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**ALTERNATIVES FOR REDUCING
HOT-WATER BILLS**

BEL 81-06

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TABLE OF CONTENTS

	<u>Page</u>
INTRODUCTION	1
A REFERENCE CASE	3
STAGE ONE: DOING THE EASY THINGS	5
A TALE OF FIVE CITIES	9
STAGE TWO: CONSIDER A BETTER WAY	11
Gas Water Heating	11
Solar Water Heating	11
Heat Pump Water Heater	17
Heat Recovery From Heat Pumps and Air Conditioners	19
COMPARISON OF STAGE II ALTERNATIVES	25
REFERENCES	33
APPENDIX A	A-1

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LIST OF FIGURES

<u>Number</u>		<u>Page</u>
1	Five Representative Cities in the MASEC Region	2
2	Representative Energy Use For Water Heating	3
3	Indirect/Antifreeze Solar Water Heater	13
4	Direct/Draindown Solar Water Heater	14
5	Heat Pump Water Heater	18
6	Typical Installation of An Air Conditioner (or Heat Pump) Water Heating Recovery Unit	20
7	Water Heating Costs Stages I and II Detroit, Michigan	27
8	Effect of Inflation on Stages I and II Costs Detroit, Michigan	28
9	Electric Water Heating Cost Detroit, Michigan	30
10	Solar Water Heating Costs Detroit, Michigan	31

LIST OF TABLES

<u>Number</u>		<u>Page</u>
I	Representative Water Heater Parameters	4
II	Stage I Water Heater Parameters	7
III	Effects Of Stage I Measures	8
IV	Solar Water Heater Design Parameters	15
V	Summary of Stage II Alternatives	26

INTRODUCTION

This study of "Alternatives for Reducing Water Heating Bills" has been funded by the Mid-American Solar Energy Complex (MASEC). The objective of the study is to examine the use of conservation and solar energy to decrease residential water heating bills.

A two stage approach to reducing residential water heating bills is described. In Stage I, simple conservation measures were included to reduce the daily hot water energy consumption and the energy losses from the water tank. Once these savings are achieved, Stage II considers more costly options for further reducing the water heating bill. Four alternatives are considered in Stage II:

- Gas Water Heaters
- Solar Water Heaters (two types)
- Heat Pump Water Heaters
- Heat Recovery from a Heat Pump or Air Conditioner

To account for variations within the MASEC region, the five "representative" cities shown in Figure 1 were examined in detail. The five cities were chosen to provide good coverage of: geography; major population centers; fuel prices; climate, and state solar incentives. Hopefully, the potential for reducing water heating bills described here will encourage families to do the simple things in Stage I and request cost and technical information tailored to their individual needs from local dealers for the alternatives in Stage II.

FIGURE 1
FIVE REPRESENTATIVE CITIES IN THE MASEC REGION

A REFERENCE CASE

To provide a basis for comparison with the alternatives presented in the later sections a representative set of reference values describing hot water heaters and hot water use are presented. The actual hot water use and water heater performance experienced by each household will likely be different but the relative merits of the alternatives should remain unchanged.

The "daily hot water energy consumption" represents the useful output of the water heater and is defined as the product of the daily hot water usage, temperature rise, and the density of water. The reference case is based on a hot water consumption of 450 gallons per week (64.3 gal/day) and a temperature rise of 90°F. A daily hot water energy consumption of 47,700 BTU is obtained by using the definition of one BTU as the energy needed to raise one pound of water one degree Fahrenheit and a nominal density of 8.25 pounds per gallon.

As shown in Figure 2 below, each unit of energy purchased for gas and electric water heating is divided among the useful output contained in the water actually used, the energy lost in converting from the input fuel to heated water, and the standby energy used to keep the water in the tank up to its desired temperature. The standby losses consist of the heat loss through the jacket of the tank and the flue, if one exists.

FIGURE 2
REPRESENTATIVE ENERGY USE FOR WATER HEATING

The water heater parameters used to estimate the reference energy use are given in Table I. The larger size of the electric resistance water heater compensates for its lower recovery rate. The conversion efficiency for the two units reflects the high end-use efficiency of converting electricity to heat. (However, electricity is a more expensive fuel, because of the energy intensive electric generating facilities used to produce the electricity.) The higher standby loss for the gas water heater reflect the industry practice of using less insulation on gas water heaters and the additional standby losses from the flue. The energy factor is a measure of the overall efficiency of the water heater and is equal to the ratio of the daily hot water energy consumption to the energy input of the water heater.⁽¹⁹⁾

TABLE I
REPRESENTATIVE WATER HEATER PARAMETERS

	SIZE (GAL)	CONVERSION EFFECIENCY %	STANDBY LOSS (BTU/DAY)	ENERGY FACTOR %
ELECTRIC RESISTANCE	52	100	5,900	89
GAS-FIRED	40	76	24,800	50

STAGE ONE: DOING THE EASY THINGS

There have been numerous reports recommending simple ways to reduce the hot water bill. A partial list of actions include:

- cold water laundry
- reducing the hot water temperature
- increased insulation of the hot water tank
- low flow shower heads and faucets
- insulation of the hot water pipes
- reducing the water pressure
- clock timer (for electric units)

Recent articles in Consumer Report⁽¹⁵⁾ and Solar Age⁽²⁰⁾ cite energy savings of 23 to 66% respectively through the use of steps such as these.

One of the simplest actions is to use less hot water in the laundry. Clothes washing consumes 42% of the hot water in the average household. A recent study by the Oak Ridge National Laboratory recommended that a warm wash and cold rinse combination provided the best balance between energy savings and clean clothes.⁽⁶⁾ The study also cited several surveys which indicated that the average wash of 5-6 pounds is being washed in a washer with a capacity of 12 pounds or more. A shift to a warm wash/cold rinse, when combined with fuller loads will save a major part of the 25 gallons of hot water used in each of the 34 washer loads run per month in the average home. The key point here is to experiment with cooler water temperatures and note any changes in color, texture or soap consumption.

A typical temperature setting for a water heater is 140-150°F. One of the major reasons for a temperature setting this high is to provide water hot enough for an automatic dishwasher. If the hot water temperature is too low the dishwasher will not adequately remove the grease from the dishes and utensils. The dishwasher is normally

the only use in the household for water this hot. The consensus in the appliance and water heating industry would favor a temperature setting of 135°F or higher. This ensures temperatures high enough for dishwashers and reduces the possibility of running out of hot water.

Setting the temperature back to as low as 120°F will provide significant energy savings by reducing the initial energy needed to heat the water as well as the standby losses from the tank while the hot water is being stored. In some cases, such as showers, the energy savings will be marginal since the user will adjust the hot/cold mixture to maintain the same comfort level. However, the standby losses will be reduced in any case. The degree of setback that is consistent with the appliances in each home will vary as will the possible effect on the family's lifestyle. A setback of 120°F is used for Stage I to highlight the potential for savings by this method. Check your dishwasher to see if it has a special cycle which heats the water up to the required temperature. If not, gradually reduce the hot water setting as much as you can. If you need to replace your dishwasher, look for a temperature booster feature that will allow a lower water temperature setting.

Most existing hot water heaters have inadequate tank insulation for today's energy prices. Your local hardware or lumber supplier has a do-it-yourself kit, costing approximately \$20, consisting of an insulation blanket which fits around your water heater tank. If you are more ambitious, you can use readily available materials to make a cheaper do-it-yourself job to provide even more insulation than the R-14 in the insulation kit typically provides. If you are doing it yourself, special care should be taken to assure that the facing on the insulation being used is not flammable.

Shower use is the biggest hot water user in many families. Low flow shower heads offer an excellent potential for reducing both energy and water use. In contrast to the previous measures, this requires some adaption on the part of the family members. The low flow devices have come a long way during the last few years. There is a wide variety of excellent low flow devices on the market for less than \$20. Most have a shut-off button to allow full flow for washing hair and lathering up. Try it, you've only got money to save!

Other measures that will further reduce demand are to insulate the hot water pipes, reduce the water pressure (and hence the flow for all uses), and to use a clock timer for electric water heaters. Each of these options will save money eventually, but to a lesser extent the previous examples.

