DOE/R4/10101--T1

12-0072

10101
FL-19-003

DOE/R4/10101--T1

DE84 000746

SOLAR-ASSISTED ELECTRIC CLOTHES DRYER

USING A HOME ATTIC AS A HEAT SOURCE

DEPARTMENT OF ENERGY

APPROPRIATE TECHNOLOGY SMALL GRANTS PROGRAM

GRANT # DE-FG44-80R410101

PROPOSAL # 12-0072

JAMES M. STANA

ENERGY ALTERNATIVES

118 Albrighton Drive
Longwood, Florida 32750

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

The following pages are an exact
representation of what is in the original
document folder.

INDEX

SECTION	PAGE
I EXECUTIVE SUMMARY	1
II OBJECTIVES	2
III DESCRIPTION OF EQUIPMENT USED	
A. Electric clothes dryer	2
B. Attic duct	6
C. Solar air collector	6
D. House	6
E. Instrumentation	10
IV ELECTRIC CLOTHES DRYER- THEORY OF OPERATION	11
V THE ATTIC AS A SOURCE OF HEATED AIR	17
VI DESIGN OF ATTIC DUCT	18
VII TEST PROCEDURES/DESCRIPTION OF HOUSEHOLD	23
VIII RESULTS OF TESTING	
A. Energy consumption of dryer	24
B. Attic source temperatures	24
C. Energy savings as a result of preheating dryer inlet air	28
IX NEGATIVE EFFECTS OF ATTIC DUCT	34
X SOLAR HOT AIR COLLECTOR	34
XI CONCLUSIONS	36

APPENDICES	PAGE
A RAW DATA	37
B CONSTRUCTION OF SOLAR AIR COLLECTOR	51
C SUMMARY OF PROJECT SUITABLE FOR PUBLICATION	55
D RECORD OF GRANT EXPENSES	63
E CORRESPONDENCES, PUBLICITY	64

(Copyrighted, pages of App. E removed)

ACKNOWLEDGEMENT

My sincere thanks to my wife, Eileen, for her patience in assisting my data collection.

NOTICE

PORTIONS OF THIS REPORT ARE ILLEGIBLE.

It has been reproduced from the best available copy to permit the broadest possible availability.

I EXECUTIVE SUMMARY

This study was undertaken to determine the suitability of using a Southeastern home attic as a means of reducing the energy consumption of an electric clothes dryer. An inexpensive duct (duplicable for \$25) was constructed to collect hot attic air from the peak of a south facing roof and introduce it into the dryer inlet. Instrumentation was added to measure inlet temperatures and operating time/energy consumption of the dryer. Standardized test loads, in addition to normal laundry, were observed over the period of one year. The heat-on time of the dryer tested was shown to be reduced .16 to .35 minutes per °C rise in inlet temperature. Inlet temperatures produced by the attic duct peaked at 56°C (133°F) in May/June and 40°C (104°F) in February. Based on peak temperatures available between 2 and 4 pm each month, a potential 20% yearly average savings could be realized. Economic viability of the system, dependant primarily on dryer usage, can be computed using a formula derived from the test results and included in the report.

II OBJECTIVES

- A. To measure the typical energy consumption of an electric clothes dryer under actual home use.
- B. To determine the suitability of the Southeastern home attic as a source of heat for assisting an electric clothes dryer.
- C. To design an inexpensive system which can introduce hot attic air into the inlet of an electric clothes dryer.
- D. To measure the energy savings resulting from supplying pre-warmed air into the inlet of an electric clothes dryer. Any negative effects of operation or operator interface problems should also be noted.
- E. To determine if a more expensive hot air solar collector can cut energy consumption of the assisted clothes dryer enough to offset its higher initial cost.

III DESCRIPTION OF EQUIPMENT USED

A. Electric clothes dryer

1. Whirlpool Supreme
Model LAE 7800AO, Serial M34205595, Stock #LAE780.
2. Three (3) cycles
 - Perma-Press
 - Regular
 - Timed (not used in this study)

The first two cycles are marked with graduations according to the "degree of dryness" desired. Numbers were added to the graduations to assist in identifying the setting selected. Due to the play in the selector knob, the setting obtained varied up to one digit from that selected. Regardless, the setting obtained was ultimately measured by the instrumentation.

The nature of the perma-press and regular cycles will be explained in theory of operation, section IV. The timed cycle turns on the heating element for a preset period of drying. It does not lend itself to determining if an energy savings has occurred because of preheated inlet air.

III Description of Equipment Used (continued)

3. Five (5) temperatures

SETTING	Thermostat On Below		Thermostat Off Above	
	°C	°F	°C	°F
Fluff/air	heater disconnected entirely			
Low/delicate	40.5	105	71-74	160-165
Warm/knits	44	112	81-82	178-180
Medium/perma press	47	117	84-85	183-185
High/heavy	52	125	88	190

Temperatures measured with a Fluke digital thermocouple at the exhaust filter with no clothes in dryer.

The dryer controls are shown in figure 1.

4. 240V 24 amp 5600 watt heating element.
5. 120-150 cfm blower driven by main drive motor.
6. 1/4 hp blower and drum drive motor. Blower and drive motor draw 260 watts.

FIGURE 1 DRYER CONTROLS

Cycle selector
"dryness" or cycle time selector

Start
button

Fabric temperature
selector

III Description of Equipment Used (continued)

7. Modifications to dryer

Other than instrumentation for test purposes, the only modification made to the dryer was an aluminum duct to extend from the inlet of the dryer heating element to the back of the dryer. (See figure 2.)

Figure 2.

Rear view of dryer showing sheet metal duct extension

III Description of Equipment Used (continued)

This duct was constructed of .010 thick aluminum roofing valley, formed by hand and held together by "pop" rivets. Care was taken during construction so that the aluminum would not come close to the 240 VAC terminals of the heating element. It was essential that this duct be constructed of metal because of the 300+°F experienced by the heating element enclosure. Steel could also have been used. This duct was made just long enough to enable insertion into a vertical duct adjacent to the back of the dryer. The dimensions of this duct are shown in figure 3.

FIGURE 3

III Description of Equipment Used (continued)

Scraps of fiberglass insulation were placed around wires to plug the necessary clearance holes in the duct. Care was taken to avoid placing insulation too near the heating element enclosure where it would smolder from the heat.

B. Attic Duct

An insulated duct was constructed from a 4' X 10' sheet of 1 inch thick duct board. The fiberglass sheet was notched and folded foil side out to form an 8 1/2" X 11 1/2" (inside dimensions) duct. The dimensions were selected to utilize the full sheet of material, produce a duct of approximately 100 sq. in. of cross sectional area, and conform to the physical constraints of the space involved.

The bottom of the duct was closed off and a hole the size of the aluminum dryer inlet duct extension cut in the side facing the dryer. An opening in the laundry room ceiling was cut between the roof trusses and the duct inserted through the opening until it stood upright on the laundry room floor. As originally configured, the duct extended approximately 2 feet above the ceiling into the attic above. See figure 4.

An 11 1/2" X 8" flap was cut 51" from the floor to allow opening the duct to the laundry room air when necessary.

This duct was later extended by a series of ducts made of styrofoam. A 6' X 6' sheet 1 inch thick was nailed across the lower side of the four 2" X 4" roof trusses (spaced 24" on center) on the south facing roof. The top part of this space was closed in and a 10" X 10" (interior dimension) styrofoam duct extended down from the roof inside of the attic to join the duct from the laundry room. Although joints were sealed with duct tape, the duct work cannot be considered completely leak proof. The duct is shown in detail in figure 5.

C. Solar Air collector - details will be given in section X and appendix B.

D. House

The house in which the research took place is located in Longwood, Florida (northern suburb of Orlando) at 29° north latitude. The house is of typical Florida construction - concrete block walls on concrete slab and 2" X 4" truss roof. The roof is vented by intermittent soffit vents between every other truss and three gable vents. The location of the laundry room and details of the roof structure are shown in figure 6. A picture is shown in appendix B.

FIGURE 4
ATTIC DUCT DETAILS

Cut V-notch before
folding 90°

FIGURE 6

PLAN VIEW OF HOUSE USED IN STUDY

(Pg. 8 removed)

III- Description of Equipment Used (continued)

E. Instrumentation

1. Three 30-100°C mercury thermometers graduated in 1°C increments were used in all air temperature measurements except where noted. Generally, the inlet temperature of the air in the duct was measured along with any other temperature of interest.
2. A dry/wet bulb thermometer set was placed in the garage adjacent to the laundry room to monitor humidity conditions which would normally be encountered by the dryer. (instruments 1 and 2 above were purchased from Edmund Scientific).
3. Two 110 VAC clock timers were wired into the dryer circuitry to monitor total fan-on time, cycle duration and, indirectly, heater-on time. The circuit of the dryer is shown in figure 7.

FIGURE 7

DRYER CONTROL CIRCUIT AND INSTRUMENTATION

WARNING Disconnect from Electrical Supply Before Servicing Unit

MFG. UNDER ONE OR MORE OF THE FOLLOWING U.S. PATENTS. OTHER PATENTS PENDING:
3,218,732 3,248,389 3,310,889 3,391,488 3,394,485 3,394,486 3,394,487 3,398,485
3,400,987 3,471,938 3,491,488 3,497,944 3,822,850 3,871,041 3,897,139

INSTALLATION NOTE: EXHAUSTED UNITS MAY BE INSTALLED FLUSH WITH ADJACENT STRUCTURES ON TWO SIDES AND REAR

NON-EXHAUSTED UNITS MUST USE EXHAUST DEFLECTOR AND MUST BE SPACED 4 INCHES FROM REAR WALL. CABINET SIDES MAY BE INSTALLED FLUSH WITH ADJACENT STRUCTURES.

TIMER SCHEDULE IN MINUTES						
SWITCH CLOSED	CYCLE					
	REG.	OFF	PERM. R	OFF	TIMED	OFF
Y - R	42	42	10	42	45	45
Y - BG	42	42	42	42	70	70
Y - TM	42	42	42	42	70	70

• ELECTRIC DRYER WIRING DIAGRAM. NEUTRAL TERMINAL LINKED TO CABINET

PART NO. 343943 REV. D

* taken from sticker on rear of machine

III Description of Equipment Used (continued)

During operation, the cycle timer is only advanced when the heating element is off and for two minutes following the fan shut off. Therefore, the total time the heating element was on during the operation of the dryer is:

$$\text{heat-on time} = \text{fan time} - (\text{cycle time} - 2 \text{ min})$$

At first, a digital readout mechanical timer was used for the fan timer but was found to advance erratically. Both fan and cycle timers were standard 110 VAC synchronous electric clocks read to the nearest hour and minute. In cases where extreme accuracy was desired, the second hand was also read.

4. Although an attempt was made to use a Dwyer air flow meter to measure air flow in the attic duct, the experimenter could not produce repeatable measurements. No way of dependably measuring the air flow in the system was ever found. The zero flow suction pressure of the blower was measured, however.

One end of a simple water filled U tube was placed in the suction of the blower while inlet air flow was blocked completely.

IV ELECTRIC CLOTHES DRYER: THEORY OF OPERATION

When the project was started, the experimenter was under several misconceptions of how an electric clothes dryer worked. After obtaining information from various dryer manufacturers and taking measurements, a clearer understanding of the operation of the dryer evolved. In order to predict the effect of pre-heating the inlet air, it is important to understand how the dryer normally functions.

The following discussion concerns the operation of the perma press or regular automatic cycle of a clothes dryer. Certain elements will also apply to a "timed cycle" dryer.

The dryer is best understood if one follows the path of the air-flow through the machine. (See figure 8.)

T_1 , T_2 and T_3 are the temperatures of the air at the inlet, post heating element, and at the thermostat respectively.

W_1 and W_2 are the specific humidities in grains of water per lb. of dry air at the inlet and thermostat respectively.

FIGURE 8
 DRYER AIR FLOW DIAGRAM AND SYSTEM MODEL

The air flow moves through the heater box, and then passes through the inlet manifold into the drum area. There it absorbs moisture from the clothes and passes through the lint filter and finally is exhausted.

*taken from Whirlpool service literature

SYSTEM MODEL

IV Electric Clothes Dryer: Theory of Operation (continued)

P_{in} and P_{out} are the inlet and outlet air pressures induced by the dryer blower. P_{in} is lower than atmospheric pressure, which causes a volume V of air to flow through the machine every minute. Restriction of the blower outlet or inlet will reduce the pressure drop and thus the flow of air through the machine. (example: clogged filter, too long of a hose on outlet side, or a restriction on the inlet).

M is the weight of clothes when dry. m is the weight of water absorbed by the clothes when washed. The amount of water absorbed varies with the fabric type. Cotton towels may absorb 90% of their weight in water. Synthetic fabrics like nylon or polyester absorb considerably less.

The sole purpose of an electric clothes dryer is to take a wet load of clothes weighing $M + m$ lbs and remove the moisture until the clothes return to their original dry weight of M lbs and "feel" dry to the person operating the dryer.

The flow of air can be followed on a psychrometric chart (see figure 9) for a typical load of towels on a regular cycle.

Assume the ambient air temperature is 86°F (30°C) dry bulb and 82°F wet bulb (85% RH). This is a specific humidity, w_1 , of 160 grains of moisture per pound of dry air. See point 1 on figure 9.

This air becomes heated in the attic by contact with the hot solar heated roof. Since no moisture is added or removed, the attic heated air will have the same specific humidity. In this example, $T_1 = 114^\circ\text{F}$ dry bulb (45.5°C) and 88°F wet bulb. (Point 2 on figure 9.) As the air enters the dryer, it is heated further by the heating element, again without moisture addition or removal. When the air enters the dryer drum it has a temperature, T_2 , of about 180-225°F (82 - 107°C), $w_1 = 160$ grains of moisture per lb. of dry air, and a relative humidity of < 7%. (Point 3 on figure 10.)

As the air passes over the tumbling wet clothes, moisture from the clothes is evaporated into the dry air. The evaporation is assisted somewhat by the slight negative pressure existing in the drum due to the fan. The heat energy needed to evaporate the moisture from the clothes is supplied by the air, and it is therefore cooled as it passes through the drum.

This evaporation process takes place along a constant wet bulb temperature line on the psychrometric chart. If the process were complete, it would continue to the saturation line and the exiting air would be saturated with water vapor. (100% RH) Instead, the moist air leaves the dryer in a less than saturated state. When the heating element first comes on, the outlet temperature reaches 140°F dry, 99°F wet. (220 grains/lb dry air, 25% RH) See point 4 on figure 10. After the drying process

PSYCHROMETRIC CHART FIGURE 9

86°F Dry Ambient

FIGURE 10

IV Electric Clothes Dryer: Theory of Operation (continued)

proceeds for several minutes, the exit temperature reaches 156°F dry, 106°F wet. (20% RH, 270 grains/lb dry air) Thus the moist air gains 54 to 120 grains of moisture per pound of dry air. In our example, an average of 91 grains/pound of dry air in the first five minutes.

$$91 \text{ grains/lb} = \left(\frac{91 \text{ grains}}{1 \text{ lb}} \right) \left(\frac{.0648 \text{ grams}}{\text{grain}} \right) \left(\frac{1 \text{ lb}}{454 \text{ grams}} \right)$$

$$= .013 \text{ lb H}_2\text{O} / \text{lb dry air}$$

At point 4 (exit to the dryer), the specific volume of the air is 16-16.5 cubic feet per pound of dry air.

IV Electric Clothes Dryer: Theory of Operation (continued)

$$\frac{150 \text{ cfm}}{16.25 \text{ ft}^3/\text{lb}} = 9.23 \text{ lb/minute}$$

$$\text{moisture evaporated} = (9.23 \text{ lb/min}) \left(.013 \frac{\text{lb H}_2\text{O}}{\text{lb dry air}} \right)$$

$$= .12 \text{ lb H}_2\text{O/minute}$$

$$= .6 \text{ lb H}_2\text{O evaporated in 5 minutes}$$

The drying process continues as shown in figure 11.

The control thermostat senses the dry bulb temperature of the exiting air as it leaves the dryer. This device turns the heating element on or off according to limits defined by the temperature selector setting. With the selector on medium, the thermostat turns off the heating element when the air leaving the drum is 180°F (81°C) and advances the cycle timer until the air cools below 117°F (47°C). This process continues until the cycle timer advances the total number of minutes initially set by the operator. The permanent press cycle differs from the regular cycle only in that it turns off the heating element in the last 10 minutes regardless of the thermostat temperatures (as oppose to 5 minutes on the regular cycle). This allows the permanent press fabrics to cool down more to avoid wrinkling.

The effect of pre-heating the inlet air should be to allow the exit temperature to reach the thermostat upper limit sooner and take longer to cool down to the lower "turn heater on" temperature. In addition, the dryer sheetmetal and drum should come up to operating temperatures faster and run hotter because they are not being cooled by air drawn in by the inlet blower. Data from Whirlpool Corporation (see appendix E) suggests the effect is on the order of 1% less energy for every 2 1/2°F above a 75°F inlet temperature. If an inlet temperature of 130°F (54°C) could be attained by tapping the attic as a heat source, this relationship would suggest as much as 20% could be saved on dryer electricity consumption. If a solar air collector yielding 180°F (82°C) could be constructed at a reasonable cost, then the 40% expected savings might result in a reasonable return on investment. However, the higher temperatures might interfere with the normal operation of the dryer by not allowing the thermostat to again turn on the heater after its initial shut off. The warm pre-heated air would not be hot enough to completely dry the clothes in the cycle time set by the operator.

