U/BDS/FS/WPSC

ORIGINAL

Decision 83 03 031 MAR 16 1983

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Application of Solar Edwards to upgrade the sizing criteria for its solar system.

Application 82-12-34
(Filed December 13, 1982)

## OPINION ON SOLAR WATER HEATER ELIGIBILITY

Solar Edwards (Edwards) requests that the current eligibility of its solar water heaters[a] in the OII 42 utility rebate program be made less restrictive. In support of its request, Edwards provides standard test data which was unavailable when its earlier decision was granted. Edwards also asks for eligibility of similar larger units sold by it, based on hot water output estimated from the test of the smaller unit.

By this decision, the Commission grants Edwards smaller minimum sizing based on staff analysis of the standard test data now available.

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[a] Granted by D.82-04-020 in A.61086.

## Program Background

On September 16, 1980, we issued Decision (D.) 92251 establishing demonstration solar financing programs for Pacific Gas and Electric Company, San Diego Gas & Electric Company, Southern California Edison Company, and Southern California Gas Company. We subsequently modified this decision by D.92501, December 5, 1980, and D.92769, March 3, 1981. In these decisions, we specified a checklist of requirements for domestic solar water heaters. Since March 1, 1981, all solar water heaters have been required to meet OII 42 sizing and checklist requirements to be eligible for the solar financing program. For thermosyphon systems, to which some program assumptions do not apply, eligibility has been granted only after application by manufacturers on a case-by-case basis.

## Description

Edwards' prior decision D.82-04-020 concerned its thermosyphon solar water heater consisting of a roof-mounted tank of 80 or 112-gallon capacity coupled with two or three flat-plate solar collectors of about 20 sq. ft. each. Conservative sizing was granted absent submittal of any test data.

In this application Edwards provides test data on its two-collector, 80-gallon unit. It also proposes to mount as many as four collectors as a single system, and couple all four collectors to a single 160-gallon tank. Collector piping connections within that system (series vs. parallel) which affect performance are not specified.

These systems may be installed to preheat water entering a conventional water heater. They may also be used alone, since the solar tanks contain electric auxiliary heaters which start automatically when solar heat alone is not meeting the demand for hot water.

## Freeze Protection

Freeze protection is provided by electric resistance heaters in the collectors (separate from the auxiliary water heater in the tank). In California, the electricity consumed by this feature in a thermosyphon system is about the same as that used by the pump in a typical active system, provided the installation is made below a certain elevation, chosen in OII 42 as 2,300 feet.

Although Edwards' original application did not ask that we remove this restriction, the ECB staff notes that some thermosyphon manufacturers, possibly including Edwards, have asked for utility approval of a nonelectric method of freeze protection which might seem to eliminate our reasons for establishing this maximum elevation.

We reaffirm in this decision that all installations which rely on heat as a method of freeze protection require an exemption to Item B7c of the Inspection Checklist which prohibits the use of heat for freeze protection. Such installations include those using a nonelectric intermittent drain valve as well as those with electric resistance antifreeze heaters or active recirculation controllers. All are limited to a maximum elevation of 2,300 feet for eligibility in the OII 42 rebate program. Whether the source of heat is electricity, or supply water mixed with solar-heated water, resources are dissipated. Only those systems using more efficient methods should be permitted in higher or colder locations. The technical reasoning of the ECB is given in Appendix C.

Edwards amended its application on February 11, 1983 to introduce a more efficient method of thermosyphon freeze protection. Instead of using a single intermittent-drain valve, Edwards proposes to use two valves, with the second valve closing not opening at low temperatures.

The second valve is located between the tank and the collectors, thereby isolating the collectors at freezing temperatures. The collectors are drained of water in the same fashion as are active pumped systems using "draindown" freeze protection, except that no electricity is needed to operate the valves.

Utility inspectors should ascertain that freeze protection valves on Edwards systems installed higher than 2,300 feet elevation conform to the graphical description of Appendix D, and that collector slope does not prevent complete draining through the lower valve.

Installations using single intermittent-drain valves manufactured by NOK or Eaton/Dole are limited to 2,300 feet for the reasons described above and in Appendix C.

## Sizing

All solar water heaters eligible under the OII 42 program are subject to minimum collector area and solar-heated storage volume requirements. For solar water heaters which are connected to a separate conventional water heater, the minimum solar storage is 25 gallons of water per bedroom in single family dwellings (20 gallons per bedroom in multi-family dwellings). The minimum collector area for conventional flat-plate systems is determined from the OII 42 Sizing Chart Handbook.

