7250.	0.	2524.	1779.	1675.	1027.	1072.
APR	12.70	19.31	9.12	253.79	1606.	2805.	914.	1382.	1023.	962.	511.	583.
MAY	18.48	16.09	14.72	234.12	1440.	818.	2358.	1030.	919.	736.	290.	290.
JUN	23.10	14.48	19.62	229.39	1207.	0.	4626.	1126.	1142.	846.	541.	226.
JUL	25.51	12.87	22.78	231.58	1123.	0.	6404.	1406.	1408.	1118.	1177.	257.
AUG	25.27	12.87	23.15	231.04	1109.	0.	6021.	1337.	1342.	1054.	1109.	247.
SEP	20.82	14.48	20.74	225.55	1165.	0.	3285.	885.	943.	732.	612.	193.
OCT	14.56	16.09	16.06	243.02	1387.	1888.	1350.	1141.	893.	835.	343.	352.
NOV	6.42	19.31	10.64	268.06	1549.	5782.	0.	2037.	1424.	1340.	744.	817.
DEC	1.00	17.70	5.61	277.07	1798.	9917.	0.	3254.	2337.	2196.	1292.	1336.
ANNUAL	12.71	16.63	12.65		17884.	49121.	24959.	22878.	18250.	16241.	10387.	9120.
ANNUAL COP								1.12	1.40	1.57	2.46	3.15

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	434.	2745.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	434.	2957.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	534.	3497.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 17 P(M2)= 17	2950.	1793.	1358.	530.	240.	1074.	518.	8463.
5	FULL,BR.CHILL, BIN(M3)= 95 P(M2)= 2	2950.	4313.	768.	530.	240.	1074.	518.	10393.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1030.21	REF.	REF.	REF.	16910.	20430.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	821.82	208.40	1.0	1	13489.	18456.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	731.33	298.88	2.5	2	12004.	17758.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 17	1929.	467.73	562.48	10.2	3	7677.	18070.	2
5	FULL ACES, BR.CHILL, BIN (M3)= 95	1929.	365.66	664.55	11.5	4	6002.	19324.	3

KANSAS CITY, MISSOURI

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0397
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 11890.
COOLING = 6762.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.17
BLOWER CAPACITY (M3/H) = 2547.

AIR TEMP: OUTDOOR INDOOR
WINTER = -16 C 21 C
SUMMER = 36 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.6M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES FR.CHILL
JAN	-1.63	16.09	2.92	279.76	1903.	11774.	0.	3800.	2821.	2655.	1531.	1490.
FEB	1.63	17.70	2.54	275.65	1733.	8430.	0.	2823.	2009.	1890.	1151.	1107.
MAR	5.36	19.31	5.01	270.47	1822.	6856.	0.	2411.	1685.	1587.	980.	945.
APR	13.23	19.31	9.66	252.60	1586.	2544.	875.	1297.	970.	914.	478.	469.
MAY	19.40	17.70	15.51	235.31	1409.	604.	2471.	981.	899.	717.	266.	266.
JUN	24.44	16.09	20.66	235.71	1168.	0.	5109.	1197.	1205.	898.	588.	233.
JUL	26.99	14.48	24.01	238.22	1075.	0.	7279.	1542.	1543.	1268.	1336.	271.
AUG	26.71	14.48	24.45	237.58	1058.	0.	6865.	1467.	1468.	1198.	1260.	260.
SEP	21.85	14.48	21.98	226.56	1118.	0.	3410.	893.	930.	712.	634.	190.
OCT	15.66	14.48	17.12	237.25	1346.	1422.	1346.	999.	810.	759.	291.	269.
NOV	7.06	17.70	11.45	263.32	1518.	5351.	0.	1908.	1318.	1241.	701.	684.
DEC	1.52	16.09	6.18	272.63	1776.	9467.	0.	3123.	2183.	2049.	1240.	1225.
ANNUAL	13.52	16.49	13.46		17510.	46448.	27355.	22442.	17839.	15888.	10455.	7409.
ANNUAL COP								1.13	1.42	1.60	2.43	3.42

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	970.	40.	173.	200.	759.	434.	2856.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	434.	2957.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	534.	3497.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 17 P(M2)= 17	2950.	1734.	1376.	530.	240.	1074.	518.	8422.
5	FULL,BR.CHILL, BIN(M3)= 109 P(M2)= 0	2950.	4637.	0.	530.	240.	1074.	518.	9949.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERICD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	891.38	REF.	REF.	REF.	14631.	19263.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	708.58	182.80	0.6	1	11630.	16597.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	631.09	260.29	2.5	2	10358.	16113.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 17	1929.	415.27	476.11	11.7	3	6816.	17167.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 109	1929.	294.29	597.09	11.9	4	4830.	16708.	3

SPRINGFIELD, MISSOURI

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0467
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 11672.
COOLING = 6756.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.24
BLOWER CAPACITY (M3/H) = 2547.

AIR TEMP: OUTDOOR INDOOR
WINTER = -15 C 21 C
SUMMER = 34 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-0.65	20.92	2.62	287.38	1915.	11688.	0.	3779.	2844.	2676.	1529.	1529.
FEB	2.10	22.53	2.67	284.42	1728.	8609.	0.	2872.	2051.	1927.	1175.	1179.
MAR	6.15	24.13	5.48	278.50	1803.	6787.	0.	2386.	1683.	1582.	971.	1018.
APR	13.75	22.53	10.22	257.98	1565.	2492.	1042.	1305.	984.	924.	473.	576.
MAY	18.75	19.31	15.89	240.08	1394.	700.	2547.	1017.	922.	732.	277.	277.
JUN	22.55	19.31	20.66	237.99	1168.	0.	4589.	1108.	1127.	834.	535.	221.
JUL	25.15	16.09	23.51	237.32	1095.	0.	6560.	1425.	1427.	1145.	1205.	257.
AUG	25.04	16.09	23.46	237.08	1097.	0.	6185.	1361.	1366.	1082.	1137.	249.
SEP	20.91	17.70	20.67	231.89	1167.	0.	3440.	912.	962.	742.	640.	196.
OCT	15.05	19.31	15.73	248.47	1400.	1838.	1497.	1155.	915.	854.	341.	337.
NOV	6.75	20.92	10.24	270.58	1564.	5778.	0.	2040.	1428.	1343.	750.	824.
DEC	1.64	20.92	5.36	282.19	1808.	9834.	0.	3234.	2307.	2165.	1283.	1326.
ANNUAL	13.10	19.98	13.04		17704.	47728.	25861.	22596.	18018.	16005.	10315.	7989.
ANNUAL COP								1.12	1.41	1.58	2.46	3.17

SYSTEMS FIRST COSTS

		COST,$						
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	970.	40.	173.	200.	759.	434.	2856.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	434.	2957.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	534.	3497.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 17 P(M2)= 15	2950.	1740.	1268.	530.	240.	1074.	518.	8321.
5	FULL,BR.CHILL, BIN(M3)= 100 P(M2)= 0	2950.	4411.	0.	530.	240.	1074.	518.	9723.

COMPARATIVE SYSTEMS COSTS

		MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERIOD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1055.22	REF.	REF.	REF.	17320.	20952.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	841.45	213.77	0.5	1	13811.	18778.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	747.45	307.77	2.1	2	12268.	18023.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 17	1929.	481.72	573.50	9.5	3	7907.	13157.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 100	1929.	373.08	682.14	10.1	4	6124.	17776.	1

BILLINGS, MONTANA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0269
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 15891.
COOLING = 4924.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 3396.

AIR TEMP: OUTDOOR INDOOR
WINTER = -25 C 21 C
SUMMER = 33 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.7M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-4.13	20.92	3.92	295.26	1864.	14444.	0.	4531.	3723.	3557.	1824.	1824.
FEB	-2.08	19.31	2.32	287.33	1741.	11100.	0.	3567.	2814.	2662.	1449.	1449.
MAR	1.10	19.31	2.26	280.13	1930.	9669.	0.	3222.	2402.	2269.	1307.	1319.
APR	6.50	19.31	3.90	267.88	1805.	5812.	0.	2116.	1482.	1400.	858.	866.
MAY	13.03	17.70	6.91	249.77	1747.	2690.	1152.	1429.	1081.	1019.	519.	519.
JUN	18.31	17.70	10.31	237.79	1561.	868.	2482.	1099.	979.	786.	311.	311.
JUL	22.82	16.09	13.38	232.03	1493.	0.	4214.	1135.	1162.	893.	247.	247.
AUG	21.99	16.09	15.15	230.16	1423.	0.	3824.	1049.	1086.	841.	712.	231.
SEP	15.35	16.09	15.17	241.22	1377.	1700.	1831.	1168.	943.	759.	354.	341.
OCT	10.07	17.70	13.42	256.49	1491.	3947.	0.	1511.	1139.	1079.	548.	557.
NOV	2.28	20.92	10.48	280.73	1555.	8723.	0.	2855.	2057.	1938.	1045.	1074.
DEC	-0.65	20.92	6.97	287.37	1745.	11805.	0.	3764.	2786.	2628.	1488.	1501.
ANNUAL	8.72	18.50	8.68		19730.	70758.	13504.	27445.	21655.	19830.	10660.	10239.
ANNUAL COP								1.05	1.33	1.46	2.71	2.82

SYSTEMS FIRST COSTS

		COST, $							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	310.	930.	40.	213.	200.	688.	392.	2773.
2	HEAT PUMP WITH ELECTRIC HOT WATER	310.	1080.	58.	231.	200.	714.	392.	2985.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	310.	1080.	58.	631.	240.	714.	492.	3525.
	ACES SYSTEMS, INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN., BR.CHILL, BIN(M3)= 20 P(M2)= 21	3350.	2032.	1533.	550.	240.	1288.	518.	9510.
5	FULL, BR.CHILL, BIN(M3)= 37 P(M2)= 17	3350.	2672.	1348.	550.	240.	1288.	518.	9966.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	738.27	REF.	REF.	REF.	12118.	15666.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	582.52	155.75	1.4	1	9561.	14556.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	533.43	204.84	3.7	2	8756.	14538.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 20	1929.	286.74	451.53	14.9	3	4707.	16146.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 37	1929.	275.42	462.85	15.5	4	4521.	16416.	5

GREAT FALLS, MONTANA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0269
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 17392.
COOLING = 4469.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 3736.

AIR TEMP: OUTDOOR INDOOR
WINTER = -28 C 21 C
SUMMER = 31 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (2.3M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-5.00	27.35	4.74	310.35	1832.	16458.	0.	5081.	4289.	4138.	2042.	2042.
FEB	-3.03	25.74	3.07	302.62	1714.	12731.	0.	4013.	3272.	3126.	1627.	1627.
MAR	-0.14	22.53	2.41	289.49	1924.	10994.	0.	3588.	2780.	2636.	1453.	1454.
APR	6.25	22.53	3.14	274.99	1834.	6255.	0.	2247.	1548.	1464.	911.	911.
MAY	12.27	19.31	5.09	254.78	1818.	3074.	952.	1522.	1122.	1062.	565.	566.
JUN	16.88	19.31	7.64	244.32	1663.	1286.	1949.	1152.	975.	800.	355.	355.
JUL	20.89	17.70	10.25	231.94	1616.	0.	3667.	1075.	1141.	906.	248.	248.
AUG	20.14	17.70	12.10	233.65	1543.	0.	3287.	990.	1071.	861.	328.	328.
SEP	14.24	19.31	12.70	250.30	1470.	2185.	1479.	1268.	983.	923.	299.	382.
OCT	9.47	22.53	11.91	267.69	1550.	4601.	0.	1709.	1250.	1186.	621.	622.
NOV	0.97	25.74	9.99	293.53	1573.	10557.	0.	3370.	2538.	2401.	1336.	1337.
DEC	-2.28	27.35	7.35	304.19	1730.	14092.	0.	4395.	3533.	3387.	1787.	1787.
ANNUAL	7.56	22.26	7.53		20267.	82232.	11334.	30411.	24501.	22889.	11572.	11659.
ANNUAL COP								1.04	1.29	1.38	2.73	2.71

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	310.	930.	40.	213.	200.	688.	392.	2773.
2	HEAT PUMP WITH ELECTRIC HOT WATER	310.	1080.	58.	231.	200.	714.	392.	2985.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	310.	1080.	58.	631.	240.	714.	492.	3525.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 23 P(M2)= 24	3350.	2194.	1642.	550.	240.	1288.	518.	9781.
5	FULL,BR.CHILL, BIN(M3)= 25 P(M2)= 24	3350.	2281.	1620.	550.	240.	1288.	518.	9846.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WOPTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	818.06	REF.	REF.	REF.	13427.	16976.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	659.09	158.98	1.3	1	10818.	15813.	1
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	615.72	202.34	3.7	2	10106.	15889.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 23	1929.	311.28	506.79	13.8	3	5109.	16820.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 25	1929.	313.64	504.43	14.0	4	5148.	16923.	4

MISSOULA, MONTANA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0269
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 19980.
COOLING = 4416.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 4330.

AIR TEMP: OUTDOOR INDOOR
WINTER = -34 C 21 C
SUMMER = 31 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (2.6M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-5.26	8.05	4.52	271.62	1841.	14168.	0.	4447.	3579.	3410.	1791.	1791.
FEB	-2.55	9.65	3.05	268.75	1715.	10575.	0.	3414.	2545.	2396.	1377.	1375.
MAR	0.64	11.26	2.40	264.79	1924.	9226.	0.	3098.	2206.	2076.	1244.	1242.
APR	6.20	11.26	2.91	252.17	1843.	5347.	0.	1997.	1377.	1300.	800.	799.
MAY	11.21	11.26	4.46	240.80	1843.	3220.	795.	1542.	1128.	1065.	578.	578.
JUN	15.48	11.26	6.56	231.10	1704.	1615.	1657.	1205.	987.	817.	389.	389.
JUL	19.93	11.26	8.76	221.01	1674.	736.	3538.	1274.	1173.	918.	331.	331.
AUG	18.42	11.26	10.38	224.43	1610.	950.	2898.	1207.	1076.	853.	334.	334.
SEP	13.00	9.65	10.98	233.46	1536.	2395.	1284.	1311.	1000.	938.	404.	403.
OCT	6.41	8.05	10.42	245.12	1609.	5181.	0.	1886.	1289.	1214.	665.	664.
NOV	-0.35	8.05	8.89	260.48	1615.	9667.	0.	3134.	2234.	2098.	1128.	1123.
DEC	-2.84	6.44	6.72	262.86	1754.	12095.	0.	3847.	2851.	2688.	1516.	1516.
ANNUAL	6.69	9.79	6.67		20668.	75176.	10170.	28364.	21445.	19774.	10556.	10544.
ANNUAL COP								1.04	1.37	1.49	2.79	2.79

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	310.	930.	40.	213.	200.	688.	392.	2773.
2	HEAT PUMP WITH ELECTRIC HOT WATER	310.	1080.	58.	231.	200.	714.	392.	2985.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	310.	1080.	58.	631.	240.	714.	492.	3525.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 20 P(M2)= 50	3750.	2172.	2644.	620.	240.	1454.	518.	11398.
5	FULL,BR.CHILL, BIN(M3)= 20 P(M2)= 50	3750.	2172.	2644.	620.	240.	1454.	518.	11398.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	762.98	REF.	REF.	REF.	12523.	16072.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	576.86	186.12	1.1	1	9468.	14463.	1
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	531.92	231.06	3.3	2	8731.	14513.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 20	1929.	283.96	479.02	18.0	3	4661.	17988.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 20	1929.	283.96	479.02	18.0	4	4661.	17988.	5

GRAND ISLAND, NEBRASKA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0477
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 14233.
COOLING = 6252.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.10
BLOWER CAPACITY (M3/H) = 3056.

AIR TEMP: OUTDOOR INDOOR
WINTER = -21 C 21 C
SUMMER = 35 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.7M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-5.85	19.31	4.12	295.90	1857.	15809.	0.	4908.	3997.	3846.	1959.	1959.
FEB	-2.78	19.31	2.39	288.93	1738.	11829.	0.	3769.	2932.	2784.	1518.	1520.
MAR	1.16	22.53	2.48	286.55	1921.	9974.	0.	3304.	2391.	2262.	1325.	1355.
APR	9.56	24.13	4.54	270.77	1780.	4641.	0.	1784.	1321.	1256.	715.	730.
MAY	16.02	20.92	8.14	249.55	1699.	1646.	1709.	1221.	1001.	827.	393.	393.
JUN	21.78	20.92	12.10	239.52	1493.	0.	3638.	1036.	1077.	845.	234.	234.
JUL	24.57	17.70	15.58	239.30	1406.	0.	5459.	1323.	1329.	980.	823.	265.
AUG	24.14	19.31	17.50	241.59	1331.	0.	5237.	1265.	1277.	942.	968.	253.
SEP	18.20	19.31	17.35	241.32	1294.	1052.	2455.	1071.	929.	731.	465.	338.
OCT	11.81	19.31	15.17	255.83	1422.	3339.	942.	1484.	1064.	1002.	482.	494.
NOV	2.71	20.92	11.66	279.76	1510.	8491.	0.	2778.	1941.	1832.	988.	1038.
DEC	-2.23	19.31	7.58	287.69	1721.	12711.	0.	4009.	2995.	2851.	1567.	1581.
ANNUAL	9.92	20.25	9.88		19172.	69492.	19441.	27953.	22256.	20159.	11437.	10159.
ANNUAL COP								1.07	1.35	1.49	2.63	2.96

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST, $ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS, INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN., BR.CHILL, BIN(F3)= 22 P(M2)= 29	3350.	2065.	1817.	550.	240.	1288.	518.	9827.
5	FULL, BR.CHILL, BIN(F3)= 63 P(M2)= 14	3350.	3482.	1249.	550.	240.	1288.	518.	10677.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1332.50	REF.	REF.	REF.	21871.	25349.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	1060.92	271.57	0.8	1	17414.	22339.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	960.96	371.54	2.0	2	15773.	21485.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 22	1929.	545.20	787.29	9.0	3	8949.	20705.	2
5	FULL ACES, BR.CHILL, BIN (M3)= 63	1929.	484.30	848.20	9.4	4	7949.	20556.	1

LINCOLN, NEBRASKA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0349
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 13541.
COOLING = 6500.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.20
BLOWER CAPACITY (M3/H) = 2887.

AIR TEMP: OUTDOOR INDOOR
WINTER = -20 C 21 C
SUMMER = 36 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS					SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.7M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES ER.CHILL
JAN	-6.23	16.09	4.26	290.21	1851.	15776.	0.	4897.	4091.	3936.	1946.	1948.
FEB	-3.60	17.70	2.53	287.51	1733.	12242.	0.	3882.	3069.	2919.	1540.	1557.
MAR	1.55	19.31	2.67	279.10	1913.	9525.	0.	3178.	2302.	2176.	1259.	1284.
APR	10.59	19.31	4.83	258.59	1770.	3733.	0.	1529.	1174.	1120.	605.	615.
MAY	17.97	17.70	8.53	238.57	1683.	943.	2107.	1090.	961.	789.	323.	323.
JUN	22.26	16.09	12.59	230.77	1474.	0.	3925.	1080.	1100.	849.	239.	239.
JUL	24.40	14.48	16.14	232.34	1384.	0.	5443.	1314.	1317.	969.	1006.	263.
AUG	24.03	14.48	18.06	231.51	1309.	0.	5062.	1228.	1238.	914.	936.	246.
SEP	18.57	16.09	17.86	233.92	1274.	729.	2079.	912.	812.	650.	396.	287.
OCT	13.09	16.09	15.59	246.37	1406.	2557.	702.	1221.	892.	844.	394.	405.
NOV	3.63	17.70	11.97	271.10	1498.	7857.	0.	2599.	1806.	1703.	908.	953.
DEC	-2.97	16.09	7.78	282.81	1713.	14341.	0.	4460.	3472.	3328.	1698.	1698.
ANNUAL	10.27	16.76	10.23		19009.	67702.	19318.	27389.	22234.	20197.	11252.	9818.
ANNUAL COP								1.08	1.32	1.46	2.62	3.00

SYSTEMS FIRST COSTS

		COST, $							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	434.	2745.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	434.	2957.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	534.	3497.
	ACES SYSTEMS, INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN., BR.CHILL, BIN(M3)= 22 P(M2)= 70	3350.	2008.	3416.	550.	240.	1288.	518.	11370.
5	FULL, BR.CHILL, BIN(M3)= 67 P(M2)= 24	3350.	3539.	1631.	550.	240.	1288.	518.	11115.

COMPARATIVE SYSTEMS COSTS

		MAINT.	1ST YEAR	1ST YEAR	SIMPLE	SIMPLE	POWER	LIFE	LIFE
	NEW CONSTRUCTION ALTERNATIVES	PRESENT WORTH	POWER COST	POWER SAVING	PAYBACK PERIOD	PAYBACK RANKING	PRESENT WORTH	CYCLE COST	CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	955.89	REF.	REF.	REF.	15690.	19210.	4
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	775.96	179.93	1.2	1	12736.	17703.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	704.87	251.02	3.0	2	11569.	17324.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 22	1929.	392.70	563.19	15.3	4	6446.	19745.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 67	1929.	342.64	613.24	13.7	3	5624.	18669.	3

NORTH PLATTE, NEBRASKA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0332
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 14245.
COOLING = 5581.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.04
BLOWER CAPACITY (M3/H) = 3056.

AIR TEMP: OUTDOOR INDOOR
WINTER = -21 C 21 C
SUMMER = 34 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS					SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.8M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-5.29	14.48	4.22	284.80	1853.	14654.	0.	4586.	3803.	3648.	1839.	1839.
FEB	-2.73	17.70	2.49	285.55	1735.	11656.	0.	3720.	2967.	2817.	1503.	1503.
MAR	1.00	19.31	2.37	280.35	1925.	9855.	0.	3273.	2432.	2304.	1317.	1337.
APR	8.31	20.92	4.07	267.05	1798.	5212.	0.	1947.	1427.	1355.	784.	795.
MAY	14.89	20.92	7.23	252.11	1734.	2153.	1520.	1340.	1057.	997.	459.	460.
JUN	20.60	19.31	10.82	235.87	1542.	0.	2982.	938.	1004.	814.	225.	225.
JUL	23.78	16.09	14.08	234.21	1465.	0.	4762.	1221.	1234.	929.	570.	256.
AUG	23.36	16.09	16.00	233.28	1390.	0.	4538.	1161.	1180.	890.	842.	243.
SEP	17.13	17.70	16.06	240.47	1343.	1413.	2341.	1165.	978.	773.	446.	332.
OCT	10.50	16.09	14.25	252.24	1458.	3999.	916.	1673.	1190.	1119.	553.	564.
NOV	1.68	17.70	11.17	275.54	1529.	8955.	0.	2912.	2096.	1980.	1039.	1081.
DEC	-2.57	16.09	7.46	281.91	1725.	12605.	0.	3981.	3083.	2936.	1559.	1573.
ANNUAL	9.22	17.70	9.19		19497.	70502.	17058.	27917.	22452.	20562.	11135.	10208.
ANNUAL COP								1.07	1.32	1.45	2.67	2.91

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 20 P(M2)= 25	3350.	1978.	1677.	550.	240.	1288.	518.	9601.
5	FULL,BR.CHILL, BIN(M3)= 51 P(M2)= 16	3350.	3081.	1308.	550.	240.	1288.	518.	10335.