V THE ATTIC AS A SOURCE OF HEATED AIR

An electric clothes dryer operating at 150 cfm requiring inlet air at 130°F (from an ambient of 75°F) will require the following heat input from the sun:

$$\text{Solar Heat Input} = Q = V \rho C_p (T_{\text{inlet}} - T_{\text{ambient}}) \frac{\text{BTU}}{\text{min}}$$

$$T_{\text{inlet}} = 130^{\circ}\text{F}$$

$$T_{\text{ambient}} = 75^{\circ}\text{F} \quad (70^{\circ}\text{F wet bulb})$$

$$\rho = \frac{1}{14.7 \frac{\text{ft}^3}{\text{lb}}} = .068 \text{ lb/ft}^3$$

$$C_p = .241 \frac{\text{BTU}}{\text{lb}^{\circ}\text{F}}$$

$$C_p \rho = .0167 \frac{\text{BTU}}{\text{ft}^3^{\circ}\text{F}}$$

$$Q = (150 \text{ cfm}) \left(.068 \frac{\text{lb}}{\text{ft}^3} \right) \left(.241 \frac{\text{BTU}}{\text{lb}^{\circ}\text{F}} \right) (130 - 75^{\circ}\text{F})$$

$$= 135 \text{ BTU/min}$$

Solar insolation data for five Florida cities (Orlando, Jacksonville, Tallahassee, Miami and Tampa) indicate 1200 BTU/ft² day is not an unreasonable expectation for solar heat input.¹ Using a 12 hour day results in a $\frac{100 \text{ BTU}}{\text{ft}^2\text{hr}} = 1.7 \frac{\text{BTU}}{\text{ft}^2\text{min}}$ average.

For a 100% efficient collector, this would require $\frac{135}{1.7} = 80 \text{ ft}^2$ of collector surface. The roof under test was approximately 1300 ft² in area, so that a 6% efficiency would result in the desired inlet temperature.

In the winter months, only the south facing slopes of the roof will collect direct solar insolation. The other roof sections will tend to dissipate the heat and lower the attic air temperature from that of summer. To enhance the collection of heated attic air in the winter, a duct can be constructed under the trusses of the south facing roof. This will ensure that the air collected is first drawn along the heated southern roof exposure.

¹ Mean solar radiation for Florida cities:
Florida Solar Energy Center
300 State Road 401
Cape Canaveral, FL 32920

VI DESIGN OF ATTIC DUCT

Once the heated attic air is collected, it must be transported down to the inlet of the dryer by virtue of the suction provided by the dryer blower. In order to prevent severe restriction of the airflow through the dryer, the duct must be of sufficient cross sectional area to minimize frictional losses. In addition, the duct must be insulated to prevent excessive heat loss from the hot air in the duct.

The unrestricted flow of the dryer blower is given by the manufacturer (Appendix E) as 150 cfm maximum. The zero flow suction of the blower was measured by a U tube manometer to be .93 inches of water. The flow rate-pressure head for a typical centrifugal blower can be approximated conservatively as a straight line.

Dryer fan pressure differential

Thus, to avoid more than a 10% loss in flow through the dryer, the inlet duct must have a friction loss of less than .09 in H₂O ΔP .

According to Marks Engineering Handbook, pressure losses in duct systems are due to friction of the air in contact with the sides and dynamic losses due to change in duct shape, size, or direction.

The head loss due to friction is given by:

$$H_f = f \frac{L}{D} \left(\frac{V}{4005} \right)^2$$

VI DESIGN OF ATTIC DUCT (continued)

where f = non dimensional friction coefficient. For subsonic flows, f can be taken from the Moody friction chart figure 12.

L = length of duct, ft

D = effective diameter of duct, ft (for a square duct, this diameter is $\left(\frac{4 \times \text{area of duct}}{\text{perimeter of duct}} \right)$)

V = velocity of air in ft/min
 $= \frac{\text{volume of air in ft}^3/\text{min}}{\text{effective cross sectional area of duct}}$

$$= \frac{V}{\left(\frac{\pi D^2}{4} \right)}$$

Dynamic losses due to changes in duct shape, size or direction are given by

$$H_v = C \left\{ \frac{V}{4005} \right\}^2$$

where C = experimentally determined constant = $\approx .9$ for right angle turn

For the original attic duct

$$L = 10'$$

$$A = \left(\frac{8.5}{12} \right) \times \left(\frac{11.5}{12} \right) \text{ ft}^2 = .679 \text{ ft}^2$$

$$\text{Perimeter} = 3.33 \text{ ft.}$$

$$D = \frac{4A}{P} = \frac{4(.679)}{3.33} = .815 \text{ ft.}$$

$$V = \frac{V}{\frac{\pi D^2}{4}} = \frac{150 \text{ ft}^3/\text{min}}{\frac{\pi (.815)^2}{4}}$$

$$= 288 \text{ ft/min.}$$

$$Re = \frac{VD}{\nu}$$

$$\text{Where } \nu = \text{Kinematic viscosity} = .00021 \frac{\text{ft}^2}{\text{sec}}$$

VI Design of Attic Duct (continued)

$$\text{Re} = \frac{(288 \text{ ft/min}) (.815 \text{ ft})}{.0021 \text{ ft}^2/\text{sec} \left(\frac{60 \text{ sec}}{\text{min}} \right)}$$

$$= 18600$$

Assume fiberglass duct board has same surface roughness as concrete. For an effective dia. of .815 ft. and e of .003, the relative roughness is .0035. For a Re of 18600 and $e/D = .0035$, $f = .033$. (see figure 12.)

Then the head loss due to friction is

$$H_f = (.033) \left(\frac{10'}{.815'} \right) \left(\frac{288}{4005} \right)^2$$

$$= .0021 \text{ in H}_2\text{O} \quad (.00021 \text{ in H}_2\text{O/ft of duct})$$

FIGURE 12 Friction Factors for Flow in Pipes

(a) Friction factors for flow in pipes.

VI Design of Attic Duct (continued)

The pressure loss due to a right hand turn is

$$H_v = 0.9 \left(\frac{288}{4005} \right)^2$$

$$= .0047 \text{ in } H_2O$$

The total pressure loss expected is approximately .0068 in H_2O or less than 0.7 % loss in flow expected.

Even if the duct is extended to the attic roof as shown in figure 5, the additional loss of pressure will be of the order of .013 in H_2O . This would be a total of .019 in H_2O or about 2% reduction in air flow.

If the duct were made of 6" by 6" cross section throughout;

$$A = (6/12)(6/12) = .25 \text{ ft}^2$$

$$D = (4)(.25)/2 = .5 \text{ ft}$$

$$V = 150 / ((.5)^2 / 4) = 764 \text{ ft/minute}$$

$$Re = (764)(.5) / (.00021)(60) = 30317$$

$$e/D = .003 / .5 = .006$$

$$f = .035$$

$$H_f = .035 \left(\frac{10}{.5} \right) \left(\frac{764}{4005} \right)^2$$

$$= .025 \text{ in } H_2O \quad (.0025 \text{ in } H_2O \text{ per foot of duct})$$

$$H_v = 0.9 \left(\frac{764}{4005} \right)^2$$

$$= .033 \text{ in } H_2O$$

The loss of a six inch square attic duct would be .058 in H_2O or approximately 6 % loss in flow. Extending the duct in a similar way to the roof would result in a total loss of flow of 18%. Although a smaller duct might cost half that of the larger one, the 18% loss in air flow would offset the benefit of preheating the inlet air.

VI Design of Attic Duct (continued)

The heat lost to the surroundings from the duct can be estimated as follows;

R value of walls = 5

Roof temperature = 130°F

Attic temperature = 110°F

Laundry room temperature = 75°F

$$\begin{aligned}\text{Heat loss, } Q &= (130-110)(6')(4')/5 + (130-75)(10')(2(8.5+11.5)/1) \\ &= 96 + 367 \\ &= 463 \text{ BTU/hr.}\end{aligned}$$

The heat lost comes from the hot air in the duct

$$Q = C_p \rho V \Delta T$$

$$(463 \text{ BTU/hr})(1 \text{ hr}/60 \text{ min}) = (.017 \text{ BTU}/\text{ft}^3 \text{ }^{\circ}\text{F})(150 \text{ ft}^3/\text{minute}) \Delta T$$

$$\Delta T = 3^{\circ}\text{F} \quad (\text{Hot attic air will cool by } 3^{\circ}\text{F} \text{ by the time it gets to the dryer.})$$

If the energy consumption of the dryer is reduced 1% for every 2.5°F as indicated earlier, then this heat loss would result in a 1.2% loss in system efficiency.

VII TEST PROCEDURES/ DESCRIPTION OF HOUSEHOLD

All loads of laundry were the result of the normal operation of a household except where noted in Appendix A. The nature of the household changed slightly during the test period. From May 1980 to August 14, 1980, the household consisted of a husband and housewife. After August 14, a baby girl was added. Thus, laundry after August 14, 1980 included typical baby laundry- i.e. sheets, bibs, sleepers, etc. Except for a brief 3 week period, there were no cloth diapers in the laundry. Two test loads of permanent press and cotton fabrics were also used but were treated separately in the data.

FIGURE 13 ATTIC DUCT CODES ILLUSTRATED

VII Test Procedures/ Description of Household (continued)

The house was equipped with a 40 gallon solar hot water heater. This was an additional incentive to do laundry on a sunny afternoon.

The configurations of inlet ducts tested are shown in figure 13.

All data concerning date, time, temperature, load type, duct code, cycle settings, and timers were recorded prior to starting the load. The duct temperature was recorded after the drying cycle had proceeded a few minutes. The timer values were recorded after the drying cycle was complete.

VIII RESULTS OF TESTING

A. ENERGY CONSUMPTION OF DRYER

The raw data taken from a year's observation of the dryer and attic duct is given in Appendix A.

The data was broken down into two periods. May 1980-August 14, 1980 (2 adult household) and August 14, 1980-May 1981 (2 adult plus infant household). The data, summarized in figure 14, accomplishes the first objective of this study: to measure the dryer energy usage under typical conditions.

It must be kept in mind that the data included in figure 14 includes any benefit from the attic duct. Consumption presumably would have been higher for an unmodified dryer.

In addition, the data indicates how much money is spent on clothes drying and thus potentially how much can be saved. This will be important when discussing the economic payback of the solar assist system.

B. ATTIC SOURCE TEMPERATURES

The second objective of the study was to determine the suitability of the attic as a source of heat for assisting an electric clothes dryer.

Figure 15 shows the inlet temperature of the dryer versus time of day for the original duct. Figure 16 shows the same data for the extended attic duct. Although some attempt was made to wash clothes during the early afternoon period, there were many loads washed during morning, evening, or cloudy times out of necessity. It would appear from the figures that the period 2 - 4 pm is optimum for obtaining maximum inlet temperature. Note, however, that drying an hour earlier or later than 2 - 4 pm does not reduce the maximum inlet temperature more than 5°C.

It would appear that extending the attic duct to the south facing roof slope (duct code D) boosted the winter and spring inlet temperatures. The summer temperatures are about the same as the original duct C. It is evident from the data points that a cloudy versus sunny day can vary 2 pm inlet temperatures considerably. This is especially true if the roof has been cooled by the afternoon rainshowers common to Central Florida.

FIGURE 14
SUMMARY OF TEST RESULTS

Household members	2 adult household	2 adult + infant household	Combined total period
Test dates	May 80-Aug 14,80	Aug 14,80-May 81	May 80 - May 81
Duration of test	14 wks	42 wks	56 wks
Total number of Permaprest lds	30	132	162
Avg PP loads/week	2.14	3.14	2.89
Number of PP loads by temperature setting			
warm	6	24	30
low	0	1	1
med	24	107	131
Avg duration of PP cycle time set by operator	28.02 min	23.91 min	24.67 min
Total heat-on time for all PP loads combined	552 min	2343 min	2895 min
Avg heat-on time per PP load	18.4	17.75	17.87
Total kwhr used for PP loads	51.5	218.7	270.2
Avg kwhr/PP load	1.72	1.66	1.67
Total number of regular cycle loads	37	187	224
Avg reg cycle loads/week	2.64	4.45	4.00
Number of regular loads at fabric temp setting			
warm	1	3	4
med	31	150	181
high	5	34	39
Avg duration of reg cycle time	22.58 min	21.40 min	21.60 min
Total reg cycle heat-on time	706 min	4460 min	5166 min
Avg heat-on time/reg load	19.08	23.85	23.06
Total kwhr used for reg loads	65.9	416.2	482.1
Avg kwhr used/reg load	1.78	2.23	2.15
Total kwhr used, all loads	117.4	634.9	752.3
Avg kwhr used /week	8.39	15.12	13.44
Avg cost/week at \$.07/kwhr	\$0.59	\$1.06	\$0.94
Yearly cost (52 weeks)	\$30.68	\$55.12	\$48.88

PP = permanent press

461510

 10 X 10 TO THE CENTIMETER 18 X 25 CM.
 KEUFFEL & ESSER CO. MADE IN U.S.A.

ATTIC DUCT CODE C & C'

ATTIC DUCT CODE C & C'

FIGURE 16

461510

K&E 10 X 10 TO THE CENTIMETER 18 X 25 CM. KEUFFEL & ESSER CO. MADE IN U.S.A.

VIII RESULTS OF TESTING (continued)

C. ENERGY SAVINGS AS A RESULT OF PREHEATING DRYER INLET AIR

Several factors can affect the heat-on time required to dry a load of clothes besides the inlet temperature. The size or weight of the clothes (dry), the amount of moisture absorbed by the load, the type of fabric and its willingness to "give up" the moisture absorbed when subjected to heated air, the cycle time (or degree of dryness preferred) set by the operator, and the temperature setting (thermostat limits) also set by the operator. In addition, ambient temperature, humidity, and whether a load has immediately preceded the one being tested may have an influence on the duration of the heating element on-time.

There were two approaches taken in this study to rule out these other effects and determine the effect of inlet temperature alone. The first was to record heat-on time used by a number of laundry loads over an extended period. (1 year) In the mild environment of Florida, the nature and amount of articles laundered and dried would not change appreciably over time. Over a large sample, variations due to load size, type, etc. would average out.

Figure 17 shows a series of plots of heat-on time versus inlet temperature for regular and PermaPrest cycles, duct codes A & B, C & C', and D. Also plotted are the average cycle times selected. All the data has been averaged over N data points and the standard deviation plotted (height of the line) to indicate how much data scatter is present.

Examining the plots of cycle time versus inlet temperature indicates that the average cycle time is consistent over the range of inlet temperatures tested. This would indicate that the operator is not skewing the results by picking shorter cycle times (less stringent dryness requirements) for higher inlet temperatures.

Examining the permanent press cycle heat-on time charts is disappointing. There is no clear correlation indicated between heat-on time (energy used) and inlet temperature.

Examining the regular cycle heat-on time charts is more promising. Despite the large standard deviation in some cases, the data suggests a significant reduction of heat-on time with increasing inlet temperature. Even the unassisted dryer suggests the dependance over its smaller range of test temperatures.

FIGURE 17 HEAT-ON TIME & CYCLE TIME VERSUS DRYER INLET TEMPERATURE

VIII Results of Testing (continued)

It is difficult to say whether the difference in the graphs of regular and permanent press cycles is due to the differences in the cycle itself or to the actual differences in the fabric dried. Looking through the test data, one may find instances where a load of clothes might be dried with a regular setting one time and a perma prest cycle another time with a different operator.

The second way of eliminating other test variables is to identify a standard set of test loads and dry them under controlled circumstances. Two such loads were formulated. Test load number one was composed of permanent press type synthetic fabric scraps and a bedsheet treated with a permanent press finish. (The test load later had to be altered by substituting some of the garment scraps for other ones. This load is identified as 1'.) The second test load was composed of 7 cotton towels and 3 wash cloths. Test load number 1 was dried on the permanent press cycle for approximately 20 minutes on the cycle timer and a medium fabric temperature. Test load number 2 was dried on the regular cycle for 20 minutes and a medium fabric temperature.

The results of the test loads are given in figure 18. The weight loss of each test load (wet load weight-dry load weight) was found to be consistent within ounces. The cycle time was consistent within a minute. (Variations were due mainly to the mechanical "play" in the timer knob itself.)

Test load #1 showed only moderate change in heat-on time versus inlet temperature. (The total heat-on time was only 9-12 min.) Four test runs made on two days showed 6 and 22% decrease in heat-on time for a ΔT of 20°C . A best fit of the data indicates an improvement of .11-.22 minutes saved per $^{\circ}\text{C}$.

Test load #2 showed a much more consistent improvement in heat-on time versus inlet temperature. Three sets of test runs on the same day produced improvements of 19, 24 and 28% for 10, 12, and 22°C ΔT respectively. A best fit line shows an improvement of .31-.4 minutes saved per $^{\circ}\text{C}$.

The amount of energy saved by use of the attic duct can now be computed as follows;

From the data of figure 17, it is evident that the inlet temperature can be maintained at a minimum of 30°C . During cloudy days or early morning/late evening hours, the duct can be opened to the laundry room where the waste heat of the dryer helps to heat the room. (This was not necessarily done during the testing.) The savings will be computed only for those C, C' & D duct loads which were run with an inlet temperature of 30°C or higher. It will be assumed that all other loads could have been maintained at 30°C by opening the inlet to the laundry room.