For nonflat-plate, nonpumped (passive or innovative) systems of modular tank-collector units such as Edwards' system, the minimum number of systems needed on a dwelling for OII 42 eligibility may be more than one. That number is determined by individual laboratory tests of energy output.

Edwards submitted the results of a solar water heater performance test, known as SRCC-OG200, on its two-collector, 80-gallon model L305. This test is a national standard, and certification based on it is required for California solar tax credit eligibility for OII 42. The output of the L305 in a California climate was calculated from the results of the SRCC-OG200 test as described in Appendix A.

The ECB is applying this method to all applicants uniformly. Edwards' request for an adjustment in the way calculations are made <u>at the test lab</u> is a technical issue also discussed in Appendix A.

The minimum eligible system output of 101 therms per year for a three-bedroom dwelling is developed in Appendix B, based on adopted OII 42 criteria.

Using calculations based on the test data, the ECB concludes that an annual average output of 20,800 Btu per day should be adopted for each two-collector 80-gallon L305 unit which is properly installed in California under the OII 42 program. This output corresponds to 76 therms per unit per year. Therefore, one L305 system (1.3 rounded) would be needed to meet the annual load of a three-bedroom home, for example, under OII 42.

## Sizing of Models Having Larger Collector Area or Storage

Edwards is currently eligible to install its Model L305 on dwellings of two bedrooms maximum. An 80-gallon tank and two of Edwards' SE-20 collector panels are used in its Model L305. Edwards asks for the eligibility of its L305 to be extended to three bedrooms.

Edwards further requests that a third collector added to the L305 make the combination eligible for four-bedroom installations. Such a combination is not listed among the models designated by Edwards in the product specification sheet provided to the ECB. The construction and performance of such a "hybrid" model would be difficult for a utility inspector to evaluate in the field.

For five-bedroom dwellings, Edwards proposes to increase only the tank size, which appears to result in its three-panel, 116-gallon Model L440; and for six bedrooms, it proposes a four-panel, 160-gallon combination, which would be an L600. Edwards does not request sizing by model designations in this application.

It does not follow that because two collector panels were eligible for a two-bedroom hot water load, then three panels will be enough for a three-bedroom load. The effects of rounding are only one reason, e.g., a two-panel requirement might actually be 2.4 rounded to the nearest whole number of panels, in which case the 50% larger load of three bedrooms would call for 3.6 or four panels not three, when rounded to the nearest whole.

A more important reason to carefully evaluate Edwards' request is the effect of heat losses at higher water temperatures. For instance, a 50% increase in panel area could deliver much less than 50% more usable energy unless the panels were piped in parallel, and unless storage and load were correspondingly increased with collector area.

According to Roger Johnson of the SRCC Board of Directors, SRCC is willing to certify other than the tested model of a solar system provided it has nominally the same amount of storage per collector as the tested model, or more.

On this basis, the ECB is willing to consider other than whole multiples of Edwards' two-panel, 80-gallon Model L305, and recommends the sizing of Table 1 for eligibility.

## TABLE 1

### OII 42 Minimum Sizing of Solar Edwards Thermosyphon Solar Water Heater

| Number of Bedrooms (a) | No. of Collectors (b) | Solar Storage (Gallons) (c) |
|---|---|---|
| 1 | 2 | 80 |
| 2 | 2 | 80 |
| 3 | 3 | 116 |
| 4 | 3 | 116 |
| 5 | 4 | 160 |
| 6 | Two 3-Bedroom Systems | |

Ideally, the minimum sizing granted would depend on many factors such as the exact location within California. But we recognize that solar water heaters increasingly are marketed as modular appliances independent of small differences in climate, orientation, tilt, and so on. Less obvious or controllable factors such as the actual hot water use profile, installation quality, and weather variations affect solar system performance so strongly that actual savings from a given system can only be predicted within a reasonably broad range. For these reasons, and the fact that ratepayer benefits from the OII 42 program will stem from the average effect of all of the systems installed, we believe that all Edwards systems installed under OII 42 should be sized by Table 1, provided that they comply with the minimum guidelines for orientation and tilt which have been in effect for the California solar tax credit.

## Monitoring

Edwards solar systems should be evaluated in the monitoring program now beginning for all other solar water heaters which are installed under the OII 42 program.

## Warranty and Disclaimer

Eligibility is granted in this decision under the same requirements for warranty and disclaimers as stated in Edwards' currently effective decision D.82-04-020.

