ME 420 Final Project Report

Billings, Montana; 2007; -5.5°F

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1. Introduction

1.1 Project Overview

The following report details the thermal system design and economic analysis for the given office building located in Billings, Montana and built in 2007. The weather and solar data used throughout the project was collected from the National Solar Radiation Data Base at the given location, and the system was designed to a 99% dry bulb temperature of -5.5°F based off of data collected from the ASHRAE data base. The project aims to evaluate the cost and viability of two separate heating systems, a hot water system and an solar powered electrical heating system. Each system's design is fleshed out and economic analysis is performed to find the cheapest heating solution.

1.2 Office Layout

Figure 1 displays the floorplan of the office analyzed in this report. Given in the provided project materials, the office has a 15 foot tall flat ceiling, with a 10 foot tall false ceiling below it. All walls are 15 feet tall, with six foot tall windows located two feet above the ground. The exterior doors shown are made out of glass. Furthermore, the western wall is adjacent to another tenant and the building is built on top of a concrete slab.

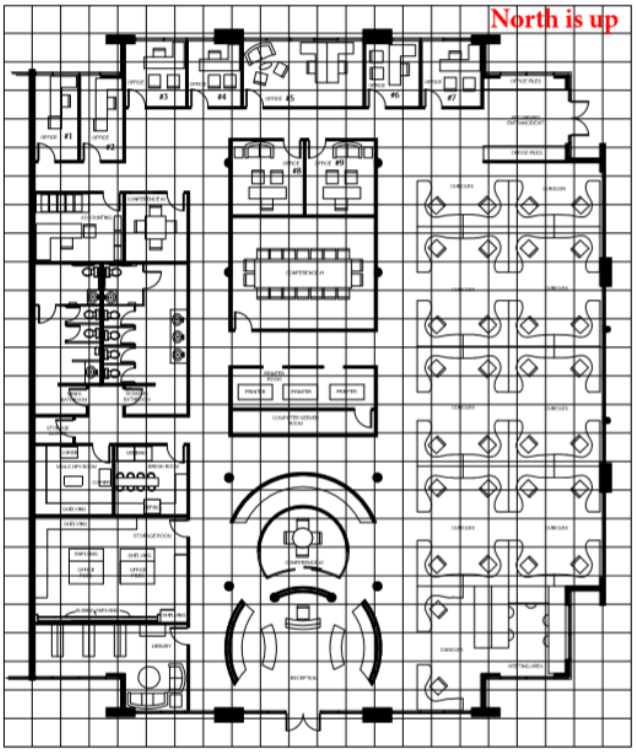


Figure 1 Office Floor Plan

Given the previously stated geometric parameters of the office and its floor plan layout, the office 3D model shown in *Figure 2* was created.

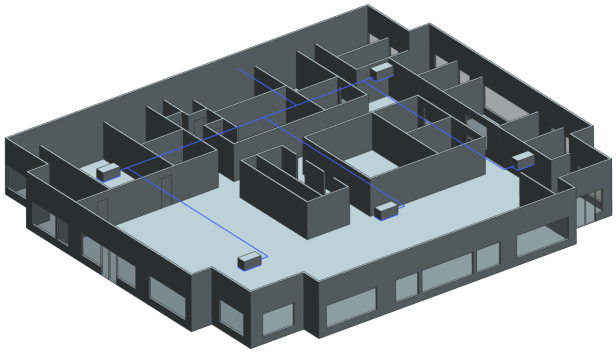


Figure 2 Office 3D Model

1.3 Maximum Heating Load Calculation

After creating the 3D model shown in *Figure 2*, it was used to calculate the maximum heating load for the office given the specified 99% dry bulb temperature of -5.5°F and an interior temperature of 70°F. The following three methods of heat transfer out of the office building are considered: conductive heat transfer through the concrete slab beneath the office building, convective heat transfer from the walls and roof to the exterior air, and heat exchange due to infiltration, or mixing of interior and exterior air due to opening and closing doors. Appendix A contains the heating load calculations in spreadsheet form.

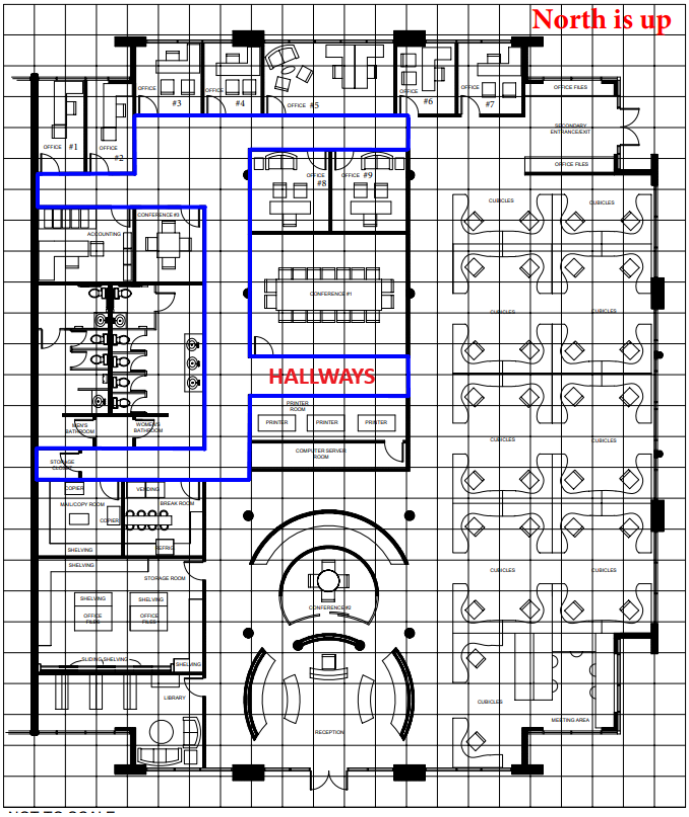


Figure 3 Segmented Office for Heating Load Calculations

To perform the heating load calculations, the office floor plan was segmented into many individual sub-sections, their individual heat transfer rates calculated and then summed together. *Figure 3* shows the divisions of the office space used in the heat load calculations. Note that most subsections such as Office 1 or Library are already depicted on the floor plan, so only the hallway section is marked, with the large open space marked as the cubicles.

$$q = F_p P \Delta T \tag{1}$$

q = Heat transfer rate [BTU/hr]

F_p = Concrete slab loss coefficient [BTU/°F/ft/hr]

P = Perimeter [ft]

ΔT = Difference between interior and exterior temperature [°F]

Equation 1 is used to calculate the heat transfer rate due to conduction from the concrete slab to the earth surrounding the office building. The concrete slab loss coefficient is based on California's Title 24 prescriptive requirements, and the exterior perimeter of each subsection is tabulated and used with Equation 1 to find the maximum heat transfer rate due to conduction for each subsection.

$$q = \sum UA\Delta T \tag{2}$$

q = Heat transfer rate [BTU/hr]

U = Heat transfer coefficient [Btu/hr×ft^2×°F]

A = Area [ft^2]

ΔT = Difference between interior and exterior temperature [°F]

Equation 2 is used to calculate the convective heat transfer rate through the roof, walls and windows of the office building. To use this equation, individual areas of each of the walls, windows and the roof are tabulated. The U-values used in the analysis are based off of California's Title 24 prescriptive requirements and the office's year of construction. Values for each component of area are multiplied together and summed to find the total convective heat transfer.