COMPARATIVE SYSTEMS COSTS

		MAINT.	1ST YEAR	1ST YEAR	SIMPLE	SIMPLE	POWER	LIFE	LIFE
	NEW CONSTRUCTION ALTERNATIVES	PRESENT	POWER	POWER	PAYBACK	PAYBACK	PRESENT	CYCLE	CYCLE
NO.	SYSTEMS	WORTH $	COST $	SAVING $	PERIOD YEARS	RANKING	WORTH $	COST $	RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	926.27	REF.	REF.	REF.	15203.	18682.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	744.95	181.33	1.2	1	12227.	17152.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	682.23	244.04	3.1	2	11198.	16910.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 20	1929.	369.47	556.80	12.4	3	6064.	17595.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 51	1929.	338.70	587.57	13.0	4	5559.	17823.	4

ELY, NEVADA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0337
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 14737.
COOLING = 4600.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 3141.

AIR TEMP: OUTDOOR INDOOR
WINTER = -22 C 21 C
SUMMER = 31 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (2.4M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-5.23	17.70	4.72	291.23	1833.	14717.	0.	4598.	3855.	3695.	1856.	1856.
FEB	-2.17	19.31	3.15	287.55	1711.	10958.	0.	3520.	2747.	2599.	1434.	1435.
MAR	1.11	17.70	2.49	276.82	1921.	9349.	0.	3131.	2282.	2155.	1270.	1274.
APR	6.29	19.31	3.10	268.35	1836.	6244.	0.	2245.	1615.	1527.	910.	913.
MAY	10.04	19.31	4.84	259.84	1828.	4478.	1009.	1924.	1375.	1292.	726.	728.
JUN	17.02	19.31	7.15	244.00	1681.	1847.	2838.	1465.	1223.	969.	446.	446.
JUL	20.58	17.70	9.54	232.64	1644.	815.	3827.	1337.	1226.	949.	343.	343.
AUG	19.40	17.70	11.28	235.31	1575.	1035.	3596.	1340.	1201.	930.	515.	355.
SEP	14.14	17.70	11.88	247.25	1502.	2749.	2328.	1579.	1230.	1142.	451.	449.
OCT	7.62	17.70	11.22	262.06	1578.	5734.	0.	2031.	1514.	1430.	726.	729.
NOV	0.49	17.70	9.50	278.23	1592.	9574.	0.	3102.	2331.	2202.	1112.	1117.
DEC	-3.10	17.70	7.11	286.37	1739.	12990.	0.	4092.	3298.	3144.	1611.	1611.
ANNUAL	7.18	18.24	7.16		20440.	80491.	13600.	30363.	23899.	22034.	11402.	11256.
ANNUAL COP								1.05	1.33	1.44	2.79	2.83

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 21 P(M2)= 18	3350.	2000.	1397.	550.	240.	1288.	518.	9343.
5	FULL,BR.CHILL, BIN(M3)= 26 P(M2)= 17	3350.	2231.	1343.	550.	240.	1288.	518.	9519.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1022.61	REF.	REF.	REF.	16785.	20263.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	804.91	217.70	1.0	1	13211.	18136.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	742.09	280.52	2.7	2	12180.	17893.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 21	1929.	384.01	638.60	10.4	3	6303.	17575.	1
5	FULL ACES, BR.CHILL, BIN (M3)= 26	1929.	379.09	643.52	10.6	4	6222.	17671.	2

LAS VEGAS, NEVADA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0313
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 7101.
COOLING = 7283.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 1783.

AIR TEMP: OUTDOOR INDOOR
WINTER = -3 C 21 C
SUMMER = 41 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS					SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP	AVE WIND SPEED	INLET WATER TEMP	HEAT LOSS COEF.	WATER HEAT	SPACE HEAT	SPACE COOL	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
	C	KM/H	C (0.5M)	W/C	MJ	MJ	MJ					
JAN	7.10	11.26	9.08	250.13	1662.	5058.	0.	1867.	1289.	1207.	781.	732.
FEB	10.42	12.87	9.30	245.87	1493.	3225.	0.	1311.	999.	943.	563.	514.
MAR	13.44	16.09	12.24	245.56	1538.	2489.	1547.	1383.	1057.	978.	483.	473.
APR	18.83	16.09	17.02	233.34	1306.	864.	2931.	1104.	986.	764.	294.	294.
MAY	23.79	17.70	22.64	237.51	1129.	0.	4828.	1138.	1168.	871.	891.	223.
JUN	29.80	17.70	27.27	251.16	917.	0.	7644.	1561.	1563.	1334.	1399.	1117.
JUL	32.89	16.09	29.92	254.90	843.	0.	9677.	1887.	1887.	1686.	1768.	1771.
AUG	31.66	14.48	29.70	248.82	852.	0.	8857.	1750.	1750.	1543.	1619.	1622.
SEP	27.24	14.48	26.78	238.80	935.	0.	6340.	1343.	1347.	1109.	1163.	1166.
OCT	20.26	12.87	21.80	223.54	1162.	0.	3659.	948.	1018.	784.	679.	682.
NOV	11.39	11.26	16.36	240.38	1331.	2948.	990.	1358.	982.	910.	467.	442.
DEC	7.58	9.65	11.63	245.77	1562.	4722.	0.	1746.	1209.	1132.	709.	685.
ANNUAL	19.53	14.21	19.48		14728.	19307.	46473.	17395.	15254.	13261.	10816.	9720.
ANNUAL COP								1.29	1.47	1.69	2.07	2.30

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 8 P(M2)= 4	2500.	1127.	838.	480.	240.	714.	392.	6291.
5	FULL,BR.CHILL, BIN(M3)= 41 P(M2)= 0	2500.	2418.	0.	480.	240.	714.	392.	6744.

COMPARATIVE SYSTEMS COSTS

		MAINT.	1ST YEAR	1ST YEAR	SIMPLE	SIMPLE	POWER	LIFE	LIFE
	NEW CONSTRUCTION ALTERNATIVES	PRESENT WORTH	POWER COST	POWER SAVING	PAYBACK PERIOD	PAYBACK RANKING	PRESENT WORTH	CYCLE COST	CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	544.99	REF.	REF.	REF.	8945.	12534.	1
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	477.92	67.07	3.8	1	7844.	12921.	3
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	415.46	129.53	6.1	2	6819.	12684.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 8	1929.	338.87	206.12	16.9	4	5562.	13782.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 41	1929.	304.53	240.46	16.3	3	4998.	13672.	4

WINNEMUCCA, NEVADA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0423
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 12623.
COOLING = 5728.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 2717.

AIR TEMP: OUTDOOR INDOOR
WINTER = -17 C 21 C
SUMMER = 35 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.2M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-2.48	12.87	3.23	275.14	1891.	12258.	0.	3931.	2998.	2832.	1591.	1591.
FEB	1.42	12.87	2.28	266.29	1742.	8020.	0.	2712.	1915.	1806.	1101.	1121.
MAR	4.12	14.48	3.21	263.45	1892.	7232.	0.	2535.	1769.	1671.	1026.	1068.
APR	8.56	14.48	5.87	253.37	1730.	4716.	0.	1791.	1332.	1264.	724.	752.
MAY	13.46	14.48	9.68	242.24	1638.	2704.	1611.	1481.	1135.	1064.	512.	515.
JUN	18.97	14.48	13.41	229.73	1443.	1111.	3222.	1260.	1112.	862.	341.	341.
JUL	23.64	12.87	16.28	227.36	1379.	0.	4935.	1226.	1285.	970.	582.	251.
AUG	21.96	12.87	17.34	223.54	1337.	0.	4615.	1160.	1254.	959.	855.	240.
SEP	16.52	11.26	16.38	228.75	1330.	1789.	2955.	1371.	1143.	883.	558.	387.
OCT	10.02	11.26	13.60	243.49	1484.	4151.	1106.	1754.	1263.	1182.	573.	598.
NOV	2.55	11.26	9.89	260.45	1577.	7775.	0.	2598.	1863.	1758.	931.	1012.
DEC	-1.06	11.26	6.05	268.65	1781.	10983.	0.	3546.	2642.	2494.	1403.	1451.
ANNUAL	9.81	12.87	9.77		19226.	60739.	18444.	25366.	19712.	17745.	10198.	9325.
ANNUAL COP								1.08	1.39	1.54	2.68	2.93

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 18 P(M2)= 20	2950.	1795.	1476.	530.	240.	1074.	518.	8584.
5	FULL,BR.CHILL, BIN(M3)= 53 P(M2)= 9	2950.	3069.	1033.	530.	240.	1074.	518.	9414.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1072.21	REF.	REF.	REF.	17599.	21077.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	833.24	238.98	0.9	1	13676.	18601.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	750.09	322.13	2.3	2	12312.	18024.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 18	1929.	431.06	641.15	9.2	3	7075.	17588.	1
5	FULL ACES, BR.CHILL, BIN (M3)= 53	1929.	394.16	678.05	9.9	4	6470.	17813.	2

TRENTON, NEW JERSEY

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0603
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 10013.
COOLING = 5531.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.21
BLOWER CAPACITY (M3/H) = 2122.

AIR TEMP: OUTDOOR INDOOR
WINTER = -11 C 21 C
SUMMER = 31 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.8M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES EP.CHILL
JAN	-0.81	16.09	3.21	277.91	1892.	11406.	0.	3694.	2674.	2505.	1489.	1489.
FEB	0.38	16.09	2.46	275.21	1736.	9192.	0.	3036.	2151.	2014.	1229.	1230.
MAR	4.02	17.70	4.02	270.22	1860.	7527.	0.	2608.	1770.	1658.	1050.	1079.
APR	10.42	16.09	7.52	252.42	1667.	3601.	0.	1464.	1091.	1033.	589.	612.
MAY	16.32	14.48	12.21	235.75	1539.	1377.	1703.	1101.	914.	751.	347.	347.
JUN	21.09	12.87	16.58	221.66	1323.	0.	3444.	956.	991.	770.	212.	212.
JUL	23.44	12.87	19.69	226.90	1245.	0.	4867.	1177.	1182.	871.	900.	236.
AUG	22.49	12.87	20.53	224.74	1212.	0.	4493.	1104.	1116.	829.	831.	224.
SEP	18.90	12.87	18.95	226.61	1233.	553.	2705.	958.	882.	688.	508.	311.
OCT	13.33	14.48	15.29	242.54	1418.	2168.	819.	1136.	850.	798.	366.	382.
NOV	7.67	16.09	10.74	258.67	1545.	4847.	0.	1776.	1200.	1127.	642.	690.
DEC	0.78	14.48	6.26	271.01	1773.	9965.	0.	3261.	2299.	2151.	1280.	1291.
ANNUAL	11.50	14.75	11.45		18442.	50636.	18031.	22271.	17119.	15194.	9443.	8102.
ANNUAL COP								1.09	1.41	1.59	2.56	2.99

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	930.	40.	160.	200.	688.	392.	2660.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	392.	2843.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	492.	3383.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 17 P(M2)= 21	2950.	1693.	1510.	480.	240.	1074.	434.	8381.
5	FULL,BR.CHILL, BIN(M3)= 61 P(M2)= 8	2950.	3249.	999.	480.	240.	1074.	434.	9425.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1342.04	REF.	REF.	REF.	22028.	25463.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	1031.59	310.46	0.6	1	16932.	21785.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	915.60	426.44	1.7	2	15028.	20669.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 17	1929.	569.05	772.99	7.4	3	9340.	19650.	2
5	FULL ACES, BR.CHILL, BIN (M3)= 61	1929.	488.23	853.81	7.9	4	8014.	19368.	1

ALBUQUERQUE, NEW MEXICO

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0570
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 9762.
COOLING = 5425.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 2122.

AIR TEMP: OUTDOOR INDOOR
WINTER = -10 C 21 C
SUMMER = 34 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	2.02	12.87	3.89	264.92	1865.	7958.	0.	2729.	1887.	1766.	1119.	1070.
FEB	4.48	14.48	4.15	262.63	1676.	6074.	0.	2153.	1483.	1390.	895.	844.
MAR	7.94	16.09	6.98	258.06	1744.	4938.	0.	1856.	1321.	1242.	772.	728.
APR	13.50	17.70	11.53	248.72	1515.	2505.	1437.	1362.	1035.	961.	478.	469.
MAY	18.50	16.09	16.84	234.08	1357.	917.	2847.	1118.	993.	775.	303.	303.
JUN	24.53	16.09	21.19	235.92	1148.	0.	4735.	1128.	1140.	838.	711.	223.
JUL	25.32	14.48	23.65	234.43	1089.	0.	5080.	1171.	1171.	885.	936.	224.
AUG	24.41	12.87	23.37	229.09	1100.	0.	4641.	1099.	1099.	809.	857.	216.
SEP	21.37	14.48	20.57	225.47	1171.	0.	3644.	948.	980.	747.	677.	321.
OCT	14.45	12.87	15.83	236.72	1396.	1806.	1662.	1174.	933.	864.	340.	327.
NOV	6.69	12.87	10.69	254.32	1547.	5013.	0.	1822.	1243.	1165.	696.	662.
DEC	2.36	11.26	6.25	260.88	1773.	7560.	0.	2593.	1770.	1655.	1041.	1017.
ANNUAL	13.80	14.35	13.74		17381.	36770.	24046.	19152.	15054.	13097.	8824.	6404.
ANNUAL COP								1.13	1.44	1.66	2.46	3.39

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	930.	40.	160.	200.	688.	392.	2660.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	392.	2843.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	492.	3383.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 12 P(M2)= 7	2650.	1470.	963.	480.	240.	889.	434.	7126.
5	FULL,BR.CHILL, BIN(M3)= 84 P(M2)= 0	2650.	3903.	0.	480.	240.	889.	434.	8596.

COMPARATIVE SYSTEMS COSTS

	NEW CONSTRUCTION ALTERNATIVES	MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERIOD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1090.89	REF.	REF.	REF.	17905.	21341.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	857.50	233.39	0.8	1	14075.	18928.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	746.02	344.87	2.1	2	12245.	17885.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 12	1929.	502.59	588.30	7.6	3	8249.	17304.	2
5	FULL ACES, BR.CHILL, BIN (M3)= 84	1929.	364.75	726.14	8.2	4	5987.	16512.	1

ROSWELL, NEW MEXICO

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0440
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 9509.
COOLING = 5905.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 2038.

AIR TEMP: OUTDOOR INDOOR
WINTER = -10 C 21 C
SUMMER = 37 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	3.83	12.87	6.01	260.82	1782.	7202.	0.	2496.	1781.	1671.	1032.	979.
FEB	6.50	14.48	6.41	258.04	1596.	5251.	0.	1902.	1382.	1298.	803.	746.
MAR	10.20	16.09	9.36	252.92	1651.	4072.	984.	1758.	1257.	1171.	676.	645.
APR	16.20	16.09	13.98	239.30	1422.	1664.	2258.	1243.	1022.	812.	386.	386.
MAY	21.86	14.48	19.27	226.57	1261.	0.	3953.	1026.	1069.	816.	475.	217.
JUN	26.35	14.48	23.54	236.78	1058.	0.	5497.	1233.	1238.	962.	1011.	230.
JUL	27.09	11.26	25.86	231.89	1002.	0.	5906.	1287.	1287.	1029.	1085.	448.
AUG	26.71	11.26	25.44	231.02	1019.	0.	5656.	1249.	1249.	985.	1040.	1044.
SEP	22.81	11.26	22.52	222.19	1097.	0.	4086.	1003.	1019.	757.	756.	760.
OCT	16.55	12.87	17.72	231.96	1322.	1244.	2229.	1094.	925.	734.	425.	428.
NOV	8.72	11.26	12.59	246.44	1475.	4138.	0.	1559.	1167.	1099.	600.	567.
DEC	4.74	11.26	8.23	255.48	1695.	6430.	0.	2257.	1567.	1468.	911.	885.
ANNUAL	15.96	13.14	15.91		16380.	30001.	30569.	18108.	14964.	12803.	9201.	7333.
ANNUAL COP								1.18	1.43	1.67	2.32	2.92

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	930.	40.	160.	200.	688.	392.	2660.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	392.	2843.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	492.	3383.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 11 P(M2)= 5	2650.	1376.	912.	480.	240.	889.	434.	6981.
5	FULL,BR.CHILL, BIN(M3)= 66 P(M2)= 0	2650.	3343.	0.	480.	240.	889.	434.	8036.

COMPARATIVE SYSTEMS COSTS

		MAINT.	1ST YEAR	1ST YEAR	SIMPLE	SIMPLE	POWER	LIFE	LIFE
	NEW CONSTRUCTION ALTERNATIVES	PRESENT WORTH	POWER COST	POWER SAVING	PAYBACK PERIOD	PAYBACK RANKING	PRESENT WORTH	CYCLE COST	CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	796.37	REF.	REF.	REF.	13071.	16507.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	658.11	138.26	1.3	1	10802.	15655.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	563.07	233.30	3.1	2	9242.	14883.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 11	1929.	404.67	391.70	11.0	3	6642.	15552.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 66	1929.	322.52	473.85	11.3	4	5294.	15259.	2

ALBANY, NEW YORK

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0370
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 13782.
COOLING = 4735.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.14
BLOWER CAPACITY (M3/H) = 2971.

AIR TEMP: OUTDOOR INDOOR
WINTER = -20 C 21 C
SUMMER = 31 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS					SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.8M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-5.76	16.09	4.25	289.13	1851.	15847.	0.	4917.	4159.	3996.	1954.	1954.
FEB	-3.44	17.70	2.54	287.16	1733.	12468.	0.	3945.	3183.	3025.	1573.	1585.
MAR	0.57	17.70	2.32	278.04	1927.	10329.	0.	3405.	2500.	2357.	1354.	1362.
APR	8.50	17.70	3.85	260.06	1807.	4802.	0.	1836.	1302.	1233.	728.	732.
MAY	14.56	14.48	6.78	239.76	1752.	1983.	1122.	1229.	967.	915.	433.	434.
JUN	19.82	12.87	10.17	224.54	1567.	0.	2520.	866.	927.	766.	218.	218.
JUL	21.94	11.26	13.31	220.21	1496.	0.	3588.	1029.	1050.	821.	234.	234.
AUG	20.96	11.26	15.20	218.68	1421.	0.	3393.	974.	1010.	793.	634.	222.
SEP	16.73	11.26	15.36	228.27	1369.	1120.	1737.	988.	839.	693.	336.	292.
OCT	10.77	12.87	13.74	245.08	1479.	3286.	0.	1324.	965.	917.	461.	467.
NOV	4.19	14.48	10.87	263.28	1540.	7289.	0.	2453.	1667.	1567.	870.	888.
DEC	-2.68	14.48	7.37	278.87	1729.	13079.	0.	4114.	3227.	3071.	1597.	1600.
ANNUAL	8.85	14.35	8.81		19670.	70202.	12361.	27079.	21795.	20143.	10391.	9987.
ANNUAL COP								1.05	1.30	1.41	2.73	2.84

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 22 P(M2)= 70	3350.	2022.	3427.	550.	240.	1288.	518.	11394.
5	FULL,BR.CHILL, BIN(M3)= 36 P(M2)= 48	3350.	2545.	2569.	550.	240.	1288.	518.	11059.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1002.19	REF.	REF.	REF.	16450.	19928.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	806.64	195.55	1.1	1	13240.	18165.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	745.48	256.70	2.9	2	12236.	17949.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 22	1929.	384.56	617.63	14.1	4	6312.	19635.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 36	1929.	369.61	632.58	13.2	3	6067.	19055.	3

BINGHAMTON, NEW YORK

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0431
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 12897.
COOLING = 4186.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.10
BLOWER CAPACITY (M3/H) = 2802.

AIR TEMP: OUTDOOR INDOOR
WINTER = -18 C 21 C
SUMMER = 29 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS					SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP	AVE WIND SPEED	INLET WATER TEMP	HEAT LOSS COEF.	WATER HEAT	SPACE HEAT	SPACE COOL	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
	C	KM/H	C (2.3M)	W/C	MJ	MJ	MJ					
JAN	-5.91	20.92	4.88	299.31	1826.	16861.	0.	5191.	4426.	4267.	2044.	2044.
FEB	-3.86	20.92	3.09	294.66	1713.	13269.	0.	4162.	3397.	3242.	1649.	1649.
MAR	-1.03	19.31	2.34	284.96	1926.	11866.	0.	3831.	2910.	2745.	1517.	1515.
APR	6.94	19.31	3.03	266.87	1838.	5859.	0.	2138.	1501.	1418.	845.	844.
MAY	12.91	17.70	5.02	250.05	1821.	2661.	816.	1385.	1039.	984.	508.	508.
JUN	18.07	16.09	7.65	235.07	1662.	753.	1953.	1005.	900.	746.	297.	297.
JUL	20.17	17.70	10.38	233.59	1611.	0.	2808.	927.	964.	795.	228.	228.
AUG	19.54	14.48	12.36	228.45	1533.	0.	2601.	870.	915.	749.	216.	216.
SEP	15.68	14.48	13.05	237.20	1457.	1338.	1383.	1013.	833.	692.	307.	307.
OCT	10.09	16.09	12.30	253.17	1535.	3752.	0.	1469.	1045.	991.	505.	505.
NOV	3.23	19.31	10.35	275.31	1560.	8533.	0.	2804.	1912.	1793.	981.	978.
DEC	-3.46	19.31	7.61	290.47	1719.	14506.	0.	4507.	3642.	3489.	1724.	1723.
ANNUAL	7.70	17.97	7.67		20202.	79398.	9560.	29303.	23485.	21901.	10822.	10813.
ANNUAL COP								1.03	1.29	1.38	2.80	2.80

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 23 P(M2)= 106*	2950.	2046.	4792.	530.	240.	1074.	518.	12149.*
5	FULL,BR.CHILL, BIN(M3)= 23 P(M2)= 106*	2950.	2046.	4792.	530.	240.	1074.	518.	12149.*

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1263.83	REF.	REF.	REF.	20744.	24222.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	1012.89	250.94	0.8	1	16625.	21550.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	944.58	319.25	2.4	2	15504.	21216.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 23	1929.	466.74	797.09	11.9	3	7661.	21740.*	3
5	FULL ACES, BR.CHILL, BIN (M3)= 23	1929.	466.74	797.09	11.9	4	7661.	21740.*	4

*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
POWER COSTS ($/KWH) = 0.0370
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 11557.
COOLING = 4826.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.17
BLOWER CAPACITY (M3/H) = 2462.