## Findings

1. Solar Edwards (Edwards) solar water heater systems are currently eligible for OII 42 utility rebates at the minimum sizing given in D.82-04-020.

2. Edwards seeks a revision to smaller minimum sizing.

3. Edwards provided standard test results to ECB.

4. Edwards' test results convert to the minimum sizing of Table 1.

5. Edwards proposes an innovative method of freeze protection by draindown which uses no electricity.

6. Edwards requests a refinement in the standard heat loss test which the consensus committee did not adopt when developing the test and which has not been used in prior Commission decisions.

## Conclusions

1. Solar Edwards systems should be eligible for utility financing under the revised sizing of Table 1.

2. Solar Edwards systems installed above 2,300 feet elevation should be considered to have adequate freeze protection only when the two-valve nonelectric intermittent draindown system identical to that shown in Appendix D is installed.

3. Solar Edwards systems installed below 2,300 feet are eligible with the electric freeze protection authorized in D.82-04-020 and also with intermittent drain valves manufactured by either NOK or Eaton/Dole.

4. The terms of Edwards' eligibility in the OII 42 program should remain unchanged except for the sizing revisions above.

## ORDER

1. Solar Edwards' eligibility for utility financing under OII 42 is revised in accordance with the conclusions.

2. Except as granted, and provided, Solar Edwards and its contractors shall adhere to all other currently effective installation requirements set forth in D.92251, 92501, 92769, 82-04-020 or subsequent orders in this proceeding.

This order is effective today.

Dated MAR 16 1983, at San Francisco, California.

LEONARD M. GRIMES, JR.
President
VICTOR CALVO
PRISCILLA C. GREW
DONALD VIAL
Commissioners

I CERTIFY THAT THIS DECISION
WAS APPROVED BY THE ABOVE
COMMISSIONERS TODAY.

Joseph E. Bodovitz, Executive Director

# APPENDIX A

## Method Used to Process the Solar Edwards L305 Solar Water Heater Test Results

The minimum number of L305 units to be installed per bedroom follows from the results of Solar Edwards' SRCC-OG200 test by comparing the results against the 101-therm minimum criterion for a three-bedroom dwelling (Appendix B). The SRCC-OG200 test conditions reflect national average values, not California values, for available solar radiation and other variables. Therefore, the annual solar output under California conditions was determined by modifying the results as follows:

The method used to estimate performance under conditions which differ from the test conditions ideally should have national consensus. Such a consensus is now in its early stages. Since a usable method may not be available before the OII 42 program is over, the ECB staff, with informal review from the solar community, is applying its own approach uniformly to all applicants.

Of the many conditions chosen for the SRCC-OG200 test, three vary significantly for systems installed in California. These are the incident solar energy, the volume of hot water drawn per day, and the effect of overnight heat losses on the net solar energy delivered by the system.

### Incident Solar Energy

An increase in incident solar energy will increase the solar energy delivered by the system. The increase can reasonably be estimated to be in the ratio of the California annual average value to the test value, or (1700/1500), in Btus per sq. ft. per day. Theoretically it is less than this ratio.

### Hot Water Usage

The effect of varying the second factor, the amount and timing of hot water drawn per day, is more difficult to quantify; however, the direction of this effect is clear. Reducing the volume from approximately 100 gallons per day during the test, to 60 gallons per day (for a three-bedroom dwelling under OII 42).

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will reduce the net solar energy delivered.[a/] (Shifting the timing of usage from evening towards morning also reduces the energy delivered, but we do not differ with the test assumption of equal draws at morning, noon and late afternoon.)

If we quantify this reduction factor for lower water use at a value of (1500/1700), it would simplify the analysis by just offsetting the increase due to greater solar insolation. The necessary accuracy depends on the number of other factors considered and on the quality of related data used. In the absence of a recognized method to calculate this factor, ECB staff believes that (1500/1700) is a reasonable value. Therefore, the output under OII 42 conditions of radiation and water usage is unchanged from the SRCC-OG200 value.

## Overnight Heat Losses

All solar systems having outdoor storage tanks lose heat overnight. This group of principally passive (nonpumped) systems includes thermosyphon systems (tank with flat-plate collectors) and ICS systems (integral collector-storage units having only a tank). The importance of this factor in the net solar energy delivered by a solar system is recognized in the SRCC-OG200 test process by a separate 16-hour temperature decay test conducted to determine the rate of heat loss under known test conditions. The amount of energy actually lost in any given location depends on the annual average nighttime temperature. Therefore no night heat losses are deducted from the SRCC-OG200 energy output as reported.