Equations 3 though 5 are used to calculate the infiltration heat transfer due to exchanging of air between the interior and exterior. To make Equation 3 more useful, it is changed form into Equations 4 and 5, which have the infiltration rate as a function of percent volume exchanged per hour (ACH) and subsection volume. The selected ACH value of 0.3 was based on California's Title 24 prescriptive requirements, and using the known volume of the subsections, the infiltration heat transfer is calculated.

$$q = \dot{m} c_p \Delta T \tag{3}$$

$$q\left(\frac{Btu}{hr}\right) = 1.08 \cdot \dot{V}\left(\frac{ft^3}{min}\right) \cdot \Delta T(°\mathrm{F}) \tag{4}$$

$$\dot{V}\left(\frac{ft^3}{min}\right) = ACH\left(\frac{Air\ Change}{hr}\right) \cdot V\left(\frac{ft^3}{Air\ Change}\right) \cdot \frac{1\ hr}{60\ min} \tag{5}$$

q = Heat transfer rate [BTU/hr]

$\dot{m}$ = Mass flow rate [lbm/hr]

C_p = Specific heat [BTU/°F/lbm]

ΔT = Difference between interior and exterior temperature [°F]

$\dot{V}$ = Volumetric flow rate [ft^3/min]

V = Volume of subsubsection [ft^3]

ACH = Percent volume exchanged with exterior per hour

After analyzing each of the three different modes of heat transfer, the results are summed together to find the maximum heating load to be 206 kBTU/hr for the worst case design point of -5.5$^{°F}$ exterior air temperature.

1.4 Nominal Heating and Electrical Load Calculations

Since the heat transfer rates out of the office are dependent on the temperature difference between the interior and exterior, and the exterior temperatures are constantly changing, the nominal heating load constantly changes with date and time. To calculate the nominal heating load or L_{heat}, the thermal profiles of both the interior and exterior of the office with respect to time must be accounted for, in addition to any heat generation from within the office. Weather data for Billings Montana across the span of a year is used to account for the changes in exterior temperature.

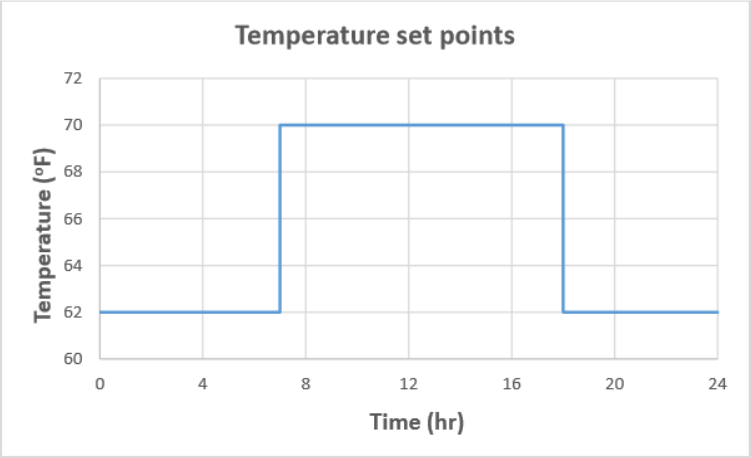


Figure 4 Daily Occupied Thermostat Profile

The thermal profile of the interior of the office is dependent on the programmed temperature cycle in the system's thermostat. *Figure 4* outlines the daily occupied thermostat temperature profile. Note that while unoccupied over the weekends, the office temperature is set to remain at $62^{\circ F}$.

Further information about the office use must be defined to calculate it's heat generation due to electronics and personnel. Additionally, the occupied and unoccupied durations and both personnel and electrical specifications must be defined. In terms of duration, it is assumed that the office follows a standard 40 hour work week, Monday through Friday, and that no employees work in the office during the weekend. *Table 1* and *Table 2* outline the considered heat generation and electrical power usage for both the occupied and unoccupied cases. For the given work week with 40 hours of occupied time and 128 hours of unoccupied time, the weekly electrical system energy consumption is 530,456 W.hr.

Table 1 Occupied and Unoccupied Thermal Heat Generation

Thermal Heat Generation	
Occupied	Unoccupied
- 40 employees (75 W ea.) - 100% office lights (0.5 W/ft^2, 11270 ft^2)	- No employees - 20% office lights (0.5 W/ft^2, 2254 ft^2)
Gain_occ = 8635 W = 29460 BTU/hr	Gain_unocc = 1127 W = 3845 BTU/hr

Table 2 Occupied and Unoccupied Electrical Power Consumption

Electrical Power Usage	
Occupied	Unoccupied
- 1 Refrigerator (100 W) - 100% office lights (0.5 W/ft^2, 11270 ft^2) - 3 Servers (200 W ea.) - 40 employee desktops (75 W ea.)	- 1 Refrigerator (100 W) - 20% office lights (0.5 W/ft^2, 2254 ft^2) - No servers running - No employee computers running
Power_occ = 9335 W	Power_unocc = 1227 W

The EES script located in Appendix I was used to analyze the heating loads of the office system over the course of a year. Appendix B contains the results of the EES analysis and tabulation of the monthly electrical power consumed.

2. Hot Water System

2.1 System Overview and Layout

The following section details the thermal design and economic analysis of a hot water heating system. The tenant to the west of the office building has a water source of $140^{\circ F}$ that they are willing to sell for the purpose of heating the office building. The hot water system will include several key components including heat exchangers, pumps, and an expansion tank .

The hot water system must be designed to the maximum heating load that the office will require, which as specified in Section 1.3 is 206 kBTU/hr. Based on this design point, the proper number of the provided heat exchanger must be selected. Assuming an air flow rate of 1000 cfm and water flow rate of 5 gpm, one heat exchanger provides approximately 43.3 kBTU/hr as shown in *Table 3*. Given this heating capacity, five heat exchangers are required to meet the maximum load requirement and provide a maximum of 216 kBTU/hr.