By implementing all three Stage I measures, the following water heater parameters are achieved:

TABLE II
STAGE I WATER HEATER PARAMETERS

	SIZE (GAL)	CONVERSION EFFECIENCY %	STANDBY LOSS (BTU/DAY)	ENERGY FACTOR %
ELECTRIC RESISTANCE	52	100	1,500	95
GAS-FIRED	40	76	10,600	57

A water main temperature of 50°F, the average for the cities analyzed in the next section, was assumed along with the DOE "representative fuel prices" that were in effect April 13, 1981: electricity at \$0.0564/kWh (3412 Btu/kWh); natural gas at \$0.426/therm (100,000 Btu/therm); and No. 2 fuel oil at \$1.24/gallon (138,600 Btu/gal). These prices are used to provide the estimates of annual operating cost for the labels on hot water heaters. The analysis of the individual cities will use the prices from the current rate schedules for each city.

The annual water heating bills presented in Table III compare the reference case with the annual bills resulting from each of the first three improvements discussed. These improvements are cheap, easy to do, and do not effect family members.

**TABLE III
EFFECTS OF STAGE I MEASURES**

	STAGE I MEASURES			
	Reference Case	Step 1	Step 2	Step 3
STAGE I MEASURES INCLUDED: Reduce water use to 55.7 GPD 120° temperature setting Add tank insulation		✓	✓ ✓	✓ ✓ ✓
DAILY HOT WATER ENERGY CONSUMPTION (BTU/DAY)	47,700	41,400	32,200	32,200
ENERGY PURCHASED (BTU/DAY)				
Electric Resistance	55,500	48,100	36,400	33,700
Gas	95,500	82,700	62,300	56,300
ANNUAL WATER HEATING BILL				
Electric Resistance	\$340	\$290	\$220	\$200
Gas	\$150	\$130	\$100	\$90

A TALE OF FIVE CITIES

To provide a rough indication of how these Stage I results will vary in the Mid-American region, five representative cities were selected:

- Chicago, Illinois
- Detroit, Michigan
- Kansas City, Missouri
- Minneapolis, Minnesota
- Rapid City, South Dakota

For each city, electric and gas prices were obtained from the SOLCOST data base as of May 1980⁽¹⁶⁾ and used with estimates of the average groundwater temperatures to estimate 1981 water heating bills for each of the cities. The Stage I reductions are impressive, although they vary by city and will depend on the actual measures taken by each family. The truly amazing thing is that many people are still wasting \$50-\$100 per year through inaction.

	Groundwater Temperature	Useful Output* (MMBtu/YR)	GAS Fuel Price (\$/MMBtu)	1981 Bill	ELECTRIC Fuel Price (\$/MMBtu)	1981 Bill
Chicago	50	11.7	3.40	70	19.20	237
Detroit	50	11.7	4.10	84	17.70	218
Kansas City	57	10.6	3.00	56	16.20	180
Minneapolis	42	13.1	3.30	76	14.80	204
Rapid City	47	12.2	3.00	64	13.00	168

*Useful output per year is calculated from the daily hot water energy consumption with a temperature set of 120°F and 55.7 gal/day usage. Stage I water heater parameters are assumed in estimating 1981 water heating bills.

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STAGE TWO: CONSIDER A BETTER WAY

For the current family with a gas water heater, Stage I will get them very close to the point where further improvements are no longer urgent. However, the owner of an electric water heater has several alternatives which need careful consideration. The following four alternatives will be analyzed:

- Convert to a gas-fired water heater
- Use solar energy
- Add a heat pump water heater
- Use heat recovery from a central air conditioner or heat pump

Gas Water Heating

Although gas hook-ups are not available everywhere, gas is the predominate water heating fuel in many parts of the country. However, many existing homes with gas hook-ups have an electric water heater. This situation has resulted from builders' preferences for lower equipment cost and ease of installation.

Many of the newer gas models are available with increased insulation and other energy saving features. An estimated installed cost of \$500 is used for a 40 gallon gas-fired water heater having R-20 insulation. This cost consists of roughly \$300 for the water heater and the remainder for the installation. The actual installation cost is dependent on the ease of venting the unit and hooking up the gas.

Solar Water Heating

Two solar water heating designs are used:

- Direct/draindown
- Indirect/antifreeze

Figures 3 and 4 provide a schematic of the two system designs and the design parameters are summarized in Table IV. The direct/draindown system heats plain water "directly" in the collectors which then flows to the storage tank for use. To protect against freezing, the water in the collectors are "drained down" by gravity flow when the collector pump is not being used.

The indirect/antifreeze system design uses a closed loop for the collector fluid which typically contains a non-freezing fluid and corrosion inhibitors. The domestic water is heated indirectly with a heat exchanger connected to the collector loop.

The direct/draindown system is typically simpler and cheaper than an indirect/antifreeze design. However, the use of tap water in areas with hard or acidic water supply can seriously damage the collectors. The indirect systems provide a straightforward method of freeze protection and a stable operating environment for the collectors, but require a more complicated and costly design.

Both designs use an auxiliary storage tank in addition to an existing water heater. Although this increases the standby losses it is a very common design used to "retrofit" existing applications. For new or replacement applications a single tank design, with lower standby losses, should be strongly considered. The information in "Hot Water From The Sun," available from the Department of Housing and Urban Development, provide many helpful suggestions on selecting a local dealer and in understanding some of the finer points in selecting a system.⁽¹¹⁾

FIGURE 3
INDIRECT/ANTIFREEZE SOLAR WATER HEATER

SOURCE: SAI, Reference 4.

FIGURE 4
DIRECT/DRAINDOWN SOLAR WATER HEATER

SOURCE: SAI, Reference 4.

TABLE IV
SOLAR WATER HEATER DESIGN PARAMETERS

	Direct Draindown	Indirect Antifreeze
PERFORMANCE PARAMETERS		
Collector		
Gross Area per Collector (ft ²)	19.5	18.6
Number of Collectors per System	3	3
Number of Covers	1	1
Cover Transmissivity	0.90	0.91
Absorber Plate Absorptivity	0.95	0.95
Intercept $F_R (\tau\alpha)$	0.727	0.718
Slope F_R	0.958	0.849
Flow Factor (F_R)	0.845	0.835
Top Loss Coefficient	1.13	1.02
PUMP		
Power Requirement	76W.	98W.
STORAGE		
Storage Tank Size (Gallons)	82	82
Height/Diameter Ratio	1.7	1.7
Jacket Insulation	20*	20*
ECONOMIC PARAMETERS		
Cost		
Collector	440	300
(Per Module) (\$)		
System (\$)	2040	2652
Installation (\$)	500	400
Total Installed System (\$)	2540	3052

*The tank insulation has been upgraded to R-20 from the original design in Reference 3.

SOURCE: SAI, Reference 3

The federal and state tax credits have a dramatic effect on the net cost of purchasing a solar water heater. The current federal tax credit provides a credit of 40% of the first \$10,000 spent on a solar water heater. The federal tax credit is scheduled to end after 1985. In addition to the federal credits, many states provide additional tax subsidies for solar purchases. The current state tax credits for the five cities are given below:

STATE TAX CREDITS CURRENTLY AVAILABLE⁽¹²⁾

Chicago, IL	None
Detroit, MI	25% on first \$2,000 and 15% the next \$8,000
Kansas City, MO	None
Minneapolis, MN	20% on first \$2,000 (Expires 12/31/81)
Rapid City, SD	None

The energy savings and annual costs were estimated using the FCHART (4.0) solar design program for each of the five cities.⁽⁸⁾ Although field test data is available for solar water heaters, the variety and rapid rate of product improvement make it very difficult to obtain performance data directly applicable to new locations and designs.^(1,2) FCHART is a widely used and tested solar design program developed by the University of Wisconsin which provides a flexible means of estimating cost and performance for a wide variety of solar designs in over 200 locations in the United States. The detailed list of assumptions and the computer analyses are presented in Appendix A.

An economic analysis of each case was included in the FCHART output to assess the ten-year trends in increasing fuel costs and the effects of financing the purchase. A 10% inflation rate was assumed with an additional real increase of 3% per year in electric prices and 4.5% per year in gas prices. The fuel price increases are based on the American Gas Association's TERA model and incorporate the enactment of the Natural Gas Policy Act of 1978 which provides for phased new gas deregulation by

1985.⁽¹⁸⁾ These estimates for gas price escalation will probably be somewhat conservative if deregulation is accelerated, however, they provide a reasonable projection at this time. The economic analysis assumes financing of the total price of the solar system with 10% down payment and a 36-month loan at an interest rate of 18% per annum. The federal and state income tax credits appear as a tax saving.