AIR TEMP: OUTDOOR INDOOR
WINTER = -15 C 21 C
SUMMER = 30 C 26 C

DESIGN AND PERFORMANCE

MONTH	WEATHER DATA: AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.8M)	BUILDING PARAMETERS AND LOADS: HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	SYSTEM ENERGY CONSUMPTION, KWH: (1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-4.81	24.13	4.51	303.36	1841.	16136.	0.	4994.	4147.	3979.	1967.	1967.
FEB	-3.78	24.13	2.72	301.04	1726.	13507.	0.	4232.	3433.	3272.	1682.	1686.
MAR	-0.14	24.13	2.33	292.77	1927.	11627.	0.	3765.	2806.	2639.	1492.	1498.
APR	7.68	22.53	3.64	271.75	1815.	5529.	0.	2040.	1418.	1336.	807.	809.
MAY	13.36	19.31	6.36	252.30	1769.	2564.	944.	1365.	1028.	969.	495.	495.
JUN	19.07	19.31	9.62	239.36	1588.	632.	2541.	1051.	963.	775.	289.	289.
JUL	21.60	17.70	12.72	232.55	1519.	0.	3700.	1054.	1075.	839.	238.	238.
AUG	20.67	17.70	14.70	232.44	1441.	0.	3407.	982.	1017.	799.	534.	224.
SEP	16.26	19.31	15.03	245.72	1382.	1333.	1536.	1016.	836.	685.	300.	307.
OCT	11.33	19.31	13.64	256.92	1483.	3259.	0.	1317.	953.	903.	454.	457.
NOV	4.80	22.53	10.97	278.30	1536.	7617.	0.	2543.	1691.	1582.	891.	902.
DEC	-1.81	22.53	7.60	293.30	1720.	13450.	0.	4214.	3253.	3092.	1606.	1608.
ANNUAL	8.69	21.05	8.65		19745.	75655.	12128.	28575.	22620.	20870.	10755.	10490.
ANNUAL COP								1.05	1.32	1.43	2.78	2.85

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST, $: FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS, INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN., BR.CHILL, BIN(M3)= 22 P(M2)= 77	2950.	1946.	3668.	530.	240.	1074.	518.	10926.
5	FULL, BR.CHILL, BIN(M3)= 33 P(M2)= 57	2950.	2348.	2927.	530.	240.	1074.	518.	10587.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1057.54	REF.	REF.	REF.	17358.	20836.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	837.16	220.38	1.0	1	13741.	18666.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	772.41	285.13	2.6	2	12678.	18390.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 22	1929.	398.03	659.52	12.5	4	6533.	19388.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 33	1929.	387.85	669.70	11.8	3	6366.	18882.	3

SYRACUSE, NEW YORK

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0370
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 13091.
COOLING = 4742.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.12
BLOWER CAPACITY (M3/H) = 2802.

AIR TEMP: OUTDOOR INDOOR
WINTER = -18 C 21 C
SUMMER = 31 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.7M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-5.07	16.09	4.11	287.58	1857.	15356.	0.	4782.	3829.	3667.	1900.	1900.
FEB	-3.20	17.70	2.39	286.60	1738.	12303.	0.	3901.	3008.	2852.	1554.	1564.
MAR	0.19	17.70	2.27	278.92	1929.	10632.	0.	3490.	2485.	2341.	1387.	1397.
APR	8.38	17.70	3.95	260.33	1803.	4857.	0.	1850.	1300.	1232.	733.	738.
MAY	14.39	16.09	7.08	243.41	1740.	2092.	1115.	1255.	979.	926.	444.	445.
JUN	19.70	14.48	10.63	228.10	1549.	0.	2583.	872.	937.	772.	217.	217.
JUL	21.83	12.87	13.87	223.25	1474.	0.	3734.	1047.	1065.	826.	234.	234.
AUG	21.17	12.87	15.77	221.73	1399.	0.	3517.	990.	1018.	793.	657.	222.
SEP	17.21	14.48	15.83	233.74	1351.	1026.	1907.	986.	847.	684.	366.	236.
OCT	11.29	14.48	14.05	247.18	1467.	3079.	0.	1263.	937.	892.	438.	444.
NOV	4.85	17.70	10.99	268.35	1535.	7188.	0.	2423.	1593.	1495.	855.	875.
DEC	-2.05	16.09	7.32	280.71	1731.	12822.	0.	4043.	3028.	2873.	1554.	1559.
ANNUAL	9.06	15.69	9.02		19573.	69355.	12857.	26901.	21026.	19354.	10338.	9881.
ANNUAL COP								1.05	1.34	1.46	2.74	2.86

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST, $ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 21 P(M2)= 72	2950.	1969.	3502.	530.	240.	1074.	518.	10783.
5	FULL,BR.CHILL, BIN(M3)= 39 P(M2)= 45	2950.	2612.	2456.	530.	240.	1074.	518.	10380.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	995.61	REF.	REF.	REF.	16342.	19820.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	778.18	217.43	1.0	1	12773.	17698.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	716.27	279.34	2.7	2	11757.	17469.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 21	1929.	382.60	613.00	13.2	4	6280.	18992.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 39	1929.	365.70	629.91	12.2	3	6002.	18312.	3

WESTHAMPTON BEACH, NEW YORK

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0368
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 10860.
COOLING = 4838.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.24
BLOWER CAPACITY (M3/H) = 2292.

AIR TEMP: OUTDOOR INDOOR
WINTER = -13 C 21 C
SUMMER = 28 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.1M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-1.22	12.87	4.01	272.28	1861.	11334.	0.	3665.	2767.	2598.	1476.	1476.
FEB	-0.58	12.87	2.67	270.84	1728.	9440.	0.	3102.	2306.	2165.	1254.	1254.
MAR	2.81	14.48	3.19	266.42	1893.	7897.	0.	2720.	1875.	1757.	1096.	1118.
APR	8.02	14.48	5.56	254.60	1742.	4404.	0.	1707.	1175.	1109.	687.	700.
MAY	13.29	11.26	9.27	236.08	1654.	1992.	600.	1115.	846.	802.	420.	425.
JUN	18.69	11.26	13.12	223.82	1454.	0.	2228.	785.	836.	693.	199.	199.
JUL	21.79	9.65	16.30	216.60	1378.	0.	4045.	1074.	1082.	824.	492.	231.
AUG	21.27	9.65	17.78	215.41	1320.	0.	3825.	1020.	1035.	790.	711.	220.
SEP	17.84	11.26	17.22	225.76	1299.	577.	2033.	868.	789.	637.	387.	239.
OCT	12.67	11.26	14.73	237.49	1440.	2150.	485.	1080.	799.	755.	365.	375.
NOV	7.21	12.87	11.12	253.15	1531.	4769.	0.	1750.	1183.	1111.	637.	670.
DEC	0.83	12.87	7.15	267.63	1738.	9705.	0.	3179.	2314.	2169.	1253.	1253.
ANNUAL	10.22	12.07	10.18		19036.	52267.	13217.	22066.	17009.	15409.	8979.	8162.
ANNUAL COP								1.06	1.38	1.52	2.62	2.88

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 16 P(M2)= 22	2950.	1667.	1565.	530.	240.	1074.	518.	8544.
5	FULL,BR.CHILL, BIN(M3)= 42 P(M2)= 13	2950.	2640.	1198.	530.	240.	1074.	518.	9150.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	812.27	REF.	REF.	REF.	13332.	16811.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	626.09	186.18	1.1	1	10276.	15201.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	567.20	245.07	3.1	2	9310.	15022.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 16	1929.	330.51	481.75	12.1	3	5425.	15898.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 42	1929.	300.44	511.83	12.6	4	4931.	16010.	4

NEW BERN, NORTH CAROLINA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0296
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 8059.
COOLING = 7954.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.43
BLOWER CAPACITY (M3/H) = 1698.

AIR TEMP: OUTDOOR INDOOR
WINTER = -6 C 21 C
SUMMER = 33 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	8.68	16.09	9.66	256.38	1639.	4377.	0.	1671.	1193.	1117.	726.	655.
FEB	9.64	19.31	9.65	260.74	1481.	3669.	0.	1431.	1038.	975.	629.	561.
MAR	11.62	19.31	11.66	256.25	1560.	3048.	648.	1391.	997.	930.	559.	516.
APR	16.77	20.92	15.12	247.84	1379.	1154.	1816.	1014.	857.	696.	308.	308.
MAY	21.14	17.70	19.27	231.50	1261.	0.	3964.	1028.	1054.	801.	606.	217.
JUN	24.72	16.09	22.79	236.36	1087.	0.	6524.	1417.	1418.	1138.	1198.	492.
JUL	26.66	16.09	24.91	240.76	1040.	0.	8764.	1786.	1786.	1527.	1604.	1607.
AUG	26.07	14.48	24.93	236.13	1039.	0.	8175.	1685.	1685.	1424.	1497.	1500.
SEP	23.34	16.09	22.93	233.23	1082.	0.	5697.	1274.	1278.	996.	1048.	1051.
OCT	18.22	14.48	19.33	231.45	1259.	594.	2615.	962.	881.	690.	492.	495.
NOV	12.37	14.48	15.31	244.72	1371.	2449.	807.	1199.	884.	822.	435.	393.
DEC	8.52	14.48	11.71	253.45	1558.	4429.	0.	1663.	1191.	1114.	699.	644.
ANNUAL	17.31	16.63	17.27		15755.	19720.	39009.	16520.	14262.	12229.	9800.	8439.
ANNUAL COP								1.25	1.45	1.69	2.11	2.45

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	1050.	40.	160.	200.	880.	434.	3014.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 7 P(M2)= 3	2650.	1113.	829.	480.	240.	889.	434.	6636.
5	FULL,BR.CHILL, BIN(M3)= 44 P(M2)= 0	2650.	2555.	0.	480.	240.	889.	434.	7248.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	654.86	REF.	REF.	REF.	10749.	14538.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	565.34	89.52	0.6	1	9279.	14356.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	484.76	170.11	3.5	2	7957.	13821.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 7	1929.	388.49	266.37	13.6	4	6377.	14942.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 44	1929.	334.50	320.36	13.2	3	5490.	14668.	4

GREENSBORO, NORTH CAROLINA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0394
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 9332.
COOLING = 6335.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.23
BLOWER CAPACITY (M3/H) = 2038.

AIR TEMP: OUTDOOR INDOOR
WINTER = -9 C 21 C
SUMMER = 33 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	3.80	12.87	5.31	260.89	1810.	7363.	0.	2548.	1766.	1655.	1057.	999.
FEB	5.49	14.48	5.56	260.33	1626.	5710.	0.	2038.	1413.	1326.	855.	799.
MAR	7.86	1.61	8.15	228.73	1698.	4099.	0.	1610.	1171.	1107.	681.	632.
APR	15.03	14.48	12.31	238.67	1485.	1754.	1364.	1133.	903.	844.	387.	383.
MAY	19.47	12.87	17.15	225.33	1345.	0.	2686.	832.	907.	735.	198.	198.
JUN	23.44	11.26	21.11	223.61	1151.	0.	4681.	1119.	1129.	830.	864.	222.
JUL	24.92	12.87	23.35	230.25	1101.	0.	6096.	1347.	1348.	1063.	1121.	247.
AUG	24.28	11.26	23.09	225.51	1111.	0.	5628.	1270.	1272.	983.	1036.	439.
SEP	20.76	11.26	20.53	219.13	1173.	0.	3458.	917.	955.	734.	643.	646.
OCT	14.65	11.26	16.20	232.99	1382.	1742.	1284.	1087.	858.	801.	332.	322.
NOV	8.50	12.87	11.51	250.23	1516.	4299.	0.	1615.	1153.	1085.	619.	587.
DEC	4.11	12.87	7.46	260.18	1725.	7059.	0.	2440.	1696.	1590.	982.	957.
ANNUAL	14.36	11.67	14.31		17122.	32026.	25197.	17958.	14572.	12755.	8775.	6431.
ANNUAL COP								1.15	1.42	1.62	2.35	3.21

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	930.	40.	160.	200.	688.	392.	2660.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	392.	2843.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	492.	3383.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 11 P(M2)= 8	2650.	1372.	1006.	480.	240.	889.	434.	7071.
5	FULL,BR.CHILL, BIN(M3)= 74 P(M2)= 0	2650.	3546.	0.	480.	240.	889.	434.	8239.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	707.92	REF.	REF.	REF.	11620.	15055.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	574.43	133.49	1.4	1	9428.	14281.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	502.79	205.14	3.5	2	8253.	13893.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 11	1929.	345.92	362.00	12.2	3	5678.	14678.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 74	1929.	253.50	454.42	12.3	4	4161.	14329.	3

BISMARCK, NORTH DAKOTA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0453
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 17994.
COOLING = 4764.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 3820.

AIR TEMP: OUTDOOR INDOOR
WINTER = -30 C 21 C
SUMMER = 32 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (4.1M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-12.32	16.09	5.91	304.04	1786.	21467.	0.	6460.	5999.	5887.	2551.	2551.
FEB	-10.18	16.09	4.32	299.17	1670.	17255.	0.	5257.	4727.	4617.	2082.	2083.
MAR	-2.44	19.31	2.92	288.17	1903.	12630.	0.	4037.	3149.	3009.	1597.	1598.
APR	6.02	20.92	2.29	272.24	1866.	6441.	0.	2308.	1622.	1549.	912.	912.
MAY	13.55	20.92	2.54	255.16	1919.	2760.	1286.	1520.	1158.	1105.	540.	540.
JUN	18.76	19.31	3.61	240.06	1816.	854.	2514.	1171.	1054.	859.	336.	336.
JUL	21.84	16.09	5.26	229.82	1812.	0.	3917.	1173.	1214.	963.	273.	273.
AUG	21.36	16.09	7.01	228.73	1743.	0.	3738.	1123.	1191.	952.	372.	372.
SEP	13.89	17.70	8.35	247.82	1636.	2397.	1453.	1369.	1057.	1005.	413.	413.
OCT	8.48	17.70	8.99	260.11	1665.	4992.	0.	1849.	1348.	1289.	636.	636.
NOV	-2.11	17.70	8.71	284.14	1622.	12117.	0.	3817.	2932.	2815.	1324.	1325.
DEC	-9.26	16.09	7.59	297.08	1720.	18733.	0.	5682.	5044.	4932.	2179.	2179.
ANNUAL	5.63	17.83	5.63		21158.	99647.	12909.	35766.	30496.	28981.	13216.	13219.
ANNUAL COP								1.04	1.22	1.28	2.81	2.81

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	310.	930.	40.	213.	200.	688.	392.	2773.
2	HEAT PUMP WITH ELECTRIC HOT WATER	310.	1080.	58.	231.	200.	714.	392.	2985.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	310.	1080.	58.	631.	240.	714.	492.	3525.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 29 P(M2)= 108*	3750.	2486.	4883.	620.	240.	1454.	518.	13951.*
5	FULL,BR.CHILL, BIN(M3)= 31 P(M2)= 105*	3750.	2552.	4780.	620.	240.	1454.	518.	13914.*

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1619.11	REF.	REF.	REF.	26575.	30124.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	1380.54	238.57	0.9	1	22660.	27655.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	1311.99	307.12	2.5	2	21534.	27317.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 29	1929.	598.30	1020.81	11.0	4	9820.	25701.*	2
5	FULL ACES, BR.CHILL, BIN (M3)= 31	1929.	598.41	1020.70	10.9	3	9822.	25666.*	1

*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
POWER COSTS ($/KWH) = 0.0407
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 18808.
COOLING = 4575.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.05
BLOWER CAPACITY (M3/H) = 4075.

AIR TEMP: OUTDOOR INDOOR
WINTER = -31 C 21 C
SUMMER = 31 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (6.1M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-16.57	16.09	5.20	313.66	1814.	25591.	0.	7613.	7397.	7304.	2913.	2887.
FEB	-12.38	16.09	4.57	304.16	1661.	19103.	0.	5768.	5338.	5244.	2267.	2266.
MAR	-6.13	17.70	3.71	293.27	1872.	15560.	0.	4843.	4037.	3918.	1903.	1902.
APR	4.61	17.70	2.93	268.88	1842.	7195.	0.	2510.	1788.	1714.	986.	986.
MAY	12.68	17.70	2.40	250.57	1924.	3105.	1091.	1584.	1186.	1137.	572.	572.
JUN	17.74	16.09	2.29	235.81	1866.	1015.	2122.	1163.	1024.	848.	350.	350.
JUL	20.87	12.87	2.62	222.14	1915.	0.	3733.	1170.	1217.	978.	280.	280.
AUG	19.80	14.48	3.31	227.87	1888.	0.	3091.	1053.	1129.	931.	263.	344.
SEP	13.51	14.48	4.15	242.12	1796.	2252.	1128.	1317.	1022.	981.	406.	405.
OCT	7.38	16.09	4.95	259.33	1824.	5404.	0.	2008.	1420.	1364.	682.	681.
NOV	-2.80	16.09	5.45	282.42	1746.	12649.	0.	3999.	3088.	2974.	1362.	1359.
DEC	-11.61	14.48	5.56	299.13	1800.	20707.	0.	6253.	5711.	5609.	2191.	2127.
ANNUAL	3.93	15.82	3.93		21948.	112580.	11166.	39280.	34355.	33004.	14176.	14160.
ANNUAL COP								1.03	1.18	1.23	2.96	2.96

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	310.	930.	40.	213.	200.	688.	392.	2773.
2	HEAT PUMP WITH ELECTRIC HOT WATER	310.	1080.	58.	231.	200.	714.	392.	2985.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	310.	1080.	58.	631.	240.	714.	492.	3525.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 34 P(M2)= 512*	3750.	2693.	20559.	620.	240.	1454.	518.	29834.*
5	FULL,BR.CHILL, BIN(M3)= 34 P(M2)= 512*	3750.	2693.	20559.	620.	240.	1454.	518.	29834.*

COMPARATIVE SYSTEMS COSTS

	NEW CONSTRUCTION ALTERNATIVES	MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERIOD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1599.89	REF.	REF.	REF.	26260.	29809.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	1399.29	200.60	1.1	1	22967.	27962.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	1344.24	255.65	2.9	2	22064.	27846.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 34	1929.	577.40	1022.49	26.5	3	9477.	41240.*	4
5	FULL ACES, BR.CHILL, BIN (M3)= 34	1929.	577.40	1022.49	26.5	4	9477.	41240.*	5

*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
POWER COSTS ($/KWH) = 0.0453
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 17470.
COOLING = 4581.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 3736.

AIR TEMP: OUTDOOR INDOOR
WINTER = -28 C 21 C
SUMMER = 31 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS					SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (3.7M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-11.94	11.26	5.90	293.33	1786.	20068.	0.	6071.	5579.	5461.	2363.	2394.
FEB	-8.32	11.26	4.13	285.12	1677.	14881.	0.	4600.	4001.	3882.	1821.	1824.
MAR	-2.99	12.87	2.73	276.31	1911.	12088.	0.	3889.	3072.	2935.	1539.	1542.
APR	6.22	14.48	2.29	258.68	1866.	5717.	0.	2107.	1511.	1444.	834.	835.
MAY	13.71	14.48	2.92	241.67	1904.	2294.	1148.	1362.	1065.	1018.	484.	485.
JUN	18.89	12.87	4.40	226.65	1786.	643.	2352.	1077.	988.	812.	307.	307.
JUL	22.52	11.26	6.42	221.52	1766.	0.	4013.	1176.	1205.	949.	271.	271.
AUG	21.93	11.26	8.39	220.19	1689.	0.	3770.	1113.	1153.	912.	482.	370.
SEP	14.33	11.26	9.72	233.72	1584.	1786.	1255.	1151.	916.	873.	346.	346.
OCT	8.13	11.26	10.14	247.78	1620.	4542.	0.	1712.	1243.	1189.	589.	591.
NOV	-1.19	11.26	9.50	268.94	1592.	10568.	0.	3378.	2540.	2420.	1170.	1175.
DEC	-6.68	11.26	7.95	281.38	1706.	15636.	0.	4818.	4014.	3894.	1781.	1856.
ANNUAL	6.22	12.07	6.21		20887.	88224.	12538.	32454.	27288.	25788.	11986.	11996.
ANNUAL COP								1.04	1.24	1.31	2.82	2.82

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	310.	930.	40.	213.	200.	688.	392.	2773.
2	HEAT PUMP WITH ELECTRIC HOT WATER	310.	1080.	58.	231.	200.	714.	392.	2985.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	310.	1080.	58.	631.	240.	714.	492.	3525.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 27 P(M2)= 104*	3350.	2397.	4726.	550.	240.	1288.	518.	13069.*
5	FULL,BR.CHILL, BIN(M3)= 31 P(M2)= 88*	3350.	2560.	4103.	550.	240.	1288.	518.	12608.*

COMPARATIVE SYSTEMS COSTS

	NEW CONSTRUCTION ALTERNATIVES	MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERICD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1469.17	REF.	REF.	REF.	24114.	27663.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	1235.33	233.84	0.9	1	20276.	25271.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	1167.41	301.77	2.5	2	19161.	24944.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 27	1929.	542.63	926.54	11.1	4	8906.	23905.*	2
5	FULL ACES, BR.CHILL, BIN (M3)= 31	1929.	543.05	926.12	10.6	3	8913.	23451.*	1

*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
POWER COSTS ($/KWH) = 0.0453
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 12183.
COOLING = 4935.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.14
BLOWER CAPACITY (M3/H) = 2632.

AIR TEMP: OUTDOOR INDOOR
WINTER = -16 C 21 C
SUMMER = 31 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.4M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-3.02	19.31	3.75	289.47	1871.	13941.	0.	4393.	3340.	3168.	1742.	1742.
FEB	-1.17	19.31	2.39	285.28	1738.	11003.	0.	3540.	2600.	2446.	1423.	1429.
MAR	1.50	19.31	2.80	279.22	1908.	9698.	0.	3224.	2276.	2140.	1288.	1303.
APR	9.16	19.31	5.03	261.85	1762.	4604.	0.	1768.	1273.	1205.	706.	712.
MAY	14.36	16.09	8.58	243.48	1681.	2038.	1118.	1224.	956.	903.	432.	434.
JUN	19.60	14.48	12.32	228.31	1485.	0.	2860.	901.	971.	788.	216.	216.
JUL	21.92	12.87	15.44	223.45	1412.	0.	3988.	1073.	1091.	836.	488.	234.
AUG	21.27	12.87	16.96	221.97	1352.	0.	3706.	1009.	1031.	794.	690.	221.
SEP	17.71	12.87	16.50	229.32	1326.	887.	1979.	953.	833.	671.	378.	271.
OCT	11.12	14.48	14.16	247.56	1462.	3149.	0.	1281.	971.	922.	448.	457.
NOV	4.60	19.31	10.69	272.18	1547.	7403.	0.	2486.	1664.	1560.	894.	914.
DEC	-1.12	19.31	6.84	285.16	1750.	12266.	0.	3894.	2865.	2703.	1505.	1507.
ANNUAL	9.66	16.63	9.62		19293.	64989.	13651.	25746.	19872.	18136.	10211.	9439.
ANNUAL COP								1.06	1.37	1.50	2.66	2.88

SYSTEMS FIRST COSTS

		COST, $						
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 20 P(M2)= 41	2950.	1876.	2278.	530.	240.	1074.	518.	9466.
5	FULL,BR.CHILL, BIN(M3)= 43 P(M2)= 25	2950.	2746.	1684.	530.	240.	1074.	518.	9742.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1167.33	REF.	REF.	REF.	19160.	22638.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	901.00	266.33	0.8	1	14789.	19714.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	822.30	345.03	2.2	2	13497.	19209.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 20	1929.	462.98	704.35	9.6	4	7599.	18994.	2
5	FULL ACES, BR.CHILL, BIN (M3)= 43	1929.	427.97	739.36	9.5	3	7025.	13696.	1

COLUMBUS, OHIO

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0477
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 12358.
COOLING = 5200.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.15
BLOWER CAPACITY (M3/H) = 2632.