Table 3 Heat Exchanger Specifications

Air Side Performance					**Liquid Side Performance**					
CFM Flow	Entering Air Dry Bulb Degrees F	Leaving Air Dry Bulb Degrees F	Face Vel SFPM	Air Pressure Drop IN, W, G.	Entering Water Temperature Degrees F	Leaving Water Temperature Degrees F	GPM Number of Gallons	Water Pressure Drop FTHD	Liquid Velocity	Total BTU/HR
Typical Air Applications										
800	60	104.08	512	0.20	140	124.51	5	0.96	2.17	38,115.85
800	60	106.18	512	0.20	140	128.41	7	1.74	3.04	39,937.27
800	60	107.45	512	0.20	140	130.74	9	2.72	3.91	41,030.15
1000	60	100.02	640	0.29	140	122.42	5	0.96	2.17	43,256.18
1000	60	102.28	640	0.29	140	126.73	7	1.74	3.04	45,705.09
1000	60	103.66	640	0.29	140	129.34	9	2.72	3.91	47,194.95
1200	60	96.73	768	0.40	140	120.63	5	0.96	2.17	47,648.32
1200	60	99.10	768	0.40	140	125.28	7	1.74	3.04	50,719.84
1200	60	100.56	768	0.40	140	128.12	9	2.72	3.91	52,609.87

After defining the number of required heat exchangers, their locations must be selected. *Figure 5* displays the locations of all five heat exchangers, along with their accompanying copper tubing to transfer the hot water to and from its. Note that the hot and cold sides of the piping system are overlaid on top of eachother in the figure. This simplifies the system design and allows for equal lengths of pipe to be used between the systems. While it is not included in *Figure 5*, there is one pump per heat exchanger, located on the hot water side just before each heat exchanger. The heat exchangers are labeled 1-5 in clockwise order starting in the top right hand corner. Additionally there are ball valves before and after every single system component and an expansion tank located in piping section A. The source line from the neighboring tenant is 250 ft long, and contains two ball valves and four 90° elbows. It is assumed that there is no change in height across the fluid system, which means the required pump head for each of the five streamlines is equal to the sum of the major and minor losses of the stream line.

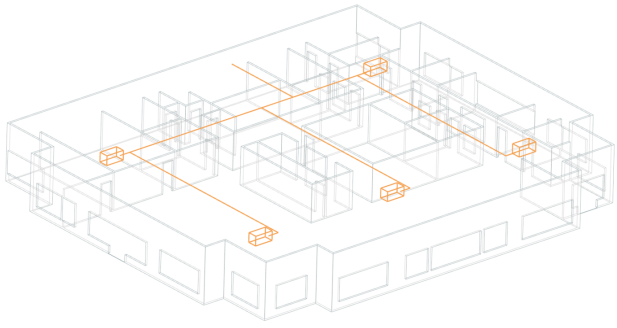


Figure 5 CAD Model Wireframe with Highlighted Water Heating System

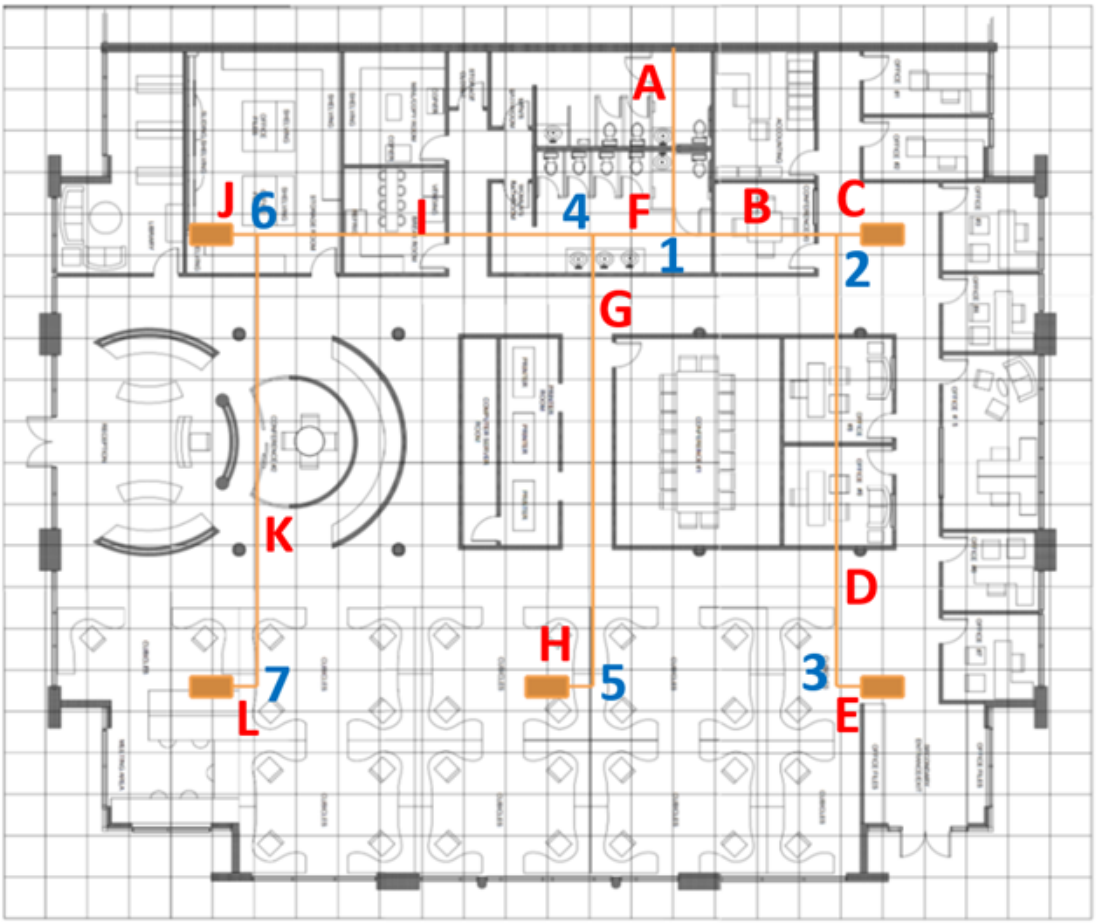


Figure 5 Heat Exchanger Locations and Piping Segments

2.2 Head Loss Analysis

After determining the locations of the heat exchangers, the pipe lengths are tabulated and they are given initial diameter sizes. The initial pipe sizing is based off of the provided recommendations outlined in *Table 4*. To calculate the major head losses in each streamline, the fluid velocity, friction factor, density and pipe diameter and length must be known. To streamline the calculation process, the Blasius correlation (Equation 6) is used to calculate the friction factor given the Reynolds number calculated from known fluid properties. Major losses are calculated per piping segment, and then combined depending on the streamline configuration. After major losses are calculated, minor losses are calculated on a per streamline basis, using the provided recommended minor loss coefficients outlined in *Table 5*.

$$f = \frac{0.316}{Re^{0.25}} \tag{6}$$

f = Friction factor

Re = Reynolds number

Table 4 Recommended Flow Rates for L-type Copper Pipe Sizes

Nominal pipe size (in)	Outside diameter (in)	Inside diameter (in)	Minimum flow rate (gal/min)	Minimum velocity (ft/s)	Maximum flow rate (gal/min)	Maximum velocity (ft/s)
½	0.625	0.545	-	-	1.5	2.1
¾	0.875	0.785	1.5	1.0	3.5	2.3
1	1.125	1.025	3.5	1.4	7.5	3.0
1¼	1.375	1.265	7	1.9	13	3.5
1½	1.625	1.505	12	2.1	20	3.6
2	2.125	1.985	20	2.1	40	4.1
2½	2.625	2.465	40	2.7	75	5.1
3	3.125	2.945	65	3.0	110	5.2
3½	3.625	3.425	90	3.1	150	5.2
4	4.125	3.905	130	3.5	210	5.2

Table 5 Minor Loss Coefficients

Minor Loss Coefficients	
Tee, Dividing line flow	0.2
Tee, Branching flow	1
90° Elbow	0.2
Gate Valve	0.2
Ball Valve	0.5

In order to ensure comparable flow rates across all five heat exchangers, the piping sizes were modified to make the head losses across all five streamlines relatively equal. This mostly entailed increasing the diameter of piping in streamlines with high head loss to reduce its friction factor and reduce the streamlines head loss. The calculations for head loss are included in Appendix C, and the results of the calculations summarized in *Table 6* below.