Heat Pump Water Heater

Although heat pumps are widely used for space heating, the heat pump water heater is a relatively new product. There are currently at least five companies marketing heat pumps:

- Energy Utilization Systems, Pittsburgh, PA
- E-TECH, Atlanta, GA
- Fedders, Edison, NJ
- Northrup, Incorporated, Hutchins, TX
- The Oregon Water Heater Company, Progress, OR

Figure 5 contains a basic schematic for a heat pump water heater. The water is gradually heated by recirculating the cooler water from the bottom water heater tank through the heat exchanger in the heat pump and returning the warmer water to the top of the tank. Since the heat pump is primarily moving heat, rather than creating it, this method of water heating offers significant savings over a conventional electric water heater when installed in an unheated area. Depending on the air temperature, humidity and incoming water temperature, the coefficient of the performance (COP) is claimed to range from 1.85 to 3.17.^(9,17,21) The design by Energy Utilization Systems, Incorporated (EUS) integrates the heat pump unit on the top of the storage tank. This system is available in three sizes (50, 66 and 82 gallons) and has a retail price of approximately \$1,100.⁽¹⁷⁾ The E-TECH, Fedders, and Oregon Water Heater are designed as additions to a conventional electric water heater. The system is typically attached

FIGURE 5
HEAT PUMP WATER HEATER

SOURCE: Fedders Corporation, Reference 9.

by replacing the pressure/temperature valve and drain faucet with new fittings. These systems can be expected to retail for approximately \$800 (without a new tank).^(9,21)

Much of the interest in heat pump water heating has been spurred by a Department of Energy program to develop and field test the units.^(10,13) The Department of Energy sponsored a demonstration program in 1979 with 20 utilities to install and monitor heat pump water heaters in 100 homes.⁽⁵⁾ More recently, EUS reports that it has had seventy-five utilities participate in a field demonstration of 225 units, with some demonstrations as long as 18 months.

Data from the first year of a 2-year field test being conducted by the Tennessee Valley Authority (TVA) showed energy savings of 46% for the EUS TEMCOR system and 57% for the E-TECH systems.⁽¹⁰⁾ The TVA experience has been that other than minor design problems that the manufacturers are addressing, both designs were reliable.

Field test data provided by EUS reports average energy savings of 50-57%. The five examples cited for the mid-west also had the same range of savings.

A heat pump water heater costing \$820 (includes \$20 tank insulation kit) with an annual COP of 2.3 will be used for estimating the 1981 water heating bills in Stage II. It should be noted that the design goals of the DOE program are to eventually obtain an average COP approaching 3.0 for systems in residential use.

Heat Recovery From Heat Pumps and Air Conditioners

A typical heat recovery unit for use with a heat pump or air conditioner is shown in Figure 6. A small pump circulates the water from the storage tank through a heat exchanger where it is heated by the heat rejected by the compressor. The circulating pump is normally activated wherever the compressor is operating. The flow is controlled to avoid imposing off-design operating conditions on the air conditioner or heat pump.

FIGURE 6
TYPICAL INSTALLATION OF AN AIR CONDITIONER
(OR HEAT PUMP) WATER HEATING RECOVERY UNIT

SOURCE: EPRI, Reference 4.

A recent study by the Electric Power Research Institute (EPRI) identified ten manufacturers of heat recovery units.⁽⁴⁾ The EPRI study also provided a set of approximate estimates of the maximum potential savings for 13 cities. These savings estimates are based on energy use (excluding standby losses) of 16 MMBtu/yr (4,685 kWh) and assume that the recovered heat can always be used for water heating. With the Stage I energy use of roughly 12 MMBtu/yr it is questionable whether all of the heat recovered could be used. Comments provided by one reviewer indicated that realistic estimates of the operating periods for heat recovery would be roughly half of the maximum potential assumed in the EPRI study. The estimates of maximum potential savings for the cities in the MASEC region, based upon the EPRI study, are given below:

**MAXIMUM POTENTIAL SAVINGS
(kWh/Year)**

	<u>With 2 1/2 ton AC</u>	<u>With 2 1/2 Heat Pump</u>
Chicago	1257	2429
Bismark	960	2130
Omaha	1589	2576

SOURCE: EPRI, Reference 4

There is little field test data available for heat recovery units in residential applications. However, the Arizona Public Service and Alabama Power Company have tests underway.

The U.S. Department of Housing and Urban Development (HUD) built an "Energy Efficient Residence" and a "Conventional Comparison House" to collect research data on energy conservation techniques.⁽⁷⁾ The conservation measures to reduce the water heating bill were:

- Heavily insulated water heater
- Temperature setting of 120°F
- Front loading clothes washer
- Energy saving dishwasher
- Low flow devices in the bathroom and kitchen
- Insulated piping
- Heat recovery unit on the heat pump

These measures closely parallel the Stage I recommendations plus a heat recovery unit. When combined with the conservation measures for heating, cooling and appliances, the total energy use for the year beginning February 1, 1978 showed a 54% and 32% reduction for the heating and cooling seasons respectively. The savings for the hot water are shown below:

	ENERGY SAVINGS			
	(kWh)			
	<u>Heating</u>		<u>Cooling</u>	
	<u>Season</u>		<u>Season</u>	
Hot Water Heating	2396	(47%) *	1209	(55%) *
Dishwasher	-54	(-60%)	-38	(-64%)
Clothes Washer	39	(51%)	18	(45%)
TOTAL	2381	(45%)	1189	(52%)

* The percentage savings are measured relative to the Conventional Comparison House. The total is not the sum of the individual elements.

Source: HUD Reference 7.

Note that the savings attributable to the water heater are partially offset by the heater in the dishwasher. The savings cited for the clothes washer does not include the effect of change in hot water temperature or use. Unfortunately the summary data does not disaggregate the savings attributed to the heat recovery unit.

A detailed analysis well beyond the scope of this study would be needed to provide an estimate for heat recovery units comparable to the other alternatives. Due to this lack of data, a quantitative comparison will not be attempted.

However, the HUD research is an encouraging example for the use of heat recovery and conservation to reduce water heating costs. Interested consumers should consult local dealers for specific cost and technical information.

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COMPARISON OF STAGE II ALTERNATIVES

Table V summarizes 1981 water heating bills and net investment for a conventional electric water heater with the Stage I measures and the gas, solar, and heat pump water heaters from Stage II.

If the primary consideration is to minimize the fuel bill and isolate the cost of water heating from further price increases, then gas and solar can reduce the 1981 bill to less than \$50 in two of the cities.

The use of gas, solar or heat pumps are all likely to result in lower fuel bills for the next 5 years based on the assumptions used for the economic analysis. Figure 7 compares the estimates of the fuel bills for Detroit, Michigan. The choice among these alternatives depends on your estimates of the relative rates of increase on the prices of gas and electricity, and the cost, performance, and reliability of each water heater type.

A word of caution is in order at this point. The events of the past several years have been replete with unfulfilled forecasts. Changes in energy prices have seldom been as gradual or predictable as those used in the economic models. For example, the assumption of an annual price increase of 14.5%/year for natural gas is based on a gradual deregulation by 1985. The exact nature of the change in residential price increases will vary widely based on state regulation, long-term contracts by gas utilities, and many other factors. Figure 8 illustrates the impact of a 5% variation in the annual rate of the price of electricity and gas for Detroit, Michigan. The savings of Stage II remains below the 1981 estimate for Stage I until past 1986 in the most pessimistic case shown.

The combination of federal and state tax incentives make solar water heating a very appealing alternative in several states. The credits in Michigan and Minnesota when combined with the federal credits reduce the installed cost of \$2540-\$3050 to as

TABLE V
SUMMARY OF STAGE II ALTERNATIVES*

	STAGE I		STAGE II					
	CONVENTIONAL ELECTRIC		GAS		SOLAR		HEAT PUMP	
	NET INVESTMENT	1981 BILL	NET INVESTMENT	1981 BILL	NET** INVESTMENT	1981 BILL	NET INVESTMENT	1981 BILL***
Chicago	20	237	500	70	1500-1800	78	800-1100	103
Detroit	20	218	500	84	900-1200	81	800-1100	95
Kansas City	20	180	500	56	1500-1800	42	800-1100	78
Minneapolis	20	204	500	76	1000-1200	77	800-1100	89
Rapid City	20	168	500	64	1500-1800	46	800-1000	73

*These estimates are for general comparison. Consult your local dealers for specific estimates tailored to your individual case.

**The net investment for the solar water heaters incorporates the reduced cost due to federal and state tax incentives. The 1981 Bill is the average of the two systems evaluated for each city.

***Based on an annual average COP of 2.3.

FIGURE 7
WATER HEATING COSTS STAGES I AND II
DETROIT, MICHIGAN

*Gas, solar, heat pump.

