Worksheet 1

1. House Location: ______________________________
2. Latitude: ______________
3. Magnetic Deviation: ______________
4. House Alignment: ______________
5. Area (in square feet) of east-facing glass: ______________
6. Area (in square feet) of west-facing glass: ______________
7. Area (in square feet) of south-facing glass: ______________
8. Area (in square feet) of north-facing glass: ______________
9. Total area (in square feet) of glass: ______________
10. Area (in square feet) of glass with nighttime insulation:__________
11. Manufacturer's U-value of window glass: __________ Patio glass: __________
12. Shade Coefficient of glass: ______________
13. U-value of glass with nighttime insulation: ______________
14. Area (in square feet) of exterior (heated) walls: ______________
15. Net area (in square feet) of exterior (heated) walls: Subtract line 9 from line 14 = _________
16. Area (in square feet) of heated lower living-space concrete wall (in sidehill design): ________
17. Area (in square feet) of insulated flat ceiling (or angled ceiling if house has a cathedral ceiling): ______________
18. Volume (in cubic feet) of the heated airspace of the house: ______________
19. Outside Winter Design Temperature: ______________
20. U-value of total framed wall area: ______________
21. U-value of total roof/ceiling area: ______________
22. U-value of total lower living-space concrete wall: ______________
23. Total heat loss from home without nighttime insulation for glass (excluding lower concrete wall): ______________
24. Total heat loss from home with nighttime insulation for glass (excluding lower concrete wall): ______________
25. Clearness number: ______________
26. Recommended size of furnace: ______________
27. Total requirement (in kilowatt-hours) of electric backup heat: ______________
28. Recommended size of woodstove: ______________
29. Estimated annual fuel consumption: ______________
30. Required thickness of poured concrete for Solar Slab: ______________

Worksheet 2
R- and U-value Calculation

A. FRAMED WALL: R-VALUE

1. 15 MPH wind (outside) ______ 0.17
2. Exterior siding: __________ __________
3. Rigid insulation: __________ __________
4. Exterior house wrap __________
5. Exterior sheathing: __________ __________
6. Fiberglass insulation: __________ __________
7. Vapor barrier: __________ __________
8. Interior wall covering: __________ __________
9. Still air (inside surface of wall) ______ 0.68

Total R-value: __________

U-value of wall =1/R =__________ Btus/hr • ft^2 • °F

(Increase U-value if framing or bridging loss is significant): ______________

B. ROOF OR CEILING: R-VALUE

1. 15 MPH wind (outside) ______ 0.17
2. Roofing material: __________ __________
3. Felt roofing paper: __________ __________
4. Roof sheathing: __________ __________
5. Fiberglass insulation: __________ __________
6. Vapor barrier : __________ __________
7. Inside roof or ceiling covering: __________ __________
8. Still air (inside suface of roof or ceiling) ______ 0.68

Total R-value: __________

U-value of roof or ceiling =1/R =__________ Btus/hr • ft^2 • °F

(Increase U-value if roof or ceiling framing or bridging loss is significant): ______________

Worksheet 2
(continued)

C. GLASS WITH NIGHTTIME INSULATION

1. 15 MPH wind (outside) 0.17
2. Glass: __________ __________
3. Dead air space (between glass and insulating device) __________
4. Insulating device: __________ __________
5. Still air (inside surface of insulating device) 0.68

Total R-value: __________

U-value of nighttime insulated glass (1 ÷ R): __________ Btus/hr • ft^2 • °F

D. LOWER LIVING-SPACE CONCRETE WALL: R-VALUE

1. Exterior rigid insulation: __________ __________
2. Concrete: __________ inches x 0.075 __________
3. Interior insulation: __________ __________
4. Vapor barrier: __________ __________
5. Interior wall covering: __________ __________
6. Still air (inside surface of wall) __________

Total R-value: __________

U-value of Lower living-space concrete wall = 1/R = __________ Btus/hr • ft^2 • °F difference