Table 6 Streamline Head Loss Results

Streamline	Combined Major Head Loss (ft)	Combined Minor Head Loss (ft)	Total Head Loss (ft)
Pump 1	4.2675	0.4955	5.723
Pump 2	6.0039	0.6809	7.645
Pump 3	5.5729	0.7058	7.239
Pump 4	5.4195	0.5410	6.920
Pump 5	6.0587	0.7130	7.732

2.3 Pump Selection

For the fluid system to have the proper heat transfer rates and flow rates, a pump must be selected that can deliver adequate pressure given the system's needs. Based on the selected flow rate of 5 gpm and maximum required head of 7.645, the Taco 005 pump was selected as it can provide the required head at the given system flow rate. The performance curve for the Taco 005 series pump is included in *Figure 6*. Appendix D contains further information on the selected pump.

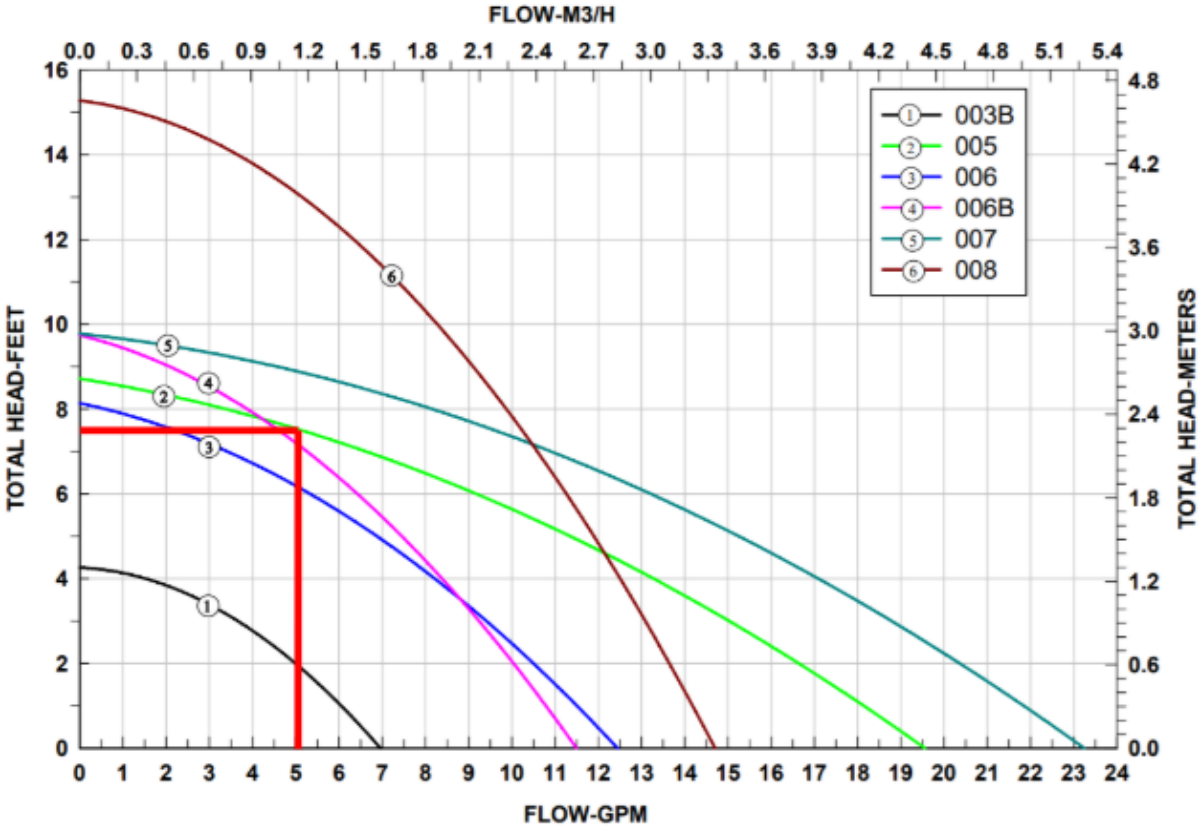


Figure 6 Taco 005 Series Pump Performance Curves

2.4 Expansion Tank Sizing

Expansion tanks are fluid components that change size based on the temperature and pressure of the fluid system, and are used to account for changes in fluid volume due to temperature. Equation 7 outlines the calculation process used to determine the required expansion tank volume. Based off of the provided fluid properties and system volume, an 8.05 gallon tank is required. Of the provided expansion tanks, the NL-80L expansion tank is selected as it's 106 gallon volume satisfies the 8.05 gallon minimum requirement. The calculations for the expansion tank sizing are included in Appendix C and with the expansion tank specification sheet as Appendix E.

$$V_T = \frac{V_W\left[\left(\frac{v_2}{v_1} - 1\right) - 3\alpha\Delta T\right]}{\left[1 - \frac{P_1}{P_2}\right]} \quad (7)$$

V_T = Volume of tank [gal]

V_W = Volume of liquid system [gal]

V_2 = Specific volume of liquid at maximum temperature [ft^3/lbm]

V_1 = Specific volume of liquid at minimum temperature [ft^3/lbm]

α = Expansion coefficient of steel [in/in.°F]

ΔT = Temperature difference between high and low fluid temperatures [°F]

P_1 = Minimum system pressure at low temperature [psig]

P_2 = Maximum system pressure at high temperatures [psia]

2.5 System Economic Analysis

There are several different options in terms of how much water can be purchased from the neighboring tenant, ranging from no water, in which all heating is done electrically, up to 25,000 gallons per day. The following section analyzes the various purchasing options to calculate the cheapest option. The potential purchasing options are outlined in *Table 7*.

Table 7 Hot Water Purchasing Options

Maximum number of gallons (per day)	Annual cost for the rights to the hot water
5000 gal / day	$500/yr ($0.27 per 1000 gal.)
10000 gal / day	$2500/yr ($0.68 per 1000 gal.)
15000 gal / day	$10000/yr ($1.83 per 1000 gal.)
20000 gal / day	$25000/yr ($3.42 per 1000 gal.)