FIGURE 8
EFFECT OF INFLATION ON STAGES I AND II COSTS
DETROIT, MICHIGAN

low as \$900. This may be one of the few cases where the homeowner can actually get something from the government!

Once the tax refund is received the homeowner actually has a cash surplus over most of the first two years. A possible alternative to accelerate the effect of the federal refund would be to estimate the 1981 federal income tax and to reduce the amount of withholding. In some cases this could result in an additional \$60-100 per month in disposable income. Figures 9 and 10 compare the net annual cost for conventional electric and solar water heaters in Detroit, Michigan.

FIGURE 9

ELECTRIC WATER HEATING COST
DETROIT, MICHIGAN

FIGURE 10
DIRECT/DRAINDOWN SOLAR WATER HEATING COSTS
DETROIT, MICHIGAN

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APPENDIX A

FCHART PARAMETERS FOR DIRECT/DRAINDOWN SOLAR WATER HEATER
EXAMPLE FOR DETROIT, MI

COLLECTOR PARAMETERS

C1. COLLECTOR AREA	58.50	FT2
C2. FR-UL PRODUCT	1.00	BTU/HR-FT2-DEG F
C3. FR-TAU-ALPHA (NORMAL INCIDENCE)	.73	
C6. NUMBER OF COVERS	1.00	
C7. INDEX OF REFRACTION	1.53	
C8. EXTINCTION COEFFICIENT X LENGTH (KL).....	.04	
C9. INCIDENCE ANGLE MODIFIER CONSTANT	0.00	
C10. COLLECTOR FLOW RATE * SPECIFIC HEAT/AREA	16.50	BTU/HR-FT2-DEG F
C12. COLLECTOR SLOPE	57.00	DEGREES
C13. COLLECTOR AZIMUTH	0.00	DEGREES
C14. GROUND REFLECTANCE	.20	

COLLECTOR-STORE TRANSFER PARAMETERS

T2. UA OF COLLECTOR INLET PIPE OR DUCT	1.70	BTU/HR-DEG F
T3. UA OF COLLECTOR OUTLET PIPE OR DUCT	1.70	BTU/HR-DEG F

STORAGE UNIT PARAMETERS

S1. TANK CAPACITY/COLLECTOR AREA	16.50	BTU/DEG F-FT2
S2. STORAGE UNIT HEIGHT/DIAMETER RATIO	2.00	
S3. HEAT LOSS COEFFICIENT	.05	BTU/HR-FT2-DEG F
S4. ENVIRONMENT TEMPERATURE (-1000 FOR TENV=TAMB) ..	70.00	DEG F
S5. HOT WATER AUXILIARY TANK UA	1.27	BTU/HR-DEG F
S6. HOT WATER AUX TANK ENVIRONMENT TEMPERATURE	70.00	DEG F

LOAD PARAMETERS

L3. HOT WATER USE	55.70	GALLONS/DAY
L4. HOT WATER SET TEMPERATURE	120.00	DEG F
L5. WATER MAINS TEMPERATURE	50.00	DEG F

AUXILIARY PARAMETERS

A3. HOT WATER AUXILIARY FUEL (1=GAS,2=ELEC,3=OIL) ..	2.	
A4. AUXILIARY WATER HEATER EFFICIENCY	1.00	

FCHART PARAMETERS FOR DIRECT/DRAINDOWN SOLAR WATER HEATER
EXAMPLE FOR DETROIT, MI

ECONOMIC PARAMETERS

E1. ECONOMIC OUTPUT DETAIL (1,2 OR 3)	3.00	
E2. REFERENCE OR COMPARISON SYSTEM (1 OR 2)	1.00	
E3. CALCULATE RATE OF RETURN (YES=1,NO=2)	2.00	
E4. INCCME PRODUCING BUILDING (YES=1,2=NO)	2.00	
E5. DEPRC: STR,LN.=1,DC.BAL.=2,SM-YR-DGT=3,NONE=4 ..	1.00	
E6. CONSIDER FEDERAL TAX CREDITS (YES=1,2=NO)	1.00	
E7. LENGTH OF ANALYSIS	10.00	YEARS
E8. TAX CREDITABLE SYSTEM BASE COST	\$ 2540.00	
E9. NON-TAX CREDITABLE SYSTEM BASE COST	\$ 0.00	
E10. ANNUAL INCREASE IN PURCHASED ENERGY DEMAND	0.00	%/YR
E11. TERM OF MORTGAGE	3.00	YEARS
E12. DOWN PAYMENT (% OF ORIGINAL INVESTMENT)	10.00	%
E13. MORTGAGE ANNUAL INTEREST RATE	18.00	%
E14. RESALE VALUE (% OF ORIGINAL INVESTMENT)	0.00	%
E15. ANNUAL NOMINAL (MARKET) DISCOUNT RATE	20.00	%
E16. EXTRA INSUR.,MAINT. IN YEAR 1 (% OF ORIG.INV.)	1.00	%
E17. ANNUAL % INCREASE IN ABOVE EXPENSES	10.00	%
E18. EFFECTIVE FEDERAL-STATE INCOME TAX RATE	35.00	%
E19. TRUE PROP. TAX RATE PER \$ OF ORIGINAL INVEST ..	0.00	%
E20. ANNUAL % INCREASE IN PROPERTY TAX RATE	0.00	%/YR
E21. STATE CREDIT IN TIER ONE.....	25.00	%
E22. STATE CREDIT TIER ONE BREAK.....	\$ 2000.00	
E23. STATE CREDIT IN TIER TWO.....	15.00	%
E24. STATE CREDIT TIER TWO BREAK.....	\$ 8000.00	
E25. USEFUL LIFE FOR DEPREC. PURPOSES	20.00	YEARS
E26. % OF ST. LINE DEP. RATE (DC. BAL. DEPRC.)	150.00	%

CHICAGO

DIRECT/DRAINDOWN SOLAR WATER HEATER IN CHICAGO

IL LATITUDE 41.5

THERMAL PERFORMANCE

	HT (MMBTU)	TA (DEG-F)	HWLOAD (MMBTU)	QU (MMBTU)	QLOSS (MMBTU)	FDHW
JAN	1.66	26.6	1.06	.52	.02	.47
FEB	1.81	28.4	.95	.51	.02	.50
MAR	2.33	37.4	1.06	.65	.03	.58
APR	2.42	50.0	1.02	.72	.04	.66
MAY	2.66	60.8	1.06	.82	.05	.73
JUN	2.79	69.8	1.02	.91	.05	.83
JUL	2.78	75.2	1.06	.96	.06	.86
AUG	2.78	73.4	1.06	.98	.06	.87
SEP	2.55	66.2	1.02	.89	.05	.83
OCT	2.43	55.4	1.06	.83	.05	.75
NOV	1.68	41.0	1.02	.58	.03	.56
DEC	1.36	30.2	1.06	.52	.02	.46
YR	27.25	51.2	12.43	8.89	.47	.68

PURCHASED ENERGY SUMMARY

	GAS	ELECTRIC	OIL	TOTAL
USE (MMBTU)	0.00	4.01	0.00	4.01
COST (\$)	0.00	77.05	0.00	77.05

DIRECT/DRAINDOWN SOLAR WATER HEATER IN CHICAGO

LIFE CYCLE COST ANALYSIS OF CURRENT SYSTEM

INITIAL COST OF SYSTEM \$ 2540.
 DOWN PAYMENT \$ 254.
 TOTAL TAX CREDITS \$ 1016.
 ANNUAL MORTGAGE PAYMENT \$ 1051. FOR 3 YEARS

A-5

****INFORMATION****				*****SYSTEM COSTS*****				*ENERGY*	***INDICATORS***		
YR	END OF YR PRINC	IN- TEREST PAID	COMM DEPREC DEDUCT	LOAN PAYMT	MAINT INS	TAX PROP TAX	CREDIT RESALE	NET FUEL COST	NET CASH FLOW	PW OF CASH FLOW	CUMU- LATIVE PW
0	2286	0	0	254	0	0	1016	0	-761	-761	-761
1	1646	411	0	1051	25	0	144	77	1010	842	80
2	891	296	0	1051	28	0	104	87	1063	738	817
3	0	160	0	1051	31	0	56	98	1124	651	1468
4	0	0	0	0	34	0	0	111	145	70	1538
5	0	0	0	0	37	0	0	126	163	65	1604
6	0	0	0	0	41	0	0	142	183	61	1665
7	0	0	0	0	45	0	0	160	205	57	1722
8	0	0	0	0	49	0	0	181	231	54	1776
9	0	0	0	0	54	0	0	205	259	50	1826
10	0	0	0	0	60	0	0	231	291	47	1873
TOTAL		867	0	3407	404	0	1320	1418	3913	1873	
PW OF TOT		641	0	2468	147	0	1241	497	1873		
				UNDISCOUNTED	ANNUALIZED	PRESENT WORTH					
ENERGY COST				1418	119	497					
TOTAL COST				3913	447	1873					