AIR TEMP: OUTDOOR INDOOR
WINTER = -17 C 21 C
SUMMER = 32 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.8M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES ER.CHILL
JAN	1.33	16.09	3.09	273.04	1897.	9994.	0.	3303.	2312.	2165.	1356.	1356.
FEB	0.94	16.09	2.61	273.93	1730.	9056.	0.	2996.	2091.	1957.	1226.	1226.
MAR	4.19	17.70	4.42	269.84	1845.	7595.	0.	2622.	1801.	1688.	1067.	1107.
APR	10.68	16.09	8.03	251.83	1648.	3475.	0.	1423.	1079.	1022.	578.	606.
MAY	16.11	12.87	12.68	232.95	1520.	1363.	1615.	1077.	893.	735.	341.	341.
JUN	21.65	11.26	16.86	219.54	1312.	0.	3970.	1043.	1079.	825.	223.	223.
JUL	23.43	9.65	19.69	220.32	1245.	0.	4856.	1176.	1187.	876.	897.	235.
AUG	22.46	9.65	20.22	218.11	1224.	0.	4136.	1047.	1064.	800.	767.	217.
SEP	18.82	9.65	18.41	220.25	1253.	614.	2584.	960.	877.	687.	487.	310.
OCT	12.12	11.26	14.64	238.74	1443.	2861.	947.	1358.	998.	934.	442.	465.
NOV	4.71	14.48	10.13	262.10	1568.	6774.	0.	2318.	1597.	1496.	863.	922.
DEC	0.75	14.48	5.84	271.08	1789.	10117.	0.	3307.	2378.	2228.	1310.	1355.
ANNUAL	11.43	13.27	11.39		18475.	51850.	18109.	22631.	17354.	15413.	9558.	8364.
ANNUAL COP								1.09	1.42	1.59	2.57	2.94

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 15 P(M2)= 21	2950.	1674.	1506.	530.	240.	1074.	518.	8492.
5	FULL,BR.CHILL, BIN(M3)= 60 P(M2)= 8	2950.	3312.	1009.	530.	240.	1074.	518.	9633.

COMPARATIVE SYSTEMS COSTS

	NEW CONSTRUCTION ALTERNATIVES	MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERIOD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1079.48	REF.	REF.	REF.	17718.	21196.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	827.76	251.71	0.8	1	13587.	18512.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	735.21	344.27	2.2	2	12067.	17780.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 15	1929.	455.92	623.56	9.3	3	7483.	17904.	2
5	FULL ACES, BR.CHILL, BIN (M3)= 60	1929.	398.98	680.49	10.2	4	6549.	18111.	3

DAYTON, OHIO

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0438
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 12573.
COOLING = 5724.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.18
BLOWER CAPACITY (M3/H) = 2717.

AIR TEMP: OUTDOOR INDOOR
WINTER = -17 C 21 C
SUMMER = 32 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.8M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-1.89	19.31	3.04	286.92	1899.	12864.	0.	4101.	3063.	2882.	1636.	1636.
FEB	1.05	20.92	2.44	283.52	1736.	9432.	0.	3103.	2207.	2072.	1257.	1271.
MAR	4.81	20.92	4.32	274.99	1849.	7421.	0.	2575.	1788.	1681.	1037.	1092.
APR	12.28	19.31	8.19	254.77	1642.	2963.	731.	1404.	1027.	967.	526.	549.
MAY	17.23	16.09	13.24	236.97	1498.	1144.	1919.	1062.	909.	741.	322.	322.
JUN	21.84	14.48	17.83	226.55	1276.	0.	3771.	999.	1028.	787.	215.	215.
JUL	24.41	12.87	20.97	229.10	1194.	0.	5453.	1263.	1267.	953.	1006.	243.
AUG	23.98	11.26	21.65	224.84	1168.	0.	5183.	1210.	1215.	908.	956.	234.
SEP	20.57	14.48	19.76	226.10	1202.	0.	3252.	890.	945.	737.	606.	299.
OCT	13.64	14.48	15.71	241.83	1401.	2106.	934.	1134.	857.	805.	359.	380.
NOV	6.39	19.31	10.81	268.14	1542.	6022.	0.	2102.	1425.	1338.	763.	834.
DEC	0.37	19.31	6.10	281.79	1779.	10937.	0.	3532.	2545.	2388.	1380.	1411.
ANNUAL	12.06	16.89	12.00		18186.	52889.	21243.	23374.	18277.	16261.	10064.	8487.
ANNUAL CCP								1.10	1.40	1.58	2.55	3.02

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 18 P(M2)= 27	2950.	1831.	1745.	530.	240.	1074.	518.	8888.
5	FULL,BR.CHILL, BIN(M3)= 76 P(M2)= 6	2950.	3760.	946.	530.	240.	1074.	518.	10018.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1024.02	REF.	REF.	REF.	16808.	20286.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	800.71	223.31	1.0	1	13143.	18068.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	712.39	311.63	2.4	2	11693.	17405.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 18	1929.	440.89	583.14	10.6	3	7237.	18054.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 76	1929.	371.81	652.21	11.2	4	6103.	18051.	2

TOLEDO, OHIO

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0595
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 13089.
COOLING = 5660.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.16
BLOWER CAPACITY (M3/H) = 2802.

AIR TEMP: OUTDOOR INDOOR
WINTER = -18 C 21 C
SUMMER = 32 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.7M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-4.82	20.92	4.21	296.83	1853.	15770.	0.	4896.	3906.	3746.	1935.	1935.
FEB	-2.90	19.31	2.57	289.20	1732.	12236.	0.	3880.	2950.	2795.	1550.	1557.
MAR	1.34	20.92	2.56	282.85	1918.	9987.	0.	3307.	2312.	2176.	1315.	1327.
APR	8.77	20.92	4.37	265.99	1787.	4851.	0.	1844.	1325.	1255.	731.	736.
MAY	15.42	17.70	7.60	244.35	1720.	1860.	1457.	1243.	998.	941.	423.	423.
JUN	20.07	16.09	11.22	230.53	1527.	0.	3040.	944.	1017.	822.	225.	225.
JUL	22.38	12.87	14.44	224.49	1451.	0.	4432.	1160.	1181.	897.	391.	247.
AUG	21.46	14.48	16.26	225.67	1380.	0.	4120.	1087.	1121.	857.	766.	233.
SEP	17.61	12.87	16.21	229.56	1337.	989.	2226.	1027.	894.	713.	424.	239.
OCT	11.62	17.70	14.29	252.98	1457.	3220.	683.	1416.	1007.	948.	462.	467.
NOV	4.37	19.31	11.13	272.71	1530.	7543.	0.	2521.	1702.	1600.	890.	916.
DEC	-2.64	19.31	7.40	288.61	1727.	13644.	0.	4270.	3254.	3102.	1642.	1644.
ANNUAL	9.39	17.70	9.35		19418.	70100.	15958.	27595.	21665.	19853.	10754.	9997.
ANNUAL COP								1.06	1.35	1.48	2.72	2.93

SYSTEMS FIRST COSTS

		COST,$						
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 22 P(M2)= 61	2950.	2058.	3065.	530.	240.	1074.	518.	10435.
5	FULL,BR.CHILL, BIN(M3)= 49 P(M2)= 37	2950.	3022.	2116.	530.	240.	1074.	518.	10450.

COMPARATIVE SYSTEMS COSTS

	NEW CONSTRUCTION ALTERNATIVES	MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERIOD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1643.02	REF.	REF.	REF.	26968.	30446.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	1289.96	353.06	0.6	1	21173.	26098.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	1182.02	460.99	1.6	2	19401.	25114.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 22	1929.	640.28	1002.74	7.7	4	10509.	22873.	2
5	FULL ACES, BR.CHILL, BIN (M3)= 49	1929.	595.23	1047.79	7.4	3	9770.	22150.	1

ALTUS, OKLAHOMA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0253
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 9912.
COOLING = 7196.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.13
BLOWER CAPACITY (M3/H) = 2122.

AIR TEMP: OUTDOOR INDOOR
WINTER = -11 C 21 C
SUMMER = 38 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	2.71	17.70	5.67	273.20	1796.	8339.	0.	2815.	1996.	1869.	1155.	1104.
FEB	5.54	19.31	5.81	270.05	1617.	6013.	0.	2120.	1482.	1389.	888.	831.
MAR	9.34	20.92	8.76	264.70	1674.	4651.	0.	1757.	1323.	1246.	735.	689.
APR	16.72	20.92	13.65	247.96	1434.	1490.	1907.	1138.	939.	758.	360.	360.
MAY	22.38	19.31	19.43	237.59	1255.	0.	3821.	1001.	1030.	785.	339.	214.
JUN	26.25	19.31	24.24	246.39	1032.	0.	6430.	1385.	1386.	1121.	1181.	248.
JUL	29.07	17.70	27.05	249.49	955.	0.	8456.	1710.	1710.	1473.	1548.	601.
AUG	28.73	16.09	26.91	245.45	961.	0.	7814.	1602.	1602.	1362.	1431.	1436.
SEP	23.92	16.09	23.98	234.54	1042.	0.	4828.	1114.	1127.	854.	890.	895.
OCT	17.76	16.09	18.89	235.76	1276.	910.	2274.	996.	872.	691.	432.	435.
NOV	9.56	17.70	13.29	257.66	1448.	3968.	0.	1505.	1115.	1049.	581.	547.
DEC	4.78	17.70	8.37	268.50	1689.	6822.	0.	2365.	1613.	1508.	954.	927.
ANNUAL	16.40	18.24	16.34		16179.	32193.	35531.	19509.	16197.	14107.	10493.	8287.
ANNUAL CCP								1.19	1.44	1.65	2.22	2.81

SYSTEMS FIRST COSTS

		COST,$						
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 13 P(M2)= 6	2650.	1453.	947.	480.	240.	889.	434.	7093.
5	FULL,BR.CHILL, BIN(M3)= 75 P(M2)= 0	2650.	3610.	0.	480.	240.	889.	434.	8303.

COMPARATIVE SYSTEMS COSTS

		MAINT.	1ST YEAR	1ST YEAR	SIMPLE	SIMPLE	POWER	LIFE	LIFE
	NEW CONSTRUCTION ALTERNATIVES	PRESENT WORTH	POWER COST	POWER SAVING	PAYBACK PERICD	PAYBACK RANKING	PRESENT WORTH	CYCLE COST	CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	493.96	REF.	REF.	REF.	8108.	11697.	1
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	410.10	83.86	3.0	1	6731.	11808.	3
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	357.19	136.77	5.8	2	5863.	11727.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 13	1929.	265.69	228.27	18.7	3	4361.	13384.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 75	1929.	209.84	284.12	19.3	4	3444.	13676.	5

OKLAHOMA CITY, OKLAHOMA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0355
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 10341.
COOLING = 7276.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.22
BLOWER CAPACITY (M3/H) = 2207.

AIR TEMP: OUTDOOR INDOOR
WINTER = -12 C 21 C
SUMMER = 36 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS					SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2E	(2) HEAT PUMP I2E	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	1.99	24.13	5.10	287.94	1818.	9484.	0.	3140.	2242.	2101.	1284.	1231.
FEB	4.65	24.13	5.15	281.91	1640.	6885.	0.	2368.	1646.	1543.	986.	929.
MAR	8.41	25.74	7.93	276.65	1707.	5323.	0.	1953.	1399.	1316.	813.	766.
APR	15.90	25.74	12.65	259.66	1472.	1720.	1488.	1141.	913.	852.	382.	380.
MAY	21.29	22.53	18.29	241.68	1300.	0.	3293.	924.	959.	748.	207.	207.
JUN	25.06	22.53	23.04	250.23	1077.	0.	6014.	1327.	1329.	1050.	1106.	243.
JUL	27.64	19.31	25.87	249.54	1002.	0.	8078.	1659.	1659.	1407.	1480.	281.
AUG	27.36	19.31	25.83	248.90	1003.	0.	7668.	1589.	1589.	1336.	1405.	1126.
SEP	23.06	20.92	23.06	242.42	1076.	0.	4523.	1072.	1090.	806.	835.	840.
OCT	17.43	20.92	18.15	246.34	1305.	1019.	2035.	993.	856.	685.	389.	393.
NOV	9.36	22.53	12.69	267.94	1471.	4220.	0.	1581.	1145.	1078.	606.	575.
DEC	4.13	22.53	7.83	279.82	1711.	7605.	0.	2588.	1772.	1659.	1040.	1015.
ANNUAL	15.52	22.53	15.47		16583.	36255.	33099.	20334.	16599.	14582.	10533.	7984.
ANNUAL COP								1.17	1.44	1.64	2.27	2.99

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	970.	40.	173.	200.	759.	434.	2856.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1180.	58.	191.	200.	796.	434.	3139.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1180.	58.	240.	240.	796.	534.	3679.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 14 P(M2)= 7	2950.	1539.	983.	530.	240.	1074.	518.	7834.
5	FULL,BR.CHILL, BIN(M3)= 84 P(M2)= 0	2950.	3871.	0.	530.	240.	1074.	518.	9183.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	721.65	REF.	REF.	REF.	11845.	15477.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	589.11	132.54	2.1	1	9669.	14818.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	517.53	204.12	4.0	2	8494.	14431.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 14	1929.	373.80	347.85	14.3	3	6135.	15890.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 84	1929.	283.36	438.29	14.4	4	4651.	15764.	4

TULSA, OKLAHOMA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0405
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 10547.
COOLING = 7777.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.25
BLOWER CAPACITY (M3/H) = 2292.

AIR TEMP: OUTDOOR INDOOR
WINTER = -12 C 21 C
SUMMER = 37 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	1.43	17.70	5.17	276.11	1815.	9522.	0.	3149.	2263.	2122.	1287.	1235.
FEB	5.01	19.31	5.17	271.26	1639.	6420.	0.	2239.	1560.	1464.	938.	878.
MAR	8.94	20.92	7.93	265.62	1707.	4769.	0.	1799.	1320.	1245.	749.	705.
APR	15.51	19.31	12.65	247.44	1472.	1709.	1372.	1118.	893.	836.	380.	377.
MAY	20.89	17.70	18.32	231.94	1299.	0.	3551.	968.	1017.	790.	212.	212.
JUN	25.26	16.09	23.10	237.57	1075.	0.	6201.	1358.	1361.	1084.	1140.	247.
JUL	27.99	14.48	25.98	240.50	998.	0.	8466.	1724.	1724.	1475.	1550.	289.
AUG	27.57	14.48	25.99	239.54	997.	0.	7960.	1637.	1638.	1387.	1458.	1463.
SEP	23.53	14.48	23.24	230.37	1070.	0.	4660.	1093.	1113.	831.	860.	864.
OCT	17.24	16.09	18.33	236.94	1298.	1084.	2078.	1017.	872.	696.	397.	400.
NOV	9.36	17.70	12.84	258.10	1465.	4028.	0.	1526.	1111.	1047.	584.	555.
DEC	4.63	17.70	7.94	268.85	1706.	6985.	0.	2414.	1648.	1544.	980.	947.
ANNUAL	15.61	17.16	15.56		16542.	34517.	34288.	20043.	16518.	14521.	10534.	8173.
ANNUAL COP								1.18	1.44	1.63	2.25	2.90

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	970.	40.	173.	200.	759.	434.	2856.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1180.	58.	191.	200.	796.	434.	3139.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1180.	58.	591.	240.	796.	534.	3679.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 14 P(M2)= 8	2950.	1550.	1013.	530.	240.	1074.	518.	7875.
5	FULL,BR.CHILL, BIN(M3)= 80 P(M2)= 0	2950.	3775.	0.	530.	240.	1074.	518.	9088.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	811.33	REF.	REF.	REF.	13317.	16949.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	668.66	142.67	2.0	1	10975.	16124.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	587.83	223.50	3.7	2	9648.	15585.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 14	1929.	426.42	384.91	13.0	4	6999.	16804.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 80	1929.	330.82	480.50	13.0	3	5430.	16447.	3

ASTORIA, OREGON

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0280
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 7231.
COOLING = 2434.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 1528.

AIR TEMP: OUTDOOR INDOOR
WINTER = -3 C 21 C
SUMMER = 22 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	5.48	12.87	6.47	257.08	1764.	6647.	0.	2337.	1619.	1503.	927.	906.
FEB	6.46	14.48	6.12	258.14	1606.	5166.	0.	1881.	1293.	1203.	777.	746.
MAR	6.65	12.87	6.84	254.43	1750.	5174.	0.	1923.	1327.	1237.	787.	762.
APR	8.88	12.87	8.47	249.37	1631.	3737.	0.	1491.	1029.	963.	611.	591.
MAY	11.43	12.87	10.67	243.57	1599.	2690.	0.	1192.	854.	806.	493.	473.
JUN	13.77	12.87	12.71	238.27	1470.	1587.	0.	849.	679.	648.	354.	338.
JUL	15.30	12.87	14.17	234.79	1462.	1073.	824.	845.	695.	653.	292.	288.
AUG	15.51	12.87	14.56	234.32	1446.	971.	960.	836.	700.	656.	279.	278.
SEP	14.46	11.26	13.83	233.42	1427.	1397.	636.	893.	701.	659.	324.	317.
OCT	11.60	11.26	12.12	239.90	1542.	2532.	0.	1132.	818.	773.	472.	450.
NOV	7.99	12.87	10.00	251.38	1573.	4589.	0.	1712.	1173.	1094.	716.	682.
DEC	6.61	14.48	7.90	257.79	1708.	5972.	0.	2133.	1440.	1336.	885.	849.
ANNUAL	10.34	12.87	10.32		18979.	41533.	2420.	17224.	12327.	11531.	6916.	6678.
ANNUAL COP								1.02	1.42	1.52	2.53	2.62

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	930.	40.	160.	200.	688.	392.	2660.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	392.	2843.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	492.	3383.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 10 P(M2)= 9	2650.	1242.	1057.	480.	240.	889.	434.	6992.
5	FULL,BR.CHILL, BIN(M3)= 10 P(M2)= 9	2650.	1242.	1057.	480.	240.	889.	434.	6992.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	482.61	REF.	REF.	REF.	7921.	11357.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	345.41	137.20	1.3	1	5669.	10522.	1
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	323.10	159.51	4.5	2	5303.	10944.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 10	1929.	193.78	288.83	15.0	3	3181.	12102.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 10	1929.	193.78	288.83	15.0	4	3181.	12102.	5

MEDFORD, OREGON

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0280
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 8392.
COOLING = 5422.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 1783.

AIR TEMP: OUTDOOR INDOOR
WINTER = -6 C 21 C
SUMMER = 34 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP	AVE WIND SPEED	INLET WATER TEMP	HEAT LOSS COEF.	WATER HEAT	SPACE HEAT	SPACE COOL	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
	C	KM/H	C (0.5M)	W/C	MJ	MJ	MJ					
JAN	3.27	8.05	4.06	252.27	1859.	7698.	0.	2655.	1761.	1639.	1087.	1087.
FEB	5.13	8.05	4.11	248.05	1677.	5446.	0.	1979.	1331.	1245.	800.	821.
MAR	7.00	8.05	6.13	243.79	1777.	4862.	0.	1845.	1270.	1191.	742.	778.
APR	10.52	9.65	9.52	239.09	1591.	3351.	0.	1373.	1053.	993.	552.	581.
MAY	13.76	9.65	13.55	231.73	1486.	2194.	1421.	1265.	973.	902.	435.	437.
JUN	18.11	9.65	16.93	221.86	1309.	940.	2750.	1095.	966.	753.	298.	298.
JUL	22.25	9.65	18.94	217.63	1274.	0.	4477.	1119.	1169.	883.	679.	230.
AUG	21.03	8.05	18.88	211.95	1277.	0.	3990.	1036.	1093.	838.	740.	220.
SEP	17.21	6.44	16.88	217.34	1312.	1150.	2571.	1123.	968.	758.	486.	313.
OCT	11.11	6.44	13.35	231.19	1494.	3000.	724.	1372.	986.	920.	455.	491.
NOV	5.93	4.83	9.44	239.67	1594.	5191.	0.	1885.	1263.	1181.	681.	740.
DEC	2.95	4.83	5.98	246.44	1783.	7700.	0.	2635.	1732.	1610.	1040.	1075.
ANNUAL	11.52	7.78	11.48		18434.	41533.	15933.	19381.	14566.	12915.	7995.	7071.
ANNUAL COP								1.09	1.45	1.63	2.64	2.98

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	930.	40.	160.	200.	688.	392.	2660.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	392.	2843.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	492.	3383.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 12 P(M2)= 19	2650.	1359.	1446.	480.	240.	889.	434.	7498.
5	FULL,BR.CHILL, BIN(M3)= 47 P(M2)= 6	2650.	2681.	923.	480.	240.	889.	434.	8297.

COMPARATIVE SYSTEMS COSTS

		MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERIOD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	543.07	REF.	REF.	REF.	8914.	12349.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	408.14	134.92	1.4	1	6699.	11552.	1
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	361.87	181.20	4.0	2	5940.	11580.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 12	1929.	224.02	319.05	15.2	3	3677.	13104.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 47	1929.	198.12	344.95	16.3	4	3252.	13478.	5

PORTLAND, OREGON

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0278
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 8763.
COOLING = 4795.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 1868.