In order to analyze the hot water system economics both the installation and annual costs must be considered. As more water is purchased less electricity needs to be used to heat the office which reduces total cost. At some point, the added cost of improving the water system will outweigh the reduced electrical cost. Based on a combination of component, labor and overhead and profit, the installation cost of the hot water system should be $67,550. Appendix F contains the tabulated component and installation costs, along with the cost analysis for each of the six potential water heating systems. Equation 8 outlines the base equation used to calculate the expected annual cost of each hot water system.

$$A_{energy} = \frac{\$}{BTU} * \frac{L_{yr\_backup}}{\eta} + \$\,(hot\ water\ purchase) + \frac{\$}{W.hr} * L_{yr\_elec} \quad (8)$$

A_{energy} = Annual cost of electricity [$]

L_{yr_backup} = Yearly backup electric heating requirement [BTU]

L_{yr_elect} = Yearly electrical load [W]

η = Electric heater efficiency (0.95)

The economic analysis is performed by taking the previously calculated L_{heat} values from Section 1.4, and subtracting the provided heat exchange per month. If the resultant is negative, then it is set to zero as the hot water system provides all necessary heating to the office. If the resultant is positive, it is added together with the other months to find L_{yr_backup}. After calculating the annual cost for the hot water system, its present worth is calculated using Equation 9.

$$P_{energy} = A_{energy} * \frac{(1+i)^n - 1}{i(1+i)^n} \quad (9)$$

P_{energy} = Present worth of electricity [$]

A_{energy} = Annual cost of electricity [$]

i = Interest rate (4%)

n = Number of cycles (20 years)

The results of the economic analysis of the hot water purchasing options is displayed graphically in *Figure 6*.

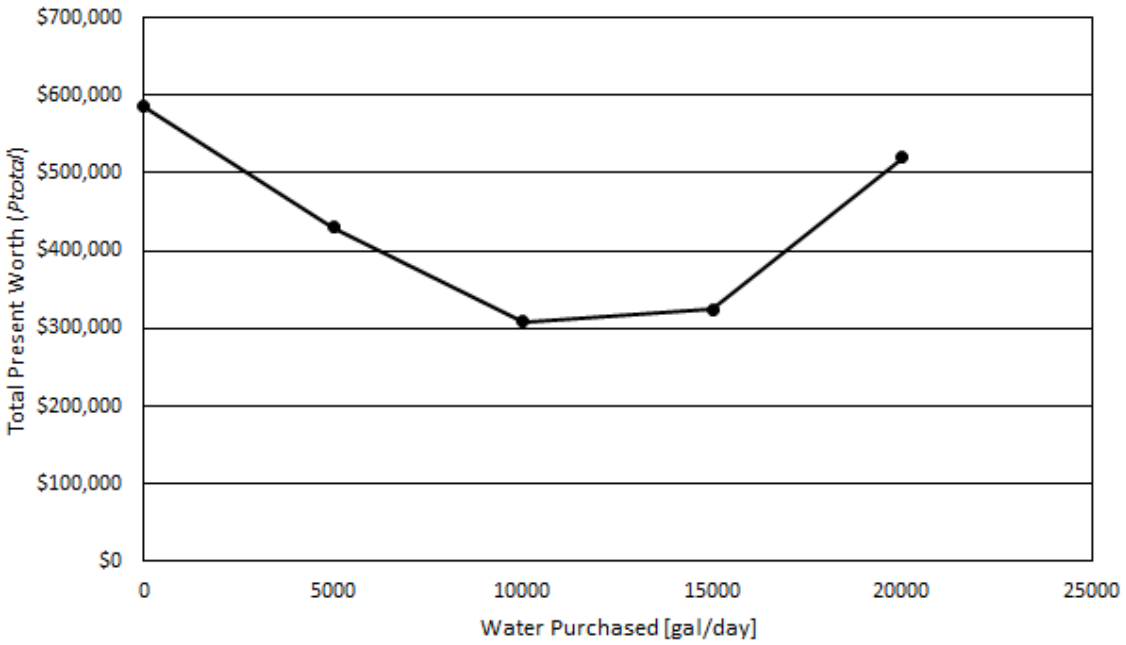


Figure 6 Total Present Worth of Various Hot Water Systems

3. Solar Power System

3.1 System Overview and Layout

The alternative system to the hot water heating system is a purely electric solar powered system that would power both electric heaters and electrical equipment such as lights or computers. The initial solar panel system includes 200 solar panels mounted to the roof of the office building. Optimal solar panel tilt is roughly equivalent to the location's latitude, so the panels are designed to be tilted 45.81° from horizontal. The solar panels being used in this analysis are the Sunmodule Plus SWA 295 MONO solar panels which have 1.675 m^2 of solar panel area. The solar panels are oriented south so their azimuth angle is equal to zero. The office 3D model with mounted solar panels is displayed below in *Figure 7*.

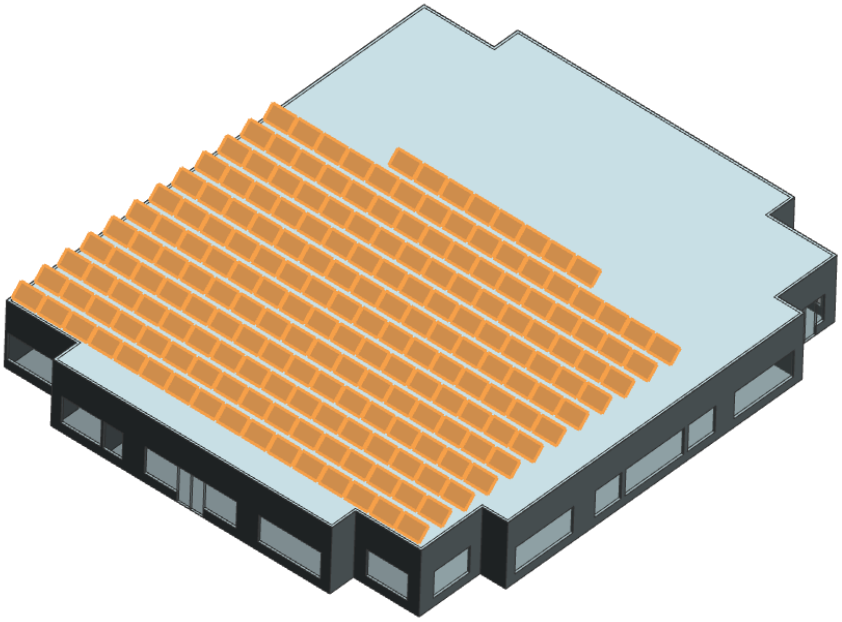


Figure 7 Office Solar Panel Installation

3.2 Performance Analysis

The solar power electricity generation is calculated to find the effectiveness of the solar panel system. The solar irradiance is calculated using weather data for Billings, Montana, and an EES script which iterates though several calculations based on the weather data. The EES script used to calculate the performance of the system is located in Appendix I.

$$f = \frac{G_{total} * Area}{L_{heat} * conv + L_{elec}} = \frac{G_{total} * Area}{L_{total}} \tag{10}$$

f = Solar Fraction
G_{total} = Total Solar Panel Electricity Generation [W/m^2]
$Area$ = Solar Panel Area [m^2]
L_{heat} = Electrical Heating Load [BTU]
L_{elec} = Electricity Load [W]

After calculating the solar panel electricity generation via the EES script, the solar fraction is then calculated. Solar Fraction is the percentage of the electrical load that is being supplied by the solar panels, and is calculated using Equation 10. These calculations can be found in Appendix B and their results are displayed in *Figure 8*.