FIGURE 18
HEAT-ON TIME VS INLET TEMPERATURE
AVERAGE OF LOADS TESTED

7

VIII Results of Testing (continued)

Savings = (avg heat-on at 30°C - avg heat-on at T°C) (Number of loads dried at T°C inlet temperature)

Reg load savings = 2.42(26)+2.9(32)+4.11(18)+6.86(9)
= 291.44 minutes of heat-on time saved.
= 6% saved

Permaprest load = 0.8(18)-1.21(17)+1.38(17)+2.27(9)
savings = 37.72 minutes saved
= 1% saved

A total of 329 minutes of 5.6 kw was saved, or \$2.15 at \$.07/kwhr

Clearly, the amount saved does not justify the expense of the attic duct.

Examining the test data, we find that only 21.3% of the laundry loads were dried between 2 and 4 pm. Only 45.8% between 1 and 5 pm. What if the operator had taken a more active role in the use of the attic duct? To optimize energy savings of the dryer;

1. open attic vent to laundry room when inlet temperature is less than laundry room temperature.
2. attempt to dry clothes only during sunny days and between 2 and 4 pm.

Examining figures 15 and 16, the potential sunny day inlet temperatures between 2 and 4 pm for each month are below.

Month	Potential clear day inlet temp (2-4pm) (°C)	ΔT above 30°C (°C)
Jan	35 (will improve with	5
Feb	35 extended collector)	5
Mar	47	17
Apr	47	17
May	55	25
June	55	25
July	52 (may improve with	22
Aug	52 extended collector)	22
Sept	47	17
Oct	47	17
Nov	37 (will improve with	7
Dec	37 extended collector)	7

VIII Results of Testing (continued)

If the number of loads per week is constant, then 17 reg and 13 PP loads will be dried per month. Using the savings shown by the test loads;

$$\begin{aligned}\text{Reg savings/yr} &= 17(5(.35)+5(.35)+17(.35)+\dots\text{etc.}) \\ &= 17(186)(.35) \\ &= 1106.7 \text{ min/yr}\end{aligned}$$

Similiarly for perma press cycle

$$\begin{aligned}\text{PP savings} &= 13(186)(.16) \\ &= 386.9 \text{ min/yr}\end{aligned}$$

A total of 139 kwhr/yr (24.89 hrs x 5.6 kw) will be saved or \$9.76 if electricity costs \$.07/kwhr. At a total cost of \$48.88/year, this represents a 20% savings.

If the clothes can be dried only when the conditions are optimum (sunny afternoon 2 - 4 pm), then a 20% overall savings can occur during the year. This may be a conservative estimate for several reasons. The 30°C baseline temperature might be actually lower in the winter if the dryer is located in an otherwise unheated laundry room. Also the attic temperature will improve during the winter months by using the extended south facing duct (D) which was not tested til March.

The amount of savings and payback period for a given household and conditions is given below.

$$\text{\$/saved/year} = \frac{186}{60}(.35N_r + .16N_{pp}) \text{ KHP} \quad \text{where}$$

N_r = number of regular loads/month

N_{pp} = number of perma prest loads / month

K = cost of electricity in \$/kwhr

H = kw rating of heating element

P = per cent of loads dried on sunny days between 2 and 4 pm. (expressed as decimal)

186 = sum of maximum clear day inlet temperatures for each month

.35 and .16 are valid for Whirlpool dryer

Payback period = Cost of attic duct/\$ saved per year

IX NEGATIVE EFFECTS OF ATTIC DUCT

If drying in the morning or evening, the attic temperature can be less than the laundry room temperature. Drying time will be lengthened if the attic duct is used in this case. The system must alert the operator to the inlet temperature or specify times the duct is to be open to the laundry room when drying.

The operator perceived the duct as ugly. (No attempt was made to integrate the duct into the existing structure.) This could be overcome easily in new structures but might require additional expense to cover the duct in a retrofit situation.

Significantly, no perceived dust or insulation (loose fiberglass or cellulose) was found in duct or outlet from dryer. Although the adult female of the household was significantly sensitive to such irritants (as well as a newborn baby), no complaints or symptoms of such irritants were received or observed. Flow was apparently low enough not to suck in any such airborne irritants of this nature. In addition, the duct inlet was always at least one foot above the insulation.

The female operator complained of having to take so much data before and after each load of laundry but did not perceive any differences in the quality of the clothes dryness or operation of the dryer. This speaks well for the passive nature of the design.

X SOLAR HOT AIR COLLECTOR

Based on the promising results of the attic air duct, a solar hot air collector was constructed as originally proposed. It was expected that the higher collector temperatures possible with a black absorber and clear glazing could produce a significant reduction in dryer energy usage.

A conversation with Lance Leonitis of the Atlanta Southern Solar Energy Center produced the following facts.

- A. The use of wood for a hot air collector as originally proposed would be a fire hazard in the long term and unnecessarily expensive. The construction of a collector using Thermax polyisocyanurate insulation would be superior in performance and cost and would weather long enough to evaluate the concept.
- B. The hotter the collector temperature, the poorer the efficiency of converting solar energy to deliverable heat. Since the study was necessarily trying to obtain higher temperatures, a larger collector area would be required. (30-50% efficiency at higher temperatures)

X SOLAR HOT AIR COLLECTOR (continued)

If one were trying to replace the heat input of the 5.6 kw drying element entirely, 19000 BTU/hr would be required.

A good efficiency for a solar collector would be 200 BTU/hr/ft² delivered. This would require 95 ft² of collector area for 5.6kw. Although it seems difficult to imagine building a collector of this size and justifying its cost solely on reduced clothes drying energy use, it is possible such a collector could be shared with a home solar heating system and used in a different mode for each purpose.

Rather than try to construct a 95 ft² collector, it was decided to build one of approximately 40" x 90" (25 ft²) and determine if such a collector delivered the expected performance.

Appendix B illustrates the construction of the collector. 3/4" thick Thermax insulation was used for the collector body and associated duct work. A panel adhesive (Maaco liquid nails or similiar) was used to assemble the sheathing into a box shape. Corrugated fiberglass was used for the glazing. The collector itself was aluminum roofing valley painted flat black. Ridges in the absorber were formed transverse to the air flow to assist mixing of the flow (and thus heat transfer). The air was brought into the top of the collector, flowed under the hot absorber, and then over the top of the absorber. In this way, both sides of the absorber was available for heat transfer. See figure 19.

Cross section view of solar air collector showing path of air flow

X SOLAR HOT AIR COLLECTOR (continued)

The assembly was sealed at all joints with silicone caulk.

One problem which severely limited the time available to evaluate the collector was the physical layout of the house and laundry room. (See figure 6 and Appendix B) The collector had to be located close to the dryer to reduce air travel path. Unfortunately, due to the west side location, roof overhang, and nearby trees, the collector was only in the sun (in winter) from about 12:30 to 2:00 pm. The collector was angled to match the altitude of the sun.

Various configurations of collector and attic duct combinations were tried. At first, the hot attic air was ducted down to the collector to boost air temperatures before entering the dryer. (Duct code E) The collector and attic air source were also tried in parallel (duct code G & H) as well as the collector by itself. (Duct codes J & L) See figure 13.

The performance of the collector itself was quite good. Air temperatures of as much as 86°C (187°F) were measured at the exit of the collector. Unfortunately, this temperature could not be maintained going into the dryer. The air lost 10°C just travelling the few feet of duct from collector to dryer inlet. (This duct was smaller in cross section, 25 in², and could have contributed to the loss.)

The effectiveness of the collector was further reduced by the size and length of the duct. The longer duct lengths tended to reduce the air flow of the dryer and lengthen drying times despite seemingly higher inlet temperatures. This could be seen by examining outlet temperatures of the dryer at the filter. (See appendix A, Mar 15, 1981 data)

Despite the disappointing performance, it is expected that a collector, properly sized and integrated into the roof of a home or building and a duct of sufficient cross section could deliver 170°F air to a clothes dryer without choking its air delivery system. Only a commercial laundry building or a solar heated home could justify the expense. A commercial laundry with extensive dryer usage and a roof collector with perhaps some thermal mass added could probably pay off the investment with a 25% reduction in energy consumption during daylight use.

XI. CONCLUSIONS/RECOMMENDATIONS

1. A properly designed attic duct can introduce hot air into the inlet of an electric dryer and reduce its energy consumption by 20% on an annual basis. But economic payback of the system depends on dryer usage and the active participation of the operator in drying clothes only on sunny afternoons.

2. A hot air solar collector could be constructed to achieve greater dryer energy savings, but the cost of the system and necessary controls would not be economical unless it was shared with a solar home heating system or in a commercial application.

Solar Assisted Clothes Dryer Test Data #DE-FG44-80R410/01

Page 1A

DATE	TIME	ROOM TEMP		Fabric Cycle Setting	Fabric Temp	Load Type	Load Weight			CLOCK READINGS						DUCT TEMP		DUCT CODE	Heat on Time (min)	Comments
		DRY BULB	WET BULB				Wet	Dry	Net	CYCLE TIMER			FAN TIMER			°C	°F			
										START	STOP	NET	START	STOP	NET					
1980	(pm)			Reg	PP															
5/10/80	1:30	80			✓	Med				12:10	12:36	:26	697.8	698.5	:42	27	80.6	A	18	Digital Fan timer
5/15	2:30	82			✓	warm				12:36	12:58	:22	698.5	699.2	:42	28	82.4	A	22	↓
	4:00	84		✓		med				12:58	1:21	:23	699.2	699.85	:39	29	84.2	A	18	
	6:00	84		✓		med				1:21	1:41	:20	699.85	700.5	:39	29	84.2	A	21	
	9:15	85		2		med				1:41	1:58 1/2	:17 1/2	700.5	700.9	:24	29	84.2	A	8.5	
5/18	1:21	89		✓		Fluff										44	111.2	C		Test attic duct
5/20	1:55	85			✓	warm				2:32	2:52	:20	701.1	701.65	:33			C	15	
5/24	11:45a	83		5		med				2:52	3:16	:24	701.65	702.5	:51	39	102.2	C	29	
	1:12	84			5	med				3:16	3:29	:13	702.5	703.2	:42	39	102.2	C	31	
					3	med				3:29	3:47	:18	703.2	703.6	:24			C	8	Restart previous load
	2:30	83			4	med				3:47	4:09	:22	703.6	704.2	:36			C	16	
	5:30	84		5		med				4:09	4:32	:23	704.2	704.9	:42			C	21	
	6:30	85		3		med				4:32	4:50	:18	704.9	705.5	:36	36	96.8	C	20	
5/30	12:45	80		5		med				4:50	5:16	:26	705.5	706.1	:36			C	12	
5/31	12:32	82			4	med				5:16	5:39	:23	706.1	706.8	:42	39	102.2	C	21	
6/1	12:10	82			5	med				5:39	6:05	:26	706.8	707.6	:48	42	107.6	C	24	
	1:25	83			5	med				6:05	6:28	:23	707.6	708.3	:42	35	95	C*	21	Duct room partly open to
6/6	12:25	85		5		med				6:28	6:50	:22	708.3	709	:42			C	22	
	1:15	88			5	warm				6:50	7:15	:25	709	709.6	:36	45	113	C	13	
	2:45	88			5	warm				7:15	7:39	:24	709.6	710.3	:42			C	20	
	4:00	88		5		med				7:39	8:04	:25	710.3	711.1	:48			C	25	
	5:00	88		5		heavy				8:04	8:47	:43	711.1	712.1	:60			C	19	
6/7	12:15	83		3		med				8:47	9:06	:19	712.1	712.5	:26	41	105.8	C	9	
6/14	1:50	84	77		4	med				9:06	9:26	:20	712.5	713.1	:34	46	114.8	C	16	
	2:45	90	80		4	med				9:26	9:46	:20	713.1	713.8	:42	48	118.4	C	24	same load
	3:35	89	80	Time 30 min	med	Fluff				9:46	10:19	:33	713.8	714.3	:30	48	118.4	C	0	T attic = 53°C
	4:00	90	80		4	Fluff				10:19	10:37	:18	714.3	714.6	:18	50	122	C	0	same load
	4:30	91	81		4	med				10:37	10:58	:21	714.6	715.1	:30			C	11	continue dry
	5:15				4	Fluff				10:58	11:18	:20	715.1	715.4	:18			C	-	
6/16	8:40	88	78	5		heavy				11:18	11:41	:23	715.4	716.47	:64	36	96.8	C	43	
6/17	1:15	88	78		5	warm				11:39	12:03	:24	716.5	717.0	:30			C	8	
6/20	5:00	88	82	5		heavy				12:03	12:26	:23	717.0	717.6	:36	39	102.2	C	15	
6/21	10:05a	89	81	5		med				12:26	12:51	:25	717.6	718.3	:42	26	78.8	C	19	cloudy day
6/21	12:00	84	80	4		med				12:51	1:11	:20	718.3	719.0	:42	28	82.4	C	24	

Solar Assisted Clothes Dryer Test Data #DE-FG44-80R410101

Page 2A

Laundry										CLOCK READINGS						DUCT TEMP		DOIT CODE	HEAT ON Time (min)	Comments
DATE	TIME (p.m)	ROOM TEMP		Fabric Cycle Setting	Fabric Temp	Load Type	Load Weight			CYCLE TIMER			FAN TIMER			°C	°F			
		DRY BULB	WET BULB				Wet	Dry	Net	START	STOP	NET	START	STOP	NET					
1980				Reg	PP															
6/21/1980	1:00	90	83		5	med				1:11	1:33	1:22	719.0	719.65	1:39	32	89.6	C	19	
	1:45	92	82		5	med				1:33	1:58	1:25	719.65	720.3	1:39			C	16	
	3:10	90	83		4	med				1:58	2:11	1:21	720.3	721.0	1:42	33	91.4	C	23?	} Fan timer reading error
	3:55	92	84	5		heavy				2:11	2:38	1:19	721.0	721.5	1:30			C	13?	
	5:12	91	83		6	med				2:38	3:27	1:49	721.5	722.6	1:66			C	19	
6/28	3:00	92	82		5	med				3:27	3:51	1:24	722.6	723.3	1:42	48	118.4	C	20	
	4:14	95	85	5		med				3:51	4:16	1:25	723.3	723.7	1:36			C	13	
	5:49	95	85	5		med				4:16	4:36	1:20	723.7	724.5	1:36	43	109.4	C	18	
	6:55	96	84		5	med				4:36	5:01	1:24	724.5	725.2	1:42	42	107.6	C	28	
	7:45	97	84	5		med				5:01	5:23	1:22	725.2	725.9	1:42	39	102.2	C	22	
7/2	4:02	88			5	med				5:39	6:15	1:36	726.3	726.9	1:36	35	95	C	2	
7/3																				Experiment with empty dryer
7/3	6:00	91	84	3		med				7:12	7:30 1/2	1:18	727.9	728.4	1:30			C	14	
7/6	5:50	92	82	5		med				12:00	12:25	1:25	12:00	12:50	1:50			C	27	Change fan timer to clock type
7/7	8:20	93	84	5		med		14		12:25	12:48	1:23	12:50	1:40	1:50	41	105.8	C	29	
	9:20	98	86	4		med	16	12	4	12:48	1:08	1:20	1:40	2:15	1:35	39	102.2	C	17	
7/12	11:15a	88	83	3		med	6	4	2	1:08	1:26	1:18	2:16	2:45	1:29	37	98.6	C	13	
	12:05	93	85		3	med	14	10	4	1:26	1:44	1:18	2:45	3:14	1:29	40	104	C	13	
	12:46	95	86	2		warm		4		1:44	1:59	1:15	3:14	3:31	1:17			C	4	
7/17	9:03a	84	80	3		med	10			1:59	2:16	1:17	3:31	4:06	1:35	31	87.6	C	20	
	10:43a	88	80		5	warm	16	11	5	2:16	2:39	1:23	4:06	4:47	1:41	29	84.2	C	20	
7/18	7:38a	82	78	5		med				2:39	3:04	1:25	4:47	5:21	1:34	30	86	C	11	
	8:45a	86	78	5		med				3:04	3:24	1:20	5:21	6:11	1:50	30	86	C	32	
	10:30a	86	78	5		heavy bed spread				3:24	3:45	1:21	6:11	6:51	1:40			C	21	
7/19	8:35	86	80		3	warm	7			3:45	4:04	1:19	6:51	7:18	1:27			C	10	} same load
	10:02	86	80		3	warm				4:04	4:23	1:19	7:18	7:38	1:20			C	3	
7/24	11:15a	87	86	5		med	15	10	5	4:23	4:45	1:22	7:39	8:22	1:43	34.5	94.1	C	29	
	12:30	88	80		4	warm	12	10	2	4:45	5:09	1:24	8:22	8:56	1:34	32	89.6	C	12	
	1:32	88	80		5	med	14	11	3	5:09	5:30	1:21	8:56	9:31	1:35	34.5	94.1	C	16	
	2:37	86	80	5		med	10	6	4	5:30	5:54	1:24	9:31	10:12	1:41			C	19	
7/26	2:13	91	82	3		fluff										45	113	C		prewarm dryer
	2:23	94	84	5		med	12	8	4	6:11	6:32 1/2	2:1 1/2	10:31	11:07 1/2	1:36 1/2	44.5	112.1	C	17	} redry same load
	3:25	91	82	5		med	12	8.5	3.5	6:34	6:58	1:24	11:11	11:50	39	37	98.6	C	17	