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[a/] For persons familiar with the development of the OII 42 eligibility criteria, this "net solar energy delivered" (in Btus for example) should be distinguished from the "solar fraction" (in %). While net solar Btus would fall in this case, the solar fraction would likely increase because it is the ratio of net usable Btus to total Btus. (The total Btus fall nearly 50% from 100 gal./day to 60 gal./day, while net Btus might only fall 20%.)

The overnight temperature decay measured in the SRCC test, must be distinguished from the specific freeze protection energy consumed by a system. Freeze protection energy consumption is not measured by the SRCC test. Some freeze protection features actively consume significant amounts of energy, depending on climate. Freeze protection is discussed separately in Appendix C of this decision.

The method of determining the amount of energy lost due to overnight temperature decay, using local temperatures and SRCC heat loss rate data, will eventually be part of a consensus standard to modify the SRCC test result. An engineering estimate of that loss is described here.

Two items of test data are used. One is the temperature of the solar heated water remaining in the solar system after the standard test day. The difference between this temperature and the annual average overnight temperature in California population centers, is used as the factor driving the overnight heat loss.

The second item is the rate of heat loss. The two rates used in this analysis reflect overnight conditions of zero wind during the three days of solar simulation and a known wind during the separate heat loss test.

These two data items are combined with an exponential heat loss model to produce an overnight heat loss which we then deduct from the SRCC rating as reported.

## Tank Stratification

The rate of heat loss measured in the SRCC-OG200 overnight decay test depends on the ratio of the tank's heat capacity (e.g. Btus per deg. F. water temperature) to its insulation (Btus lost per hour, per deg. F. difference between water and air temperatures). In this test, the water temperature is uniform in the tank initially.

Solar Edwards' requests that its sizing reflect a heat loss rate lower than reported, due to a nonuniform temperature distribution in its tank, with somewhat lower losses.

The ECB notes that the test method of an initially uniform water temperature was chosen by a national consensus committee after deliberation on the costs and benefits of more or less detailed assumptions and methods. Moreover, the PUC has already adopted this assumption implicitly, by issuing sizing decisions based on it.[b]

Finally, to the extent that stratified water temperature remains an issue in Solar Edwards' case, the test results indicate that the 123 deg. F. average temperature of the initial profile proposed by Solar Edwards occurs naturally after 7.7 hours of the 16-hour temperature decay test. Therefore, the results do incorporate that stratification for more than half of the time.

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[b] A.82-03-112, Cornell; A.60978, King.

# APPENDIX B
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## OII 42 Program Assumptions

## Solar Water Preheater Systems with Gas Auxiliary Energy
Conventional Gas Water Heater

| Line | Item | Amount |
|---|---|---|
| 1 | Single Family Daily Hot Water Usage | 20 Gallons Per Bedroom |
| 2 | Three-Bedroom Dwelling Usage | 60 Gallons per Day |
| 3 | Energy to Raise Water 70 degrees F | 128 th/yr |
| | <u>Conventional Water Heater Efficiencies</u> | |
| 4 | After Combustion and Flue Losses | 53% |
| 5 | After Jacket Losses | 80% |
| 6 | Net Efficiency (4 times 5) | 42% |
| | <u>Before Solar Conventional Energy Usage</u> | |
| 7 | (3 over 6) | 300 th/yr |
| | <u>60% Savings of Conventional Energy</u> | |
| 8 | (7 times 60%) | 180 th/yr |
| | <u>Maximum Metered Usage With Solar</u> | |
| 9 | (7 less 8) | 120 th/yr |
| 10 | Energy From Auxiliary With Solar (9 times 6) | 51 th/yr |
| 11 | Minimum Net Energy From Solar (3 less 10) | 77 th/yr |
| 12 | Solar System Piping Efficiency | 95% |
| 13 | Net Solar Plumbing Efficiency (12 times 5) | 76% |
| | <u>Gross Solar Energy Output Required</u> | |
| 14 | (11 over 13) | 101 th/yr |

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## OII 42 Program Assumptions