DIRECT/DRAINDOWN SOLAR WATER HEATER IN DETROIT

DETROIT

MI LATITUDE 42.3

THERMAL PERFORMANCE

	HT (MMBTU)	TA (DEG-F)	HWLOAD (MMBTU)	QU (MMBTU)	QLOSS (MMBTU)	FDHW
JAN	1.33	26.6	1.06	.49	.02	.46
FEB	1.61	28.4	.95	.47	.02	.46
MAR	2.09	35.6	1.06	.58	.03	.53
APR	2.33	48.2	1.02	.69	.03	.62
MAY	2.57	59.0	1.06	.78	.04	.70
JUN	2.62	69.8	1.02	.87	.05	.79
JUL	2.65	73.4	1.06	.91	.05	.82
AUG	2.56	71.6	1.06	.91	.05	.80
SEP	2.36	64.4	1.02	.82	.05	.77
OCT	2.19	53.6	1.06	.76	.04	.68
NOV	1.40	41.0	1.02	.53	.02	.52
DEC	1.16	32.0	1.06	.54	.02	.47
YR	24.86	50.3	12.43	8.34	.42	.64

PURCHASED ENERGY SUMMARY

	GAS	ELECTRIC	OIL	TOTAL
USE (MMBTU)	0.00	4.52	0.00	4.52
COST (\$)	0.00	79.95	0.00	79.95

DIRECT/DRAINDOWN SOLAR WATER HEATER IN DETROIT

LIFE CYCLE COST ANALYSIS OF CURRENT SYSTEM

INITIAL COST OF SYSTEM \$ 2540.
 DOWN PAYMENT \$ 254.
 TOTAL TAX CREDITS \$ 1597.
 ANNUAL MORTGAGE PAYMENT \$ 1051. FOR 3 YEARS

****INFORMATION****				*****SYSTEM COSTS*****				*ENERGY*	***INDICATORS***		
YR	END OF YR	IN- TEREST PAID	COMM DEPREC DEDUCT	LOAN PAYMT	MAINT INS	TAX PROP	CREDIT RESALE	NET FUEL COST	NET CASH FLOW	PW OF CASH FLOW	CUMU- LATIVE PW
0	2286	0	0	254	0	0	1597	0	-1342	-1342	-1342
1	1646	411	0	1051	25	0	144	80	1013	844	-498
2	891	296	0	1051	28	0	104	90	1066	740	241
3	0	160	0	1051	31	0	56	102	1128	653	894
4	0	0	0	0	34	0	0	115	149	72	966
5	0	0	0	0	37	0	0	130	168	67	1033
6	0	0	0	0	41	0	0	147	188	63	1096
7	0	0	0	0	45	0	0	166	211	59	1155
8	0	0	0	0	49	0	0	188	238	55	1211
9	0	0	0	0	54	0	0	213	267	52	1262
10	0	0	0	0	60	0	0	240	300	48	1311
TOTAL		867	0	3407	404	0	1901	1471	3386	1311	
PW OF TOT		641	0	2468	147	0	1822	515	1311		

	UNDISCOUNTED	ANNUALIZED	PRESENT WORTH
ENERGY COST	1471	123	515
TOTAL COST	3386	313	1311

DIRECT/DRAINDOWN SOLAR WATER HEATER IN KANSAS CITY

KANSAS CITY MO LATITUDE 39.2

THERMAL PERFORMANCE

	HT (MMBTU)	TA (DEG-F)	HWLOAD (MMBTU)	QU (MMBTU)	QLOSS (MMBTU)	FDHW
JAN	2.06	28.4	.95	.56	.03	.55
FEB	2.09	32.0	.86	.55	.03	.60
MAR	2.50	41.0	.95	.68	.04	.66
APR	2.62	53.6	.92	.75	.05	.76
MAY	2.80	64.4	.95	.84	.06	.82
JUN	2.82	73.4	.92	.90	.06	.90
JUL	3.03	77.0	.95	.99	.07	.97
AUG	3.03	77.0	.95	1.03	.07	1.00
SEP	2.72	68.0	.92	.90	.06	.92
OCT	2.68	57.2	.95	.87	.06	.84
NOV	2.17	42.8	.92	.65	.04	.69
DEC	1.89	32.0	.95	.55	.03	.54
YR	30.40	53.9	11.24	9.28	.60	.77

PURCHASED ENERGY SUMMARY

	GAS	ELECTRIC	OIL	TOTAL
USE (MMBTU)	0.00	2.56	0.00	2.56
COST (\$)	0.00	41.52	0.00	41.52

DIRECT/DRAINDOWN SOLAR WATER HEATER IN KANSAS CITY

LIFE CYCLE COST ANALYSIS OF CURRENT SYSTEM

INITIAL COST OF SYSTEM \$ 2540.
 DOWN PAYMENT \$ 254.
 TOTAL TAX CREDITS \$ 1016.
 ANNUAL MORTGAGE PAYMENT \$ 1051. FOR 3 YEARS

****INFORMATION****				*****SYSTEM COSTS*****				*ENERGY*	***INDICATORS***		
YR	END OF YR	IN- TEREST	COMM PAID	DEPREC DEDUCT	LOAN PAYMT	MAINT INS	TAX CREDIT	NET FUEL COST	NET CASH FLOW	PW OF CASH FLOW	CUMU- LATIVE PW
0	2286	0	0	0	254	0	1016	0	-761	-761	-761
1	1646	411	0	0	1051	25	144	42	974	812	50
2	891	296	0	0	1051	28	104	47	1023	710	760
3	0	160	0	0	1051	31	56	53	1079	624	1384
4	0	0	0	0	0	34	0	60	94	45	1430
5	0	0	0	0	0	37	0	68	105	42	1472
6	0	0	0	0	0	41	0	77	117	39	1511
7	0	0	0	0	0	45	0	86	131	37	1548
8	0	0	0	0	0	49	0	98	147	34	1582
9	0	0	0	0	0	54	0	110	165	32	1614
10	0	0	0	0	0	60	0	125	185	30	1644
TOTAL		867	0	0	3407	404	0	1320	766	3259	1644
PW OF TOT		641	0	0	2468	147	0	1241	269	1644	

	UNDISCOUNTED	ANNUALIZED	PRESENT WORTH
ENERGY COST	766	64	269
TOTAL COST	3259	392	1644

DIRECT/DRAINDOWN SOLAR WATER HEATER IN MINNEAPOLIS

MINNEAPOLIS MN LATITUDE 44.5

THERMAL PERFORMANCE

	HT (MMBTU)	TA (DEG-F)	HWLOAD (MMBTU)	QU (MMBTU)	QLOSS (MMBTU)	FDHW
JAN	1.71	14.0	1.17	.51	.01	.41
FEB	2.00	17.6	1.06	.53	.01	.49
MAR	2.44	33.2	1.17	.68	.02	.55
APR	2.44	44.6	1.13	.73	.03	.62
MAY	2.60	57.2	1.17	.84	.04	.68
JUN	2.71	66.2	1.13	.91	.04	.76
JUL	2.94	71.6	1.17	1.04	.05	.83
AUG	2.77	69.8	1.17	1.00	.05	.82
SEP	2.43	60.8	1.13	.87	.04	.74
OCT	2.26	50.0	1.17	.80	.03	.66
NOV	1.55	32.0	1.13	.55	.02	.49
DEC	1.36	21.2	1.17	.52	.01	.43
YR	27.19	44.6	13.78	8.98	.36	.62

PURCHASED ENERGY SUMMARY

	GAS	ELECTRIC	OIL	TOTAL
USE (MMBTU)	0.00	5.18	0.00	5.18
COST (\$)	0.00	76.64	0.00	76.64

DIRECT/DRAINDOWN SOLAR WATER HEATER IN MINNEAPOLIS

LIFE CYCLE COST ANALYSIS OF CURRENT SYSTEM

INITIAL COST OF SYSTEM \$ 2540.
 DOWN PAYMENT \$ 254.
 TOTAL TAX CREDITS \$ 1524.
 ANNUAL MORTGAGE PAYMENT \$ 1051. FOR 3 YEARS