Worksheet 3
House Heat Loss Calculation

1. EXTERIOR WALL HEAT LOSS

Area of exterior walls (from Worksheet 1, line 15) × framed wall U-value (from Worksheet 2, section A)

__________ square feet × __________ Btus/hr • ft^2 • °F = __________ Btus/hr • °F

2. ROOF OR CEILING LOSS

Area of roof or ceiling (from Worksheet 1, line 17) × roof or ceiling U-value (from Worksheet 2, section B)

__________ square feet × __________ Btus/hr • ft^2 • °F = __________ Btus/hr • °F

3. INFILTRATION LOSS USING VOLUME METHOD

Volume of heated space (from Worksheet 1, line 18) × specific heat of air × air changes per hour

__________ cubic feet × 0.018 Btus/ft^3 • °F × .67 air changes/hr = __________ Btus/hr • °F

4. HEAT LOSS THROUGH GLASS (WITHOUT NIGHT-TIME WINDOW INSULATION)

Area of window and patio door glass (from Worksheet 1, line 9) × U-value of glass (from Worksheet 2, section C)

__________ square feet × __________ Btus/hr • ft^2 • °F = __________ Btus/hr • °F

5. TOTAL HEAT LOSS:

Walls __________ Btus/hr • °F

Roof or Ceiling __________ Btus/hr • °F

Infiltration __________ Btus/hr • °F

Glass __________ Btus/hr • °F

Wall framing or bridging loss (if significant) __________ Btus/hr • ft^2 • °F

Worksheet 3
(continued)

Roof and/or ceiling framing or bridging loss (if significant) __________ Btus/hr • °F

Solar Slab perimeter loss (if significant) __________ Btus/hr • °F

Combined total rate of heat loss= __________ Btus/hr • °F

For a total of the house's predicted Heat Loss Without Nighttime Glass Insulation, multiply the above combined total rate of heat loss by 24 hours per day:

__________ Btus/hr • °F × 24 hr/day = __________ Btus/°F • day

6. REDUCTION OF HEAT LOSS DUE TO NIGHTTIME GLASS INSULATION (applicable only if nighttime insulation used)

The Heat Loss Credit for insulated glass can be calculated as follows:

Area of glass with nighttime insulation (from Worksheet 1, line 10) × [U-value of glass without nighttime insulation (from Worksheet 1, line 11) – U-value of glass with nighttime insulation (from Worksheet 2, section C)] × number of hours that nighttime insulation will be used

__________ square feet × (__________ Btus/hr • ft^2 • °F – __________ Btus/hr • ft^2 • °F) ×
__________ hours per day = __________ Btus/°F • day

Using the Heat Loss Credit just derived, the Total Heat Loss With Nighttime Insulation is calculated as follows:

Heat Loss Without Nighttime Glass Insulation (from section 5, above) – the Heat Loss Credit

__________ Btus/°F • day – __________ Btus/°F • day = __________ Btus/°F • day

7. ADDITIONAL HEAT LOSS IN SIDEHILL DESIGN

In a sidehill situation, the heat loss through the lower living-space concrete wall is a constant. For simplicity, let's call this the "Lower Concrete Wall Loss" or LCWL, which can be calculated as follows:

(continued on next page)

Worksheet 3
(continued)

Area of lower living-space concrete wall (from Worksheet 1, line 16) × U-value of lower living-space concrete wall (from Worksheet 1, line 22) × difference between inside and outside temperatures (or 65 degrees – 45 degrees)

__________square feet × __________ Btus/hr • ft^2 • °F x 20 degrees = __________ Btus/hour

8. DESIGN CHECK

Calculate the total area of the east-, west-, and south-facing glass as a percentage of the gross upper and lower heated wall area:

(__________________) square feet of E, W, and S glass (from Worksheet 1, lines 5, 6, and 7) ÷
(__________________) square feet of wall (from Worksheet 1, lines 14 and 16) × 100 = 291/
2280 × 100 =__________ percent