AIR TEMP: OUTDOOR INDOOR
WINTER = -7 C 21 C
SUMMER = 32 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	3.63	16.09	5.47	267.82	1804.	8337.	0.	2817.	1860.	1724.	1145.	1145.
FEB	6.11	14.48	5.33	258.94	1634.	5415.	0.	1958.	1290.	1202.	805.	817.
MAR	7.15	12.87	6.75	253.28	1753.	4908.	0.	1850.	1238.	1157.	754.	765.
APR	10.26	12.87	9.35	246.22	1598.	3233.	0.	1342.	958.	903.	548.	556.
MAY	13.55	11.26	12.56	235.50	1525.	1934.	785.	1095.	831.	778.	404.	408.
JUN	16.28	11.26	15.35	229.28	1370.	916.	1402.	874.	746.	621.	272.	272.
JUL	19.12	11.26	17.12	222.86	1346.	0.	2936.	876.	931.	743.	204.	204.
AUG	18.66	11.26	17.28	223.88	1339.	0.	2592.	815.	867.	701.	488.	196.
SEP	16.33	9.65	15.86	225.91	1350.	913.	1521.	889.	762.	629.	295.	272.
OCT	12.07	9.65	13.15	235.57	1502.	2323.	0.	1062.	812.	770.	402.	418.
NOV	7.38	12.87	10.04	252.76	1572.	4734.	0.	1752.	1160.	1083.	665.	698.
DEC	5.30	16.09	7.18	264.05	1736.	7060.	0.	2444.	1569.	1454.	982.	994.
ANNUAL	11.32	12.47	11.29		18527.	39772.	9237.	17774.	13025.	11764.	6965.	6746.
ANNUAL COP								1.06	1.44	1.59	2.69	2.78

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	930.	40.	160.	200.	688.	392.	2660.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	392.	2843.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	492.	3383.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 13 P(M2)= 12	2650.	1409.	1178.	480.	240.	889.	434.	7280.
5	FULL,BR.CHILL, BIN(M3)= 22 P(M2)= 9	2650.	1800.	1041.	480.	240.	889.	434.	7534.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	493.59	REF.	REF.	REF.	8102.	11537.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	361.70	131.89	1.4	1	5937.	10790.	1
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	326.68	166.91	4.3	2	5362.	11002.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 13	1929.	193.42	300.17	15.4	3	3175.	12384.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 22	1929.	187.34	306.25	15.9	4	3075.	12539.	5

MIDDLETOWN, PENNSYLVANIA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0261
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 10857.
COOLING = 5965.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.21
BLOWER CAPACITY (M3/H) = 2292.

AIR TEMP: OUTDOOR INDOOR
WINTER = -13 C 21 C
SUMMER = 33 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.9M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-1.51	17.70	3.27	282.77	1890.	12307.	0.	3944.	2865.	2683.	1586.	1596.
FEB	-0.35	19.31	2.45	283.42	1736.	10230.	0.	3324.	2366.	2215.	1343.	1344.
MAR	4.04	20.92	3.93	276.73	1864.	7694.	0.	2655.	1799.	1684.	1062.	1100.
APR	11.13	17.70	7.36	254.10	1673.	3345.	0.	1394.	1059.	1004.	558.	578.
MAY	17.04	14.48	12.03	234.12	1546.	1092.	1725.	1027.	879.	725.	317.	317.
JUN	21.80	12.87	16.42	223.16	1329.	0.	3632.	990.	1013.	781.	217.	217.
JUL	24.18	11.26	19.59	225.29	1249.	0.	5194.	1234.	1238.	908.	959.	243.
AUG	23.01	11.26	20.51	222.63	1213.	0.	4556.	1115.	1124.	832.	843.	225.
SEP	18.93	11.26	19.01	223.28	1231.	565.	2552.	935.	958.	672.	481.	302.
OCT	12.92	12.87	15.41	240.20	1413.	2289.	672.	1143.	842.	793.	375.	394.
NOV	6.72	16.09	10.88	260.81	1540.	5616.	0.	1988.	1315.	1232.	723.	780.
DEC	-0.09	17.70	6.37	279.56	1768.	11114.	0.	3579.	2540.	2376.	1400.	1429.
ANNUAL	11.48	15.29	11.44		18451.	54250.	18330.	23329.	17897.	15905.	9863.	9514.
ANNUAL COP								1.08	1.41	1.59	2.56	2.97

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 18 P(M2)= 28	2950.	1721.	1793.	530.	240.	1074.	518.	8826.
5	FULL,BR.CHILL, BIN(M3)= 64 P(M2)= 10	2950.	3323.	1074.	530.	240.	1074.	518.	9709.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	608.87	REF.	REF.	REF.	9994.	13472.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	467.10	141.78	1.5	1	7667.	12592.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	415.13	193.74	3.9	2	6814.	12526.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 18	1929.	257.41	351.46	17.4	3	4225.	14981.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 64	1929.	222.23	386.65	18.1	4	3648.	15286.	5

PHILADELPHIA, PENNSYLVANIA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0475
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 10215.
COOLING = 4655.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.20
BLOWER CAPACITY (M3/H) = 2207.

AIR TEMP:	OUTDOOR	INDOOR
WINTER =	-11 C	21 C
SUMMER =	32 C	26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS					SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.6M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-0.35	19.31	2.60	283.43	1916.	11780.	0.	3805.	2724.	2549.	1521.	1521.
FEB	0.67	17.70	2.33	277.84	1740.	9459.	0.	3111.	2166.	2025.	1255.	1258.
MAR	5.04	20.92	4.57	274.46	1839.	7070.	0.	2475.	1639.	1534.	989.	1023.
APR	11.95	17.70	8.71	252.23	1622.	2872.	595.	1350.	980.	923.	510.	522.
MAY	17.58	16.09	13.86	236.18	1474.	970.	1725.	974.	842.	693.	296.	296.
JUN	21.64	12.87	18.36	222.81	1255.	0.	3312.	915.	930.	719.	203.	203.
JUL	24.16	14.48	21.25	231.80	1183.	0.	5275.	1230.	1231.	920.	973.	238.
AUG	22.92	12.87	21.57	225.72	1171.	0.	3707.	959.	967.	730.	688.	202.
SEP	19.22	11.26	19.33	222.63	1218.	0.	2175.	710.	747.	608.	411.	234.
OCT	13.09	12.87	15.01	239.82	1429.	2148.	646.	1104.	822.	775.	361.	170.
NOV	7.79	16.09	10.02	258.38	1572.	5164.	0.	1871.	1273.	1195.	676.	738.
DEC	-0.07	14.48	5.40	272.95	1806.	10793.	0.	3500.	2410.	2250.	1367.	1379.
ANNUAL	11.97	15.55	11.92		18227.	50255.	17436.	22004.	16731.	14919.	9249.	7784.
ANNUAL COP								1.08	1.43	1.60	2.58	3.07

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	930.	40.	160.	200.	688.	392.	2660.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	392.	2843.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	492.	3383.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 17 P(M2)= 30	2950.	1687.	1876.	480.	240.	1074.	518.	8826.
5	FULL,BR.CHILL, BIN(M3)= 60 P(M2)= 10	2950.	3197.	1097.	480.	240.	1074.	518.	9556.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1044.95	REF.	REF.	REF.	17151.	20587.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	794.57	250.38	0.7	1	13042.	17895.	3
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	708.53	336.42	2.2	2	11629.	17270.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 17	1929.	439.23	605.72	10.2	3	7209.	17965.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 60	1929.	369.67	675.28	10.2	4	6068.	17553.	2

PITTSBURGH, PENNSYLVANIA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0530
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 12175.
COOLING = 4600.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.15
BLOWER CAPACITY (M3/H) = 2632.

AIR TEMP: OUTDOOR INDOOR
WINTER = -16 C 21 C
SUMMER = 31 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.2M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES FR.CHILL
JAN	-3.07	17.70	3.47	286.32	1882.	14102.	0.	4441.	3557.	3381.	1753.	1753.
FEB	-1.53	17.70	2.30	282.83	1742.	11230.	0.	3604.	2799.	2638.	1440.	1453.
MAR	2.95	19.31	3.07	275.93	1898.	9004.	0.	3029.	2160.	2031.	1206.	1218.
APR	10.22	17.70	5.69	256.16	1737.	4017.	0.	1599.	1189.	1127.	635.	640.
MAY	15.79	16.09	9.60	240.24	1641.	1607.	1416.	1144.	932.	876.	377.	377.
JUN	19.71	12.87	13.54	224.79	1439.	0.	2746.	869.	932.	756.	209.	209.
JUL	21.91	12.87	16.66	223.42	1364.	0.	3831.	1033.	1050.	805.	347.	225.
AUG	21.35	11.26	17.96	218.88	1313.	0.	3463.	956.	980.	759.	646.	212.
SEP	17.91	12.87	17.15	228.87	1301.	824.	2013.	934.	823.	662.	384.	264.
OCT	12.28	14.48	14.40	244.93	1453.	2772.	0.	1174.	910.	865.	409.	416.
NOV	5.31	16.09	10.59	264.01	1551.	6797.	0.	2319.	1567.	1469.	827.	854.
DEC	-1.33	17.70	6.54	282.36	1761.	12661.	0.	4006.	3103.	2937.	1538.	1538.
ANNUAL	10.12	15.55	10.08		19079.	63014.	13468.	25107.	20002.	18305.	9771.	9160.
ANNUAL COP								1.06	1.33	1.45	2.72	2.90

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	59.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 20 P(M2)= 59	2950.	1909.	2999.	530.	240.	1074.	518.	10220.
5	FULL,BR.CHILL, BIN(M3)= 42 P(M2)= 36	2950.	2726.	2083.	530.	240.	1074.	518.	10121.

COMPARATIVE SYSTEMS COSTS

		MAINT.	1ST YEAR	1ST YEAR	SIMPLE	SIMPLE	POWER	LIFE	LIFE
	NEW CONSTRUCTION ALTERNATIVES	PRESENT WORTH	POWER COST	POWER SAVING	PAYBACK PERIOD	PAYBACK RANKING	PRESENT WORTH	CYCLE COST	CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1331.43	REF.	REF.	REF.	21854.	25332.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	1060.70	270.73	0.8	1	17410.	22335.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	970.72	360.71	2.1	2	15933.	21646.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 20	1929.	518.18	813.26	9.2	4	8505.	20654.	2
5	FULL ACES, BR.CHILL, BIN (M3)= 42	1929.	485.74	845.69	8.8	3	7973.	20023.	1

WILKES-BARRE, PENNSYLVANIA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0416
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 12186.
COOLING = 4737.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.15
BLOWER CAPACITY (M3/H) = 2632.

AIR TEMP: OUTDOOR INDOOR
WINTER = -16 C 21 C
SUMMER = 31 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS					SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.4M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-3.34	12.87	3.63	277.10	1876.	13310.	0.	4219.	3341.	3163.	1686.	1686.
FEB	-1.28	12.87	2.30	272.42	1741.	10246.	0.	3330.	2540.	2393.	1338.	1348.
MAR	1.48	12.87	2.78	266.16	1909.	9032.	0.	3039.	2194.	2064.	1216.	1231.
APR	9.35	12.87	5.06	248.29	1761.	4012.	0.	1604.	1179.	1118.	641.	648.
MAY	14.57	11.26	8.66	233.17	1678.	1799.	1129.	1159.	919.	867.	406.	407.
JUN	19.89	9.65	12.41	217.82	1481.	0.	2676.	869.	925.	754.	212.	212.
JUL	22.16	9.65	15.52	217.44	1409.	0.	3883.	1055.	1070.	822.	354.	231.
AUG	20.98	9.65	16.99	215.34	1351.	0.	3419.	959.	983.	765.	638.	215.
SEP	17.25	9.65	16.48	223.81	1327.	870.	1921.	938.	821.	664.	368.	268.
OCT	11.13	9.65	14.08	237.69	1465.	2959.	0.	1229.	927.	880.	433.	444.
NOV	4.52	11.26	10.57	255.98	1551.	6739.	0.	2303.	1566.	1469.	831.	854.
DEC	-1.07	11.26	6.70	268.67	1755.	11293.	0.	3625.	2747.	2585.	1419.	1419.
ANNUAL	9.64	11.13	9.60		19305.	60259.	13029.	24329.	19211.	17544.	9541.	8962.
ANNUAL COP								1.06	1.34	1.47	2.70	2.87

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST, $ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS, INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN., BR.CHILL, BIN(M3)= 19 P(M2)= 43	2950.	1832.	2349.	530.	240.	1074.	518.	9493.
5	FULL, BR.CHILL, BIN(M3)= 40 P(M2)= 26	2950.	2639.	1716.	530.	240.	1074.	518.	9667.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1011.85	REF.	REF.	REF.	16608.	20087.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	798.98	212.87	1.0	1	13114.	18039.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	729.65	282.20	2.7	2	11976.	17689.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 19	1929.	396.83	615.03	11.0	4	6513.	17936.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 40	1929.	372.75	639.11	10.9	3	6118.	17714.	2

CHARLESTON, SOUTH CAROLINA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0449
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 7293.
COOLING = 7502.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.44
BLOWER CAPACITY (M3/H) = 1528.

AIR TEMP: OUTDOOR INDOOR
WINTER = -3 C 21 C
SUMMER = 33 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS					SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	7.99	16.09	10.20	257.93	1618.	4825.	0.	1790.	1257.	1175.	763.	702.
FEB	10.78	17.70	10.35	254.89	1456.	3212.	0.	1297.	990.	932.	567.	509.
MAR	12.93	17.70	12.44	250.01	1530.	2607.	942.	1310.	975.	908.	500.	471.
APR	17.87	17.70	15.84	238.79	1351.	848.	2154.	979.	864.	693.	280.	280.
MAY	21.90	14.48	19.85	226.68	1239.	0.	4346.	1087.	1108.	830.	804.	223.
JUN	24.58	14.48	23.15	232.75	1073.	0.	6244.	1365.	1366.	1089.	1147.	699.
JUL	26.14	12.87	25.05	233.02	1034.	0.	8034.	1660.	1660.	1400.	1472.	1474.
AUG	25.94	12.87	24.89	232.56	1040.	0.	7854.	1631.	1631.	1368.	1439.	1442.
SEP	23.34	12.87	22.82	226.68	1086.	0.	5507.	1242.	1249.	965.	1014.	1016.
OCT	18.23	12.87	19.27	228.14	1261.	732.	2629.	1003.	904.	707.	495.	497.
NOV	13.38	12.87	15.40	239.14	1368.	2144.	1099.	1164.	888.	824.	390.	361.
DEC	8.65	14.48	12.02	253.16	1546.	4440.	0.	1663.	1182.	1106.	692.	644.
ANNUAL	17.65	14.75	17.61		15602.	18809.	38808.	16190.	14076.	11998.	9561.	9316.
ANNUAL COP								1.26	1.45	1.70	2.13	2.45

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 8 P(M2)= 3	2650.	1123.	833.	480.	240.	889.	434.	6649.
5	FULL,BR.CHILL, BIN(M3)= 40 P(M2)= 0	2650.	2406.	0.	480.	240.	889.	434.	7099.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	727.58	REF.	REF.	REF.	11942.	15531.	4
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	632.55	95.03	2.7	1	10383.	15459.	3
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	539.20	188.38	4.2	2	8850.	14715.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 8	1929.	429.68	297.90	12.9	4	7053.	15631.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 40	1929.	373.74	353.84	12.1	3	6134.	15163.	2

GREENVILLE, SOUTH CAROLINA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0418
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 8499.
COOLING = 6596.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.24
BLOWER CAPACITY (M3/H) = 1783.

AIR TEMP:	OUTDOOR	INDOOR
WINTER =	-7 C	21 C
SUMMER =	34 C	26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS					SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	4.99	12.87	7.21	258.19	1735.	6470.	0.	2280.	1546.	1442.	948.	894.
FEB	7.20	14.48	7.33	256.45	1563.	4725.	0.	1747.	1213.	1137.	742.	685.
MAR	9.94	16.09	9.67	253.51	1638.	3852.	0.	1525.	1118.	1053.	643.	598.
APR	16.04	16.09	13.54	239.67	1438.	1336.	1502.	1027.	848.	699.	328.	328.
MAY	20.58	12.87	18.12	222.80	1307.	0.	2970.	870.	907.	717.	289.	200.
JUN	23.62	12.87	21.92	227.29	1120.	0.	4755.	1124.	1127.	832.	877.	220.
JUL	25.48	11.26	24.14	228.23	1070.	0.	6434.	1397.	1397.	1121.	1182.	252.
AUG	25.35	11.26	24.02	227.94	1075.	0.	6244.	1365.	1365.	1098.	1147.	1151.
SEP	22.00	12.87	21.69	223.63	1128.	0.	3868.	974.	988.	741.	717.	720.
OCT	16.33	12.87	17.66	232.46	1324.	1043.	1300.	880.	739.	615.	255.	258.
NOV	10.89	12.87	13.23	244.81	1450.	3004.	0.	1237.	934.	882.	488.	450.
DEC	6.01	14.48	9.34	259.15	1651.	5926.	0.	2105.	1428.	1333.	857.	825.
ANNUAL	15.70	13.41	15.66		16501.	26357.	27072.	16531.	13610.	11659.	8473.	6581.
ANNUAL COP								1.18	1.43	1.67	2.29	2.95

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	930.	40.	160.	200.	688.	434.	2702.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	434.	2885.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	534.	3425.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 10 P(M2)= 6	2650.	1282.	945.	480.	240.	889.	434.	6920.
5	FULL,BR.CHILL, BIN(M3)= 63 P(M2)= 0	2650.	3182.	0.	480.	240.	889.	434.	7875.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	690.35	REF.	REF.	REF.	11331.	14809.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	568.35	122.01	1.5	1	9329.	14224.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	486.88	203.48	3.6	2	7991.	13674.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 10	1929.	353.85	336.51	12.5	4	5808.	14657.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 63	1929.	274.84	415.51	12.5	3	4511.	14316.	3

SUMTER, SOUTH CAROLINA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0401
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 7687.
COOLING = 7301.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.29
BLOWER CAPACITY (M3/H) = 1613.

AIR TEMP: OUTDOOR INDOOR
WINTER = -5 C 21 C
SUMMER = 34 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	6.96	11.26	9.18	250.43	1658.	5061.	0.	1866.	1299.	1214.	789.	732.
FEB	9.07	12.87	9.35	248.92	1491.	3627.	0.	1422.	1027.	965.	616.	558.
MAR	11.85	14.48	11.63	245.89	1561.	2821.	638.	1327.	964.	901.	526.	491.
APR	17.58	14.48	15.34	232.90	1370.	912.	1964.	970.	846.	684.	284.	284.
MAY	22.51	11.26	19.69	221.51	1245.	0.	4133.	1052.	1071.	807.	629.	219.
JUN	25.20	11.26	23.28	227.60	1068.	0.	5872.	1300.	1300.	1023.	1079.	239.
JUL	26.20	11.26	25.33	229.88	1023.	0.	7322.	1535.	1535.	1276.	1342.	1345.
AUG	26.13	9.65	25.15	226.44	1030.	0.	7196.	1516.	1516.	1254.	1320.	1322.
SEP	23.15	9.65	22.89	219.68	1083.	0.	4804.	1122.	1132.	847.	886.	889.
OCT	17.62	9.65	19.03	222.97	1271.	732.	2039.	905.	806.	646.	389.	390.
NOV	13.16	9.65	14.82	233.09	1390.	2036.	874.	1101.	837.	781.	381.	351.
DEC	7.92	9.65	11.15	244.98	1580.	4475.	0.	1682.	1188.	1112.	700.	651.
ANNUAL	17.28	11.26	17.24		15770.	19663.	34842.	15796.	13520.	11510.	8941.	7472.
ANNUAL COP								1.24	1.44	1.70	2.18	2.61

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST, $ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS, INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN., BR.CHILL, BIN(M3)= 8 P(M2)= 4	2650.	1149.	871.	480.	240.	889.	434.	6713.
5	FULL, BR.CHILL, BIN(M3)= 44 P(M2)= 0	2650.	2543.	0.	480.	240.	889.	434.	7236.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	633.60	REF.	REF.	REF.	10400.	13989.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	542.28	91.31	2.8	1	8901.	13978.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	461.68	171.92	4.6	2	7578.	13442.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 8	1929.	358.61	274.98	14.2	4	5896.	14528.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 44	1929.	299.69	333.90	13.2	3	4919.	14084.	4

HURON, SOUTH DAKOTA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0443
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 16703.
COOLING = 5787.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.10
BLOWER CAPACITY (M3/H) = 3566.

AIR TEMP:	OUTDOOR	INDOOR
WINTER =	-27 C	21 C
SUMMER =	34 C	26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS					SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (3.0M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-10.90	19.31	5.73	307.36	1793.	20546.	0.	6206.	5623.	5502.	2447.	2447.
FEB	-7.78	19.31	3.66	300.27	1693.	15674.	0.	4825.	4178.	4056.	1908.	1920.
MAR	-1.96	20.92	2.34	290.35	1926.	12310.	0.	3955.	3044.	2901.	1562.	1572.
APR	7.36	22.53	2.37	272.48	1863.	5866.	0.	2147.	1551.	1480.	848.	853.
MAY	14.33	20.92	3.74	253.38	1871.	2446.	1370.	1433.	1114.	1060.	502.	502.
JUN	20.39	19.31	6.01	236.35	1725.	0.	3261.	1036.	1114.	905.	250.	250.
JUL	23.57	17.70	8.69	237.01	1677.	0.	5022.	1324.	1348.	1027.	446.	284.
AUG	22.97	17.70	10.98	235.66	1587.	0.	4672.	1239.	1267.	968.	869.	267.
SEP	16.45	19.31	12.22	245.29	1489.	1617.	2034.	1210.	997.	803.	392.	352.
OCT	9.52	19.31	12.15	261.02	1541.	4512.	0.	1682.	1246.	1189.	577.	584.
NOV	-0.15	20.92	10.79	286.25	1543.	10748.	0.	3414.	2516.	2397.	1176.	1195.
DEC	-6.47	19.31	8.43	297.31	1687.	16568.	0.	5071.	4242.	4123.	1945.	1954.
ANNUAL	7.28	19.71	7.26		20396.	90286.	16359.	33543.	28240.	26412.	12922.	12179.
ANNUAL COP								1.05	1.25	1.34	2.73	2.90

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	310.	930.	40.	213.	200.	688.	392.	2773.
2	HEAT PUMP WITH ELECTRIC HOT WATER	310.	1080.	58.	231.	200.	714.	392.	2985.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	310.	1080.	58.	631.	240.	714.	492.	3525.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 28 P(M2)= 115*	3350.	2385.	5158.	550.	240.	1288.	518.	13489.*
5	FULL,BR.CHILL, BIN(M3)= 50 P(M2)= 62	3350.	3170.	3101.	550.	240.	1288.	518.	12216.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1484.61	REF.	REF.	REF.	24368.	27916.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	1249.91	234.70	0.9	1	20515.	25510.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	1169.00	315.61	2.4	2	19187.	24970.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 28	1929.	571.92	912.69	11.7	4	9387.	24806.*	2
5	FULL ACES, BR.CHILL, BIN (M3)= 50	1929.	539.05	945.56	10.0	3	8848.	22994.*	1

*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
POWER COSTS ($/KWH) = 0.0395
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 14950.
COOLING = 5087.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 3226.