Solar Assisted Clothes Dryer Test Data #DE-FG44-80R410101

Page 3A

DATE	TIME	ROOM		Fabric cycle Setting	Fabric Temp	Load Type	Load Weight			CLOCK READINGS						DUCT		Heat on Time (min)	Comments		
		TEMP					Wet Dry Net			CYCLE TIMER			FAN TIMER			°C	°F				
		DRY BULB	WET BULB				Wet	Dry	Net	START	STOP	NET	START	STOP	NET						
				Reg	PP																
1980	(pm)																				
8/2/8	9:35a	83	79		3	med	PP	9	6	3	7:12 1/2	7:30	1:17 1/2	12:06	12:37	1:31	30	86	C	15 1/2	
	10:30a	85	80		4	med	PP	12.5	9.5	3	7:30	7:51	1:21	12:37	1:11 1/2	1:34 1/2	37.5	99.5	C	15 1/2	
	11:20a	88	81	4		med	whites	10	6	4	7:51	8:12	1:21	1:11 1/2	1:47 1/2	1:36	41	105.8	C	17	
	12:17	89	82	4		med	towels sheets	12	8	4	8:12	8:32	1:20	1:47 1/2	2:22	1:34 1/2	44	111.2	C	16 1/2	
	4:50	90	85	2		med	towels				8:32	8:47	1:15	2:22	2:41	1:19			C	6	
8/6	9:12	89	84	3		Fluff		11			9:12 1/2	9:28	1:15 1/2	3:05	3:18	1:13	33	91.4	C	0	} Predry same load
		89	83	3		med		9	2		9:28	9:45	1:17	3:18	3:46	1:28	33	91.4	C	13	
8/11	2:40	89	82	4		med	towels sheets	15	11	4	9:45	10:06	1:21	3:46	4:38	1:52	46	114.8	C	33	
	3:55	90	81		4	med	sheets	16	11	5	10:06	10:27	1:21	4:38	5:10	1:32	44	111.2	C	13	
	4:55	90	81	3		med	towels	5	3	2	10:27	10:46	1:19	5:10	5:29	1:19	38	100.4	C	2	finish drying damp towels
8/17	2:55	91	84	4		Fluff		17	15.5	1.5	10:46	11:07	1:21	5:30	5:48	1:18	53	127.4	C	0	} Predry same load. Tatic=146F attic air predried load
	3:30	93	86	5		Fluff		15.5	15	0.5	11:07	11:30	1:23	5:48	6:10	1:22	52	125.6	C	0	
	4:05	94	85	4		med		15	12.5	2.5	11:30	11:51	1:21	6:10	6:39	1:29	52	125.6	C	10	
	4:45	94	86	4		Fluff	socks towels	10.5	10	0.5	11:51	12:11	1:20	6:39	6:57	1:18	51	123.8	C	0	} predry same load
	5:50	94	86	4		med		10	7	3	12:11	12:32	1:21	6:57	7:31	1:34	47	116.6	C	15	
8/20	2:45	89	87	5		med					1:35	1:59	1:24	8:55	9:26	1:31	54	129.2	C	9	
8/21	2:25	94	87	4		med					1:59	2:21	1:22	9:26	10:04	1:38	50	122	C	18	
	4:30	94	86	5		heavy					2:21	2:23	1:02	10:04	10:15	1:11			C	14	stopped for unknown reason
	6:	91	84	5		heavy					2:23	2:44	1:21	10:15	10:50	1:35	38	100.4	C	16	
	9:00	87	79	4		med					2:44	3:05	1:21	10:50	11:24	1:34	34	93.2	C	15	} continued to dry damp clothes
8/22	1:30	90	84	4		med					3:05	3:24	1:19	11:24	11:51	1:27	37	98.6	C	10	
	2:30	90	84	3		med					3:24	3:40	1:16	11:51	12:08	1:17			C	3	
8/24	3:45	89	84	5		med					3:40	4:04	1:24	12:08	12:48	1:40	41	105.8	C	18	
8/26	9:40	88	85	3		med		7	5	2	4:04	4:20	1:16	12:48	1:18	1:30	30	86	C	16	
8/28	1:00	89	81	5		med		8	5	3	4:20	4:44	1:24	1:18	1:55	1:37	45	113	C	15	
	2:00	92	82	5		med		10	6	4	4:44	5:08	1:24	1:55	2:34	1:39	50	122	C	17	
	2:35	93	81	5		warm		11	6	5	5:08	5:31	1:23	2:34	3:06	1:32	54	129.2	C	11	
	3:50	94	81	5		warm		8	5	3	5:31	5:57	1:26	3:06	3:35	1:29	53	127.4	C	5	
	4:30	94	83	5		med		10	5	5	5:57	6:19	1:22	3:35	4:05	1:30	50	122	C	10	
	5:15	94	86	5		med		7	5	2	6:19	6:43	1:24	4:05	4:37	1:32	50	122	C	10	
	9:10	90	84	4		med		5	2.5	2.5	6:43	7:04 1/2	1:21.5	4:37	5:11	1:34	34	93.2	C	14.5	
8/29	4:50	91	82	5		med		9	5	4	7:04 1/2	7:28 1/2	1:23 1/2	5:11	5:49	1:38	44	111.2	C	16 1/2	
8/30	8:00a	83	78	5		med		9	5	4	7:28	7:53	1:25	5:49 1/2	6:33	1:43 1/2	27	80.6	C	20 1/2	
8/31	2:01	89	82	4		med		8	4	4	7:53	8:14	1:21	6:33	7:09	1:36	49	120.2	C	17	

Solar Assisted Clothes Dryer Test Data #D.E-FG44-80R410101

Page 4A

Laundry										CLOCK READINGS						DUCT TEMP		DUCT CODE	HEAT ON TIME	COMMENTS	
DATE	TIME	ROOM TEMP		Fabric Cycle Setting	Fabric Temp	Load Type	Load Weight			CYCLE TIMER			FAN TIMER								
		DRY BULB	WET BULB				Wet	Dry	Net	START	STOP	NET	START	STOP	NET	°C	°F				
1980	(pm)			Reg	PP																
9/10	9:00a	83	77		4	med		7	5	2	8:14	8:35	1:21	7:09	7:44	35	30	86	C'	16	1st dry of same load
9/2	1:30	82	76	5		med		9	6	3	8:35	8:58	1:23	7:44	8:24	40	42	107.6	C'	19	
9/5	3:00	89	82	5		med		8	5	3	8:58	9:23	1:25	8:24	9:04	40	46	114.8	C'	17	
9/6	12:20	88	82	3		med	whites	10	6	4	9:23	9:42	1:19	9:04	9:38	1:34	45	113	C'	17	
	1:08	88	82		4	Fluff	SAFETY towels	17	16	1	9:42	10:03 1/2	1:22	9:38	9:58	1:20	46	114.8	C'	0	} same load
	1:46	89	82		5	Med		16	11.5	4.5	10:03 1/2	10:28	1:24	9:58	10:36	1:38	50	122	C'	16	
	2:34	91	83		4	med		9	8	1	10:28	10:50	1:22	10:36	11:00	1:36	50	122	C'	16	
	3:15	91	83		4	med	PP	15 1/2	12	3 1/2	10:50	11:11	1:21	11:00	11:31	1:31	50	122	C'	12	
	4:00	91	84		2	med		4	3	1	11:11	11:18	1:07	11:31	11:43	1:12	49	120.2	C'	7	left over damp clothes
	4:15	91	84		4	med		7	5	2	11:18	11:40 1/2	1:22 1/2	11:43	12:09 1/2	1:26 1/2	49	120.2	C'	0	2nd dry of same load
	5:30	92	85		2	med			1.5		11:40 1/2	11:57	1:16 1/2	12:09 1/2	12:25	1:15 1/2	45	113	C'	1	remaining damp clothes from above load
9/7	11:09a	84	78		4	med		13	10	3	11:57	12:18	1:21	12:25	1:03	1:38	35	95	C'	19	big load, not dry
	12:11	86	80		2	med		4	3	1	12:18	12:36	1:18	1:03	1:22	1:19	41	105.8	C'	3	damp clothes from above load
9/8	4:30	92	82	5		med		12	7.5	4.5	12:36	1:01	1:25	1:22	2:07	1:45	51	123.8	C'	2 1/2	
9/9	8:00	80	76	5		med		3	2	1	1:01	1:25	1:24	2:07	2:37	1:30	41	105.8	C'	8	
9/10	4:30	88	80	5		med		8	4	4	1:25	1:48	1:23	2:37	3:18	1:41	42	107.6	C'	20	
9/13	6:15a	80	75		4	med	TL#1	7	5	2	1:48	2:10	1:22	3:18	3:51	1:33	23	73.4	C'	13	T.L. #1
	6:59a	82	76	4		med	TL#2	7.5	4.5	3	2:10	2:30	1:20	3:51	4:31	1:40	25	77	C'	22	T.L. #2
	12:06	86	80	5		med	baby	14	8	6	2:30	2:54	1:24	4:31	5:19	1:48	42	107.6	C'	26	
	1:05	88	80		4	med	PP	10 1/2	8	2 1/2	2:54	3:16	1:22	5:19	5:52	1:33	45	113	C'	13	
	2:06	90	80	4		med		13	9	4	3:16	3:37	1:21	5:52	6:30 1/2	1:38 1/2	48	118.4	C'	19 1/2	
	2:58	90	82	4		med	TL#2	7	4	3	3:37	3:57	1:20	6:30 1/2	7:01	1:30 1/2	48	118.4	C'	12 1/2	T.L. #2 slightly damp
	3:46	91	82	3		med	towels	5 1/2	3 1/2	2	3:57	4:16	1:19	7:01	7:27	1:26			C'	9	
	5:00	93	82	5		med		5	3 1/2	1 1/2	4:16	4:38 1/2	1:22 1/2	7:27	7:59	1:32			C'	11 1/2	
9/15	10:20a	82	76		4	med		10	6	4	4:38 1/2	5:03 1/2	1:25	7:59	8:41	1:42			C'	19	
	1:40	87	80	5		med		6	4	2	5:03 1/2	5:30	1:26 1/2	8:41	9:25	1:44	47	116.6	C'	19 1/2	
9/16	3:45	88	81		5	med		14	9 1/2	4 1/2	5:30	5:55	1:25	9:25	10:03	1:38	48	118.4	C'	15	
				3		med	Finishing towels				5:55	6:19	1:24	10:03	10:30	1:27			C'	5	
9/18	12:15	86	79		5	med		12	8	4	6:19	6:43	1:24	10:30	11:20	1:50	41	105.8	C'	28	
9/20	3:46				4	med		10	7	3	7:08	7:28	1:20	12:02	12:34 1/2	1:32 1/2	47	116.6	C'	14 1/2	
	4:41				5	med		8	5	3	7:28	7:49	1:21	12:54 1/2	1:06 1/2	1:32	47	116.6	C'	13	
9/21	1:37				4	med					7:49	8:30	1:41	1:06 1/2	2:07	1:00 1/2	41	105.8	C'	21 1/2	
9/22	9:30a				5	med		7	4	3	8:30	8:53 1/2	1:23 1/2	2:07	2:49	1:42	30	86	C'	20 1/2	
9/23	8:00				4	med	TL#2	7 1/2	3	4 1/2	8:53 1/2	9:14	1:20 1/2	2:49	3:25	1:36	36	96.8	C'	17 1/2	T.L. #2
	8:41				4	med	TL#1	6	4	2	9:14	9:36	1:22	3:25	3:54	1:21	34	93.2	C'	9	T.L. #1

40

Solar Assisted Clothes Dryer Test Data #DE-F544-80R410101

Page 5A

DATE	TIME	ROOM TEMP		Fabric Cycle		Fabric Temp	Load Type	Load Weight			CLOCK READINGS						DUCT TEMP		DUCT CODE	Heat on Time (min)	Comments
		DRY BULB	WET BULB	Setting				Wet	Dry	Net	CYCLE TIMER			FAN TIMER			°C	°F			
				Reg	PP	START	STOP				NET	START	STOP	NET							
1980	(pm)																				
9/26	9:00a			5		heavy		14	9	5	9:36	9:57 1/2	21 1/2	3:54	4:45	1:51	32	89.6	C'	31 1/2	
	10:15a				5	med		10	7	3	9:57 1/2	10:21	23 1/2	4:45	5:20	1:35	34	93.2	C'	12 1/2	
	11:30a				5	med		11	9	2	10:21	10:41	20	5:20	5:55	1:35	35	95	C'	17	
	12:50				5	med		8	5	3	10:41	11:05	24	5:55	6:25	1:30	38	100.4	C'	8	
	1:45			5		heavy		10	6	4	11:05	11:24	19	6:25	7:01	1:36	43	109.4	C'	19	
	2:15			5		med		9	7	2	11:24	1:49	25	7:01	7:35	1:34	38	100.4	C'	11	
	3:40			4		med		3 1/2	2 1/2	1	11:49	12:11	22	7:35	8:00	1:25	40	104	C'	5	finish dry damp items
	4:30			5		heavy		8	5	3	12:11	12:35	24	8:00	8:38	1:38	44	111.2	C'	16	
9/29	7:20			5		med		12	7 1/2	4 1/2	12:35	12:59	24	8:38	9:23	1:45			C'	23	
9/30	2:30			5		med		11	7	4	12:59	1:24	25	9:23	10:04	1:41	41	105.8	C'	18	
10/3	9:30a			5		heavy		12	8	4	1:24	1:47	23	10:04	10:56	1:52	32	89.6	C'	31	
10/3	2:00			5		heavy	towels cotton	14	10	4	1:47	2:14	27	10:56	11:42	1:46	41	105.8	C'	21	
	2:30				5	med		13	10	3	2:14	2:33	19	11:42	12:18	1:36	38	100.4	C'	19	
	4:36			5		med			10		2:33	2:58	25	12:18	12:52	1:34			C'	11	
	8:00			4		med			8		2:58	3:17	19	12:52	1:24	1:32	31	87.8	C'	15	
10/4	7:15a	78			4	med	TL#1	109 02	78 02	31 02	3:18 54	3:38 06	21 12	1:24 42	1:55 18	1:30 36	25.5	77.1	A	11 1/4	TL#1
	9:40a	78			4	med	TL#2	121 02	65 02	56 02	3:38 06	3:58 00	19 54	1:55 18	2:36 01	1:40 42	25.5	77.1	A	22 1/8	TL#2
	10:36a	79			4	med	TL#1	111 02	79 02	33 02	3:58 06	4:18 06	20 06	2:36 01	3:06 35	1:30 36	26.1	78.8	A	12 3/10	TL#1
	11:26a	80			4	med	TL#2	122 02	65 02	57 02	4:18 06	4:38 06	20 00	3:06 35	3:45 32	1:40 00	26.7	79.8	A	22 00	TL#2
	3:31			4		med					4:38 1/2	4:58	19 1/2	3:45 1/2	4:24	1:38 1/2	46	114.8	C'	21	
				3		med					4:58	5:15	17	4:24	4:44	1:20			C'	5	
	5:23			5		heavy					5:15	5:37	22	4:44	5:44	1:60	40	104	C'	40	
10/6	9:30			4		heavy					5:37	5:57 1/2	20 1/2	5:44	6:25	1:41	28	82.4	C'	22 1/2	
10/9	7:00a			4		med					5:57 1/2	6:17	19 1/2	6:25	7:04	1:39	<30	<86	C'	21 1/2	
	4:00			5		med					6:17	6:39	22	7:04	7:43	1:39	41	105.8	C'	19	
	4:45				5	med					6:39	7:02	23	7:43	8:21	1:38	44	111.2	C'	17	
	5:53				5	med					7:02	7:00	48	8:21	8:55 1/2	1:34 1/2	45	113	C'	?	Reading error!
	6:40				5	med					7:50	8:16	26	8:55 1/2	9:31	1:35 1/2	45	113	C'	11 1/2	
	7:21			5		heavy					8:16	8:36	20	9:31	10:06	1:35	40	104	C'	17	
10/11	12:55			5		med					8:36	8:59	23	10:06	10:50	1:44	39	102.2	C'	23	
10/15	10:20a			5		heavy					8:59	9:26 1/2	27 1/2	10:50	11:56	1:66	<30	<86	C'	41	
	3:20				5	warm					9:26	9:47	21	11:56	12:30	1:34			C'	15	
10/18	11:40a			5		heavy					9:47	10:18 1/2	24 1/2	12:30	1:20	1:50	33	91.4	C'	27 1/2	
	2:05			4		med					10:11 1/2	10:30	18 1/2	1:20	1:58 1/2	1:38 1/2	41	105.8	C'	22	