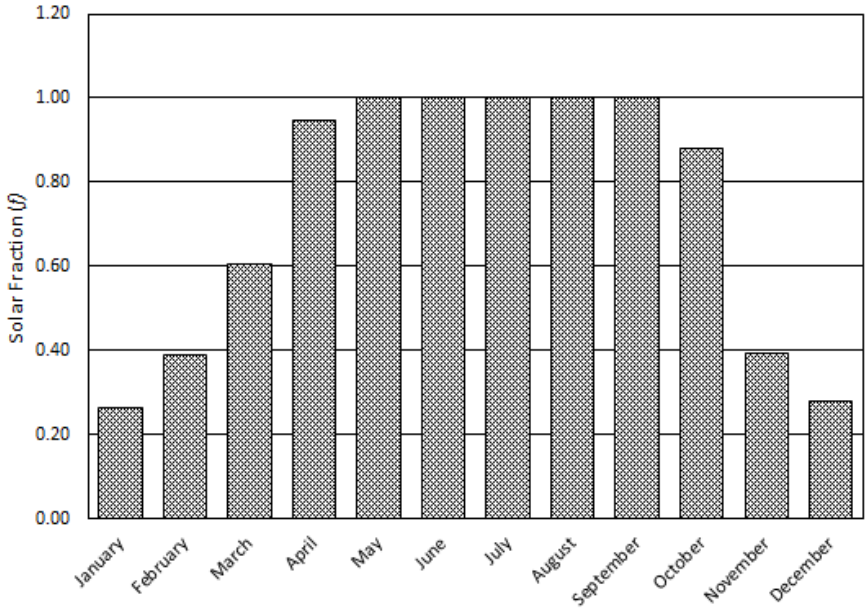


Figure 8 Solar Fraction per Month

3.3 System Economic Analysis

There are several different scales of solar panel installations available at none, 100, 200, 300, 400, and 500 panels; this section will analyze which option is most cost effective. The cost of the solar panel system includes the installation cost, engineering cost and the annual electricity costs. A similar process to the hot water system is used to calculate the annual electricity costs. Equation 8 simplifies to Equation 11 since there is the electrical and back up heating loads are the same thing. The annual electricity load is calculated by dividing the heating load by the electrical heater efficiency, converting it to kW and adding it to the electrical load.

$$A_{backup} = \frac{\$}{kW.hr} * P_{yr_{backup}} \tag{9}$$

A_{energy} = Annual cost of electricity [$]

P_{yr_backup} = Annual electricity load [kW]

After the annual electricity cost is calculated it must be converted to its present worth. This is done using Equation 9 with the same variable constants. The economic analysis results of the solar powered system are displayed in *Figure 9* and their calculations are included in Appendix G1.

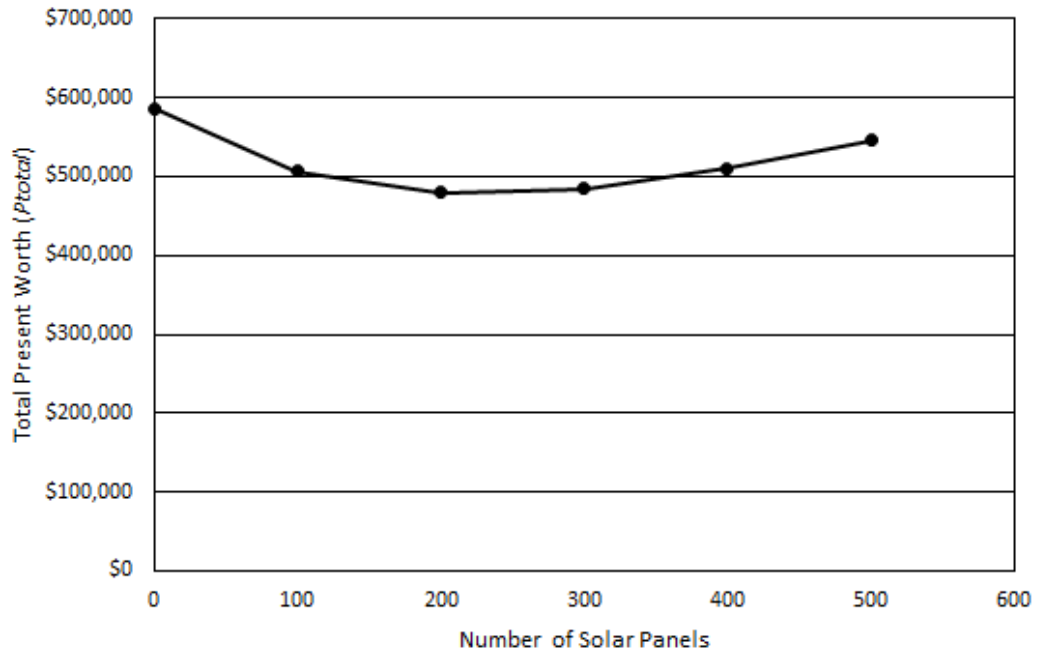


Figure 9 Total Present Worth of Various Solar Panel Installations

Finally it was asked to analyze a case where federal subsidies lowered the cost of solar power to $2.22/kW as opposed to the $3/kW used in the previous analysis. The results of this change are shown in *Figure 10*, and its calculations in Appendix H.