The resulting percentage should be between 10 and 20 percent. __________

Worksheet 4
Solar-Supplied Heat Gain

1. Using appendix 6, enter the percent sunshine for your home site:

Month	% Sunshine
September	______
October	______
November	______
December	______
January	______
February	______
March	______
April	______
May	______

2. From appendix 2, enter the east, south, and west half-day totals of Solar Heat Gain Factors for your home site latitude. (Read the table from top to bottom for sunrise to noon and from bottom to top for noon to sunset.) Assuming that your home faces south, multiply the south half-day total SHGF by 2. Ignore the west SHGFs for the AM and likewise ignore the east SHGFs for the PM (therefore, the east SHGF will equal the west SHGF).

Month	East	South (x2)	West
September	______	______	______
October	______	______	______
November	______	______	______
December	______	______	______
January	______	______	______
February	______	______	______
March	______	______	______
April	______	______	______
May	______	______	______

Multiply the SHGFs given above by the area (in square feet) of glass on each elevation, and obtain a total for each month (square feet × Btus per square foot × days per month) = Btus per month

(continued next page)

Worksheet 4
(continued)

Month	Days	____ Square feet of East Glass × East SHGF × Days per Month		____ Square feet of South Glass × South SHGF × Days per Month		____ Square feet of West Glass × West SHGF × Days per Month		Total (in millions of Btus)
Sep	30	______	+	______	+	______	=	______
Oct	31	______	+	______	+	______	=	______
Nov	30	______	+	______	+	______	=	______
Dec	31	______	+	______	+	______	=	______
Jan	31	______	+	______	+	______	=	______
Feb	28	______	+	______	+	______	=	______
Mar	31	______	+	______	+	______	=	______
Apr	30	______	+	______	+	______	=	______
May	31	______	+	______	+	______	=	______

Tabulate the Solar Heat Gain for each month. Multiply the percentage of sunshine × the monthly total Btus × the Shade Factor X the Clearness Number:

Month	% Sunshine (as decimal)		Total Btus/month (from above)		Shade Factor		Clearness Number		Total (millions of Btus)
Sept	______	×	______	×	______	×	______	=	______
Oct	______	×	______	×	______	×	______	=	______
Nov	______	×	______	×	______	×	______	=	______
Dec	______	×	______	×	______	×	______	=	______
Jan	______	×	______	×	______	×	______	=	______
Feb	______	×	______	×	______	×	______	=	______
Mar	______	×	______	×	______	×	______	=	______
Apr	______	×	______	×	______	×	______	=	______
May	______	×	______	×	______	×	______	=	______

Worksheet 5
House Heat Load Calculation

Using appendix 5, enter the monthly degree days for your house location.

Monthly Heat Load (in Btus) = Total House Loss (in Btus/°F • day) × degree days + lower sidehill concrete wall loss or LCWL (from Worksheet 3, line 7) _________ ,Btus per hour × 24 hours × days per month

If this is a sidehill design, first calculate the monthly heat loss through the lower concrete wall (MCWL) as follows:

Month	LCWL (in Btus)		Hours per day		Days per month		MCWL (millions of Btus)
Sep	______	×	24 hours	×	30 Days	=	______
Oct	______	×	24 hours	×	31 Days	=	______
Nov	______	×	24 hours	×	30 Days	=	______
Dec	______	×	24 hours	×	31 Days	=	______
Jan	______	×	24 hours	×	31 Days	=	______
Feb	______	×	24 hours	×	28 Days	=	______
Mar	______	×	24 hours	×	31 Days	=	______
Apr	______	×	24 hours	×	30 Days	=	______
May	______	×	24 hours	×	31 Days	=	______

Month	Total House Heat Loss (in Btus)		Degree Days		MCWL		Monthly Heat Load (millions of Btus)
Sep	______	×	______	+	______	=	______
Oct	______	×	______	+	______	=	______
Nov	______	×	______	+	______	=	______
Dec	______	×	______	+	______	=	______
Jan	______	×	______	+	______	=	______
Feb	______	×	______	+	______	=	______
Mar	______	×	______	+	______	=	______
Apr	______	×	______	+	______	=	______
May	______	×	______	+	______	=	______
					Total	=	______

Worksheet 6
House Solar Performance Summary

From Worksheets 4 and 5, enter the total monthly heat load and the figure for solar-supplied heat. Subtract the monthly solar-supplied figure from the total heat load. If the difference is less than "0," enter "0" in the last column.