41

E
E
E
E

Solar Assisted Clothes Dryer Test Data #DE-FG44-80R410101

Page 6A

DATE	TIME	Garage		Fabric cycle Setting	Fabric Temp	Load Type	Load Weight			CLOCK READINGS						DUCT TEMP		DUCT CODE	Heat Lon Time (min)	Comments	
		ROOM TEMP	WET BULB				Wet	Dry	Net	CYCLE TIMER			FAN TIMER			°C	°F				
										START	STOP	NET	START	STOP	NET						
1980	(pm)	DRY BULB	WET BULB	Reg	PP																
10/18	3:05			4		med				10:30	10:51	:21	1:58 1/2	2:29	130 1/2	41	105.8	C'	11 1/2		
	3:40			4		med				10:51	11:10	:19	2:29	3:04	135	41	105.8	C'	18		
	4:37			3		med				11:10	11:33	:23	3:04	3:27 1/2	123 1/2	40	104	C'	2 1/2		
10/19		93		4		med	TL#1	11 02	78 02	33 02	11:42 02	12:02 48	120 48	3:43 02	4:12 57	129 50	36 1/2	97.7	C'	11.0	TL #1
10/20	11:45a			5		heavy	Baby			12:03	12:25	:22	4:14	4:47	133	31	87.8	C'	13		
10/23	10:25a			5		heavy				12:25	12:44 1/2	119 1/2	4:47	5:40	153	<30	<86	C'	35 1/2		
10/24	1:40			5		low	baby			12:44 1/2	1:11	126 1/2	5:40	6:17	137	31	87.8	C'	12 1/2		
	2:35			5		warm	PP			1:11	1:31	:20	6:17	6:51	134	35	95	C'	16		
	3:30			5		med	whites			1:31	1:54	:23	6:51	7:36	145	38	100.4	C'	24		
	4:50			5		warm	PP			1:54	2:19	:25	7:36	8:12	136	36	96.8	C'	13		
	5:40			5		heavy	jeans pants			2:19	2:38	:19	8:12	8:48	136	35	95	C'	17		
10/25	4:18	84		4		med	TL#2	65 02		2:38 52	2:59 01	120 02	8:48 26	9:27 57	139 31	36	96.8	C'	21 23	TL #2	
10/26	9:50a			5		med				2:59	3:27	:28	9:27	10:16	149			C'	28		
10/27	10:25	80		4		med	Yonkers Cotton			3:20 56	3:41	:20	10:15 55	11:01	145			C'	27		
10/20	9:10a			5		med	baby			3:41	4:06	:24	11:01	11:56	155	31	87.8	C'	33		
10/31	12:40a			5		med				4:06	4:29	:23	11:56	12:31 1/2	135 1/2	<30	<86	C'	14 1/2		
11/1	7:00a			5		med	1 baby out fit			4:29	4:51	:22	12:31 1/2	1:00	28 1/2			C'	8 1/2		
	10:10a			5		heavy	baby			5:07	5:29 1/2	:22 1/2	1:09	2:02	153	30	88.6	B	32 1/2		
	3:30			3		med				5:29 1/2	5:46	:16 1/2	2:02	2:35	133	38	100.4	C'	18 1/2		
	4:30			5		med				5:46	6:11	:25	2:35	3:15	140	34	93.2	C'	17		
	5:00			5		med				6:11	6:34	:23	3:15	3:52	137	32	89.6	C'	16		
	6:00			4		med				6:34	6:53	:19	3:52	4:28 1/2	134 1/2	30	86	C'	17 1/2		
	7:30			5		med				6:53	7:19	:26	4:26	5:00	134	<30	<86	C'	10		
11/4	5:15			5		med				7:19	7:41	:22	5:00	5:57	151			C'	31		
11/6	2:15			5		med				7:41	8:04	:23	5:57	6:30	131	38	100.4	C'	18		
11/7	6:20			5		med				8:04	8:28 1/2	:24 1/2	6:30	7:14	144	<30	<86	C'	23 1/2		
	8:05	78		4		med				8:26 1/2	8:46 1/2	:20	7:14	7:52	138	28	82.4	B	20		
	9:05	78		3		med				8:46 1/2	9:05	:18 1/2	7:52	8:18 1/2	126 1/2	32	89.6	B	10		
	9:43	78		4		med				9:05	9:23	:18	8:18 1/2	8:51	132 1/2			B	16 1/2		
11/8	3:45	82		3		med				9:23	9:42	:19	8:51	9:18	127	35	95	C'	10		
	4:00	85		4		med	TL#2			10:00 02	10:18 57	:18 55	9:33 46	10:09 06	135 20	38	100.4	C'	18 25	TL #2 by	
	4:40	85		4		med	TL#1			10:18 57	10:40 00	:21 03	10:09 06	10:37 27	128 21	37	98.6	C'	9:08	TL #1	
11/10	10:30a			5		med				10:40	11:00	:20	10:37 1/2	11:20	142 1/2	31	87.8	C'	24 1/2		
11/12	1:00			5		med				11:00	11:21	:21	11:20	12:04	144	32	89.6	C'	25		

42

Solar Assisted Clothes Dryer Test Data #DE-FG44-80R4/0/01

Page 7A

DATE	TIME	Garage		Fabric Cycle Setting	Fabric Temp	Load Type	Load Weight			CLOCK READINGS						DUCT TEMP		DUCT CODE	Heat on Time (min)	Comments
		TEMP					Weight			CYCLE TIMER			FAN TIMER							
		DRY BULB	WET BULB				Wet	Dry	Net	START	STOP	NET	START	STOP	NET	°C	°F			
1980	(PM)																			
11/14	2:00	78		5	med	baby				11:21	11:42	:21	12:04	12:54	:50	35	95	C'	31	
	3:00	78		5	heavy	towels cottons				11:42	12:10	:28	12:54	1:45	:51	33	91.4	C'	25	
	4:00	79		5	warm	PP				12:10	12:31	:21	1:45	2:23	:38	31	87.8	C'	19	
	4:40	79		5	med	PP				12:31	12:53	:22	2:23	2:55	:32	30	86	C'	12	
	5:25			5	med	PP				12:53	1:17	:24	2:55	3:35 ⁴⁷	:40 ⁷⁴	30	86	C'	18 ³⁴	
11/15	5:04	83		4	med	baby				1:17	1:38	:21	3:35 ⁴⁷	4:02 ¹⁶	26 ⁴⁸	33	91.4	C'	7.8	
	5:50	83		2	med	2 damp towels				1:38	1:52	:14	4:02 ¹⁶	4:17 ¹²	:15	32	89.6	C'	4	
11/17	12:45	78		5	med	baby				1:51	2:17	:26	4:17	5:06	:49	29	84.2	C'	25	
	4:40			3	heavy	towels				2:17	2:33 ⁴⁶	:17	5:06	5:39 ²⁵	33 ²⁴	<30	<86	C'	18.4	
11/19	7:31	72		3	med					2:33 ⁴⁶	2:51 ¹⁰	:17 ¹²	5:39 ²⁵	6:20 ⁵⁴	:41.5	24	75.2	B	26	
11/21	1:00	70		4	med	baby				2:51	3:14	:23	6:20	7:00	:40	<30	<86	C'	19	
	2:15	74		5	med	whites				3:14	3:35	:21	7:00	7:43	:43	23	73.4	B	24	
	3:00	74		5	heavy					3:35	4:00	:25	7:43	8:35	:52	23	73.4	B	29	
	4:05	74		5	med					4:00	4:23	:23	8:35	9:17	:42	23	73.4	B	21	
11/22	7:40 a	60		5	heavy					4:23	4:44	:21	9:17	10:10	:53			B	34	
11/23	12:10	72		5	med					4:44	5:06	:22	10:10	10:53	:43	22	71.6	B	28	
11/26	1:45	75		5	heavy					5:06	5:29	:23	10:53	11:32 ¹²	:40 ¹²	24	75.2	B	19.5	
	11:05	77		5	med					5:29	5:53	:24	11:33 ¹²	12:20 ¹⁰	:46 ⁴⁸	26	78.8	B	24.8	
11/29	12:45	65		4	med	baby				5:53	6:13	:20	12:20 ¹⁰	1:07 ¹⁰	46 ⁵⁴	24	75.2	B	28.9	
	3:00	70		4	med	PP				6:13	6:34	:21	1:07 ¹⁰	1:48 ⁵²	41 ⁴²	27	80.6	C'	22.7	
	4:07			3	med	Finish damp				6:34	6:52	:18	1:49	2:16 ¹⁴	27 ¹⁴	25	77	C'	11 ¹⁴	
11/30	9:25 a			6	med					6:52	7:17	:25	2:16	3:06	:50			C'	27	
12/1	3:20			5	med					7:17	7:37	:20	3:06	3:50	:44	29	84.2	C'	26	
	4:45			5	med					7:37	8:02	:25	3:50	4:34	:44	29	84.2	C'	21	
	5:40			5	heavy					8:02	8:26	:24	4:34	5:19	:45	<30	<86	C'	23	
12/3	11:30 a			5	warm					8:26	8:46	:20	5:19	5:49	:30			C'	12	
12/4	3:50	71		5	med					8:46	9:09 ¹²	:23 ¹²	5:50	6:34 ²⁰	:44 ²⁰	<30	<86	C'	22.8	
12/7	12:30	72		4	med					9:09 ¹²	9:29	:19 ¹²	6:34 ²⁰	7:17	42 ⁴⁰	32	89.6	C'	25.2	
12/8	1:30	75		5	med					9:29	9:50	:21	7:17	7:57	:40	32	89.6	C'	21	
	3:55			5	med					9:50	10:16	:26	7:57	8:44	:47	32	89.6	C'	23	
	4:45			5	warm					10:16	10:36	:20 ¹²	8:44	9:24 ¹²	40 ¹²	29 ¹²	85.5	C'	22 ¹²	
	5:26	76		6	warm					10:36	11:00	:24	9:24 ¹²	10:04	39 ¹²	29	85.1	C'	17.5	
	6:24	75		6	warm					11:00	11:26 ¹²	:26 ¹²	10:04	11:00	:56	27	80.6	C'	31.5	
	8:00			5	heavy					11:26 ¹²	11:47	:20 ¹²	11:00	11:56	:56	23	73.4	C'	37.5	

43

Solar Assisted Clothes Dryer Test Data #DE-FG44-80R4/0/01

Page 8A

DATE	TIME	Garage		Fabric Cycle Setting	Fabric Temp	Load Type	Load Weight			CLOCK READINGS						DUCT TEMP		DUCT CODE	Heat on Time (min)	Comments
		ROOM TEMP					Wet	Dry	Net	CYCLE TIMER			FAN TIMER			°C	°F			
		DRY BULB	WET BULB							START	STOP	NET	START	STOP	NET					
1980-1981	(pm)			Reg	PP															
12/9	4:00			5		warm				11:47	12:14	:27	11:56	12:25 1/2	29 1/2			C'	4 1/2	
12/10	11:45a	73		5		med				12:14	12:34	:20	12:25 1/2	1:11	45 1/2	29 1/2	85.5	C'	27 1/2	
12/11	2:00	72		5		med				12:34	12:56	:22	1:11	1:41 1/2	30 1/2			C'	10 1/2	
12/12	10:33a	68		4		med				12:56	1:16	:20	1:41 1/2	2:25	43 1/2	23	73.4	A	25 1/2	
12/15	10:00a	68		5		warm				1:16	1:37	:21	2:25	3:10	45	26	78.8	C'	26	
	11:00a	68		5		med				1:37	2:00	:23	3:10	3:54	44	27	80.6	B	23	
	11:45a	70		3		med				2:00	2:20 1/2	:20 1/2	3:54	4:26	32	28	82.4	A	13 1/2	
	12:45	72		5		warm				2:20 1/2	2:39	:18 1/2	4:26	5:06	40	29	84.2	A	23 1/2	
	1:45	74		5		high				2:39	3:03	:24	5:06	5:51 1/2	45 1/2	30	86	A	23 1/2	
	2:40			5		med				3:03	3:26	:23	5:51 1/2	6:32	40 1/2	30	86	A	19 1/2	
	4:10	76		5		med				3:26	3:49	:23	6:32	7:16 1/2	44 1/2	30	86	A	23 1/2	
12/17	8:17	67		2		med	few items			4:49	5:06	:17	7:16 1/2	7:38 3/4	22 1/4	22	71.6	A	7 1/4	
12/18	1:00	68		5		med				5:06	5:31	:25	7:38	8:21 1/2	51 1/2	27	80.6	B	28 1/2	
12/19	8:30a	58		5		med				5:31	5:57	:26	8:21 1/2	9:16 1/2	47	20	68	A	23	
	9:25a	60		5		med				5:57	6:22 1/2	:25 1/2	9:16 1/2	10:04	47 1/2	20	68	A	24	
	10:15a	62		5		warm				6:22 1/2	6:45	:22 1/2	10:04	10:50	46	22	71.6	A	25 1/2	
	11:00a	66		5		med				6:45	7:13	:28	10:50	11:39	49	27	80.6	B	23	
	2:50			5		med				7:13	7:35	:22	11:39	12:22	43	23	73.4	C'	23	
12/20	7:40	62		5		med				7:35	7:46	:11	12:22	1:06	44			A	35	
1/1/81	6:10	68		4		med	baby			7:46	7:52 1/2	:06 1/2	1:06	1:31	25	20	68	B	18 1/2	Stopped at buzzer
4/2/81	1:20	72	62	5		med				7:19	7:40	:21	1:22	2:01	39	63		F	24	
1/3	2:00	68		5		med	sheet towels			7:52 1/2	8:17	:24 1/2	1:31	2:24 1/2	53 3/4	30	86	C'	31 1/4	
1/3	3:00	68		4		warm	baby			8:17	8:40	:23	2:24 1/2	2:59 3/4	34 1/4	28	82.4	C'	13.9	
1/3	4:35	65		5		warm	pp			8:40	9:06	:26	2:59 3/4	3:38	39 1/4	26	78.8	C'	14.4	
	6:30	66		5		med	whites			9:06	9:30	:24	3:38	4:31 1/2	53 1/2	21	69.8	B	31.7	duct 1/2 time open 1/2 time
	7:40	66		4		med	whites pp			9:30	9:51	:21	4:31 1/2	5:16	44 1/2	19	66.2	B	25.3	
	10:30	63		4		med	pp			9:51	10:12 1/2	:21 1/2	5:16	5:57 1/2	41 1/2	17	62.6	B	22.3	
1/4	12:03	65		4		med	jeans socks			10:12 1/2	10:33	:20 1/2	5:57 1/2	6:44	46 1/2	18	64.4	B	27.8	
1/7	9:00	66		5		med	baby			10:33	10:57 1/2	:24 1/2	6:44	7:36	52	26	78.8	B	29.5	
1/8	12:45	64		5		med	hand towels			10:57 1/2	11:23 1/2	:26	7:36	8:26 1/2	50 1/2	26	78.8	B	26 1/2	
1/11	2:57	63		5		med	baby			11:23 1/2	11:47	:23 1/2	8:26 1/2	9:24 1/2	58	25	77	C'	36 1/2	
1/12	11:00a	48		5		med	collared towels			11:47	12:14	:27	9:24 1/2	10:21	64 1/2	22	71.6	C'	39.5	
	12:07	56		5		med	sheet towels			12:14	12:33	:19	10:29	11:12 1/2	43 1/2	25	77	C'	26.5	
	1:40	58		5		heavy	jeans socks			12:33	12:59	:26	11:12 1/2	12:21	68 1/2			C'	44.5	

Solar Assisted Clothes Dryer Test Data

#DE-FG44-80R4/0/01

Page 9A

DATE	TIME	Garage		Fabric Cycle Setting	Fabric Temp	Load Type	Load Weight			CLOCK READINGS						DUCT TEMP		DUCT CODE	Heat on Time (min)	Comments	
		ROOM TEMP					Wet Dry Net			CYCLE TIMER			FAN TIMER			°C	°F				
		DRY BULB	WET BULB							START	STOP	NET	START	STOP	NET						
1981	(pm)			Reg	PP																
1/12	3:00	62			5	warm	pp				12:59	1:24	1:25	12:21	1:04	1:43	25	77	C	20	
	4:00	63			5	med	pp				1:24	1:44	1:20	1:04	1:42	1:38	23	73.4	C	20	
	5:30	59		5		med	towel rug				1:44	2:07 1/2	1:23 1/2	1:42	2:54	1:72	23	73.4	B	50.5	duct temp 180° prior to opening
1/15	11:00a	60		5		high	jeans				2:07 1/2	2:31	1:23 1/2	2:54	3:45	1:51	25	77	B	29.5	
	12:15	66		5		warm	cotton				2:31	2:56	1:25	3:45	4:27	1:42	25	77	C	19	
	1:25	66		5		med	baby				2:56	3:18	1:22	4:27	5:13	1:46	26	78.8	C	26	
1/17	8:00a	56		3		med	rugs				3:18	3:35	1:17	5:13	5:57	1:44	13	55.4	B	29	
1/18	1:03	58		3		med	baby				3:35	3:52 1/2	1:17 1/2	5:57	6:36	1:39	24	75.2	C	23.5	
1/22	11:20	60		4		med	baby				3:52 1/2	4:11	1:18 1/2	6:36	7:38 1/2	1:02 1/2	16	60.8	B	45.8	
1/24	10:48a	62		4		med	whites				4:11	4:16 1/2	5 1/2	7:38 1/2	8:11 1/2	32.7	17	62.6	B	27.2	CUT short
	11:27a	64			3	med	pp				4:16 1/2	4:34	1:17 1/2	8:11	8:38 1/4	27 1/4	24	75.2	C	11.8	
	12:17	65			3	med	pp				4:34	4:53	1:19	8:38 1/4	9:13	34 1/4	28	82.4	C	17 1/4	
	1:05	68		3		med	sheets + towels				4:53	5:09 1/2	1:16 1/2	9:13	9:44 3/4	31 1/4			C	17 1/4	
	1:40	68		4		med	sheets + towels				5:09 1/2	5:28	1:18 1/2	9:44 3/4	10:11 1/2	26 3/4	31	87.8	C	10.4	drum belt failed extended duct to south east, replaced belt shut off early
1/28	6:15	70			5	med	(large) Baby				5:33 1/2	5:45 1/2	1:12	10:20	11:59	1:39	25	77	D	27	
1/31	11:45a	66		3		med	baby				5:45 1/2	6:02	1:16 1/2	10:55 1/2	11:34 1/2	39	27	80.6	D	24 1/2	cloudy day
	12:29	68			3	med	pp				6:02	6:20 1/2	1:18 1/2	11:34 1/2	12:06 1/2	32	30	86	D	15 1/2	
	1:30	70			4	med	pp				6:20 1/2	6:42	1:22 1/2	12:06 1/2	12:45 1/2	38.8	34	93.2	D	18.3	
	2:32	72		4		med	towels				6:42	7:02 1/2	1:20 1/2	12:45 1/2	1:22 3/5	37.4 1/5	36	96.8	D	18.9	
	3:41	72		3		med	jeans socks				7:02 1/2	7:20	1:17 1/2	1:22 3/5	1:57 1/5	34.7	34	93.2	D	19.2	
2/3	9:40	62		4							7:20	7:38	1:18	1:57 1/5	2:45	47.8	17	62.6	A	31.8	
2/6	10:24a	59		4		med	baby				7:38	8:00	2:22	2:45	3:29	1:44	22	71.6	B	24	
	11:15a	61		5		med	whites				8:00	8:23	2:23	3:29	4:21	1:52	28	82.4	D	31	
	12:05	63		5		med	cotton sheets				8:23	8:46	2:23	4:21	5:06	1:45	29	84.2	D	24	
	1:12	64		5		warm	pp				8:46	9:10	2:24	5:06	5:40	1:34	29	84.2	D	12	
	2:03	66		5		heavy	jeans				9:10	9:31	2:21	5:40	6:38 1/2	1:58 1/2	29	84.2	D	39.5	
	3:25	67		5		med	pants				9:31	9:54	2:23	6:38 1/2	7:23	44 1/2	29	84.2	D	23.5	
	4:00	67		5		heavy	pillows				9:54	10:18	2:24	7:23	8:04	41	26	78.8	D	19	
2/7	3:40	72					fluff										32	89.6	D		sunny day test
2/8	10:22	62		5		med	baby				10:26	10:47	2:21	8:11 1/2	8:59	47 1/2	26	78.8	D	28.5	
2/13	11:25	67		5		med	baby				10:47	11:13	2:26	8:59	9:43	44	29	84.2	D	20	
	1:15	69		5		med	towel sheets				11:13	11:31	1:18	9:43	10:29	46	33 1/2	92.3	D	28	stoppage short
	2:00	70		5		med	sheets + towels				11:31	11:55	2:24	10:29	11:10	41	30	86	D	19	