### Solar Water Preheater Systems with Gas Auxiliary Energy
### High-Efficiency Gas Water Heater

| Line | Item | Amount |
|---|---|---|
| 1 | Single Family Daily Hot Water Usage | 20 Gallons Per Bedroom |
| 2 | Three-Bedroom Dwelling Usage | 60 Gallons per Day |
| 3 | Energy to Raise Water 70 degrees F | 128 th/yr |
|  | **Conventional Water Heater Efficiencies** |  |
| 4 | After Combustion and Flue Losses | 75% |
| 5 | After Jacket Losses | 80% |
| 6 | Net Efficiency (4 times 5) | 60% |
|  | **Before Solar Conventional Energy Usage** |  |
| 7 | (3 over 6) | 213 th/yr |
|  | **60% Savings of Conventional Energy** |  |
| 8 | (7 times 60%) | 128 th/yr |
|  | **Maximum Metered Usage With Solar** |  |
| 9 | (7 less 8) | 85 th/yr |
| 10 | Energy From Auxiliary With Solar (9 times 6) | 51 th/yr |
| 11 | Minimum Net Energy From Solar (3 less 10) | 77 th/yr |
| 12 | Solar System Piping Efficiency | 95% |
| 13 | Net Solar Plumbing Efficiency (12 times 5) | 76% |
|  | **Gross Solar Energy Output Required** |  |
| 14 | (11 over 13) | 101 th/yr |

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## OII 42 Program Assumptions

### Solar Water Preheater Systems with Electric Auxiliary Energy

| Line | Item | Amount |
|---|---|---|
| 1 | Single Family Daily Hot Water Usage | 20 Gallons Per Bedroom |
| 2 | Three-Bedroom Dwelling Usage | 60 Gallons per Day |
| 3 | Energy to Raise Water 70 degrees F | 3750 kWh/yr = 128 th/yr |
|  | Conventional Water Heater Efficiencies |  |
| 4 | After Combustion and Flue Losses | 100% |
| 5 | After Jacket Losses | 80% |
| 6 | Net Efficiency (4 times 5) | 80% |
|  | Before Solar Conventional Energy Usage |  |
| 7 | (3 over 6) | 4687 kWh/yr = 160 th/yr |
|  | 60% Savings of Conventional Energy |  |
| 8 | (7 times 60%) | 2813 kWh/yr = 96 th/yr |
|  | Maximum Metered Usage With Solar |  |
| 9 | (7 less 8) | 1874 kWh/yr = 64 th/yr |
| 10 | Energy From Auxiliary With Solar (9 times 6) | 1499 kWh/yr = 51 th/yr |
| 11 | Minimum Net Energy From Solar (3 less 10) | 2251 kWh/yr = 77 th/yr |
| 12 | Solar System Piping Efficiency | 95% |
| 13 | Net Solar Plumbing Efficiency (12 times 5) | 76% |
|  | Gross Solar Energy Output Required |  |
| 14 | (11 over 13) | 2962 kWh/yr = 101 th/yr |

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## Use of Heat to Prevent Freezing in Solar Systems

Water confined in an exposed solar collector may cause damage to it by freezing and expanding if the air temperature falls much below 45 deg. F. (depending on wind and cloud cover). Water will freeze occasionally in all parts of California.

Typically the flat-plate components of active and of thermosyphon systems require freeze protection because they contain little heat when solar radiation is not available. ICS systems typically do not require freeze protection because of their large thermal mass.

Freeze protection for piping leading to and from solar systems is not discussed in individual solar decisions for two reasons. Piping is relatively inexpensive in comparison to the collector components of a solar system, and secondly, because good plumbing practice for all water piping calls for insulation as heavy as the local climate warrants.

The water in solar collectors should be drained to prevent damage, but for practical or economic reasons, the user may only try to prevent freezing. In that case, antifreeze may be added, to so-called closed loop systems, where the potable water supply does not flow directly through the collectors.

Another method is to provide heat to the collectors. It is used in those designs where potable water is always present throughout the system. In mild climates, the long-term performance of these systems will not greatly reduced. There are now at least three methods to heat collectors.

A common one is to simply start the system electric pump, in an active system, to circulate warm water from the indoor storage tank. Another is to turn on electric heaters in the collectors themselves. The Commission has limited use of both of these in OII 42 to climates defined by a maximum elevation for installation. A third method is now being used, chiefly in thermosyphon systems.