AIR TEMP: OUTDOOR INDOOR
WINTER = -23 C 21 C
SUMMER = 33 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (2.0M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-4.95	16.09	4.60	287.31	1838.	14565.	0.	4557.	3799.	3644.	1829.	1829.
FEB	-3.53	17.70	2.73	287.36	1726.	12053.	0.	3828.	3127.	2978.	1544.	1544.
MAR	-0.00	19.31	2.24	282.63	1930.	10531.	0.	3462.	2636.	2497.	1396.	1409.
APR	6.80	20.92	3.47	270.47	1821.	5841.	0.	2128.	1493.	1414.	858.	865.
MAY	13.74	19.31	6.16	251.44	1776.	2377.	1099.	1341.	1026.	971.	483.	495.
JUN	19.29	17.70	9.44	235.56	1594.	555.	2508.	1026.	948.	766.	281.	281.
JUL	23.08	16.09	12.60	232.64	1523.	0.	4029.	1112.	1123.	866.	246.	246.
AUG	22.96	16.09	14.67	232.35	1442.	0.	4154.	1110.	1140.	874.	773.	240.
SEP	16.38	17.70	15.09	242.17	1379.	1444.	2043.	1133.	942.	755.	392.	329.
OCT	11.07	17.70	13.77	254.23	1477.	3515.	853.	1533.	1092.	1029.	507.	512.
NOV	1.55	19.31	11.14	279.10	1530.	9128.	0.	2961.	2156.	2037.	1066.	1098.
DEC	-2.35	16.09	7.75	281.41	1714.	12415.	0.	3925.	3098.	2951.	1538.	1551.
ANNUAL	8.67	17.83	8.64		19751.	72424.	14685.	28116.	22580.	20781.	10912.	10389.
ANNUAL CCP								1.06	1.31	1.43	2.72	2.85

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 20 P(M2)= 25	3350.	2001.	1655.	550.	240.	1288.	518.	9601.
5	FULL,BR.CHILL, BIN(M3)= 40 P(M2)= 19	3350.	2743.	1420.	550.	240.	1288.	518.	10109.

COMPARATIVE SYSTEMS COSTS

	NEW CONSTRUCTION ALTERNATIVES	MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERIOD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1109.45	REF.	REF.	REF.	18210.	21688.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	891.00	218.44	1.0	1	14625.	19550.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	820.01	289.44	2.6	2	13459.	19172.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 20	1929.	430.60	678.84	10.2	3	7068.	18599.	1
5	FULL ACES, BR.CHILL, BIN (M3)= 40	1929.	409.93	699.51	10.6	4	6728.	18767.	2

BRISTOL, TENNESSEE

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0303
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 10372.
COOLING = 5487.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.15
BLOWER CAPACITY (M3/H) = 2207.

AIR TEMP: OUTDOOR INDOOR
WINTER = -12 C 21 C
SUMMER = 32 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	2.25	11.26	4.49	261.13	1842.	8384.	0.	2841.	1993.	1866.	1169.	1169.
FEB	5.14	11.26	4.65	254.58	1658.	5748.	0.	2057.	1439.	1352.	858.	870.
MAR	7.29	12.87	7.20	252.97	1735.	5106.	0.	1901.	1342.	1263.	786.	828.
APR	13.68	12.87	11.39	238.46	1520.	2173.	1101.	1214.	934.	875.	435.	545.
MAY	19.23	9.65	16.32	219.32	1377.	569.	2581.	982.	904.	717.	261.	261.
JUN	22.29	8.05	20.39	214.43	1178.	0.	3831.	982.	993.	748.	584.	206.
JUL	24.06	6.44	22.75	215.18	1125.	0.	5142.	1191.	1193.	998.	948.	229.
AUG	23.73	6.44	22.58	214.45	1131.	0.	4794.	1133.	1136.	838.	885.	222.
SEP	20.85	8.05	20.05	212.37	1191.	0.	3175.	873.	909.	706.	592.	193.
OCT	14.43	8.05	15.69	226.94	1402.	1647.	1209.	1054.	839.	785.	322.	440.
NOV	7.89	9.65	10.92	245.05	1538.	4389.	0.	1647.	1163.	1095.	623.	680.
DEC	2.93	9.65	6.75	256.31	1753.	7697.	0.	2625.	1842.	1726.	1054.	1089.
ANNUAL	13.65	9.52	13.60		17451.	35713.	21832.	18499.	14690.	12869.	8518.	6732.
ANNUAL COP								1.13	1.42	1.62	2.45	3.09

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 13 P(M2)= 12	2950.	1477.	1158.	530.	240.	1074.	518.	7947.
5	FULL,BR.CHILL, BIN(M3)= 81 P(M2)= 0	2950.	3794.	0.	530.	240.	1074.	518.	9106.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	559.98	REF.	REF.	REF.	9191.	12670.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	444.65	115.32	1.8	1	7298.	12223.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	389.53	170.44	4.4	2	6394.	12106.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 13	1929.	257.84	302.14	17.4	3	4232.	14108.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 81	1929.	203.77	356.20	18.0	4	3345.	14380.	5

KNOXVILLE, TENNESSEE

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0304
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 9529.
COOLING = 6783.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.26
BLOWER CAPACITY (M3/H) = 2038.

AIR TEMP: OUTDOOR INDOOR
WINTER = -10 C 21 C
SUMMER = 33 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	2.20	14.48	5.34	267.81	1808.	9071.	0.	3022.	2069.	1930.	1220.	1185.
FEB	6.32	12.87	5.59	255.18	1625.	5345.	0.	1936.	1372.	1290.	801.	759.
MAR	8.42	17.70	8.26	260.24	1694.	4612.	0.	1752.	1138.	1117.	716.	687.
APR	15.76	12.87	12.57	233.74	1475.	1220.	1079.	933.	772.	727.	312.	309.
MAY	20.04	12.87	17.59	224.04	1327.	0.	2552.	805.	858.	695.	193.	193.
JUN	23.45	11.26	21.71	223.64	1128.	0.	4498.	1082.	1102.	814.	677.	215.
JUL	25.34	9.65	24.04	224.65	1074.	0.	6120.	1344.	1344.	1066.	1125.	245.
AUG	24.94	9.65	23.78	223.75	1084.	0.	6145.	1351.	1351.	1071.	1130.	469.
SEP	22.03	9.65	21.13	217.13	1150.	0.	3309.	885.	899.	687.	616.	619.
OCT	15.20	9.65	16.65	228.46	1364.	1192.	903.	864.	704.	663.	281.	273.
NOV	8.98	11.26	11.79	245.85	1505.	3658.	0.	1434.	985.	929.	541.	521.
DEC	3.94	9.65	7.58	254.01	1721.	7092.	0.	2448.	1651.	1542.	985.	960.
ANNUAL	14.72	11.80	14.67		16955.	32190.	24605.	17857.	14295.	12531.	8597.	6437.
ANNUAL COP								1.15	1.43	1.63	2.36	3.18

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	434.	2885.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	534.	3425.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 14 P(M2)= 15	2650.	1483.	1267.	480.	240.	889.	434.	7442.
5	FULL,BR.CHILL, BIN(M3)= 76 P(M2)= 0	2650.	3623.	0.	480.	240.	889.	434.	8316.

COMPARATIVE SYSTEMS COSTS

	NEW CONSTRUCTION ALTERNATIVES	MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERICD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	542.13	REF.	REF.	REF.	8898.	12487.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	434.00	108.13	0.7	1	7124.	12019.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	380.45	161.68	3.8	2	6245.	11927.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 14	1929.	261.01	281.12	16.5	4	4284.	13656.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 76	1929.	195.44	346.69	15.9	3	3208.	13453.	4

MEMPHIS, TENNESSEE

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0303
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 9497.
COOLING = 7637.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.33
BLOWER CAPACITY (M3/H) = 2038.

AIR TEMP: OUTDOOR INDOOR
WINTER = -10 C 21 C
SUMMER = 36 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	3.28	17.70	6.50	271.90	1763.	8215.	0.	2772.	1919.	1791.	1142.	1087.
FEB	6.59	17.70	6.68	264.39	1586.	5368.	0.	1932.	1350.	1266.	816.	758.
MAR	9.92	19.31	9.39	260.11	1649.	4020.	0.	1575.	1145.	1078.	659.	618.
APR	16.88	17.70	13.82	241.04	1428.	1191.	1679.	1014.	854.	700.	314.	314.
MAY	21.77	14.48	19.03	226.37	1271.	0.	4026.	1041.	1074.	817.	352.	220.
JUN	25.27	12.87	23.32	231.04	1067.	0.	6005.	1322.	1324.	1048.	1104.	242.
JUL	27.16	12.87	25.80	235.33	1005.	0.	8292.	1696.	1696.	1445.	1518.	595.
AUG	26.93	11.26	25.60	231.54	1013.	0.	7826.	1618.	1619.	1364.	1434.	1438.
SEP	23.25	8.05	22.91	216.62	1082.	0.	4793.	1119.	1129.	845.	884.	888.
OCT	17.24	12.87	18.31	230.39	1299.	1067.	2253.	1042.	899.	713.	428.	432.
NOV	10.09	16.09	13.27	253.17	1449.	3637.	0.	1413.	1039.	979.	550.	513.
DEC	5.75	16.09	8.87	263.02	1670.	6222.	0.	2192.	1438.	1390.	898.	860.
ANNUAL	16.18	14.75	16.13		16280.	29720.	34872.	18737.	15538.	13435.	10100.	7964.
ANNUAL COP								1.20	1.45	1.67	2.22	2.82

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 12 P(M2)= 7	2650.	1428.	985.	480.	240.	889.	434.	7105.
5	FULL,BR.CHILL, BIN(M3)= 70 P(M2)= 0	2650.	3441.	0.	480.	240.	889.	434.	8134.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	567.18	REF.	REF.	REF.	9309.	12899.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	470.32	96.86	2.6	1	7720.	12797.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	406.66	160.51	4.9	2	6675.	12539.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 12	1929.	305.72	261.46	16.4	4	5018.	14053.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 70	1929.	241.07	326.10	16.3	3	3957.	14021.	4

NASHVILLE, TENNESSEE

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0285
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 10354.
COOLING = 6806.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.24
BLOWER CAPACITY (M3/H) = 2207.

AIR TEMP: OUTDOOR INDOOR
WINTER = -12 C 21 C
SUMMER = 35 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP	AVE WIND SPEED	INLET WATER TEMP	HEAT LOSS COEF.	WATER HEAT	SPACE HEAT	SPACE COOL	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
	C	KM/H	C (0.5M)	W/C	MJ	MJ	MJ					
JAN	2.28	14.48	5.02	267.62	1821.	8959.	0.	2995.	2147.	2016.	1232.	1174.
FEB	4.69	14.48	5.20	262.15	1639.	6399.	0.	2233.	1595.	1501.	934.	876.
MAR	8.21	16.09	7.88	257.45	1709.	4874.	0.	1829.	1291.	1218.	757.	717.
APR	15.31	14.48	12.27	238.05	1487.	1709.	1369.	1122.	898.	840.	381.	378.
MAY	20.40	12.87	17.43	223.22	1333.	0.	3207.	918.	984.	779.	208.	208.
JUN	23.67	11.26	21.70	224.14	1128.	0.	4972.	1163.	1172.	875.	917.	226.
JUL	25.53	9.65	24.16	225.09	1069.	0.	6490.	1406.	1408.	1132.	1192.	253.
AUG	25.23	9.65	23.98	224.39	1076.	0.	6114.	1344.	1346.	1067.	1124.	687.
SEP	21.64	9.65	21.31	216.26	1143.	0.	3930.	989.	1024.	773.	728.	732.
OCT	15.30	9.65	16.74	228.23	1361.	1612.	1583.	1096.	885.	824.	315.	312.
NOV	9.00	12.87	11.74	249.09	1507.	4163.	0.	1575.	1139.	1075.	601.	572.
DEC	4.17	12.87	7.38	260.05	1728.	7294.	0.	2506.	1760.	1653.	1017.	983.
ANNUAL	14.62	12.34	14.57		17001.	35010.	27666.	19176.	15650.	13753.	9406.	7119.
ANNUAL COP								1.15	1.41	1.61	2.35	3.11

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST, $ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	970.	40.	173.	200.	759.	434.	2856.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	434.	2957.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	534.	3497.
	ACES SYSTEMS, INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN., BR.CHILL, BIN(M3)= 13 P(M2)= 11	2950.	1509.	1131.	530.	240.	1074.	518.	7952.
5	FULL, BR.CHILL, BIN(M3)= 81 P(M2)= 0	2950.	3783.	0.	530.	240.	1074.	518.	9095.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	545.75	REF.	REF.	REF.	8958.	12590.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	445.39	100.36	1.0	1	7310.	12277.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	391.42	154.32	4.2	2	6425.	12179.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 13	1929.	267.68	278.06	18.3	4	4394.	14275.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 81	1929.	202.61	343.14	18.2	3	3326.	14350.	5

EL PASO, TEXAS

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0493
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 8077.
COOLING = 5996.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 1698.

AIR TEMP: OUTDOOR INDOOR
WINTER = -6 C 21 C
SUMMER = 37 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	6.57	16.09	8.53	261.17	1683.	5518.	0.	2001.	1397.	1307.	843.	785.
FEB	9.18	17.70	9.03	258.50	1502.	3914.	0.	1505.	1116.	1049.	649.	590.
MAR	12.99	20.92	11.88	256.43	1552.	2734.	1241.	1402.	1052.	976.	514.	494.
APR	18.43	20.92	16.19	244.08	1338.	956.	2638.	1088.	958.	751.	300.	300.
MAY	23.23	19.31	21.05	239.52	1191.	0.	4331.	1071.	1098.	821.	801.	218.
JUN	27.63	17.70	24.88	246.23	1007.	0.	6193.	1338.	1340.	1081.	1137.	465.
JUL	27.74	16.09	26.88	243.20	963.	0.	6330.	1349.	1349.	1103.	1162.	1165.
AUG	27.06	14.48	26.32	238.39	984.	0.	5924.	1286.	1286.	1032.	1088.	1092.
SEP	24.07	14.48	23.51	231.59	1059.	0.	4546.	1071.	1076.	797.	839.	842.
OCT	18.23	14.48	19.03	231.41	1271.	752.	2793.	1039.	936.	728.	525.	529.
NOV	10.63	16.09	14.33	251.94	1408.	3373.	752.	1457.	1033.	959.	527.	499.
DEC	6.87	16.09	10.42	260.49	1609.	5328.	0.	1927.	1315.	1229.	786.	756.
ANNUAL	17.72	17.03	17.67		15568.	22575.	34749.	16533.	13955.	11833.	9172.	7734.
ANNUAL COP								1.22	1.45	1.71	2.21	2.62

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	930.	40.	160.	200.	688.	392.	2660.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	392.	2843.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	492.	3383.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 9 P(M2)= 3	2650.	1214.	835.	480.	240.	889.	434.	6742.
5	FULL,BR.CHILL, BIN(M3)= 48 P(M2)= 0	2650.	2732.	0.	480.	240.	889.	434.	7425.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	814.60	REF.	REF.	REF.	13371.	16806.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	687.55	127.06	1.4	1	11285.	16139.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	583.01	231.59	3.1	2	9569.	15210.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 9	1929.	451.90	362.70	11.3	4	7417.	16089.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 48	1929.	381.04	433.56	11.0	3	6254.	15608.	2

FORTH WORTH, TEXAS

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0438
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 8634.
COOLING = 7861.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.23
BLOWER CAPACITY (M3/H) = 1868.

AIR TEMP: OUTDOOR INDOOR
WINTER = -7 C 21 C
SUMMER = 38 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	6.28	20.92	9.18	271.65	1658.	6255.	0.	2198.	1533.	1433.	923.	862.
FEB	8.96	20.92	9.20	265.57	1496.	4159.	0.	1571.	1123.	1054.	685.	616.
MAR	12.53	22.53	11.72	260.75	1558.	2953.	954.	1416.	1039.	969.	543.	512.
APR	18.68	24.13	16.01	250.07	1345.	801.	2121.	958.	849.	682.	273.	273.
MAY	23.50	20.92	21.14	243.42	1188.	0.	4804.	1151.	1162.	855.	723.	228.
JUN	27.31	20.92	25.46	252.06	985.	0.	7817.	1609.	1609.	1362.	1432.	854.
JUL	29.81	19.31	28.06	254.45	916.	0.	9814.	1931.	1931.	1710.	1793.	1797.
AUG	29.60	17.70	28.04	250.69	917.	0.	9190.	1825.	1825.	1601.	1680.	1684.
SEP	25.86	19.31	25.54	245.50	982.	0.	6333.	1355.	1358.	1106.	1163.	1166.
OCT	20.12	19.31	21.08	236.96	1190.	0.	3027.	848.	908.	715.	565.	568.
NOV	12.80	20.92	16.11	256.86	1341.	2582.	924.	1248.	917.	853.	435.	405.
DEC	8.39	20.92	11.68	266.87	1560.	4835.	0.	1776.	1238.	1159.	744.	697.
ANNUAL	18.65	20.65	18.60		15135.	21585.	44983.	17887.	15494.	13499.	10957.	9653.
ANNUAL COP								1.27	1.46	1.68	2.07	2.35

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST, $ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS, INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN., BR.CHILL, BIN(M3)= 10 P(M2)= 4	2650.	1273.	844.	480.	240.	889.	434.	6809.
5	FULL, BR.CHILL, BIN(M3)= 48 P(M2)= 0	2650.	2719.	0.	480.	240.	889.	434.	7412.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	783.98	REF.	REF.	REF.	12868.	16457.	4
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	679.08	104.90	2.4	1	11146.	16223.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	591.66	192.32	4.1	2	9711.	15576.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 10	1929.	480.27	303.71	13.2	4	7883.	16621.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 48	1929.	423.07	360.91	12.7	3	6944.	16286.	3

HOUSTON, TEXAS

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0405
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 6669.
COOLING = 8124.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.47
BLOWER CAPACITY (M3/H) = 1443.

AIR TEMP: OUTDOOR INDOOR
WINTER = -2 C 21 C
SUMMER = 34 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	10.87	17.70	13.18	254.68	1501.	3423.	0.	1368.	1045.	985.	619.	536.
FEB	12.88	17.70	13.26	250.13	1352.	2258.	823.	1144.	851.	794.	480.	411.
MAR	15.98	19.31	15.21	246.35	1421.	1375.	1623.	1054.	871.	712.	333.	333.
APR	20.58	19.31	18.44	235.92	1252.	0.	3513.	948.	991.	767.	542.	207.
MAY	24.36	17.70	22.28	238.81	1143.	0.	6147.	1368.	1371.	1074.	1130.	1131.
JUN	26.94	16.09	25.47	241.40	985.	0.	8361.	1702.	1702.	1457.	1530.	1531.
JUL	28.18	12.87	27.35	237.66	944.	0.	9709.	1921.	1921.	1692.	1774.	1776.
AUG	27.96	12.87	27.26	237.16	947.	0.	9609.	1905.	1905.	1674.	1756.	1758.
SEP	25.98	14.48	25.33	235.92	990.	0.	7424.	1544.	1544.	1294.	1360.	1362.
OCT	21.34	14.48	21.96	225.41	1156.	0.	4342.	1063.	1097.	820.	803.	804.
NOV	16.00	16.09	18.25	239.76	1259.	1392.	2072.	1091.	907.	719.	395.	396.
DEC	12.35	16.09	14.98	248.04	1430.	2585.	804.	1253.	921.	859.	525.	434.
ANNUAL	20.29	16.22	20.25		14380.	11034.	54426.	16359.	15127.	12846.	11247.	10679.
ANNUAL COP								1.36	1.47	1.73	1.97	2.08

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	1050.	40.	160.	200.	880.	434.	3014.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 6 P(M2)= 1	2500.	981.	755.	480.	240.	714.	392.	6063.
5	FULL,BR.CHILL, BIN(M3)= 18 P(M2)= 0	2500.	1585.	0.	480.	240.	714.	392.	5911.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	662.87	REF.	REF.	REF.	10880.	14670.	2
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	612.95	49.93	1.1	1	10061.	15139.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	520.51	142.37	4.2	2	8543.	14408.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 6	1929.	455.74	207.14	14.7	4	7480.	15472.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 18	1929.	432.71	230.17	12.6	3	7102.	14943.	3

SAN ANTONIO, TEXAS

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0458
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 7018.
COOLING = 7691.

COND. LOSS COEF. (W/C) = 158.
BLOWER CAPACITY (M3/H) = 1528.

AIR TEMP: OUTDOOR INDOOR
WINTER = -3 C 21 C
SUMMER = 36 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2B	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	12.62	14.48	13.98	244.15	1469.	2514.	844.	1251.	931.	869.	537.	452.
FEB	14.25	16.09	14.12	243.73	1322.	1787.	1092.	1050.	821.	764.	429.	363.
MAR	17.10	16.09	16.12	237.27	1385.	1130.	1883.	1021.	870.	705.	308.	308.
APR	20.80	17.70	19.39	232.15	1216.	0.	2942.	840.	883.	695.	549.	280.
MAY	24.68	16.09	23.23	236.27	1106.	0.	5784.	1295.	1300.	1012.	1064.	1064.
JUN	28.03	16.09	26.41	243.86	949.	0.	9604.	1734.	1734.	1499.	1574.	1574.
JUL	29.45	16.09	28.24	247.09	909.	0.	10092.	1977.	1977.	1758.	1843.	1844.
AUG	29.47	12.87	28.09	240.58	915.	0.	9639.	1901.	1901.	1679.	1761.	1762.
SEP	26.69	12.87	26.11	234.26	961.	0.	7154.	1489.	1489.	1247.	1311.	1312.
OCT	21.81	12.87	22.70	223.20	1127.	0.	4089.	1012.	1041.	780.	757.	757.
NOV	15.76	14.48	18.98	237.02	1232.	1365.	1611.	997.	816.	659.	311.	312.
DEC	12.88	14.48	15.73	243.57	1400.	2352.	800.	1179.	875.	816.	499.	412.
ANNUAL	21.13	15.02	21.09		13990.	9149.	54535.	15746.	14639.	12484.	10943.	10441.
ANNUAL COP								1.37	1.47	1.73	1.97	2.07

SYSTEMS FIRST COSTS

		COST,$						
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 5 P(M2)= 0	2500.	926.	0.	480.	240.	714.	392.	5253.
5	FULL,BR.CHILL, BIN(M3)= 11 P(M2)= 0	2500.	1270.	0.	480.	240.	714.	392.	5596.

COMPARATIVE SYSTEMS COSTS

	NEW CONSTRUCTION ALTERNATIVES	MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERIOD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	720.53	REF.	REF.	REF.	11827.	15416.	4
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	669.87	50.66	5.0	1	10995.	16072.	5
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	571.26	149.28	5.3	2	9376.	15241.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 5	1929.	500.75	219.78	11.1	3	8219.	15401.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 11	1929.	477.78	242.75	11.5	4	7842.	15368.	2

SALT LAKE CITY, UTAH

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0445
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 11738.
COOLING = 5202.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 2547.