45

Solar Assisted Clothes Dryer Test Data #D.E-FG44-80R410101

Page 10A

DATE	TIME	Garage		Fabric Cycle Setting	Fabric Temp	Load Type	Load Weight			CLOCK READINGS						DUCT TEMP		DUCT CODE	Heat ch Time (min)	Comments	
		ROOM TEMP					Wet	Dry	Net	CYCLE TIMER			FAN TIMER			°C	°F				
		DRY BULB	WET BULB							START	STOP	NET	START	STOP	NET						
1981	(pm)			Reg	PP																
2/13	2:55	71			5	warm	PP				11:55	12:20	25	11:10	11:51	41	29	84.2	D	18	
	4:00	70			5	warm	PP				12:20	12:37	17	11:51	12:36	45	28	82.4	D	30	
	4:40	70			5	warm	PP				12:37	1:04	27	12:36	1:12	36	27	80.6	D	11	
	7:00	70		5		heavy	jeans socks				1:04	1:25 1/2	22 1/2	1:12	2:00 1/2	49 1/2	21	69.8	D	30	
2/15	10:45	72	67	3.5		med	baby				1:25 1/2	1:45	20 1/2	2:00 3/8	2:44 02	43.4	22	71.6	B	24.9	
2/18	10:20	70	68	5		med	baby				1:45	2:12 1/2	27 1/2	2:44	3:31	47			D	21.5	
2/20	1:50	76	65	5		med	baby				2:12 1/2	2:34 1/2	22	3:31	4:09	38	34	93.2	D	18	
	2:45	76	64		5	med	PP				2:34 1/2	2:58	23 1/2	4:09	4:50	41	37	98.6	D	19.5	
	4:00	77	64		5	warm	PP				2:58	3:24	26	4:50	5:33 1/2	43 1/2	32	89.6	D	19.5	
	9:00	76	66	5		heavy	jeans				3:24	3:46	22	5:33 1/2	6:25	51 1/2			B	31.5	
2/21	3:25	71	63	4		med	TL#2				3:46 13	4:07 04	20 5/8	6:25 15	7:06 05	40 48	40	104	D	21.57	TL#2 + 1 extra wash cloth
2/23	12:15	72	64		5	med	baby				4:07	4:31	24	7:06	7:55	49	25	77	D	27	
2/25	9:50a	64	56		5	med	baby				4:31	4:56	25	7:55	8:45	50	21	69.8	D	27	
2/28	7:35a	66	60	4		med	TL#2				4:56 09	5:16 29	20 15	8:44 51	9:33 17	48 26	15	57.9	D	30.11	TL#2
	10:20	72	66	3		med	whites				5:16	5:34	18	9:33	10:04	31	27	80.6	D	15	
	11:14	74	66	3		med	baby				5:34	5:53	19	10:04	10:39 1/2	35 1/2	34	93.2	D	18.5	
		76	66		4	med	PP				5:53	6:14 1/2	21 1/2	10:39 1/2	11:16 11	36.7	63	145.4	E	17.2	inlet from attic
						med															exhaust from collector = 74°C
	1:30	79	66	4		med	TL#2				6:14 29	6:35 53	21 24	11:16 11	11:57 47	1:35 36	64	147.2	E	16.2	collector in shade
	2:52	80	67		4	med	PP				6:36	6:58	22	11:52	12:33	41	39	102.2	E	21	collector in
	3:47	80	68	4		med	Towels heavy				6:58	7:18	20	12:33	1:21 1/2	48 1/2	42	107.6	E	30 1/2	shade
3/3	1:20	72	62	5		med	TL#2				7:18	7:40	22	1:22 1/2	2:01	39	63	145.4	E	19	TL#2
	12:20	74	64		5	med					7:40	8:06 1/2	26 1/2	2:01	2:40	39	64	147.2	E	14 1/2	TL#2
3/4	12:40	72	64	4		med	TL#2				8:06 25	8:26 48	20 23	2:34 58	3:20 25	45 27	43	109.4	E	27	TL#2
3/5	1:05	74	66	4		med	TL#2				8:26 48	8:47 24	20 36	3:20 25	4:00 36	40 11	45	113	B	22	TL#2
3/6	4:57	76	66		5	med					8:50	9:15	25	4:05	4:49	44	32	89.6	H	21	
	5:56	76	66	5		med					9:15	9:34	19	4:49	5:41	52	28	82.4	H	35	
	7:01	77	68	4		med					9:34	9:50 1/2	16 1/2	5:41	6:15 42	36 3/4	22	71.6	H	22 1/2	
3/8	12:43	76	64	4		med		7.6	4.0	3.6	9:50 10	10:10 06	20	6:17 55	6:55 16	37 21	47-56	122	G	19 1/2	T collector = 83°C
		78	66			Fluff											48	118.4	G		42 at filter of dryer exhaust collector part shade
	2:39	78	66	3		med		7.5	4.1	3.4	10:12 45	10:29 04	16 17	6:58 27	7:28 50	30 23	43	109.4	G	16	Towels slightly damp in places
3/9	12:00	70	64		5	med					10:29	10:52	23	7:28	8:02	39	29	84.2	G	12	

94

Solar Assisted Clothes Dryer Test Data #DE-FG44-SOR410101

Page 11A

		Garage		Fabric Cycle Setting	Fabric Temp	Load Type	Load Weight			CLOCK READINGS						DUCT TEMP		DUCT CODE	Heat on Time (min)	Comments
DATE	TIME	ROOM TEMP					Wet	Dry	Net	CYCLE TIMER			FAN TIMER			°C	°F			
		DRY BULB	WET BULB							START	STOP	NET	START	STOP	NET					
1981	(PM)			Reg	PP															
3/11	11:37a	76	66		5	Warm PP				10:52	11:16	24	8:02	8:40	38	32	89.6	G	16	T collector = 42°C
	12:17	70	66		5	warm PP				11:16	11:34	18	8:40	9:16	36	40	104	G	20	T collector = 63°C
	1:20	73	69		5	med PP				11:34	11:58	24	9:16	9:49 1/2	33 1/2	47 1/2	117.5	G	11 1/2	T collector = 65°C
	2:05	73	68	5		heavy jeans				11:58	12:19	21	9:49 1/2	10:36	46 1/2	47	116.6	G	27 1/2	T collector = 57
3/12	8:58	74	65	4		med diapers				12:19	12:39	20	10:36	11:14	38	23	73.4	B	20	
	9:53	74	65	4		med baby				12:39	12:58	19	11:14	11:55	41			B	24	
3/14	1:04	70	61	4		med TL#2	7.5	3.9	3.6	12:58	1:18 50	19 50	11:55 01	12:33 26	38 25	52	125.6	G	20 1/2	TL #2 Tcoll = 79°C
	2:00	76	62	4		med TL#2	7.6	4.0	3.6	1:18	1:38	19	12:33 1/2	1:12 1/2	39	43	109.4	H	22	TL #2
3/15	1:24	76	62			fluff										57	124.6	J		Tcoll = 74
						fluff										53	127.4	G		T dryer outlet = 38
						fluff										55 1/2	131.9	H		Tcoll = 76
						fluff										42	107.6	K		T dryer out = 39
						fluff										55 1/2	131.9	H		Tcoll = 79.5
						fluff										42	107.6	K		T dryer out = 40
						fluff										42	107.6	K		Tcoll = 80
						fluff										42	107.6	K		T dryer = 34
3/15	1:42	76	62	4		med lot load stand in washer before drying	7.2	3.9	3.3	1:54	2:13	19	11:27 55	2:04 12	36 1/2	55	131	H	19 1/2	TL #2
	9:00	76	67	3		med diapers				2:13	2:30	17	2:04 1/2	2:33 1/2	29	27	80.6	K	14	
	10:05	75	67	5		med baby				2:30	2:52	22	2:33 1/2	3:25	51 1/2			K	31 1/2	
3/17	12:10	70	58	5		med rugs				2:52	3:16	24	3:25	4:02	37	56 1/2	133.7	H	15	Tcoll = 86°C
3/19	5:50	68	62	5		med baby				3:16	3:40	24	4:02	4:58	56	22	71.6	H	34	
	7:07	68	61	4		med baby				3:40	3:59	19	4:58	5:40	42	20	68	K	25	
3/20	9:00a	64	54	5		med whites				3:59	4:20	21	5:40	6:31	51	16	60.8	D	32	
	12:13	66	54	5		med PP				4:20	4:41	21	6:31	7:20	49	29 1/2	85.1	D	30	
	1:14	66	56	5		med PP				4:41	5:04	23	7:20	8:01	41	31	87.8	D	20	
	2:22	68	58	5		med PP				5:04	5:28	24	8:01	8:56	55	31 1/2	88.7	D	33	
	6:24	68	60	5		heavy jeans				5:28	5:53 1/2	25 1/2	8:56	9:57	61	20	68	D	37 1/2	
3/21	2:42	72	60	4		med TL#2	7.6	3.9	3.7	5:53 38	6:12 29	18 51	9:56 53	10:39 37	42 44			A	25 53	TL #2
3/23	11:55a	66	64	5		med baby				6:13	6:34	21	10:39 1/2	11:27	47 1/2	27	80.6	A	28 1/2	
3/25	2:21	70	62	5		med baby				6:34	6:57	23	11:27	12:06	39	28	82.4	A	18	
3/27	1:55	75	67	5		med sheets t Towels				6:57	7:24	27	12:06	12:54	48	30	86	A	23	
	3:00	76	68	5		med sheets t Towels				7:24	7:46	22	12:54	1:42	48	31 1/2	88.7	A	28	
	5:10	78	70	5		warm PP				7:46	8:03	17	1:42	2:21	39	30	86	A	24	
	5:45	78	70	5		med baby				8:03	8:33 1/2	30 1/2	2:21	3:11	50	29	84.2	A	21 1/2	

47

Solar Assisted Clothes Dryer Test Data #D.E-FG44-80R410101

Page 12A

DATE	TIME	Gauge		Fabric Cycle Setting	Fabric Temp	Load Type	Load Weight			CLOCK READINGS						DUCT TEMP		DUCT CODE	Heat on time (min)	Comments
		ROOM TEMP					Wet	Dry	Net	CYCLE TIMER			FAN TIMER			°C	°F			
										START	STOP	NET	START	STOP	NET					
1981	(pm)	DRY BULB	WET BULB	Reg	PP															
3/27	6:47	78	71	3		med	small whites			8:33 1/2	8:52 1/2	19	3:11	3:44	33		A	16		
	7:56	77	70		4	med	pp, wet			8:52 1/2	9:15	22 1/2	3:44	4:21	37		A	16 1/2		
	8:42	77	70	4		med	jeans towels			9:15	9:35	20	4:21	5:06 1/2	45 1/2		A	27 1/2		
3/28	6:56	82	72	4		med	diapers			9:35	9:56	21	5:06 1/2	5:43	36 1/2		A	17 1/2		
3/30	4:25	74	70		5	med	baby			9:56	10:22	26	5:43	6:27	44		D	20		
3/31	9:40	86	78		5	med	couch covers			10:22	10:44	22	6:27	7:05	38		D	18		
4/1	1:09	82	76	4		med	TL#2			10:44	11:08	24	7:05	7:43	38	35	95	D	16	TL#2 warm rinse
	7:00	82	77		?	med	bedspread			11:08	11:33	25	7:43	8:24	41			D	18	
	9:44	82	77	4		med	TL#2			11:33	11:54	21	8:24 15	9:04 20	40 11			A	21	TL#2 warm phase
4/2	2:10	82	72	4		med	TL#2			11:54	12:17	23	9:04	9:41 1/2	37 1/2	51	123.8	D	16 1/2	TL#2 warm phase
	7:00	84	77	4		med	baby			12:17	12:36	19	9:41 1/2	10:24	42 1/2	32	89.6	D	25 1/2	
4/3	12:35	76	68		5	warm	pp			12:36	1:04	28	10:24	11:06	42	43	109.4	D	16	
	1:35	78	71		5	med	pp			1:04	1:30	26	11:06	11:56	50	45	113	D	26	
	2:45	80	72	4		med	TL#2			1:30	1:51	21	11:56	12:31	35	44	111.2	D	16	TL#2 warm phase
	4:00	82	74	5		heavy	jeans			1:51	2:15	24	12:31	1:08 1/2	37 1/2	42	107.6	D	15 1/2	
4/4	1:50	85	73	4		med	TL#2			2:15	2:36	21	1:08 27	1:49 52	41 25			A	22 1/2	TL#2 warm rinse
4/5	1:47	82	71	4		med	TL#2			2:36	2:56 1/2	20 1/2	1:49 52	2:31 07	41 14			A	22 3/4	TL#2 cold rinse
	3:59	84	72	4		med	TL#2			2:56 1/2	2:17 1/2	21	2:31 07	3:08 42	37 1/2	41	105.8	D	18 1/2	TL#2
4/6	9:10a	74	66		5	med	baby			3:17 1/2	3:43	25 1/2	3:09	3:53	43	28 1/2	83.3	D	19.5	
4/10	7:41a	71	66	5		med	whites towels			3:43	4:09	26	3:53	4:50	57	25	77	D	33	
	8:44a	72	66	5		med	sheets towels			4:09	4:32	23	4:50	5:35	45	28	82.4	D	24	
	9:54a	74	68		5	med	pp			4:32	4:56 1/2	24 1/2	5:35	6:21	46	33 1/2	92.3	D	23 1/2	
	10:51a	76	69		5	med	sheets pp			4:56 1/2	5:23	26 1/2	6:21	7:13	52	35	95	D	27 1/2	
	11:56	78	70		5	med	pants sock			5:23	5:46	23	7:13	7:47 1/2	34 1/2	36	96.8	D	13 1/2	
4/11	2:18	82	72		4	med	mixed			5:46	6:08	22	7:47 1/2	8:28	40 1/2	47	116.6	D	20 1/2	
	3:10	82	72	3		med	damp clothes from above			6:08	6:24	16	8:28	8:48	20	47	116.6	D	6	
4/12	2:10	84	73		4	med	TL#1			6:24	6:45	21	8:48 04	9:17 00	29	50	122	D	10	TL#1
	3:21	85	74		4	med	TL#1			6:45	7:06	21	9:17 00	9:48 47	31 47	-		A	12 3/4	TL#1
	5:12	84	75		4	med	baby			7:06	7:26	20	9:48	10:21	32			D	14	
4/13	12:40	78	70		5	med	pp			7:26	7:50	24	10:21	11:11	50	45	113	D	28	
4/15	6:25	86	80	4		med				7:50	8:10 1/2	20 1/2	11:11	11:45	34	37	98.6	D	15 1/2	
4/20	3:09	84	74		4	med	baby			9:19	9:38 1/2	19 1/2	1:20	1:47	27	45	113	D	9 1/2	
	3:56	84	74		5	med	pp			9:38 1/2	10:03	24 1/2	1:47	2:20	33	43	109.4	D	10 1/2	
	4:44	86	76		4	med	pp			10:03	10:23	20	2:20	2:55	35	41	105.8	D	17	