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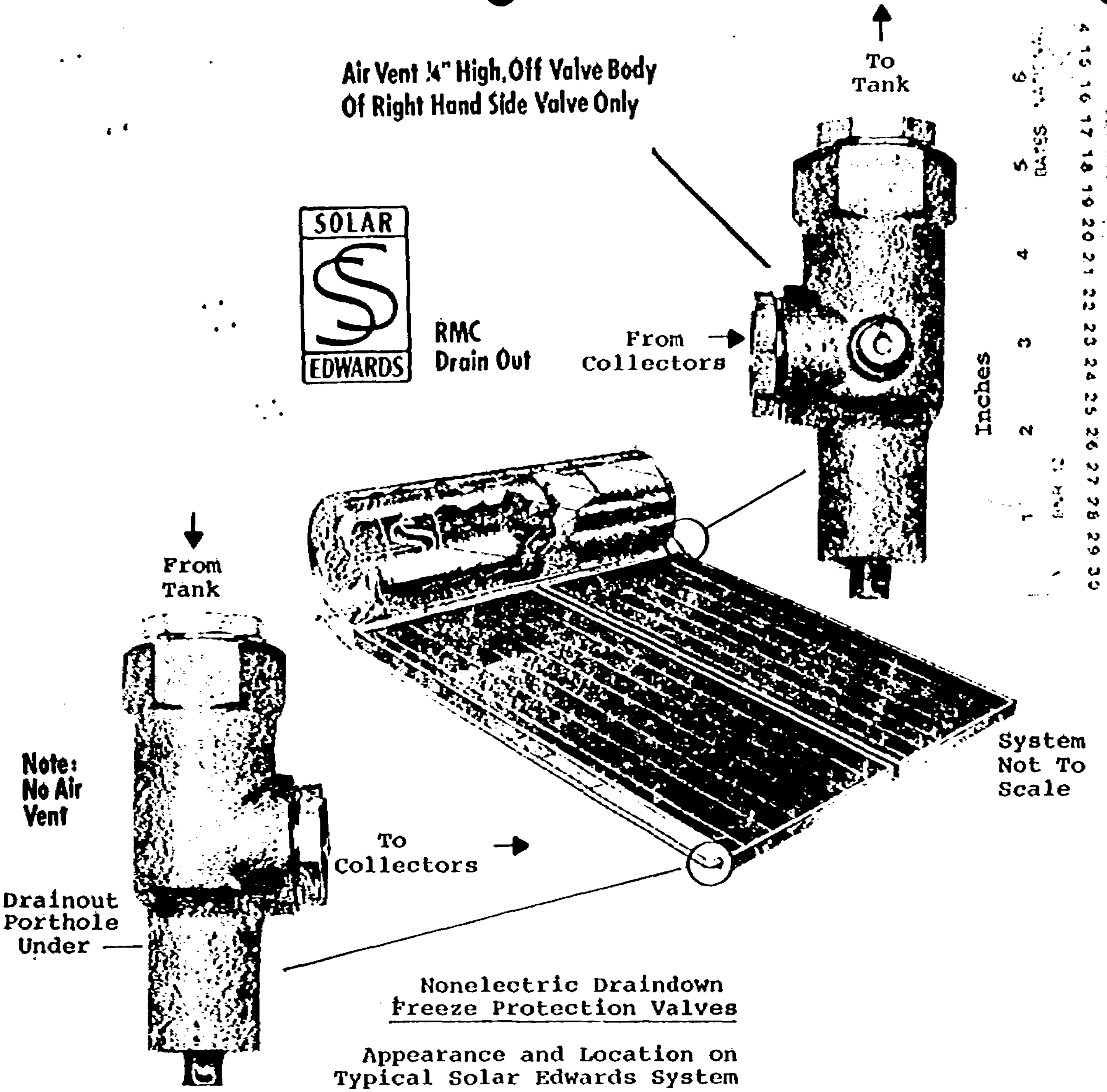
In that method a valve is activated by thermal contraction when the temperature drops into the freezing range of water. It opens to permit water to move through the system under line pressure, as if a hot water tap were opened in the dwelling. The coldest water is forced out first, over the valve actuator followed by water which warms the coldest parts of the system, including the valve. The valve actuator expands and closes, and when the heat provided by the water has dissipated, the cycle repeats itself. In very cold weather, the valve may remain open.

While this method relies only on water pressure for reliability, it is from an energy standpoint, no different from the recirculation method used in active systems, or the electric anti-freeze used in thermosyphon systems.

All three methods rely on heat to keep ice from forming. Therefore, their use of resources and effect on net energy production is the same on a statewide average. The conditions of exposure are the same, because all three methods are equally eligible regardless of insolation, water supply temperature, climate, or dwelling size. The recirculation method actually is limited to 1,000 feet elevation, not 2,300 feet, but only because it is less efficient. Electricity is used both to collect heat and to recirculate some of it, before dissipating that heat, but ice forms no more easily because the recirculation method is used.



Nonelectric Draindown Freeze Protection Valves

Appearance and Location on Typical Solar Edwards System

Appendix D