A-11

****INFORMATION****				*****SYSTEM COSTS*****				*ENERGY*		***INDICATORS***		
	END OF YR	IN- TEREST	COMM DEPREC	LOAN PAYMT	MAINT INS	PROP TAX	CREDIT RESALE	NET FUEL COST	NET CASH FLOW	PW OF CASH FLOW	CUMU- LATIVE PW	
YR	PRINC	PAID	DEDUCT									
0	2286	0	0	254	0	0	1524	0	-1269	-1269	-1269	
1	1646	411	0	1051	25	0	144	77	1009	841	-428	
2	891	296	0	1051	28	0	104	87	1062	738	309	
3	0	160	0	1051	31	0	56	98	1124	650	959	
4	0	0	0	0	34	0	0	111	144	70	1029	
5	0	0	0	0	37	0	0	125	162	65	1094	
6	0	0	0	0	41	0	0	141	182	61	1155	
7	0	0	0	0	45	0	0	160	205	57	1212	
8	0	0	0	0	49	0	0	180	230	53	1266	
9	0	0	0	0	54	0	0	204	258	50	1316	
10	0	0	0	0	60	0	0	230	290	47	1362	
TOTAL		867	0	3407	404	0	1828	1413	3397	1362		
PW OF TOT		641	0	2468	147	0	1749	495	1362			
				UNDISCOUNTED	ANNUALIZED	PRESENT WORTH						
ENERGY COST				1413	118	495						
TOTAL COST				3397	325	1362						

DIRECT/DRAINDOWN SOLAR WATER HEATER IN RAPID CITY

RAPID CITY SD LATITUDE 44.0

THERMAL PERFORMANCE

	HT (MMBTU)	TA (DEG-F)	HWLOAD (MMBTU)	QU (MMBTU)	QLOSS (MMBTU)	FDHW
JAN	2.04	23.0	1.10	.58	.02	.52
FEB	2.17	28.4	.99	.62	.03	.58
MAR	2.74	32.0	1.10	.74	.04	.64
APR	2.70	44.6	1.06	.77	.04	.68
MAY	2.81	55.4	1.10	.84	.04	.72
JUN	2.97	64.4	1.06	.93	.05	.82
JUL	3.17	73.4	1.10	1.08	.06	.92
AUG	3.23	71.6	1.10	1.11	.07	.95
SEP	3.00	60.8	1.06	1.00	.06	.89
OCT	2.91	50.0	1.10	.95	.05	.82
NOV	2.23	35.6	1.06	.69	.03	.64
DEC	1.95	28.4	1.10	.61	.02	.53
YR	31.93	47.3	12.94	9.92	.51	.73

PURCHASED ENERGY SUMMARY

	GAS	ELECTRIC	OIL	TOTAL
USE (MMBTU)	0.00	3.53	0.00	3.53
COST (\$)	0.00	45.93	0.00	45.93

DIRECT/DRAINDOWN SOLAR WATER HEATER IN RAPID CITY

LIFE CYCLE COST ANALYSIS OF CURRENT SYSTEM

INITIAL COST OF SYSTEM \$ 2540.
 DOWN PAYMENT \$ 254.
 TOTAL TAX CREDITS \$ 1016.
 ANNUAL MORTGAGE PAYMENT \$ 1051. FOR 3 YEARS

****INFORMATION****				*****SYSTEM COSTS*****				*ENERGY*	***INDICATORS***		
YR	END OF YR PRINC	IN- TEREST PAID	COMM DEPREC DEDUCT	LOAN PAYMT	MAINT INS	TAX PROP TAX	CREDIT RESALE	NET FUEL COST	NET CASH FLOW	PW OF CASH FLOW	CUMU- LATIVE PW
0	2286	0	0	254	0	0	1016	0	-761	-761	-761
1	1646	411	0	1051	25	0	144	46	979	816	54
2	891	296	0	1051	28	0	104	52	1028	714	767
3	0	160	0	1051	31	0	56	59	1085	628	1395
4	0	0	0	0	34	0	0	66	100	48	1443
5	0	0	0	0	37	0	0	75	112	45	1488
6	0	0	0	0	41	0	0	85	126	42	1530
7	0	0	0	0	45	0	0	96	141	39	1569
8	0	0	0	0	49	0	0	108	158	37	1606
9	0	0	0	0	54	0	0	122	177	34	1640
10	0	0	0	0	60	0	0	138	198	32	1672
TOTAL		867	0	3407	404	0	1320	847	3343	1672	
PW OF TOT		641	0	2468	147	0	1241	297	1672		

	UNDISCOUNTED	ANNUALIZED	PRESENT WORTH
ENERGY COST	847	71	297
TOTAL COST	3343	399	1672

FCHART PARAMETERS FOR INDIRECT/ANTIFREEZE SOLAR WATER HEATER
EXAMPLE FOR DETROIT, MI

COLLECTOR PARAMETERS

C1. COLLECTOR AREA	55.80	FT2
C2. FR-UL PRODUCT	.85	BTU/HR-FT2-DEG F
C3. FR-TAU-ALPHA (NORMAL INCIDENCE)	.72	
C6. NUMBER OF COVERS	1.00	
C7. INDEX OF REFRACTION	1.53	
C8. EXTINCTION COEFFICIENT X LENGTH (KL).....	.04	
C9. INCIDENCE ANGLE MODIFIER CONSTANT	0.00	
C10. COLLECTOR FLOW RATE * SPECIFIC HEAT/AREA	14.36	BTU/HR-FT2-DEG F
C12. COLLECTOR SLOPE	57.00	DEGREES
C13. COLLECTOR AZIMUTH	0.00	DEGREES
C14. GROUND REFLECTANCE	.20	

COLLECTOR-STORE TRANSFER PARAMETERS

T1. EPS-CMIN OF COLLECTOR-STORE HX/COLLECTOR AREA ..	7.18	BTU/HR-FT2-DEG F
T2. UA OF COLLECTOR INLET PIPE OR DUCT	1.70	BTU/HR-DEG F
T3. UA OF COLLECTOR OUTLET PIPE OR DUCT	1.70	BTU/HR-DEG F

STORAGE UNIT PARAMETERS

S1. TANK CAPACITY/COLLECTOR AREA	16.50	BTU/DEG F-FT2
S2. STORAGE UNIT HEIGHT/DIAMETER RATIO	2.00	
S3. HEAT LOSS COEFFICIENT	.05	BTU/HR-FT2-DEG F
S4. ENVIRONMENT TEMPERATURE (-1000 FOR TENV=TAMB) ..	70.00	DEG F
S5. HOT WATER AUXILIARY TANK UA	1.27	BTU/HR-DEG F
S6. HOT WATER AUX TANK ENVIRONMENT TEMPERATURE	70.00	DEG F

LOAD PARAMETERS

L3. HOT WATER USE	55.70	GALLONS/DAY
L4. HOT WATER SET TEMPERATURE	120.00	DEG F
L5. WATER MAINS TEMPERATURE	50.00	DEG F

AUXILIARY PARAMETERS

A3. HOT WATER AUXILIARY FUEL (1=GAS,2=ELEC,3=OIL) ..	2.	
A4. AUXILIARY WATER HEATER EFFICIENCY	1.00	

FCHART PARAMETERS FOR INDIRECT/ANTIFREEZE SOLAR WATER HEATER
EXAMPLE FOR DETROIT, MI

ECONOMIC PARAMETERS

E1. ECONOMIC OUTPUT DETAIL (1,2 OR 3)	3.00	
E2. REFERENCE OR COMPARISON SYSTEM (1 OR 2)	1.00	
E3. CALCULATE RATE OF RETURN (YES=1,NO=2)	2.00	
E4. INCOME PRODUCING BUILDING (YES=1,2=NO)	2.00	
E5. DEPRC: STR,LN.=1,DC.BAL.=2,SM-YR-DGT=3,NONE=4 ..	1.00	
E6. CONSIDER FEDERAL TAX CREDITS (YES=1,2=NO)	1.00	
E7. LENGTH OF ANALYSIS	10.00	YEARS
E8. TAX CREDITABLE SYSTEM BASE COST	\$ 3050.00	
E9. NON-TAX CREDITABLE SYSTEM BASE COST	\$ 0.00	
E10. ANNUAL INCREASE IN PURCHASED ENERGY DEMAND	0.00	%/YR
E11. TERM OF MORTGAGE	3.00	YEARS
E12. DOWN PAYMENT (% OF ORIGINAL INVESTMENT)	10.00	%
E13. MORTGAGE ANNUAL INTEREST RATE	18.00	%
E14. RESALE VALUE (% OF ORIGINAL INVESTMENT)	0.00	%
E15. ANNUAL NOMINAL (MARKET) DISCOUNT RATE	20.00	%
E16. EXTRA INSUR.,MAINT. IN YEAR 1 (% OF ORIG.INV.)	1.00	%
E17. ANNUAL % INCREASE IN ABOVE EXPENSES	10.00	%
E18. EFFECTIVE FEDERAL-STATE INCOME TAX RATE	35.00	%
E19. TRUE PROP. TAX RATE PER \$ OF ORIGINAL INVEST ..	0.00	%
E20. ANNUAL % INCREASE IN PROPERTY TAX RATE	0.00	%/YR
E21. STATE CREDIT IN TIER ONE.....	25.00	%
E22. STATE CREDIT TIER ONE BREAK.....	\$ 2000.00	
E23. STATE CREDIT IN TIER TWO.....	15.00	%
E24. STATE CREDIT TIER TWO BREAK.....	\$ 8000.00	
E25. USEFUL LIFE FOR DEPREC. PURPOSES	20.00	YEARS
E26. % OF ST. LINE DEP. RATE (DC. BAL. DEPRC.)	150.00	%