Solar Assisted Clothes Dryer Test Data #DE-FG44-80R410101

Page 13A

DATE	TIME	Gauge		Fabric cycle Setting	Fabric Temp	Load Type	Load Weight			CLOCK READINGS						DUCT TEMP		DOCT CODE	Heat on Time (min)	Comments	
		ROOM TEMP								CYCLE TIMER			FAN TIMER								
		DRY BULB	WET BULB				Wet	Dry	Net	START	STOP	NET	START	STOP	NET	°C	°F				
1981	(pm)			Reg	PP																
4/20/81	5:28	86	75		4	med	PP				10:23	10:43	20	2:55	3:33	38	36	96.8	D	20	
	9:30				4	med	PP				10:43	11:07	24	3:33	4:16	43			D	21	
4/24	4:40	84	76		4	med	baby				11:07	11:28 1/2	21 1/2	4:16	4:53	37			D	17 1/2	
4/26	4:25	79	71	4	4	med	baby				11:28 1/2	12:14	15 1/2	4:53	6:17	24	37	98.6	D	10 1/2	?
4/27	2:26	80	70	4		med	whites				12:14	12:31	17	6:17	6:52	35	45	113	D	20	
	3:46	82	70	5		med	whites				12:31	12:56	25	6:52	7:30	38	40	104	D	15	
	4:46				5	med	PP				12:56	1:16	20	7:30	8:12	42	40	104	D	24	
	6:08	82	73	3		med	cotton				1:16	1:33	17	8:12	8:37	25	37	98.6	D	10	
	6:57	81	73	4		med					1:33	1:53	20	8:37	9:11	34	34	93.2	D	10	
4/28	2:00	78	70	4		med	TL#2				1:53	2:14	21	9:11	9:41	30	47	116.6	D	11	TL#2 damp when done
5/1/81	10:20	80	74	5		med					2:14	2:40	26	9:41	10:26 1/2	45 1/2	35	95	D	21.5	
5/2	12:17	80	71	4		med	sheets				2:40	3:01	21	10:26 1/2	11:02 40	36	44	111.2	D	17	
	1:05	82	71		5	med	PP				3:01	3:26	25	11:02 40	11:45 18	42 1/2	44	111.2	D	19 1/2	
	2:17	85	72	4		med	Towels				3:26	3:46 1/2	20 1/2	11:45 18	12:15	29 3/4	57	128.8	D	11 1/4	
	3:06	86	73	3		med	(small) whites				3:46 1/2	4:05	18 1/2	12:15	12:39	24	52	125.6	D	7.5	
	3:35	86	73		4	med	TL#1				4:04 55	4:27 35	22 40	12:39 58	1:09 18	30 20	52	125.6	D	9.7	TL#1
	5:13	86	73	3		med	jeans				4:27 1/2	4:47	19 1/2	1:09	1:37	28	43	109.4	D	10.5	
	10:17	81	72	4		med	baby				4:47	5:09	22	1:37	2:16	39			B	19	
5/6	12:08	78	68		5	med	whites				5:09	5:30	21	2:16	2:58	42	39	102.2	D	23	
5/8	9:25	78	71		5	med	baby				5:30	5:54	24	2:58	3:39	41	26	78.8	D	19	
	1:18				4	med	PP				5:54	6:14 1/2	20 1/2	3:39	4:11	32	36	96.8	D	13.5	
5/9	1:25	79	72		5	med	PP				6:14 1/2	6:35 1/2	21	4:11	4:48	37	37	98.6	D	18	cloudy
5/10	1:10	80	73	4		med	whites				6:35 1/2	6:54	18 1/2	4:48	5:19	31	43	109.4	D	14.5	
	2:04	82	74	3		med	towels				6:54	7:09 1/2	15 1/2	5:19	5:45	26	46	114.8	D	12 1/2	same load continued
	4:05			3		med	continue above				7:09 1/2	7:25	15 1/2	5:45	6:06	21			D	7 1/2	
	4:38	84	75	4		med	socks & trousers				7:25	7:44	19	6:06	6:32 1/2	26 1/2	45	113	D	9.5	
5/11	4:10	89	78		5	med	baby				7:44	8:07 1/2	23 1/2	6:32 1/2	7:08	35 1/2	47	116.6	D	14	
5/15	9:40	76	70		5	med	baby				8:31	8:55	24	7:43	8:25	42	32	89.6	D	20	
	10:40	82	70		5	med	PP				8:55	9:20	25	8:25	9:01	36	35	95	D	13	
	12:30	82	69	5		high	whites & towels				9:20	9:39	19	9:01	9:50	49	46	114.8	D	32	
	1:30	84	70		5	med	PP sheets & rug				9:39	10:04	25	9:50	10:21	31	45	113	D	8	
	2:16	86	72		5	med	PP				10:04	10:26	22	10:21	10:54	33	50	122	D	13	
	3:05	86	73	5		high	jeans				10:26	10:50	25	10:54	11:34 1/2	38 1/2	50	122	D	14 1/2	
	8:42	87	78	5		med	draps				10:57	11:14	23	11:31 1/2	12:19	47 1/2	31	87.8	D	26.5	

Solar Assisted Clothes Dryer Test Data

#DE-FG44-80R410101

Page 14A

DATE	TIME	Garage		Fabric cycle Setting	Fabric Temp	Load Type	Load Weight			CLOCK READINGS						DUCT TEMP		DUCT CODE	Heat on Time (min)	Comments	
		ROOM TEMP					Wet	Dry	Net	CYCLE TIMER			FAN TIMER			°C	°F				
		DRY BULB	WET BULB							START	STOP	NET	START	STOP	NET						
1981	(pm)			Reg	PP																
5/16	3:53	90	78		4	med				11:14	11:34 1/2	20 1/2	12:18 54	12:46 15	27 1/4	55	131	D	8 1/4	TL#1	
5/17	11:15a	85	76	4		med				11:34 1/2	11:53	18.5	12:46	1:14	28	39	102.2	D	11 1/2		
5/18	4:00	89	79		5	med				11:53	12:16	23	1:14	1:54	40	53	127.4	D	19	↓ finish drying damp items	
	5:15	90	78	3		med				12:16	12:31 1/2	15.5	1:54	2:14	20	48	118.4	D	6 1/5		
5/19	10:26a	88	78		5	med				12:31 1/2	12:55	23 1/2	2:14	2:43	29	31	87.8	D	7 1/2		
5/21	10:05a	78	72		5	med				1:14	1:34	20	3:00	3:47	47	30	86	D	29	↓ finish drying damp clothes from above	
	1:45	84	76	3		med				1:34	1:51	17	3:47	4:05	18			D	3		
5/22				?		heavy				1:51	2:40	49	4:05	5:45	1:40			D	53	? not recorded	
5/23	2:18	84	71		4	med				2:39 55	3:01 1/2	21 08	5:14 44	6:14 23	29 1/2	50	122	D	10 1/5	TL#1	
	3:21	85	73		4	med				3:01 03	3:20 1/2	19 07	6:14 23	6:42 45	28 2/3	30	86	A	11 1/5	TL#1	
5/24	1:49	85	74	4		med				3:20	3:39	19	6:43	7:16	33	51	123.8	D	16	duct blocked	
	evening				P	med				3:39	4:01	22	7:16	7:53	37			D	17	" "	
5/27	6:00	85	79	5		med				4:01	4:22	21	7:53	8:32	39	40	104	D	20	" "	
5/29	9:30a	80	76	4		med				4:22	4:42	20	8:32	9:01	31	28	82.4	D	13	" "	
	10:03a	81	76	4		med				4:42	5:01	19	9:03	9:38	35	32	89.6	D	18	" "	
	11:02	82	76		4	med				5:01	5:22	21	9:38	10:12	34	36	96.8	D	15		
	11:47	83	76		4	med				5:22	5:42 1/2	20 1/2	10:12	10:42 1/2	30 1/2	40	104	D	12		
5/29	9:00	88	80	4		med				5:42 1/2	6:02	19 1/2	10:42 1/2	11:13 1/2	31	33	91.4	D	13 1/2		
5/30	1:40	90	78		4	med				6:01 47	6:23 24	21 37	11:13 31	11:42 24	28 53	56	132.8	D	9 1/2	TL#1	
	3:21	90	79	4		med				6:25 56	6:46 07	20 11	11:45 54	12:16 01	30 07	56	122.8	D	12	TL#2	
	4:01			2		med				6:46 02	6:59 30	13 28	12:16 01	12:29 21	13 20	54	129.2	D	1 52	↓ finish drying TL#2	
6/6/81	12:48	86	78		4	flocc				8:59 23	9:08 01	8 38	3:53 45	4:00 11	6 26	44	114.2	D	-	TL#1	
	12:59				4	med				9:08 01	9:29 01	21 02	4:00 11	4:28 53	28 42	46	114.8	D	9 40	↓ cont dry	
	2:34	90	80		4	med				9:29 03	9:48 45	19 42	4:28 53	4:56 06	27 13	49	120.2	D	9 38	TL#1	
6/7/81	2:30	92	83		4	warm				9:55 50	10:14 43	18 53	5:03 07	5:25 20	22 13	56	132.8	D	5 20	TL#1 still dry at end	
	2:58	93	82	4		high				10:14 43	10:34 21	19 35	5:25 20	5:58 21	33 01	56	132.8	D	15 23	TL#2	
	5:14	94	83	4		high				10:34 21	10:53 26	19 05	5:58 21	6:36 50	38 29			A	21 24	TL#2	
6/25	6:00a	85	77	4		med				6:32 25	6:51 12	18 43	6:02 54	6:39 09	36 15	27	81	A	19 21	TL#2	
7/4/81	2:14	92	79	4		high				43°C dry	2:03	2:22 13	19 11	6:27 14	7:00 58	33 44	60	140	L	16 31	Tcoll = 65°C Twat at exhaust = 37°C
7/23	2:45	91	82	5		med										57		D			
7/28	12:45	88	80		5	med										48		D			
8/5	1:20	92	82		6	warm				4:42	5:08	26	5:45	6:24	39	52		D	13		

APPENDIX B

Construction of solar air collector

A solar air collector was constructed from $\frac{3}{4}$ " Thermax polyisocyanurate sheathing, aluminum roofing valley painted flat black, and corrugated fiberglass. The size of the absorber was 40" by 90" or 25 square feet. The basic concept, taken from a Mother Earth News magazine design for a passive window heater, was modified to boost heat transfer under forced convection. The collector had a total of 5 inches separating the fiberglass glazing from the bottom insulation. The absorber itself was located midway between, or $2\frac{1}{2}$ inches from the bottom. This allowed approximately 100 square inches (40" x $2\frac{1}{2}$ ") of cross sectional area for air to flow down beneath the absorber and back up between the absorber and glazing. The collector was assembled with a panel adhesive suitable for foam.

Photographic details of the construction and installation follow.

Body of collector before
installation of absorber

Painted absorber mounted
in collector

Lower section of collector showing 5" gap between
absorber and end for air to turn around

Complete collector shown in test position next to outside laundry room wall

Rear view of collector and ductwork extending into laundry room window

Duct from collector joined to attic duct inside laundry

Overall view from SSW of home, collector, and trees nearby

APPENDIX C Article suitable for publication

If you want to eliminate the cost of drying clothes, get a clothesline. You'll have to work 10-20 minutes per load in the hot sun hanging and unhangng each garment, as well as dusting off any bugs or debris which land on the clothes as they are drying. But you'll save the cost of the 2-3 kwhr per load that it normally takes to run an electric clothes dryer.

But if you can't quite give up the convenience of an electric clothes dryer and still want to take advantage of all that abundant sunshine, then look up...to your attic!

That's what James Stana of Longwood, Florida did. He tapped the attic of his typical Sunbelt home and found the hot air just right for boosting the efficiency of his electric clothes dryer. With backing from the Department of Energy Appropriate Technology Program, he built a prototype duct system and tested it for over a year. The results indicated a potential 20% average annual savings. Although higher summer savings was offset by the lower winter savings, the latter was still significant. The duct system was designed to collect attic air and draw it along a south facing roof slope to maximize winter performance. The best part of the system is its cost, less than \$25.

To take advantage of Mr. Stana's solar assisted dryer concept, you need to have several things in your favor.

1. An electric clothes dryer with an inlet that can be extended out the back of the dryer a few inches. The inlet is usually located at the back next to the heating element. (Be sure to unplug the dryer before examining the unit.)

2. A reasonable do-it-yourself skill is required. This concept requires extending the dryer inlet duct with sheet metal. The sheet metal may have to be near the 220VAC wires to the heater coil. It is essential that the person doing the work have a knowledge of working safely with high voltage appliances. The remaining duct work can be constructed by anyone of reasonable skill.

3. An attic roof which faces roughly south and can be reached from the dryer inlet with less than 25' of duct work.

If you meet all of the above, then you can expect an economic payback in \$/year of approximately:

$$\text{payback } \$ = \frac{186}{60} (.35N_r + .16N_{pp}) \text{ KHP}$$

APPENDIX C Article Suitable for Publication (continued)

where 186 = sum of peak monthly attic temperatures achieved in Florida ($^{\circ}\text{C}$)

.35 & .16 are experimental constants derived from the Whirlpool dryer used in the testing

N_r = number of laundry loads dried in the automatic regular cycle per month

N_{pp} = number of laundry loads dried in the automatic permanent press cycle per month

K = cost of kwhr in \$

H = kw rating of heating element in dryer

P = per cent of loads (expressed in decimal) dried on a sunny day between 2 and 4 pm. (savings are still significant even for 1-5 pm.)

For example, a family of 6 drying 50 regular loads and 32 permanent press loads a month using a 5.6 kw rated dryer at \$.07/kwhr can save up to \$27.48 a year by drying their clothes on sunny days between 2 and 4 pm. If you already have a solar hot water system, you're probably already washing your clothes then anyway. (A commercial laundramat could obviously benefit.)

The system works by preheating the air entering the inlet of the dryer with an automatic cycle. The heating element does not have to remain on as long to heat the air til the control thermostat turns it off. And it remains off longer until the thermostat turns it on again. A simple timed cycle dryer should also be assisted, but the savings cannot be easily measured since it will depend on the operator setting shorter drying times. Exact plans for building the device will vary for each installation due to variations in dryers and houses involved. By showing the one built by Mr. Stana and outlining a few do's and dont's, you can duplicate his results by adapting the concept to your own situation.

Mr Stana first extended his dryer inlet by forming a 5" x 6" duct out of .010" aluminum roofing valley and "Pop" rivets. (Steel could have been used.) Care was taken to unplug the dryer prior to working on it and avoiding having the duct come anywhere near the 220VAC wires to the heating element. Any spaces around the wires were plugged with pieces of non conducting fiberglass insulation. (Check to be sure that the hole plugged does not get hot enough to smolder the insulation.) The duct extended the dryer inlet only a few inches out from the back of the dryer. (See figure 1.)

Although Mr. Stana used fiberglass duct board for the lower portion of his attic duct, it is too expensive. Three-fourths inch (3/4") thick Thermax poly isocyanurate foil faced insulating sheathing would be cheaper and easier to work with. It can be cut with a knife and glued with any of the panel adhesives (such as Maaco liquid nails) suitable for foam.

APPENDIX C Article Suitable for Publication (continued)

The duct to the attic roof should be approximately 100 in.² in cross section and contain as few bends as possible. A smaller duct chokes the airflow and offsets the benefit of pre-heating the air. A hole is cut at the bottom of the duct to match the dryer extension duct. A flap (preferably opening inward) is cut just above the dryer. This flap is opened on cloudy days or evenings when the attic is cooler than the laundry room. (See figure 2.)

Styrofoam may be used for the attic portion of the duct as long as temperatures don't exceed 160°F. The lower portion of the duct needs to be fiberglass or Thermax since it is indirectly exposed to the heat of the dryer.

The attic collector itself was a 6 foot by 6 foot styrofoam sheet nailed to the underside of the roof joists along a south facing pitch. The air is drawn in from the attic, along the south face, and down to the dryer. (See figure 3.)

Inlet temperatures exceeding 100°F were obtained on even cool winter days.

Mr. Stana also experimented with a solar collector designed explicitly for the dryer. But results indicated the attic could obtain close to the same results for a lot less money.

Figure 4 shows the kind of peak inlet temperatures obtained from the system. Highest were generally between 2:00 p.m. and 4:00 p.m., although any drying initiated between 1:00 p.m. and 5:00 p.m. resulted in significant energy savings. (In the summer, inlet temperatures remained above the laundry room for several hours into the early evening.) Figure 5 shows some of the overall results obtained.

Use of the device is simple. Try to dry between 2:00 p.m. and 4:00 p.m. on a sunny day. Use the attic duct whenever the inlet temperature (determined with a household thermometer in the duct) exceeds the temperature of the laundry room with an operating dryer. (If you're not sure, run the dryer blower for a few minutes on "fluff" or "air" with the heating element off.) The laundry room may get slightly warmer than usual when using the duct since the dryer is not drawing air from the room but is radiating more heat. (This device should not be used if the dryer is in a kitchen or area normally cooled by an A/C in the summer.) In the evening or on cloudy days, open the duct flap to the laundry room.

The method is especially suitable for homes with an existing active hot air solar heating system, and Mr. Stana is continuing his research on his own to pursue using the same concept to boost his electric furnace on cool winter days.