Month	Heat Load (millions Btus) from Worksheet 5	Solar Supplied (millions Btus) from Worksheet 4	Difference: Not Solar Supplied (millions Btus)
Sep	______	______	______
Oct	______	______	______
Nov	______	______	______
Dec	______	______	______
Jan	______	______	______
Feb	______	______	______
Mar	______	______	______
Apr	______	______	______
May	______	______	______
	Total = ______		Total = ______

Difference: Not Solar Supplied = Btus to be supplied by purchased fuel

Totals are:

A. Total Purchased Fuel (from column 3, above) ____________________ Btus

B. Total Heat Load (from column 1, above) ____________________ Btus

C. % Purchased Fuel (A ÷ B × 100) ________________ ÷ ________________ x 100 = ______%

D. % Solar (100 – C) 100 - ______ = ______%

Worksheet 7
Backup Heat and Annual Fuel Usage Calculation

1. NET AVAILABLE BTUS FOR VARIOUS FUELS

A. #2 fuel oil: (theoretical heat energy = 140,000 Btus per gallon). Assuming 70% combustion efficiency, the net heat will be 0.70 × 140,000= 98,000 Btus per gallon.

B. Propane gas: (theoretical heat energy = 91,500 Btus per gallon). Assuming 75% combustion efficiency, the net heat will be 0.75 × 91,500 = 68,625 Btus per gallon.

C. Electricity (theoretical heat energy = net heat in this case): 3,415 Btus per kilowatt-hour.

D. Split and dry hardwood: Average net heat energy is 17,000,000 Btus per cord (a cord is 128 cubic feet), or __________ Btus/cord for the specific firewood to be burned.

2. FOR COMBUSTION EFFICIENCY IN STEP 2, BELOW, USE THE FOLLOWING VALUES OR SUBSTITUTE MANUFACTURER'S SPECIFIED EFFICIENCY:

Oil furnace: .70
Propane gas furnace: .75
Electric resistance heaters or electric furnace: 1.00
Woodstove: .85

3. SIZING THE CONVENTIONAL BACKUP HEAT EQUIPMENT

The appropriate furnace size (in Btus per hour) can be calculated as follows:

Step 1.

Total Heat Loss (from Worksheet 3, line 5*) __________ Btus/°F • day ÷ 24 hr/day × (72 – ______ °F Outside Winter Design Temperature) + Sidehill Lower Concrete Wall Loss** __________ Btus per hour = __________ Btus per hour

*Use Total Heat Loss without taking nighttime insulation credit
**Area of lower concrete wall (Worksheet 1, line 16) _____ square feet X U-value of lower concrete wall _____ (Btus/hr • ft^2 • °F) × (72 – 45 Degrees) = _____ Btus per hour

Step 2.

The answer from Step __________ Btus per hour ÷ combustion efficiency (as a decimal, from section 2, above) = __________ Btus per hour ÷ ______ = __________ Btus per hour

Rounded for simplicity to the nearest thousand:

Furnace Size = __________ Btus per hour***

*** Btus per hour net at bonnet. Increase slightly for duct and other losses.

(continued next page)

Worksheet 7
(continued)

4. SIZING A WOODSTOVE

The recommended woodstove size can be calculated as follows:

Step 1.

Take the average of Heat Loss (from Worksheet 3, lines 5 and 6) (11,126 + 10,019) ÷ 2 Btus per hour ÷ 24 hours per day × (72 - outside Design Temperature) _______ degrees + sidehill LCWL (from section 1, above) _______ Btus per hour = __________ Btus per hour

Step 2.