INDIRECT/ANTIFREEZE SOLAR WATER HEATER IN CHICAGO

CHICAGO

IL

LATITUDE 41.5

THERMAL PERFORMANCE

	HT (MMBTU)	TA (DEG-F)	HWLOAD (MMBTU)	QU (MMBTU)	QLOSS (MMBTU)	FDHW
JAN	1.58	26.6	1.06	.51	.02	.47
FEB	1.72	28.4	.95	.51	.02	.51
MAR	2.22	37.4	1.06	.65	.03	.59
APR	2.31	50.0	1.02	.71	.04	.66
MAY	2.53	60.8	1.06	.81	.04	.73
JUN	2.66	69.8	1.02	.90	.05	.82
JUL	2.65	75.2	1.06	.94	.05	.85
AUG	2.65	73.4	1.06	.96	.06	.85
SEP	2.43	66.2	1.02	.87	.05	.82
OCT	2.32	55.4	1.06	.82	.04	.74
NOV	1.61	41.0	1.02	.57	.03	.55
DEC	1.30	30.2	1.06	.51	.02	.45
YR	25.99	51.2	12.43	8.77	.45	.67

PURCHASED ENERGY SUMMARY

	GAS	ELECTRIC	OIL	TOTAL
USE (MMBTU)	0.00	4.11	0.00	4.11
COST (\$)	0.00	78.86	0.00	78.86

INDIRECT/ANTIFREEZE SOLAR WATER HEATER IN CHICAGO

LIFE CYCLE COST ANALYSIS OF CURRENT SYSTEM

INITIAL COST OF SYSTEM \$ 3050.
 DOWN PAYMENT \$ 305.
 TOTAL TAX CREDITS \$ 1220.
 ANNUAL MORTGAGE PAYMENT \$ 1262. FOR 3 YEARS

****INFORMATION****				*****SYSTEM COSTS*****				*ENERGY*	***INDICATORS***		
	END OF YR	IN- TEREST PAID	COMM DEPREC DEDUCT	LOAN PAYMT	MAINT INS	TAX PROP TAX	CREDIT RESALE	NET FUEL COST	NET CASH FLOW	PW OF CASH FLOW	CUMU- LATIVE PW
YR	PRINC										
0	2745	0	0	305	0	0	1220	0	-914	-914	-914
1	1977	494	0	1262	30	0	173	79	1199	999	84
2	1070	356	0	1262	34	0	125	89	1261	875	960
3	0	193	0	1262	37	0	67	101	1333	771	1731
4	0	0	0	0	41	0	0	114	154	74	1805
5	0	0	0	0	45	0	0	129	173	70	1875
6	0	0	0	0	49	0	0	145	194	65	1940
7	0	0	0	0	54	0	0	164	218	61	2001
8	0	0	0	0	59	0	0	186	245	57	2058
9	0	0	0	0	65	0	0	210	275	53	2111
10	0	0	0	0	72	0	0	237	309	50	2161
TOTAL		1043	0	4091	486	0	1585	1454	4447	2161	
PW OF TOT		771	0	2963	177	0	1490	509	2161		

	UNDISCOUNTED	ANNUALIZED	PRESENT WORTH
ENERGY COST	1454	121	509
TOTAL COST	4447	515	2161

INDIRECT/ANTIFREEZE SOLAR WATER HEATER IN DETROIT

DETROIT

MI

LATITUDE 42.3

THERMAL PERFORMANCE

	HT	TA	HWLOAD	QU	QLOSS	FDHW
	(MMBTU)	(DEG-F)	(MMBTU)	(MMBTU)	(MMBTU)	
JAN	1.27	26.6	1.06	.47	.02	.44
FEB	1.54	28.4	.95	.47	.02	.46
MAR	1.99	35.6	1.06	.58	.02	.53
APR	2.22	48.2	1.02	.68	.03	.62
MAY	2.45	59.0	1.06	.77	.04	.70
JUN	2.50	69.8	1.02	.86	.05	.78
JUL	2.53	73.4	1.06	.89	.05	.81
AUG	2.44	71.6	1.06	.89	.05	.79
SEP	2.25	64.4	1.02	.81	.04	.76
OCT	2.09	53.6	1.06	.74	.04	.67
NOV	1.33	41.0	1.02	.51	.02	.51
DEC	1.11	32.0	1.06	.51	.02	.45
YR	23.72	50.3	12.43	8.19	.40	.63

PURCHASED ENERGY SUMMARY

	GAS	ELECTRIC	OIL	TOTAL
USE (MMBTU)	0.00	4.64	0.00	4.64
COST (\$)	0.00	82.11	0.00	82.11

INDIRECT/ANTIFREEZE SOLAR WATER HEATER IN DETROIT

LIFE CYCLE COST ANALYSIS OF CURRENT SYSTEM

INITIAL COST OF SYSTEM \$ 3050.
 DOWN PAYMENT \$ 305.
 TOTAL TAX CREDITS \$ 1878.
 ANNUAL MORTGAGE PAYMENT \$ 1262. FOR 3 YEARS

A-19

****INFORMATION****				*****SYSTEM COSTS*****				*ENERGY*	***INDICATORS***		
YR	END OF YR	IN- TEREST PAID	COMM DEPREC DEDUCT	LOAN PAYMT	MAINT INS	TAX PROP TAX	CREDIT RESALE	NET FUEL COST	NET CASH FLOW	PW OF CASH FLOW	CUMU- LATIVE PW
0	2745	0	0	305	0	0	1877	0	-1571	-1571	-1571
1	1977	494	0	1262	30	0	173	82	1202	1002	-570
2	1070	356	0	1262	34	0	125	93	1264	878	307
3	0	193	0	1262	37	0	67	105	1337	774	1081
4	0	0	0	0	41	0	0	118	159	77	1158
5	0	0	0	0	45	0	0	134	179	72	1229
6	0	0	0	0	49	0	0	151	200	67	1297
7	0	0	0	0	54	0	0	171	225	63	1359
8	0	0	0	0	59	0	0	193	253	59	1418
9	0	0	0	0	65	0	0	218	284	55	1473
10	0	0	0	0	72	0	0	247	319	51	1524
TOTAL		1043	0	4091	486	0	2242	1512	3851	1524	
PW OF TOT		771	0	2963	177	0	2147	530	1524		
				UNDISCOUNTED		ANNUALIZED		PRESENT WORTH			
ENERGY COST				1512		126		530			
TOTAL COST				3851		364		1524			

INDIRECT/ANTIFREEZE SOLAR WATER HEATER IN KANSAS CITY

KANSAS CITY MO LATITUDE 39.2

THERMAL PERFORMANCE

	HT (MMBTU)	TA (DEG-F)	HWLOAD (MMBTU)	QU (MMBTU)	QLOSS (MMBTU)	FDHW
JAN	1.96	28.4	.95	.57	.03	.56
FEB	1.99	32.0	.86	.56	.03	.61
MAR	2.38	41.0	.95	.68	.04	.66
APR	2.50	53.6	.92	.75	.05	.75
MAY	2.68	64.4	.95	.83	.05	.82
JUN	2.69	73.4	.92	.89	.06	.89
JUL	2.89	77.0	.95	.98	.07	.96
AUG	2.89	77.0	.95	1.01	.07	.98
SEP	2.59	68.0	.92	.89	.06	.91
OCT	2.56	57.2	.95	.86	.06	.84
NOV	2.07	42.8	.92	.65	.04	.69
DEC	1.80	32.0	.95	.55	.03	.54
YR	28.99	53.9	11.24	9.22	.58	.77