APPENDIX C Article Suitable for Publication (continued)

Mr. Stana emphasizes that his solar assisted dryer is not for everyone. If you have a small family, a low electric rate, or want to look for big economic payback - forget it. But if using an otherwise wasted heat source to save a few dollars appeals to you, then look up!

FIGURE 1

FIGURE 2
ATTIC DUCT DETAILS

Author shown with prototype
attic duct used in study

FIGURE 3

ATTIC COLLECTOR AND DUCT

OVER HEAD VIEW

FIGURE 4

Maximum inlet temperatures obtained from attic duct
(Longwood, Florida 29° north latitude)

<u>MONTH</u>	MAXIMUM CLEAR DAY INLET TEMPERATURE OBTAINED	
	^{°C}	^{°F}
January	35 *	95
February	35 *	95
March	47	117
April	47	117
May	55	131
June	55	131
July	52 *	126
August	52 *	126
September	47 *	117
October	47 *	117
November	37 *	99
December	37 *	99

* Data obtained without benefit of extended south facing duct

FIGURE 5

HEAT-ON TIME VS INLET TEMPERATURE

AVERAGE OF LOADS TESTED

TEST LOADS 1 & 2

PP = permanent press
 Duct codes A, C, C' & D refer to
 several configurations Tested

Cost Category	Amount Budgeted	Amount Spent	Description
I Salaries	\$1 / hr (\$120 maximum)	\$120.00	Over 150 hours were spent on research, gathering test data, and final report preparation.
II Fringe Benefits	\$0	0.00	
III Equipment	\$24.75	12.70	psychrometer
		10.30	3 thermometers
		23.00	subtotal
IV Consultants	\$0	0.00	
V Space costs & rentals	\$0	0.00	
VI Materials & Supplies	\$115	20.77	duct board
		8.01	2 sheets styrofoam
		14.32	aluminum flashing for absorber
		1.03	black paint
		1.73	black paint
		12.30	fiberglass glazing
		19.32	Thermax insulation
		.81	adhesive
		.81	adhesive
		.81	adhesive
		.91	sealant
		4.04	duct tape
		84.86	subtotal
VII Travel	\$0	0.00	
VIII Overhead	\$0	0.00	
IX Other costs	\$10	3.60	stamps
Phone, stamps, printing		4.59	picture reprints
		.77	picture reprints
		8.96	subtotal
TOTAL	\$269.75	\$236.82	
Net due DOE		32.93	
Interest income from project bank account		13.35	
Total returned to DOE		\$46.28	

(Copyrighted Pages removed)

Sample of letter sent
to dryer manufacturers

118 Albrighton Drive
Longwood, Florida 32750
22 February 1980

Dear Sirs:

I am writing to request certain information about your largest selling electric clothes dryer model.

I am currently conducting research on a solar assisted clothes dryer concept funded by the Appropriate Technology Small Grants program of the Department of Energy. This concept would supply solar pre-heated air to the dryer inlet to decrease heating element power consumption. The following information will assist me in determining the overall suitability and size requirements of a solar assist device.

Largest selling electric clothes dryer

Standard size

Large capacity size

1. Model number
2. Capacity (lb)
3. Maximum power consumption
of air heating element(watts)
4. Cubic feet per minute air
volume delivery of air blower
(maximum expected)
5. Location of inlet air supply
to heating element
6. Maximum air temperature
delivered to clothes by
heating element during hottest
setting
7. Minimum air temperature
delivered to clothes by heating
element during lowest setting
(Do not include cool down cycle
when element is normally off)

If you are unable to answer these questions on the basis of available literature, would you please pass this letter on to someone in your engineering department. The answers can be filled out in the space above and mailed in the self addressed stamped envelope attached.

Thank you very much for your cooperation.

Truly yours,

James Stana B.S., M.S. Mech. Engr.

Department of Energy
Appropriate Technology Small Grants Program
RA-DE-FG44-80R410101

Consumer Affairs Division

UPTON DRIVE, ST. JOSEPH, MICHIGAN 49085 • AREA CODE 616 982-6168

March 28, 1980

Mr. James Stana
118 Albrighton Drive
Longwood, Florida 32750

Dear Mr. Stana:

The following is in response to your request for information on dryer model LAE800A0. *(my error jnd)*

- 1) Whirlpool has not produced such a model. We have built models LAE8800 and LAE9800. Neither of these is a large capacity size.
- 2) A clothes dryer capacity cannot satisfactorily be rated in pounds. Our models LAE8800, 9800 have a 5.9 cu. ft. drum.
- 3) Models LAE8800, 9800 had a 5600 watt heat element. We are now using 5200 watt elements on most models.
- 4) At no back pressure exhaust air flow is 120-150 CFM.
- 5) Air is drawn into the heater box from openings in various places around the cabinet. It passes over the heat element, enters the drum cavity, exits the drum thru a lint screen and is discharged. Enclosed is a drawing of the air flow.
- 6) This is a difficult question to answer. The heat element reaches a temperature of 1500-1700°F. The air is heated to 500-600°F. Maximum exhaust temperature is controlled by a thermostat and is limited to 155°F.
- 7) The operating thermostat has about a 15°F differential, so if it opens at 155°F, it would reclose at 140°F.

We do, to some extent, preheat the air entering the dryer. After it has been in operation the cabinet, motor, and sheet metal parts are warmed and air entering the heater box is drawn over these warmed parts.

We have found when conducting D.O.E. tests a 1% change in energy usage for every 2.5°F change in room ambients from the nominal 75°F, 50% RH.

I hope that this information will be of help to you.

Sincerely,

Jerry Jaske
Jerry Jaske, P.E.
Product Manager
Customer Assurance

JJ/mc
Enc.

Response from dryer manufacturer

CONSUMERS INSTITUTE General Electric/Hotpoint/Appliance Park, Ky. 40225

March 31, 1980

Mr. James Stana
118 Albrighton Drive
Longwood, FL 32750

Dear Mr. Stana:

We do hope you will accept our apology for the delay in responding to your letter of February 22, requesting information on our General Electric and Hotpoint dryer models.

First, enclosed are forms for your use in ordering a service manual for the particular dryer model you select to use in your study. Some of the information you requested is contained in the service manuals. Secondly, our standard General Electric and Hotpoint dryer is rated at 14 lbs. capacity (dry clothes load) and the large capacity is rated at 18 lbs. (dry clothes load).

Next, you'll find information regarding the inlet air supply included in the full line catalogues enclosed. In answer to questions number 4 regarding cfm, the blower produces from 150 to 180 cfm of air flow. Next, the heating coils wattage is approximately 5600 watts.

We hope the above and enclosed information is helpful and if we can be of assistance in any other way, please let us hear from you.

Very truly yours,

Helen Gibson
MANAGER-CONSUMER INQUIRY

HG/sj
Enclosures
3

1 BRAND GE
 2 CUSTOMER Retail
 3 CORE X DERIV. SPECIAL
 4 SHIPPING RELEASE JAN. 1979
 5 COLORS WH, HA, AD

6

(1 of 6 specifications sent from GE/Hotpoint)

7 FUEL Elec. and Gas
 8 CAPACITY Standard
 9 APPEARANCE 6" St V
 10 _____
 11 _____
 12 DRY CONTROL Timed
 13 _____

41 CYCLES 2
 42 • Special Cycles (More Dry,
 43 Permanent Press, Polyester
 44 Knits, 25, 15, Cool Down)
 45 • Regular Cycles (130 Min. in
 46 20 min. Increments 10 To 130)
 47 _____

14 EXTRA CARE _____
 15 EOC SIGNAL _____
 16 DRUM LAMP _____
 17 DOOR DRY RACK _____
 18 OTHER _____
 19 _____
 20 _____
 21 _____

48 DRY SELECTIONS 3 (Toggle)
 49 • Normal
 50 • Low-Polyester Knits
 51 • No Heat
 52 _____
 53 _____
 54 _____
 55 _____

22 ELECTRIC RATING 60 Hz 120/240V
 23 5600W. 22A. or 120/208V. 4400W.
 24 22A. Individual 30 A. Circuit
 25 Req'd. 120 v. 2 Wire 1625 W.
 26 13A. Individual 20 Amp Circuit
 27 Req'd.
 28 GAS RATING 22,000 BTU/Hr. Factory
 29 Equipped For Natural Gas, Tested
 30 For Mixed, LP and Mfg. Gases
 31 115V. 60 Hz 6 Amp. --A 15 or 20
 32 Amp Circuit is Req'd 1/2" rigid
 33 gas supply line req. (3/8" copper
 34 tubing may be used if operated on LP
 35 gas).

56 DIMENSIONS 42 1/2H, 27W, 25D
 57 _____
 58 APPROX SHIP WT: ELEC 136
 59 GAS 156
 60 MAXIMUM DUCT: ELEC _____
 61 GAS _____
 62 EXHAUST DIRECTIONS: ELEC 4-Way
 63 GAS 3-Way
 64 OTHER _____
 65 _____
 66 _____
 67 _____
 68 _____
 69 _____

Response from dryer manufacturer

March 10, 1980

Mr. James Stana
118 Albrighton Drive
Longwood, Florida 32750

Dear Mr. Stana:

Your letter of February 22, requesting information on Maytag electric clothes dryers, has been directed to my attention.

The Maytag Company manufactures one size of compact electric clothes dryer (2.2 cubic feet) and six models of full size electric clothes dryers (6.1 cubic feet). The industry standard for measuring dryer capacity is the volume of the dryer tumbler measured in cubic feet.

The heated air enters our full size dryer tumbler in the upper right quadrant of the drum back. The air flow rate with no venting restriction is approximately 180 cubic feet per minute and will drop to about 150 cubic feet per minute with a venting restriction.

The maximum air temperature (measured in the tumbler using thermal tubes) is approximately 180° on the highest temperature setting and approximately 150° on the lowest heat setting. The heating element is rated at 5300 watts at 240 volts.

I hope this answers questions you had regarding Maytag clothes dryers.

Sincerely yours,

Douglas M. Ringger
Manager, Product Test Lab

DMR/lf

City of North Miami

776 Northeast 125th Street, North Miami, Florida 33161

(305) 893-6511

August 7, 1980

Mr. James Stana
118 Albrighton Drive
Longwood, Florida 32750

Dear Mr. Stana:

I have recently learned of your research in "Heated Attic Air" for use in clothes dryers, from an article published in the "Florida Solar Coalition Newsletter" July, 1980.

The City of North Miami is currently studying all possible energy conservation measures which would help our citizenry fight the rising costs of energy. As your device is simple and relatively inexpensive, and from the article, offers a short pay-back period, I would be most appreciative if you could send additional information so that this conservation measure can be presented to the City's Energy Advisory Board for consideration as a pilot project.

Thank you for your consideration in this matter.

Sincerely,

Paul K. Glasser
Energy Program Coordinator

PKG/mm

(Pgs. 70 & 71 removed)

J_M Energy Alternatives
118 Albrighton Drive
Longwood, Florida 32750

Thank you for your interest in my solar assisted clothes dryer Appropriate Technology project.

I am currently in the middle of evaluating the feasibility and cost effectiveness of adding a duct from the attic to the inlet of the dryer. Since I have not completed my evaluation, I feel it would be premature for someone to duplicate the project at this time. There are several open questions which could affect the recommendations of the study. Namely;

1. Measurements of actual electricity use of the clothes dryer heating element for a family of two indicate an average of 2 kw per load and 24 loads per month. The energy use of the dryer limits the initial investment and payback period of any energy saving device.

2. The clothes dryer operates on hotter inlet temperatures than I was originally led to believe. Air entering the drum can approach 280° F with the heating element on. With 140° solar heated inlet air, the savings should be about 30%. I am trying to show this in actual use experiments. While hotter solar air might be obtainable with a special collector, its use would require some control element to avoid overheated clothes at the end of the cycle.

3. The inlet duct from the attic is constructed of 1 inch thick duct board formed into a 1 foot square duct. The connection to the dryer itself was made with a piece of formed aluminum sheet attached to the heater element housing. Since the heating element is 220v and gets extremely hot, the extension can only be made by a trained technician or skilled craftsman. The duct board itself is relatively expensive (\$20) but I am continuing to search for a cheaper substitute which can withstand the temperatures involved without degradation or risk of fire.

4. I have been able to obtain inlet temperatures from the attic as high as 125° F in mid afternoon. I am attempting to define attic locations and conditions which would optimize the inlet air temperature obtained.

As you can see, my research is still in the active stage of evaluation. As soon as I have prepared my report for DOE, I will send you a copy for your information.

Sincerely yours,

James Stana
James Stana

Cont.
Inquiry from publisher

September 18, 198.

Mr. James M. Stana
118 Albright Drive
Longwood, FL 32750

RE: Employment of Attic Heat to Preheat Air for an Electric C

Dear Mr. Stana:

We are presently developing a book which will be an A to Z comp
most up-to-date information on home energy conservation. We wa
what's already been written on conservation and report what is
innovative. The book will, of course, have a do-it-yourself for

As part of our research for this book, we want to find residenti
conservation projects and talented individuals that represent the
conservation. As a recipient of an Appropriate Energy Technology
are doing work in residential energy conservation that may produc
new information, and we would like to know more about your projec
clippings or a summary of your work would be very helpful to us.
most appreciative if you would take the time to write to us about
project.

Thank you for your attention in this matter. Have a good day.

Sincerely,

Joe Carter MB

Joe Carter
Associate Editor
Book Division

JC:kb

(Pgs 74 & 75 removed)

Rodale Press, Inc., 33 East Minor Street, Emmaus, PA 18049
215-967-5171 Telex #847338

Response to publisher

JMS Energy Alternatives
118 Albrighton Drive
Longwood, Florida 32750

Joe Carter
Associate Editor
Book Division
Rodale Press
33 E. Minor Street
Emmaus, Pennsylvania 18049

Dear Mr. Carter:

Thank you for your inquiry concerning my Appropriate Technology study to use a home attic as a preheater for an electric clothes dryer.

The study was undertaken to determine the suitability of using a Southeastern home attic as a source of heat for boosting an electric clothes dryer. An inexpensive duct (duplicable for \$25) was constructed of sheet aluminum, duct board, and styrofoam to collect hot attic air from the peak of the roof and introduce it into the inlet of the dryer. During a year's testing, inlet temperatures of 104-133°F were recorded, generally peaking between 2 and 4 pm. Analysis of the energy consumption measurements taken indicated a 20% annual reduction of energy consumption was possible if most of the drying was done between 1 and 5 pm. (Higher savings in summer months.) Payback, of course, depends on local cost per kwhr, percentage of loads dried during sunny periods, and number of loads dried per year. Due to the small investment required, payback could occur in as little as one year with a family of four adults. The concept is suitable for both retrofits or new construction, especially if an active solar home heating system is present. If an individual has solar hot water heating, he or she is probably already doing laundry on sunny afternoons to take advantage of the solar water system.

My final report to the Department of Energy is in preparation. As part of that report, I am including a summary article suitable for publication in such magazines as your own NEW SHELTER. It would include details of construction (including pitfalls to avoid), performance results, and a payback formula. I had planned on sending this information to several publications as well as advertise it as available to the public for a nominal fee (to cover cost of duplication, postage, and handling). This summary will be available in a few weeks.

I would be happy to send you this summary, as well as any additional information you may desire. I trust that if any of my information is used in a publication, I will be suitably credited.

If I can be of further assistance, Mr. Carter, please let me know. I can be reached at the above address or by phone during the day at 800-327-6900 x164 at my place of employment. My home phone is 305-862-5601.

Sincerely yours,

James Stana

James Stana

E. Instrumentation

1. Three 30-100°C mercury thermometers graduated in 1°C increments were used in all air temperature measurements except where noted. Generally, the inlet temperature of the air in the duct was measured along with any other temperature of interest.
2. A dry/wet bulb thermometer set was placed in the garage adjacent to the laundry room to monitor humidity conditions which would normally be encountered by the dryer. (instruments 1 and 2 above were purchased from Edmund Scientific).
3. Two 110 VAC clock timers were wired into the dryer circuitry to monitor total fan-on time, cycle duration and, indirectly, heater-on time. The circuit of the dryer is shown in figure 7.

FIGURE 7

DRYER CONTROL CIRCUIT* AND INSTRUMENTATION

WARNING Disconnect from Electrical Supply Before Servicing Unit

MFG. UNDER ONE OR MORE OF THE FOLLOWING U.S. PATENTS, OTHER PATENTS PENDING:
3,218,732 3,285,380 3,310,869 3,391,488 3,394,485 3,395,480 3,398,481 3,398,485
3,400,097 3,471,938 3,491,458 3,497,044 3,522,850 3,571,941 3,597,139

INSTALLATION NOTE: EXHAUSTED UNITS MAY BE INSTALLED FLUSH WITH ADJACENT STRUCTURES ON TWO SIDES AND REAR.

NON-EXHAUSTED UNITS MUST USE EXHAUST DEFLECTOR AND MUST BE SPACED 4 INCHES FROM REAR WALL. CABINET SIDES MAY BE INSTALLED FLUSH WITH ADJACENT STRUCTURES.

SWITCH	TIMER SCHEDULE IN MINUTES				
	REG.	OFF	PERM. P. OFF	TIMED	OFF
Y-R	45		10		45
Y-BG	42		42		70
Y-TM					

• ELECTRIC DRYER WIRING DIAGRAM

NEUTRAL TERMINAL LINKED TO CABINET

PART NO. 343943 REV. D

* taken from sticker on rear of machine