AIR TEMP: OUTDOOR INDOOR
WINTER = -15 C 21 C
SUMMER = 34 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.2M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-2.48	11.26	3.49	271.85	1881.	12145.	0.	3897.	2900.	2726.	1563.	1563.
FEB	0.21	12.87	2.29	269.03	1742.	8890.	0.	2954.	2114.	1987.	1188.	1201.
MAR	3.37	14.48	3.11	265.14	1896.	7581.	0.	2633.	1811.	1702.	1056.	1086.
APR	8.90	14.48	5.83	252.60	1732.	4078.	0.	1614.	1154.	1093.	647.	664.
MAY	14.40	16.09	9.87	243.39	1631.	1995.	1300.	1229.	966.	907.	426.	427.
JUN	19.88	14.48	13.92	227.67	1424.	0.	2853.	883.	963.	780.	210.	210.
JUL	24.79	14.48	17.12	233.23	1546.	0.	4788.	1192.	1198.	892.	726.	244.
AUG	23.47	16.09	18.45	233.50	1294.	0.	4235.	1083.	1101.	830.	785.	227.
SEP	17.88	14.48	17.59	232.22	1284.	884.	2241.	985.	866.	688.	426.	272.
OCT	11.60	14.48	14.74	246.46	1439.	2886.	656.	1314.	940.	883.	434.	449.
NOV	2.91	12.87	10.81	262.91	1542.	7494.	0.	2510.	1686.	1579.	894.	959.
DEC	-0.56	11.26	6.64	267.50	1757.	10588.	0.	3429.	2406.	2254.	1344.	1372.
ANNUAL	10.37	13.94	10.32		18968.	56540.	16074.	23723.	18105.	16320.	9698.	8674.
ANNUAL COP								1.07	1.41	1.56	2.62	2.93

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 17 P(M2)= 29	2950.	1760.	1823.	530.	240.	1074.	519.	8895.
5	FULL,BR.CHILL, BIN(M3)= 51 P(M2)= 13	2950.	2993.	1192.	530.	240.	1074.	518.	9497.

COMPARATIVE SYSTEMS COSTS

	NEW CONSTRUCTION ALTERNATIVES	MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERIOD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1056.38	REF.	REF.	REF.	17339.	20817.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	806.21	250.17	0.9	1	13233.	18159.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	726.72	329.65	2.3	2	11928.	17641.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 17	1929.	431.87	624.51	9.9	3	7089.	17913.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 51	1929.	386.24	670.14	10.1	4	6340.	17766.	2

BURLINGTON, VERMONT

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0353
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 15236.
COOLING = 4666.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.11
BLOWER CAPACITY (M3/H) = 3311.

AIR TEMP: OUTDOOR INDOOR
WINTER = -23 C 21 C
SUMMER = 31 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (2.9M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-8.29	16.09	5.29	294.89	1810.	18204.	0.	5560.	4802.	4664.	2199.	2199.
FEB	-7.25	16.09	3.43	292.51	1701.	15236.	0.	4705.	3963.	3829.	1863.	1862.
MAR	-1.96	16.09	2.26	280.52	1930.	12238.	0.	3936.	2935.	2781.	1557.	1556.
APR	6.01	16.09	2.32	262.44	1865.	5958.	0.	2173.	1496.	1420.	858.	857.
MAY	13.02	14.48	3.59	243.24	1877.	2588.	898.	1394.	1059.	1009.	508.	508.
JUN	18.30	14.48	5.67	231.27	1738.	791.	2120.	1065.	956.	789.	313.	313.
JUL	20.57	12.87	8.11	222.83	1700.	0.	3188.	1017.	1055.	851.	246.	246.
AUG	19.21	12.87	10.17	225.93	1619.	0.	2655.	903.	973.	803.	226.	295.
SEP	15.00	12.87	11.27	235.48	1525.	1635.	1315.	1102.	887.	840.	327.	327.
OCT	9.14	14.48	11.17	252.04	1579.	4126.	0.	1585.	1104.	1051.	545.	544.
NOV	2.97	16.09	9.91	269.34	1576.	9277.	0.	2737.	1837.	1733.	953.	950.
DEC	-5.58	16.09	7.75	288.73	1714.	15857.	0.	4881.	3993.	3859.	1865.	1864.
ANNUAL	6.76	14.88	6.74		20635.	84911.	10176.	31060.	25061.	23630.	11461.	11522.
ANNUAL COP								1.04	1.28	1.36	2.91	2.79

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 25 P(M2)= 133*	3350.	2196.	5836.	550.	240.	1288.	518.	13978.*
5	FULL,BR.CHILL, BIN(M3)= 25 P(M2)= 133*	3350.	2196.	5836.	550.	240.	1288.	518.	13978.*

COMPARATIVE SYSTEMS COSTS

		MAINT.	1ST YEAR	1ST YEAR	SIMPLE	SIMPLE	POWER	LIFE	LIFE
	NEW CONSTRUCTION ALTERNATIVES	PRESENT WORTH	POWER COST	POWER SAVING	PAYBACK PERIOD	PAYBACK RANKING	PRESENT WORTH	CYCLE COST	CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1097.96	REF.	REF.	REF.	18022.	21500.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	885.92	212.04	1.0	1	14541.	19466.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	835.31	262.65	2.9	2	13710.	19423.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 25	1929.	405.14	692.82	16.3	3	6650.	22557.*	4
5	FULL ACES, BR.CHILL, BIN (M3)= 25	1929.	405.14	692.82	16.3	4	6650.	22557.*	5

*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
POWER COSTS ($/KWH) = 0.0516
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 8135.
COOLING = 7332.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.40
BLOWER CAPACITY (M3/H) = 1783.

AIR TEMP: OUTDOOR INDOOR
WINTER = -6 C 21 C
SUMMER = 33 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	3.44	17.70	5.86	271.54	1788.	7928.	0.	2699.	1839.	1715.	1105.	1058.
FEB	4.95	19.31	5.67	271.40	1622.	6152.	0.	2160.	1465.	1368.	894.	847.
MAR	8.13	19.31	7.87	264.17	1709.	4853.	0.	1823.	1263.	1185.	753.	715.
APR	14.16	19.31	11.84	250.49	1503.	2035.	996.	1153.	883.	826.	417.	407.
MAY	19.16	16.09	16.74	232.60	1361.	0.	2591.	821.	888.	722.	198.	198.
JUN	23.27	14.48	20.98	229.78	1156.	0.	4999.	1175.	1181.	877.	922.	229.
JUL	25.61	12.87	23.66	231.81	1089.	0.	7064.	1510.	1510.	1231.	1296.	267.
AUG	25.01	14.48	23.88	233.73	1080.	0.	6918.	1482.	1483.	1206.	1270.	769.
SEP	21.94	14.48	21.69	226.76	1129.	0.	4315.	1051.	1063.	787.	798.	802.
OCT	16.00	16.09	17.55	239.76	1329.	1078.	1323.	895.	749.	622.	260.	263.
NOV	10.98	17.70	12.80	254.44	1467.	3074.	0.	1261.	930.	879.	482.	452.
DEC	4.95	17.70	8.46	268.11	1686.	6834.	0.	2367.	1613.	1506.	952.	928.
ANNUAL	14.80	16.63	14.75		16918.	31953.	28206.	18396.	14865.	12924.	9346.	6935.
ANNUAL COP								1.16	1.44	1.66	2.29	3.09

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1180.	29.	178.	200.	796.	434.	3067.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1180.	29.	578.	240.	796.	534.	3607.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 12 P(M2)= 7	2650.	1382.	985.	480.	240.	889.	434.	7060.
5	FULL,BR.CHILL, BIN(M3)= 77 P(M2)= 0	2650.	3598.	0.	480.	240.	889.	434.	8291.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	948.30	REF.	REF.	REF.	15565.	19154.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	766.28	182.02	1.4	1	12577.	17654.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	666.23	282.07	2.8	2	10935.	16800.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 12	1929.	481.79	466.51	9.1	3	7908.	16897.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 77	1929.	357.51	590.79	9.3	4	5868.	16089.	1

RICHMOND, VIRGINIA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0516
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 9325.
COOLING = 6741.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.29
BLOWER CAPACITY (M3/H) = 2038.

AIR TEMP: OUTDOOR INDOOR
WINTER = -9 C 21 C
SUMMER = 33 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	4.70	12.87	5.72	258.85	1794.	6861.	0.	2404.	1660.	1553.	1005.	943.
FEB	5.61	14.48	5.86	260.07	1615.	5691.	0.	2030.	1406.	1317.	853.	796.
MAR	8.24	14.48	8.28	254.08	1693.	4690.	0.	1773.	1251.	1175.	741.	695.
APR	14.42	14.48	12.27	240.06	1487.	1963.	1278.	1177.	920.	857.	410.	404.
MAY	19.00	12.87	16.97	226.40	1352.	580.	2687.	996.	916.	721.	262.	262.
JUN	23.11	11.26	20.86	222.86	1160.	0.	4912.	1162.	1175.	870.	906.	228.
JUL	25.39	11.26	23.12	228.04	1110.	0.	6592.	1435.	1436.	1149.	1211.	259.
AUG	24.00	11.26	22.97	224.88	1116.	0.	5671.	1279.	1291.	991.	1044.	644.
SEP	20.55	11.26	20.57	219.60	1171.	0.	3603.	941.	981.	750.	669.	673.
OCT	15.08	11.26	16.42	232.01	1373.	1522.	1320.	1030.	827.	770.	308.	264.
NOV	8.81	12.87	11.87	249.53	1502.	4147.	0.	1569.	1120.	1053.	606.	570.
DEC	4.48	11.26	7.89	256.07	1709.	6852.	0.	2378.	1651.	1544.	961.	933.
ANNUAL	14.45	12.47	14.40		17080.	32304.	26063.	18172.	14624.	12751.	8978.	6670.
ANNUAL COP								1.15	1.43	1.64	2.33	3.14

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	970.	40.	160.	200.	759.	434.	2813.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	434.	2885.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	534.	3425.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 11 P(M2)= 8	2650.	1365.	1015.	480.	240.	899.	434.	7073.
5	FULL,BR.CHILL, BIN(M3)= 75 P(M2)= 0	2650.	3606.	0.	480.	240.	899.	434.	8298.

COMPARATIVE SYSTEMS COSTS

	NEW CONSTRUCTION ALTERNATIVES	MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERIOD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	936.78	REF.	REF.	REF.	15376.	18965.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	753.89	182.89	0.4	1	12374.	17269.	4
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	657.31	279.47	2.2	2	10789.	16471.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 11	1929.	462.80	473.98	9.0	3	7596.	16599.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 75	1929.	343.85	592.93	9.3	4	5644.	15872.	1

ROANOKE, VIRGINIA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0391
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 9755.
COOLING = 5733.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.15
BLOWER CAPACITY (M3/H) = 2122.

AIR TEMP: OUTDOOR INDOOR
WINTER = -10 C 21 C
SUMMER = 33 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES FR.CHILL
JAN	2.57	16.09	4.44	270.24	1844.	8628.	0.	2909.	2013.	1881.	1193.	1193.
FEB	4.49	17.70	4.59	269.16	1660.	6598.	0.	2294.	1575.	1473.	951.	954.
MAR	6.94	17.70	7.13	263.60	1738.	5652.	0.	2053.	1425.	1336.	847.	878.
APR	13.95	16.09	11.32	244.42	1523.	2157.	1204.	1228.	947.	884.	435.	494.
MAY	18.63	12.87	16.25	227.24	1380.	709.	2322.	977.	880.	704.	271.	271.
JUN	22.51	11.26	20.35	221.50	1180.	0.	3994.	1010.	1029.	773.	475.	210.
JUL	24.65	9.65	22.72	223.07	1126.	0.	5457.	1245.	1247.	953.	1005.	236.
AUG	23.88	9.65	22.57	221.34	1132.	0.	4940.	1158.	1163.	865.	911.	225.
SEP	20.10	9.65	20.05	217.35	1191.	0.	2983.	840.	890.	700.	557.	282.
OCT	14.26	11.26	15.69	233.87	1402.	1797.	1086.	1074.	836.	782.	338.	444.
NOV	7.75	14.48	10.91	255.19	1538.	4743.	0.	1745.	1210.	1136.	665.	710.
DEC	3.63	14.48	6.73	264.56	1754.	7700.	0.	2626.	1812.	1694.	1051.	1087.
ANNUAL	13.61	13.41	13.56		17467.	37984.	21986.	19161.	15026.	13181.	8700.	6985.
ANNUAL COP								1.12	1.43	1.63	2.47	3.08

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	930.	40.	160.	200.	688.	392.	2660.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	392.	2843.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	492.	3383.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 13 P(M2)= 10	2650.	1467.	1100.	480.	240.	889.	434.	7260.
5	FULL,BR.CHILL, BIN(M3)= 80 P(M2)= 0	2650.	3742.	0.	480.	240.	889.	434.	8434.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERICD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	750.15	REF.	REF.	REF.	12313.	15748.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	588.28	161.87	1.1	1	9656.	14509.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	516.03	234.11	3.1	2	8470.	14110.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 13	1929.	340.60	409.55	11.2	3	5590.	14780.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 80	1929.	273.45	476.70	12.1	4	4488.	14852.	4

MOSES LAKE, WASHINGTON

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0160
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 12174.
COOLING = 6028.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 2632.

AIR TEMP: OUTDOOR INDOOR
WINTER = -16 C 21 C
SUMMER = 34 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.1M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-2.52	8.05	2.91	265.39	1904.	12064.	0.	3880.	2850.	2677.	1561.	1561.
FEB	1.42	9.65	2.36	259.73	1739.	7849.	0.	2664.	1847.	1734.	1065.	1095.
MAR	5.58	12.87	3.91	256.85	1865.	6046.	0.	2198.	1486.	1399.	875.	903.
APR	10.94	14.48	7.18	247.96	1680.	3331.	0.	1392.	1039.	988.	554.	570.
MAY	15.64	12.87	11.46	234.02	1568.	1651.	1765.	1196.	974.	796.	389.	389.
JUN	20.19	12.87	15.38	223.71	1368.	0.	3179.	923.	986.	783.	211.	211.
JUL	23.93	12.87	18.10	228.00	1307.	0.	4877.	1196.	1219.	907.	737.	242.
AUG	22.20	11.26	18.72	220.79	1283.	0.	4584.	1140.	1172.	879.	849.	233.
SEP	17.34	11.26	17.16	226.88	1301.	1016.	2358.	1046.	908.	717.	447.	329.
OCT	10.22	11.26	13.75	243.05	1478.	3445.	0.	1368.	978.	926.	481.	517.
NOV	2.51	9.65	9.59	257.27	1589.	7857.	0.	2624.	1758.	1646.	937.	1039.
DEC	-0.82	8.05	5.56	261.54	1800.	10788.	0.	3497.	2413.	2258.	1370.	1418.
ANNUAL	10.55	11.26	10.51		18882.	54046.	16764.	23124.	17630.	15710.	9478.	8508.
ANNUAL COP								1.08	1.41	1.59	2.63	2.93

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 17 P(M2)= 41	2950.	1761.	2290.	530.	240.	1074.	518.	9363.
5	FULL,BR.CHILL, BIN(M3)= 56 P(M2)= 13	2950.	3129.	1212.	530.	240.	1074.	518.	9653.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	369.98	REF.	REF.	REF.	6073.	9551.	1
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	282.08	87.90	2.4	1	4630.	9555.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	251.35	118.63	6.3	2	4126.	9838.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 17	1929.	151.65	218.33	30.5	4	2489.	13782.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 56	1929.	136.13	233.85	29.7	3	2234.	13817.	5

SEATTLE, WASHINGTON

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0113
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 7817.
COOLING = 3516.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 1698.

AIR TEMP: OUTDOOR INDOOR
WINTER = -5 C 21 C
SUMMER = 28 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	3.87	12.87	4.94	260.73	1824.	7980.	0.	2724.	1816.	1682.	1109.	1109.
FEB	5.96	12.87	4.86	256.00	1651.	5540.	0.	1998.	1324.	1231.	813.	810.
MAR	6.38	14.48	6.21	258.30	1774.	5616.	0.	2053.	1366.	1272.	827.	825.
APR	9.17	12.87	8.61	248.69	1626.	3789.	0.	1504.	1043.	978.	606.	605.
MAY	12.01	12.87	11.56	242.27	1564.	2746.	624.	1304.	940.	877.	494.	493.
JUN	15.25	12.87	14.09	234.90	1418.	1445.	1243.	1008.	808.	750.	341.	341.
JUL	17.71	11.26	15.67	226.04	1403.	778.	2266.	993.	884.	709.	280.	280.
AUG	17.38	11.26	15.77	226.80	1399.	763.	1937.	932.	825.	671.	271.	271.
SEP	14.61	11.26	14.42	233.09	1405.	1519.	894.	965.	758.	708.	304.	303.
OCT	10.72	11.26	11.92	241.92	1550.	2996.	0.	1263.	887.	835.	467.	463.
NOV	6.30	11.26	9.07	251.94	1609.	5592.	0.	2000.	1309.	1214.	796.	793.
DEC	4.59	12.87	6.47	259.09	1764.	7460.	0.	2562.	1690.	1564.	1039.	1039.
ANNUAL	10.33	12.34	10.30		18986.	46226.	6963.	19306.	13650.	12491.	7346.	7331.
ANNUAL COP								1.04	1.47	1.61	2.72	2.73

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	250.	930.	40.	160.	200.	688.	392.	2660.
2	HEAT PUMP WITH ELECTRIC HOT WATER	250.	1080.	29.	178.	200.	714.	392.	2843.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	250.	1080.	29.	578.	240.	714.	492.	3383.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 12 P(M2)= 15	2650.	1351.	1295.	480.	240.	889.	434.	7339.
5	FULL,BR.CHILL, BIN(M3)= 12 P(M2)= 15	2650.	1351.	1295.	480.	240.	889.	434.	7339.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	217.77	REF.	REF.	REF.	3574.	7010.	1
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	153.97	63.80	2.9	1	2527.	7380.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	140.89	76.87	9.4	2	2313.	7953.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 12	1929.	82.86	134.90	34.7	3	1360.	10628.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 12	1929.	82.86	134.90	34.7	4	1360.	10628.	5

SPOKANE, WASHINGTON

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0158
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 13782.
COOLING = 4702.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 2971.

AIR TEMP: OUTDOOR INDOOR
WINTER = -20 C 21 C
SUMMER = 31 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS					SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (1.7M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-3.52	12.87	3.56	277.49	1879.	13375.	0.	4238.	3217.	3038.	1697.	1697.
FEB	-0.33	14.48	2.33	273.55	1740.	9563.	0.	3140.	2212.	2074.	1254.	1258.
MAR	2.51	14.48	2.54	267.11	1918.	8107.	0.	2785.	1894.	1777.	1107.	1110.
APR	7.76	14.48	4.25	255.18	1792.	4642.	0.	1787.	1230.	1162.	709.	711.
MAY	12.29	12.87	7.09	241.61	1740.	2739.	923.	1402.	1044.	983.	512.	513.
JUN	16.66	12.87	10.15	231.72	1567.	1145.	1895.	1077.	920.	754.	329.	329.
JUL	20.98	12.87	12.77	221.90	1517.	0.	3707.	1055.	1112.	875.	238.	238.
AUG	19.64	12.87	14.12	224.95	1464.	0.	3116.	939.	1016.	817.	493.	311.
SEP	15.07	12.87	13.87	235.33	1426.	1608.	1472.	1094.	878.	821.	318.	318.
OCT	8.16	12.87	12.07	251.00	1544.	4490.	0.	1676.	1136.	1070.	586.	589.
NOV	0.88	12.87	9.30	267.53	1600.	9389.	0.	3053.	2079.	1944.	1088.	1116.
DEC	-1.50	12.87	6.15	272.92	1777.	12069.	0.	3847.	2705.	2535.	1480.	1493.
ANNUAL	8.22	13.27	8.18		19963.	67129.	11112.	26093.	19444.	17851.	9813.	9685.
ANNUAL COP								1.05	1.40	1.53	2.78	2.82

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 19 P(M2)= 54	3350.	1894.	2773.	550.	240.	1298.	518.	10613.
5	FULL,BR.CHILL, BIN(M3)= 26 P(M2)= 45	3350.	2164.	2463.	550.	240.	1288.	518.	10572.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	413.05	REF.	REF.	REF.	6780.	10258.	2
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	307.80	105.25	2.0	1	5052.	9977.	1
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	282.58	130.47	5.8	2	4638.	10351.	3
4	MIN. ACES, BR.CHILL, BIN (M3)= 19	1929.	155.34	257.70	30.7	4	2550.	15092.	5
5	FULL ACES, BR.CHILL, BIN (M3)= 26	1929.	153.31	259.74	30.3	3	2516.	15018.	4

CHARLESTON, WEST VIRGINIA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0346
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 10803.
COOLING = 5726.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.17
BLOWER CAPACITY (M3/H) = 2292.

AIR TEMP: OUTDOOR INDOOR
WINTER = -13 C 21 C
SUMMER = 32 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (0.5M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES ER.CHILL
JAN	1.49	12.87	3.88	266.14	1866.	9294.	0.	3100.	2223.	2087.	1270.	1270.
FEB	3.78	12.87	3.99	260.93	1681.	6832.	0.	2365.	1668.	1567.	986.	987.
MAR	6.46	14.48	6.52	258.12	1762.	5813.	0.	2104.	1469.	1382.	869.	907.
APR	13.58	12.87	10.72	238.69	1546.	2254.	1122.	1247.	959.	899.	447.	485.
MAY	18.16	11.26	15.69	225.03	1402.	879.	2256.	1019.	900.	721.	290.	290.
JUN	21.93	9.65	19.83	216.91	1199.	0.	3918.	1003.	1028.	778.	468.	210.
JUL	23.98	8.05	22.25	218.29	1144.	0.	5256.	1216.	1221.	921.	969.	234.
AUG	23.24	6.44	22.13	213.32	1149.	0.	4831.	1145.	1155.	852.	892.	225.
SEP	20.07	8.05	19.62	214.13	1207.	0.	3058.	858.	916.	721.	571.	288.
OCT	13.73	8.05	15.25	228.53	1419.	1963.	1113.	1130.	876.	820.	356.	420.
NOV	7.36	11.26	10.43	249.53	1557.	4893.	0.	1792.	1266.	1192.	677.	735.
DEC	3.32	11.26	6.20	258.69	1775.	7745.	0.	2645.	1863.	1749.	1066.	1102.
ANNUAL	13.09	10.59	13.04		17708.	39674.	21552.	19623.	15545.	13689.	8863.	7153.
ANNUAL COP								1.12	1.41	1.60	2.47	3.07

SYSTEMS FIRST COSTS

		COST, $							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS, INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN., BR.CHILL, BIN(M3)= 14 P(M2)= 13	2950.	1549.	1208.	530.	240.	1074.	518.	8069.
5	FULL, BR.CHILL, BIN(M3)= 77 P(M2)= 2	2950.	3693.	762.	530.	240.	1074.	518.	9767.