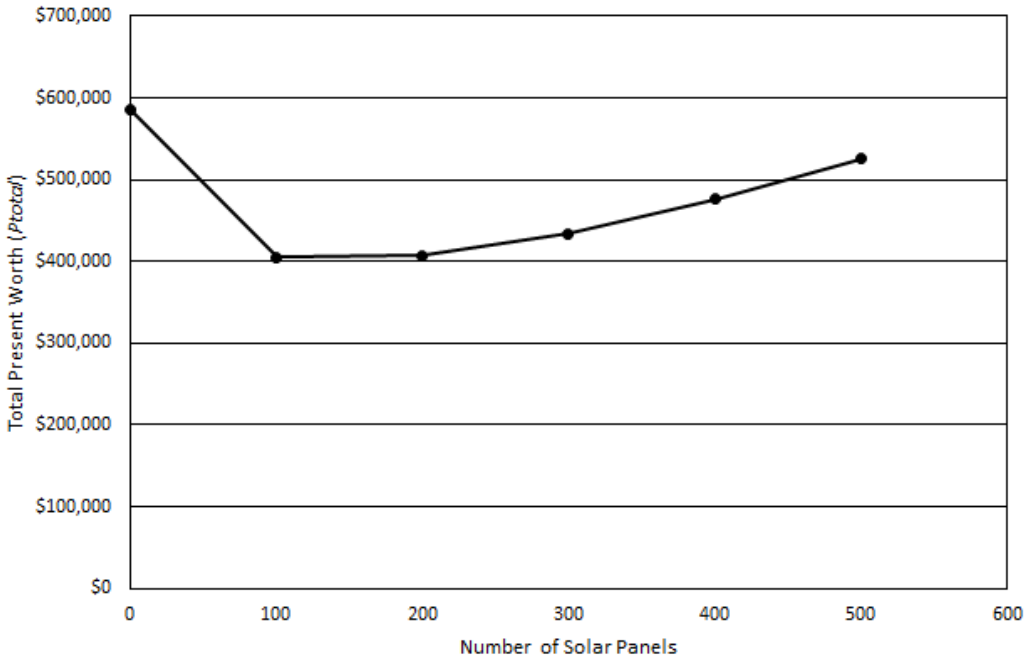


Figure 10 Total Present Worth of Government Subsidized Solar Panel Installations

4. Conclusions & Recommendation

Given the analysis performed throughout the course of the document, I recommend installing the hot water heating system as it is the lowest cost option at $309k as opposed to the lowest cost solar panel design at $480k, over 50% more expensive. Even if the panels are subsidized, the present worth of the solar system only drops $75k to $405k, still 30% more than the hot water heating system. Had air conditioning also been analyzed in this analysis, solar power would have likely proven cheaper, as the hot water heating system can only heat the office, thus more electrical load would have been needed to power the AC units.

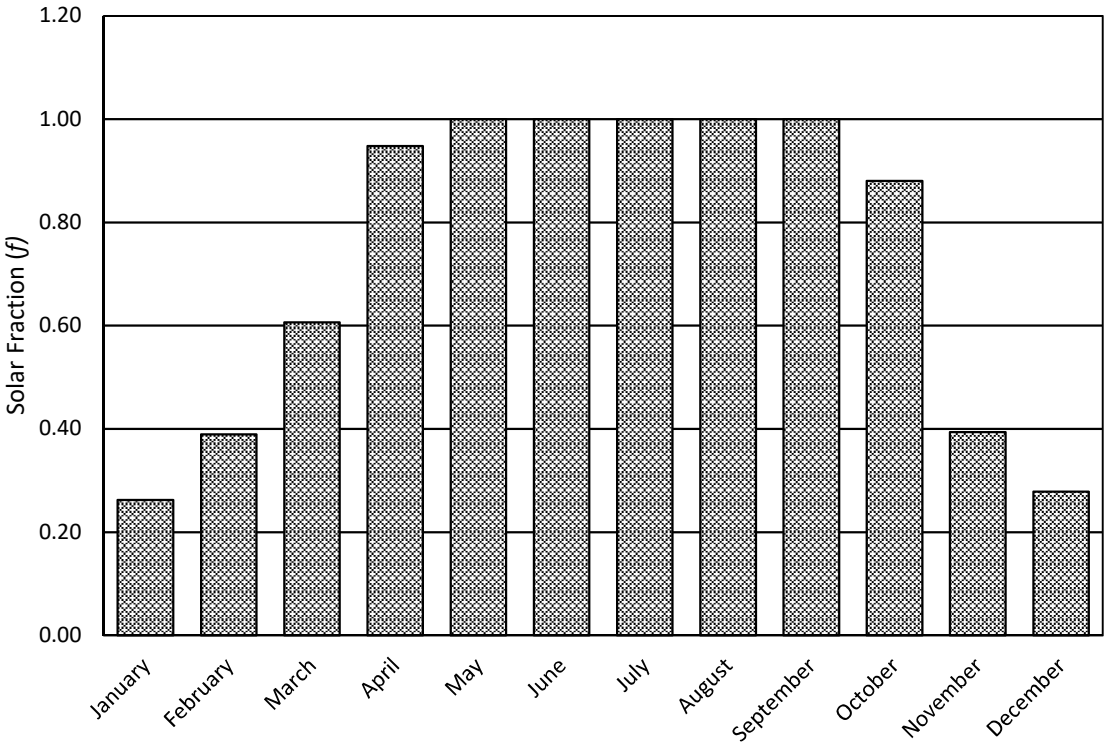
Appendix A

	Floor	Gross Outide Wall Area (sq ft)				Window Area (sq ft)				Outside Door Area (sq ft)				Height	Roof	Perim.	Skylight	Infil.	Load
Description	**(sq ft)**	**N**	**E**	**S**	**W**	**N**	**E**	**S**	**W**	**N**	**E**	**S**	**W**	**(ft)**	**(sq ft)**	**(ft)**	**(sq ft)**	**(ACH)**	**(Btu/hr)**
Office #1	130.0	127.5	0.0	0.0	0.0	46.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	130.0	8.3	0.0	0.30	4023
Office #2	122.0	112.5	0.0	0.0	0.0	21.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	122.0	7.5	0.0	0.30	3089
Office #3	137.8	168.8	0.0	0.0	90.0	52.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	137.8	17.3	0.0	0.30	5796
Office #4	119.4	146.3	0.0	0.0	0.0	27.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	119.4	9.8	0.0	0.30	3617
Office #5	263.4	322.5	0.0	0.0	0.0	126.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	263.4	21.5	0.0	0.30	9783
Office #6	119.4	146.3	0.0	0.0	0.0	28.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	119.4	9.8	0.0	0.30	3658
Office #7	134.8	165.0	95.0	0.0	0.0	53.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	134.8	17.3	0.0	0.30	5792
Office #8	173.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	173.3	0.0	0.0	0.30	1727
Office #9	173.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	173.3	0.0	0.0	0.30	1727
Conference #1	510.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	510.0	0.0	0.0	0.30	5083
Conference #3	138.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	138.8	0.0	0.0	0.30	1383
Accounting	196.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	196.0	0.0	0.0	0.30	1953
Men's Bathroom	315.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	315.0	0.0	0.0	0.30	3139
Women's Bathroom	384.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	384.1	0.0	0.0	0.30	3828
Mail/copy room	179.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	179.2	0.0	0.0	0.30	1786
Break room	162.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	162.5	0.0	0.0	0.30	1619
Storage room	512.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	512.5	0.0	0.0	0.30	5108
Library	340.6	0.0	0.0	413.8	90.0	0.0	0.0	131.0	0.0	0.0	0.0	0.0	0.0	15.0	340.6	33.6	0.0	0.30	12788
Cubicles & reception	5671.5	320.0	1683.0	1095.5	0.0	59.0	477.2	307.0	0.0	0.0	0.0	0.0	0.0	15.0	5671.5	206.5	0.0	0.30	115307
Printer room	189.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	189.1	0.0	0.0	0.30	1885
Computer Server room	116.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	116.9	0.0	0.0	0.30	1165
Hallways	1179.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	1179.6	0.0	0.0	0.30	11756
Totals:	**11269.2**																		**206012**