PURCHASED ENERGY SUMMARY

	GAS	ELECTRIC	OIL	TOTAL
USE (MMBTU)	0.00	2.60	0.00	2.60
COST (\$)	0.00	42.14	0.00	42.14

INDIRECT/ANTIFREEZE SOLAR WATER HEATER IN KANSAS CITY

LIFE CYCLE COST ANALYSIS OF CURRENT SYSTEM

INITIAL COST OF SYSTEM \$ 3050.
 DOWN PAYMENT \$ 305.
 TOTAL TAX CREDITS \$ 1220.
 ANNUAL MORTGAGE PAYMENT \$ 1262. FOR 3 YEARS

****INFORMATION****				*****SYSTEM COSTS*****				*ENERGY*	***INDICATORS***		
YR	END OF YR	IN- TEREST PAID	COMM DEPREC DEDUCT	LOAN PAYMT	MAINT INS	TAX PROP	CREDIT RESALE	NET FUEL COST	NET CASH FLOW	PW OF CASH FLOW	CUMU- LATIVE PW
0	2745	0	0	305	0	0	1220	0	-914	-914	-914
1	1977	494	0	1262	30	0	173	42	1162	968	53
2	1070	356	0	1262	34	0	125	48	1219	847	900
3	0	193	0	1262	37	0	67	54	1286	744	1644
4	0	0	0	0	41	0	0	61	101	49	1693
5	0	0	0	0	45	0	0	69	113	46	1739
6	0	0	0	0	49	0	0	78	127	42	1781
7	0	0	0	0	54	0	0	88	142	40	1821
8	0	0	0	0	59	0	0	99	159	37	1858
9	0	0	0	0	65	0	0	112	177	34	1892
10	0	0	0	0	72	0	0	127	199	32	1924
TOTAL		1043	0	4091	486	0	1585	778	3771	1924	
PW OF TOT		771	0	2963	177	0	1490	273	1924		
				UNDISCOUNTED	ANNUALIZED	PRESENT WORTH					
ENERGY COST				778	65	273					
TOTAL COST				3771	459	1924					

INDIRECT/ANTIFREEZE SOLAR WATER HEATER IN MINNEAPOLIS

MINNEAPOLIS MN LATITUDE 44.5

THERMAL PERFORMANCE

	HT (MMBTU)	TA (DEG-F)	HWLOAD (MMBTU)	QU (MMBTU)	QLOSS (MMBTU)	FDHW
JAN	1.63	14.0	1.17	.51	.01	.41
FEB	1.91	17.6	1.06	.54	.01	.50
MAR	2.32	30.2	1.17	.68	.02	.56
APR	2.33	44.6	1.13	.72	.03	.62
MAY	2.48	57.2	1.17	.83	.03	.67
JUN	2.58	66.2	1.13	.90	.04	.75
JUL	2.80	71.6	1.17	1.02	.05	.82
AUG	2.64	69.8	1.17	.98	.05	.80
SEP	2.31	60.8	1.13	.86	.04	.72
OCT	2.16	50.0	1.17	.79	.03	.65
NOV	1.48	32.0	1.13	.54	.01	.48
DEC	1.30	21.2	1.17	.51	.01	.42
YR	25.94	44.6	13.78	8.86	.34	.62

PURCHASED ENERGY SUMMARY

	GAS	ELECTRIC	OIL	TOTAL
USE (MMBTU)	0.00	5.28	0.00	5.28
COST (\$)	0.00	78.13	0.00	78.13

INDIRECT/ANTIFREEZE SOLAR WATER HEATER IN MINNEAPOLIS

LIFE CYCLE COST ANALYSIS OF CURRENT SYSTEM

INITIAL COST OF SYSTEM \$ 3050.
 DOWN PAYMENT \$ 305.
 TOTAL TAX CREDITS \$ 1830.
 ANNUAL MORTGAGE PAYMENT \$ 1262. FOR 3 YEARS

****INFORMATION****				*****SYSTEM COSTS*****				*ENERGY*	***INDICATORS***		
YR	END OF YR	IN- TEREST PAID	COMM DEPREC DEDUCT	LOAN PAYMT	MAINT INS	TAX PROP TAX	CREDIT RESALE	NET FUEL COST	NET CASH FLOW	PW OF CASH FLOW	CUMU- LATIVE PW
0	2745	0	0	305	0	0	1830	0	-1524	-1524	-1524
1	1977	494	0	1262	30	0	173	78	1198	998	-526
2	1070	356	0	1262	34	0	125	88	1260	875	348
3	0	193	0	1262	37	0	67	100	1332	771	1119
4	0	0	0	0	41	0	0	113	153	74	1193
5	0	0	0	0	45	0	0	127	172	69	1262
6	0	0	0	0	49	0	0	144	193	65	1327
7	0	0	0	0	54	0	0	163	217	60	1387
8	0	0	0	0	59	0	0	184	243	57	1444
9	0	0	0	0	65	0	0	208	273	53	1497
10	0	0	0	0	72	0	0	235	307	50	1546
TOTAL		1043	0	4091	486	0	2195	1440	3824	1546	
PW OF TOT		771	0	2963	177	0	2100	504	1546		

	UNDISCOUNTED	ANNUALIZED	PRESENT WORTH
ENERGY COST	1440	120	504
TOTAL COST	3824	369	1546

INDIRECT/ANTIFREEZE SOLAR WATER HEATER IN RAPID CITY

RAPID CITY SD LATITUDE 44.0

THERMAL PERFORMANCE

	HT (MMBTU)	TA (DEG-F)	HWLOAD (MMBTU)	QU (MMBTU)	QLOSS (MMBTU)	FDHW
JAN	1.94	23.0	1.10	.59	.02	.52
FEB	2.07	28.4	.99	.62	.03	.59
MAR	2.62	32.0	1.10	.74	.03	.65
APR	2.57	44.6	1.06	.77	.04	.68
MAY	2.68	55.4	1.10	.83	.04	.72
JUN	2.83	64.4	1.06	.92	.05	.81
JUL	3.02	73.4	1.10	1.06	.06	.91
AUG	3.09	71.6	1.10	1.09	.06	.94
SEP	2.86	60.8	1.06	.99	.06	.89
OCT	2.77	50.0	1.10	.94	.05	.81
NOV	2.13	35.6	1.06	.69	.03	.64
DEC	1.86	28.4	1.10	.61	.02	.53
YR	30.46	47.3	12.94	9.85	.49	.72

PURCHASED ENERGY SUMMARY

	GAS	ELECTRIC	OIL	TOTAL
USE (MMBTU)	0.00	3.58	0.00	3.58
COST (\$)	0.00	46.53	0.00	46.53

INDIRECT/ANTIFREEZE SOLAR WATER HEATER IN RAPID CITY

LIFE CYCLE COST ANALYSIS OF CURRENT SYSTEM

INITIAL COST OF SYSTEM \$ 3050.
 DOWN PAYMENT \$ 305.
 TOTAL TAX CREDITS \$ 1220.
 ANNUAL MORTGAGE PAYMENT \$ 1262. FOR 3 YEARS

****INFORMATION****				*****SYSTEM COSTS*****				*ENERGY*	***INDICATORS***		
YR	END OF YR	IN- TEREST PAID	COMM DEPREC DEDUCT	LOAN PAYMT	MAINT INS	TAX PROP CREDIT RESALE	TAX CREDIT RESALE	NET FUEL COST	NET CASH FLOW	PW OF CASH FLOW	CUMU- LATIVE PW
0	2745	0	0	305	0	0	1220	0	-914	-914	-914
1	1977	494	0	1262	30	0	173	47	1167	972	57
2	1070	356	0	1262	34	0	125	53	1224	850	907
3	0	193	0	1262	37	0	67	59	1291	747	1655
4	0	0	0	0	41	0	0	67	108	52	1707
5	0	0	0	0	45	0	0	76	121	48	1755
6	0	0	0	0	49	0	0	86	135	45	1800
7	0	0	0	0	54	0	0	97	151	42	1842
8	0	0	0	0	59	0	0	109	169	39	1882
9	0	0	0	0	65	0	0	124	189	37	1918
10	0	0	0	0	72	0	0	140	212	34	1952
TOTAL		1043	0	4091	486	0	1585	858	3853	1952	
PW OF TOT		771	0	2963	177	0	1490	301	1952		
				UNDISCOUNTED	ANNUALIZED	PRESENT WORTH					
ENERGY COST				858	72	301					
TOTAL COST				3853	466	1952					