COMPARATIVE SYSTEMS COSTS

	NEW CONSTRUCTION ALTERNATIVES	MAINT. PRESENT WORTH	1ST YEAR POWER COST	1ST YEAR POWER SAVING	SIMPLE PAYBACK PERIOD	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH	LIFE CYCLE COST	LIFE CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	679.55	REF.	REF.	REF.	11154.	14632.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	538.33	141.22	1.5	1	8836.	13761.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	474.07	205.48	3.7	2	7781.	13494.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 14	1929.	306.92	372.63	14.4	3	5038.	15036.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 77	1929.	247.70	431.85	16.4	4	4066.	15762.	5

ELKINS, WEST VIRGINIA

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0384
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 12165.
COOLING = 4175.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.12
BLOWER CAPACITY (M3/H) = 2632.

AIR TEMP: OUTDOOR INDOOR
WINTER = -16 C 21 C
SUMMER = 29 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP	AVE WIND SPEED	INLET WATER TEMP	HEAT LOSS COEF.	WATER HEAT	SPACE HEAT	SPACE COOL	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
	C	KM/H	C (0.9M)	W/C	MJ	MJ	MJ					
JAN	-0.99	11.26	2.89	268.47	1905.	11062.	0.	3602.	2806.	2644.	1461.	1461.
FEB	1.26	12.87	2.39	266.65	1738.	8530.	0.	2852.	2146.	2022.	1167.	1174.
MAR	3.73	12.87	3.83	261.05	1868.	7501.	0.	2603.	1865.	1755.	1059.	1078.
APR	10.19	11.26	6.85	243.11	1693.	3681.	0.	1493.	1168.	1108.	606.	617.
MAY	14.85	9.65	10.81	229.26	1594.	1789.	1471.	1191.	957.	897.	403.	402.
JUN	18.61	8.05	14.43	217.45	1405.	671.	2684.	1035.	944.	745.	277.	277.
JUL	20.70	8.05	16.93	212.72	1353.	0.	3584.	988.	1022.	793.	443.	219.
AUG	19.93	8.05	17.49	214.46	1331.	0.	3137.	906.	952.	751.	586.	207.
SEP	16.42	8.05	16.04	222.42	1343.	1216.	1978.	1049.	888.	714.	379.	306.
OCT	9.94	9.65	12.88	240.40	1512.	3742.	0.	1460.	1106.	1046.	528.	545.
NOV	4.63	11.26	9.04	255.72	1609.	6621.	0.	2287.	1644.	1546.	838.	875.
DEC	0.15	11.26	5.33	265.89	1809.	10136.	0.	3318.	2518.	2370.	1311.	1322.
ANNUAL	9.95	10.19	9.91		19160.	54951.	12854.	22784.	18016.	16392.	9058.	8484.
ANNUAL COP								1.06	1.34	1.47	2.67	2.85

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 16 P(M2)= 22	2950.	1705.	1564.	530.	240.	1074.	518.	8581.
5	FULL,BR.CHILL, BIN(M3)= 36 P(M2)= 15	2950.	2468.	1263.	530.	240.	1074.	518.	9043.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	876.06	REF.	REF.	REF.	14379.	17858.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	692.70	183.36	1.2	1	11370.	16295.	3
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	630.25	245.81	3.1	2	10345.	16057.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 16	1929.	348.29	527.77	11.1	3	5717.	16227.	2
5	FULL ACES, BR.CHILL, BIN (M3)= 36	1929.	326.20	549.86	11.5	4	5354.	16327.	4

GREEN BAY, WISCONSIN

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0414
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 15475.
COOLING = 4683.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.14
BLOWER CAPACITY (M3/H) = 3311.

AIR TEMP: OUTDOOR INDOOR
WINTER = -24 C 21 C
SUMMER = 29 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (2.9M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES ER.CHILL
JAN	-8.24	17.70	5.28	298.05	1811.	18314.	0.	5591.	4949.	4802.	2210.	2210.
FEB	-6.23	17.70	3.42	293.47	1702.	14449.	0.	4487.	3812.	3668.	1776.	1777.
MAR	-2.21	19.31	2.26	287.64	1929.	12518.	0.	4014.	3115.	2949.	1586.	1587.
APR	6.47	19.31	2.35	267.94	1864.	5999.	0.	2184.	1525.	1443.	862.	862.
MAY	12.22	17.70	3.65	251.62	1875.	3045.	799.	1503.	1111.	1053.	556.	556.
JUN	18.24	16.09	5.75	234.68	1735.	848.	2404.	1128.	1012.	825.	325.	325.
JUL	20.80	14.48	8.20	225.60	1696.	0.	3438.	1059.	1096.	876.	251.	251.
AUG	20.31	12.87	10.26	223.41	1615.	0.	3442.	1037.	1082.	862.	343.	344.
SEP	15.26	16.09	11.34	241.43	1522.	1655.	1373.	1117.	898.	846.	329.	329.
OCT	9.01	16.09	11.22	255.62	1578.	4359.	0.	1649.	1155.	1095.	567.	567.
NOV	0.99	19.31	9.93	280.38	1576.	10161.	0.	3261.	2386.	2251.	1132.	1134.
DEC	-5.02	17.70	7.75	290.74	1714.	15332.	0.	4735.	3914.	3771.	1819.	1820.
ANNUAL	6.80	17.03	6.78		20617.	86680.	11455.	31765.	26053.	24441.	11756.	11764.
ANNUAL COP								1.04	1.27	1.35	2.81	2.80

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	310.	930.	40.	213.	200.	688.	392.	2773.
2	HEAT PUMP WITH ELECTRIC HOT WATER	310.	1080.	58.	231.	200.	714.	392.	2985.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	310.	1080.	58.	631.	240.	714.	492.	3525.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 25 P(M2)= 133*	3350.	2216.	5835.	550.	240.	1288.	518.	13996.*
5	FULL,BR.CHILL, BIN(M3)= 27 P(M2)= 122*	3350.	2314.	5411.	550.	240.	1288.	518.	13670.*

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1315.06	REF.	REF.	REF.	21585.	25133.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	1078.61	236.44	0.9	1	17704.	22699.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	1011.86	303.20	2.5	2	16608.	22391.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 25	1929.	486.68	828.38	13.5	4	7988.	23914.*	4
5	FULL ACES, BR.CHILL, BIN (M3)= 27	1929.	487.04	828.02	13.2	3	7994.	23593.*	3

*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
POWER COSTS ($/KWH) = 0.0402
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 14973.
COOLING = 5167.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.16
BLOWER CAPACITY (M3/H) = 3226.

AIR TEMP: OUTDOOR INDOOR
WINTER = -23 C 21 C
SUMMER = 31 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (2.4M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-7.61	17.70	5.31	296.61	1810.	17585.	0.	5388.	4557.	4413.	2134.	2134.
FEB	-4.76	17.70	3.37	290.15	1703.	13379.	0.	4190.	3346.	3204.	1664.	1677.
MAR	-0.74	19.31	2.51	284.29	1920.	11395.	0.	3699.	2684.	2536.	1466.	1475.
APR	7.94	19.31	3.19	264.62	1832.	5203.	0.	1954.	1381.	1311.	773.	777.
MAY	14.42	17.70	5.25	246.63	1812.	2183.	1236.	1321.	1036.	982.	464.	464.
JUN	20.07	16.09	8.04	230.52	1648.	0.	2979.	967.	1038.	848.	236.	236.
JUL	22.34	12.87	10.95	224.39	1588.	0.	4306.	1177.	1197.	922.	395.	259.
AUG	21.67	14.48	13.10	226.16	1504.	0.	4056.	1111.	1141.	882.	756.	245.
SEP	16.74	14.48	13.89	234.79	1425.	1218.	1824.	1046.	882.	717.	352.	308.
OCT	10.23	16.09	13.15	252.85	1502.	3784.	0.	1468.	1066.	1014.	507.	513.
NOV	2.23	19.31	11.12	277.56	1530.	9087.	0.	2949.	2035.	1918.	1032.	1054.
DEC	-4.11	17.70	8.23	288.68	1695.	14625.	0.	4534.	3515.	3376.	1751.	1754.
ANNUAL	8.20	16.89	8.18		19968.	78457.	14401.	29803.	23878.	22122.	11529.	10896.
ANNUAL COP								1.05	1.31	1.42	2.72	2.88

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST,$ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 24 P(M2)= 93*	3350.	2155.	4291.	550.	240.	1288.	518.	12391.*
5	FULL,BR.CHILL, BIN(M3)= 44 P(M2)= 57	3350.	2863.	2908.	550.	240.	1288.	518.	11716.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERICD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	1197.50	REF.	REF.	REF.	19655.	23134.	5
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	959.41	238.08	0.9	1	15747.	20672.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	888.86	308.63	2.4	2	14589.	20302.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 24	1929.	463.23	734.27	13.2	4	7603.	21924.*	4
5	FULL ACES, BR.CHILL, BIN (M3)= 44	1929.	437.79	759.71	11.9	3	7186.	20831.*	3

*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
POWER COSTS ($/KWH) = 0.0272
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 14957.
COOLING = 4773.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 3226.

AIR TEMP: OUTDOOR INDOOR
WINTER = -23 C 21 C
SUMMER = 32 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (2.1M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-3.30	28.96	4.68	309.79	1835.	14530.	0.	4546.	3585.	3424.	1830.	1830.
FEB	-2.73	25.74	2.93	301.93	1719.	12192.	0.	3864.	3028.	2874.	1558.	1558.
MAR	-0.25	24.13	2.37	293.03	1925.	11116.	0.	3623.	2744.	2593.	1460.	1468.
APR	5.57	20.92	3.32	273.26	1827.	6658.	0.	2257.	1671.	1578.	950.	956.
MAY	12.06	19.31	5.59	255.25	1799.	3338.	1065.	1609.	1183.	1115.	593.	595.
JUN	18.50	19.31	8.45	240.64	1632.	1103.	2744.	1229.	1078.	858.	349.	349.
JUL	22.42	17.70	11.27	234.41	1575.	0.	4091.	1137.	1184.	923.	253.	253.
AUG	21.71	17.70	13.20	232.79	1500.	0.	3720.	1052.	1102.	864.	694.	237.
SEP	15.41	17.70	13.71	244.38	1432.	1977.	2023.	1293.	1036.	828.	390.	378.
OCT	8.83	20.92	12.68	265.86	1520.	4948.	0.	1797.	1314.	1241.	640.	647.
NOV	0.41	25.74	10.45	294.81	1556.	10506.	0.	3351.	2478.	2338.	1266.	1275.
DEC	-2.15	27.35	7.50	303.89	1724.	13571.	0.	4249.	3211.	3060.	1696.	1696.
ANNUAL	8.04	22.12	8.01		20043.	79938.	13642.	30106.	23614.	21697.	11680.	11241.
ANNUAL COP								1.05	1.34	1.45	2.70	2.81

SYSTEMS FIRST COSTS

NO.	CONVENTIONAL SYSTEMS	COST, $ FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS, INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN., BR.CHILL, BIN(M3)= 20 P(M2)= 23	3350.	1999.	1599.	550.	240.	1288.	518.	9543.
5	FULL, BR.CHILL, BIN(M3)= 36 P(M2)= 19	3350.	2590.	1442.	550.	240.	1288.	518.	9978.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	819.19	REF.	REF.	REF.	13446.	16924.	4
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	642.53	176.66	1.2	1	10546.	15471.	2
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	590.37	228.82	3.3	2	9690.	15403.	1
4	MIN. ACES, BR.CHILL, BIN (M3)= 20	1929.	317.82	501.36	13.6	3	5217.	16690.	3
5	FULL ACES, BR.CHILL, BIN (M3)= 36	1929.	305.86	513.33	14.2	4	5020.	16929.	5

CHEYENNE, WYOMING

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0258
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 14479.
COOLING = 4197.

COND. LOSS COEF. (W/C) = 159.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 3141.

AIR TEMP: OUTDOOR INDOOR
WINTER = -22 C 21 C
SUMMER = 30 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (2.0M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-3.53	22.53	4.39	297.19	1846.	14071.	0.	4422.	3543.	3380.	1780.	1780.
FEB	-1.54	24.13	2.80	295.96	1724.	11267.	0.	3609.	2815.	2663.	1465.	1465.
MAR	-0.38	24.13	2.34	293.31	1926.	11256.	0.	3662.	2761.	2609.	1484.	1486.
APR	5.27	22.53	3.32	277.23	1827.	6994.	0.	2450.	1747.	1651.	993.	995.
MAY	11.28	19.31	5.53	257.04	1801.	3585.	835.	1639.	1183.	1116.	621.	621.
JUN	17.15	17.70	8.25	240.43	1640.	1279.	2241.	1194.	1019.	826.	358.	353.
JUL	20.14	16.09	10.90	230.36	1590.	0.	3174.	984.	1048.	845.	234.	234.
AUG	19.69	16.09	12.66	231.38	1521.	0.	3051.	944.	1018.	823.	399.	312.
SEP	14.57	17.70	13.06	246.28	1457.	2190.	1796.	1320.	1034.	966.	385.	335.
OCT	8.81	17.70	12.01	259.35	1546.	4822.	0.	1769.	1297.	1226.	640.	642.
NOV	1.66	22.53	9.85	285.42	1579.	9371.	0.	3042.	2201.	2074.	1156.	1160.
DEC	-0.66	22.53	7.04	290.68	1742.	11676.	0.	3728.	2764.	2608.	1498.	1498.
ANNUAL	7.70	20.25	7.68		20198.	76512.	11097.	28762.	22432.	20786.	11015.	10937.
ANNUAL COP								1.04	1.34	1.44	2.72	2.74

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	280.	930.	40.	173.	200.	688.	392.	2703.
2	HEAT PUMP WITH ELECTRIC HOT WATER	280.	1080.	58.	191.	200.	714.	392.	2915.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	280.	1080.	58.	591.	240.	714.	492.	3455.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 20 P(M2)= 19	3350.	1956.	1421.	550.	240.	1288.	518.	9323.
5	FULL,BR.CHILL, BIN(M3)= 24 P(M2)= 18	3350.	2113.	1389.	550.	240.	1288.	518.	9447.

COMPARATIVE SYSTEMS COSTS

NO.	NEW CONSTRUCTION ALTERNATIVES SYSTEMS	MAINT. PRESENT WORTH $	1ST YEAR POWER COST $	1ST YEAR POWER SAVING $	SIMPLE PAYBACK PERIOD YEARS	SIMPLE PAYBACK RANKING	POWER PRESENT WORTH $	LIFE CYCLE COST $	LIFE CYCLE RANKING
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	742.36	REF.	REF.	REF.	12185.	15663.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	578.97	163.38	1.3	1	9503.	14428.	1
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	536.48	205.87	3.7	2	8806.	14519.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 20	1929.	284.29	458.07	14.5	3	4666.	15919.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 24	1929.	282.28	460.07	14.7	4	4633.	16010.	5

LANDER, WYOMING

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0272
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 16184.
COOLING = 4672.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 3481.

AIR TEMP: OUTDOOR INDOOR
WINTER = -26 C 21 C
SUMMER = 31 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA		BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP C	AVE WIND SPEED KM/H	INLET WATER TEMP C (2.7M)	HEAT LOSS COEF. W/C	WATER HEAT MJ	SPACE HEAT MJ	SPACE COOL MJ	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
JAN	-5.93	9.65	5.09	276.41	1818.	14107.	0.	4424.	3662.	3512.	1770.	1770.
FEB	-3.13	9.65	3.38	270.07	1703.	10512.	0.	3393.	2682.	2549.	1367.	1371.
MAR	-1.03	11.26	2.42	268.58	1923.	10074.	0.	3333.	2539.	2411.	1341.	1344.
APR	5.36	12.87	2.66	257.35	1852.	6014.	0.	2185.	1542.	1464.	881.	894.
MAY	11.24	12.87	4.06	244.01	1859.	3165.	798.	1532.	1132.	1076.	578.	579.
JUN	16.39	12.87	6.16	232.33	1719.	1265.	2007.	1172.	1002.	823.	360.	360.
JUL	20.90	12.87	8.51	222.09	1684.	0.	3412.	1051.	1093.	875.	249.	249.
AUG	20.34	12.87	10.40	223.35	1610.	0.	3313.	1013.	1062.	850.	431.	239.
SEP	14.75	11.26	11.30	232.77	1524.	1753.	1746.	1209.	980.	922.	347.	347.
OCT	8.11	9.65	11.01	244.56	1586.	4447.	0.	1676.	1226.	1166.	597.	600.
NOV	-0.39	9.65	9.63	263.83	1587.	9320.	0.	3030.	2284.	2166.	1075.	1080.
DEC	-4.29	9.65	7.45	272.70	1726.	12798.	0.	4035.	3199.	3056.	1573.	1573.
ANNUAL	6.86	11.26	6.84		20590.	73454.	11277.	28053.	22402.	20870.	10568.	10397.
ANNUAL COP								1.04	1.31	1.40	2.77	2.81

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	310.	930.	40.	213.	200.	688.	392.	2773.
2	HEAT PUMP WITH ELECTRIC HOT WATER	310.	1080.	58.	231.	200.	714.	392.	2985.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	310.	1080.	58.	631.	240.	714.	492.	3525.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 20 P(M2)= 28	3350.	2023.	1770.	550.	240.	1298.	518.	9739.
5	FULL,BR.CHILL, BIN(M3)= 24 P(M2)= 25	3350.	2218.	1666.	550.	240.	1298.	518.	9830.

COMPARATIVE SYSTEMS COSTS

		MAINT.	1ST YEAR	1ST YEAR	SIMPLE	SIMPLE	POWER	LIFE	LIFE
	NEW CONSTRUCTION ALTERNATIVES	PRESENT WORTH	POWER COST	POWER SAVING	PAYBACK PERIOD	PAYBACK RANKING	PRESENT WORTH	CYCLE COST	CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	763.31	REF.	REF.	REF.	12529.	16077.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	609.55	153.76	1.4	1	10005.	15000.	1
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	567.87	195.44	3.9	2	9321.	15103.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 20	1929.	287.56	475.75	14.6	3	4720.	16388.	4
5	FULL ACES, BR.CHILL, BIN (M3)= 24	1929.	282.90	480.42	14.7	4	4643.	16402.	5

SHERIDAN, WYOMING

167 SQ M HOME, WELL INSULATED
POWER COSTS ($/KWH) = 0.0247
PRESENT WORTH FACTOR= 16.41

DESIGN DAY LOADS (WATTS)
HEATING = 15682.
COOLING = 5031.

COND. LOSS COEF. (W/C) = 158.
COOLING (TOTAL/SEN.) = 1.00
BLOWER CAPACITY (M3/H) = 3396.

AIR TEMP: OUTDOOR INDOOR
WINTER = -25 C 21 C
SUMMER = 33 C 26 C

DESIGN AND PERFORMANCE

	WEATHER DATA			BUILDING PARAMETERS AND LOADS				SYSTEM ENERGY CONSUMPTION, KWH				
MONTH	AVE AIR TEMP	AVE WIND SPEED	INLET WATER TEMP	HEAT LOSS COEF.	WATER HEAT	SPACE HEAT	SPACE COOL	(1) ELEC. A/C I2R	(2) HEAT PUMP I2R	(3) HEAT PUMP D.S.	(4) MIN. ACES BR.CHILL	(5) FULL ACES BR.CHILL
	C	KM/H	C (2.3M)	W/C	MJ	MJ	MJ					
JAN	-5.00	12.87	4.72	280.86	1833.	14075.	0.	4419.	3629.	3472.	1751.	1778.
FEB	-3.18	12.87	2.98	276.74	1717.	11130.	0.	3569.	2841.	2695.	1412.	1435.
MAR	0.24	14.48	2.34	272.25	1926.	9751.	0.	3244.	2430.	2302.	1282.	1302.
APR	6.03	16.09	3.16	262.38	1833.	6004.	0.	2177.	1550.	1468.	861.	874.
MAY	12.47	14.48	5.27	244.50	1811.	2886.	1156.	1502.	1132.	1069.	539.	544.
JUN	17.84	14.48	7.98	232.30	1650.	1007.	2484.	1162.	1024.	826.	335.	335.
JUL	22.34	12.87	10.73	224.40	1597.	0.	4131.	1149.	1191.	927.	256.	256.
AUG	21.59	12.87	12.66	222.70	1521.	0.	3799.	1072.	1121.	878.	709.	241.
SEP	14.99	12.87	13.24	235.50	1450.	1961.	2018.	1292.	1038.	822.	339.	378.
OCT	8.58	12.87	12.35	250.05	1533.	4891.	0.	1785.	1284.	1215.	617.	644.
NOV	0.24	12.87	10.28	268.98	1562.	9922.	0.	3190.	2365.	2234.	1109.	1179.
DEC	-2.67	12.87	7.46	275.57	1725.	13735.	0.	4295.	3287.	3140.	1636.	1651.
ANNUAL	7.79	13.54	7.76		20159.	75364.	13589.	28858.	22892.	21057.	10896.	10615.
ANNUAL CCP								1.05	1.32	1.44	2.78	2.86

SYSTEMS FIRST COSTS

		COST,$							
NO.	CONVENTIONAL SYSTEMS	FAN UNIT	A/C, H.P.	CONTROL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
1	ELECTRIC HEAT, A/C, AND HOT WATER	310.	930.	40.	213.	200.	688.	392.	2773.
2	HEAT PUMP WITH ELECTRIC HOT WATER	310.	1080.	58.	231.	200.	714.	392.	2985.
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	310.	1080.	58.	631.	240.	714.	492.	3525.
	ACES SYSTEMS,INTEGRATED CONSTRUCTION	MECH. P.	ICE BIN	PANEL	AUXILIARY	W. HEATER	DUCTS	INSTALN.	SYSTEM
4	MIN.,BR.CHILL, BIN(M3)= 20 P(M2)= 95*	3350.	2003.	4386.	550.	240.	1288.	518.	12334.*
5	FULL,BR.CHILL, BIN(M3)= 35 P(M2)= 32	3350.	2598.	1946.	550.	240.	1288.	518.	10489.

COMPARATIVE SYSTEMS COSTS

		MAINT.	1ST YEAR	1ST YEAR	SIMPLE	SIMPLE	POWER	LIFE	LIFE
	NEW CONSTRUCTION ALTERNATIVES	PRESENT WORTH	POWER COST	POWER SAVING	PAYBACK PERIOD	PAYBACK RANKING	PRESENT WORTH	CYCLE COST	CYCLE RANKING
NO.	SYSTEMS	$	$	$	YEARS		$	$	
1	ELECTRIC HEAT, A/C, AND HOT WATER	776.	712.80	REF.	REF.	REF.	11700.	15248.	3
2	HEAT PUMP WITH ELECTRIC HOT WATER	2010.	565.44	147.37	1.4	1	9281.	14276.	1
3	HEAT PUMP WITH DESUPERHEATER HOT WATER	2257.	520.11	192.69	3.9	2	8537.	14319.	2
4	MIN. ACES, BR.CHILL, BIN (M3)= 20	1929.	269.12	443.68	21.6	4	4417.	18681.*	5
5	FULL ACES, BR.CHILL, BIN (M3)= 35	1929.	262.20	450.60	17.1	3	4304.	16722.*	4

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

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