Answer from Step 1 __________ Btus per hour ÷ .85 (combustion efficiency from section 2, above) = __________ Btus per hour

Rounded for simplicity the nearest thousand:

Woodstove size = __________ Btus per hour

5. ANNUAL FUEL CONSUMPTION

Total Purchased Fuel (from Worksheet 6, line A) ÷ net available heat energy in Btus per gallon, kilowatt-hour, or cord (from section 1, above) = annual fuel consumption in Btus*

*Monthly totals can also be obtained using the same method working with Worksheet 6, column 1.

SUMMARY:

Annual Purchased Oil Consumption (if 100% source of backup heat):

__________ Btus ÷ 98,000 Btus per gallon = __________ gallons of oil

Annual Electricity Consumption (if 100% source of backup heat):

__________ Btus ÷ 3,415 Btus per kilowatt-hour = __________ kilowatt-hours

Annual Firewood Consumption (if 100% source of backup heat):

__________ Btus ÷ __________ Btus per cord + 0.5 cord (to be conservative) = _______ cords

To calculate the cost of these various sources of backup heat, simply multiply your totals for this section by the present rate in your area for 1 gallon, 1 kilowatt-hour, or 1 cord of split and dried hardwood firewood.

Worksheet 8
Sizing the Solar Slab

1. DETERMINING THE TOTAL INSOLATION FOR YOUR HOUSE ON A SUNNY DAY IN FEBRUARY

A. Insolation for a representative February day*:

East-facing glass _______ square feet × East SHGF ½-day total _______ Btus per square feet + South-facing glass _______ square feet × South SHGF ½-day total × 2 _______ Btus per square feet + West-facing glass _______ square feet × West SHGF ½-day total _______ Btus per square feet = ____________________ Btus

*Obtain your Solar Heat Gain Factors (SHGFs) for February from Worksheet 4, part 2.

B. Peak Insolation for February day:

Multiply result from A (from above) __________ Btus × Shade Factor (as a decimal) _______ × Clearness Number (as a decimal) _______ = __________ Btus

2. DETERMINING THE PREDICTED HEAT LOSS OF THE HOUSE (WHILE COLLECTING THE BTUS INDICATED IN SECTION 1, ABOVE)

A. Calculate the heat loss from 7:00 AM to 5:00 PM as follows:

__________ Btus/hr • °F (from Worksheet 3, lines 6 or 5, if no nighttime glass insulation is used) ÷ 24 hours per day __________ Btus/°F • day × (68 – Average Winter Temperature for house location (from appendix 5) _______ degrees) × 10 hours = __________ Btus

B. If using a sidehill design, add the Lower Concrete Wall Loss (from Worksheet 3, line 7) _______ Btus per hour × 10 hours = __________
10-hour heat loss in Btus

C. Then add A + B = __________ Btus

3. DETERMINING THE EXCESS AVAILABLE HEAT TO STORE IN THE SOLAR SLAB:

Total from section 1, above __________ Btus – Total from section 2, above __________ Btus = __________ Btus

(continued on next page)

Worksheet 8
(continued)

4. DETERMINING THE VOLUME OF THE SOLAR SLAB

Total from section 3, above __________ Btus ÷ 30 Btus/ft^3 • °F* ÷ 8 degrees** = _______ cubic feet

*Specific Heat of Solar Slab (combination of 12-inch concrete blocks and poured concrete over blocks)

**Desired Maximum Temperature Difference

5. DETERMINING THE APPROPRIATE SLAB THICKNESS (MINIMUM 4 INCHES)

T = total thickness in feet

l = length in feet

w = width in feet

t = thickness of poured concrete over 12-inch blocks

A. T = Total Volume (from section 4, above) _______ cubic feet ÷ [0.85 × area of 1st-floor Solar Slab _______ square feet (using outside dimensions)] = _______ feet

Convert Total to inches: _______ feet x 12 inches/foot = _______ inches

B. t = T (from A, above) _______ inches – 6 inches* = _______ inches

*12-inch blocks are approximately ½-solid concrete