Heating DB (Dry Bulb) 99% :	-5.5	**Deg. F**
U-Value (Btu/hr×ft2×°F) :	0.110	**Walls**
	0.051	**Roof**
	0.071	**Floor**
	0.47	**Windows**
	0.66	**Skylights**
	0.46	**Doors**
Fp (Btu/hr×ft×°F) :	0.65	**Slab**

Appendix B

Month	G_{Total}	L_{heat} [BTU]	L_{elec} [W.hr]	Solar Fraction
January	18580	7.37E+07	2.34E+06	0.26
February	22419	5.91E+07	2.12E+06	0.39
March	30719	5.04E+07	2.34E+06	0.61
April	30106	2.89E+07	2.27E+06	0.95
May	33767	1.44E+07	2.34E+06	1.00
June	32469	5.17E+06	2.27E+06	1.00
July	34613	9.53E+05	2.34E+06	1.00
August	33336	1.15E+06	2.34E+06	1.00
September	31075	8.48E+06	2.27E+06	1.00
October	24372	2.39E+07	2.34E+06	0.88
November	18272	4.58E+07	2.27E+06	0.39
December	17484	6.44E+07	2.34E+06	0.28



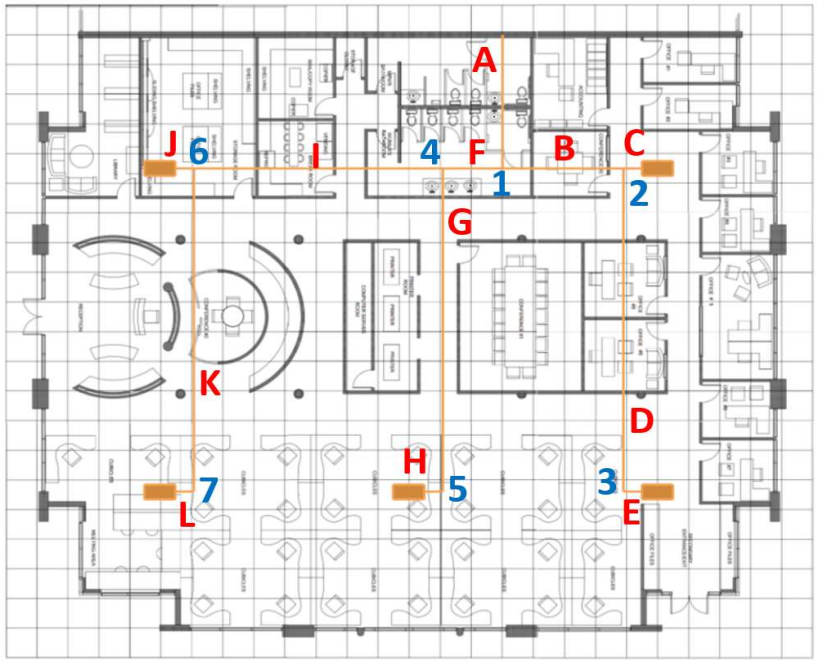
Appendix C

Pipe Segments	Length (in)	Length (ft)	Flow Rate (gpm)	Flow Rate (ft^3/s)	Pipe Size	Pipe Inner Diameter (in)	Pipe Inner Diameter (ft)	Volume (ft^3)	Fluid Velocity (ft/s)	Re_{Hot}	Re_{Cold}	f_{Hot}	f_{Cold}	Major Head $Loss_{Hot}$ (psf)	Major Head $Loss_{Cold}$ (psf)	Combined Major Head Loss (ft)
A	1770	147.5	25	0.0557	2	1.985	0.1654	12.6795	2.592	83793	72218	0.0186	0.0193	105.729	106.630	3.4026
B	234	19.5	10	0.02228	1.25	1.265	0.1054	0.6808	2.553	52594	45329	0.0209	0.0217	23.904	24.108	0.7693
C	36	3	5	0.01114	1	1.025	0.0854	0.0688	1.944	32455	27971	0.0235	0.0244	2.970	2.995	0.0956
D	654	54.5	5	0.01114	1	1.025	0.0854	1.2492	1.944	32455	27971	0.0235	0.0244	53.954	54.414	1.7364
E	36	3	5	0.01114	1	1.025	0.0854	0.0688	1.944	32455	27971	0.0235	0.0244	2.970	2.995	0.0956
F	115.5	9.625	15	0.03342	1.5	1.505	0.1254	0.4756	2.705	66311	57150	0.0197	0.0204	10.511	10.600	0.3383
G	654	54.5	5	0.01114	1	1.025	0.0854	1.2492	1.944	32455	27971	0.0235	0.0244	53.954	54.414	1.7364
H	36	3	5	0.01114	1	1.025	0.0854	0.0688	1.944	32455	27971	0.0235	0.0244	2.970	2.995	0.0956
I	481.5	40.125	10	0.02228	1.25	1.265	0.1054	1.4008	2.553	52594	45329	0.0209	0.0217	49.188	49.607	1.5830
J	36	3	5	0.01114	1	1.025	0.0854	0.0688	1.944	32455	27971	0.0235	0.0244	2.970	2.995	0.0956
K	654	54.5	5	0.01114	1.25	1.265	0.1054	1.9027	1.276	26297	22664	0.0248	0.0258	19.862	20.032	0.6392
L	36	3	5	0.01114	1	1.025	0.0854	0.0688	1.944	32455	27971	0.0235	0.0244	2.970	2.995	0.0956
							system volume	19.9816								

Hot water Properties (at 140 F)		Cold Water Properties (at 122.5 F)	
Density (slug/ft^3)	1.9007	Density (slug/ft^3)	1.9169
Viscosity (lbf*s/ft^2)	9.725E-06	Viscosity (lbf*s/ft^2)	1.138E-05

Loss Coefficients	
Tee, Dividing line flow	0.2
Tee, Branching flow	1
90° Elbow	0.2
Gate Valve	0.2
Ball Valve	0.5

Heat Exchanger Head Loss	0.96



Stream Line	Combined Major Head	Combined Minor Head	Total Head Loss (ft)
Pump 1	4.2675	0.4955	5.723
Pump 2	6.0039	0.6809	7.645
Pump 3	5.5729	0.7058	7.239
Pump 4	5.4195	0.5410	6.920
Pump 5	6.0587	0.7130	7.732

Pump 005 chosen, RPM varied to achieve desired head

alpha =	7.20E-06
v1 =	0.016034
v2 =	0.016537
Vw =	149.4620666
delt T =	125
P1 =	35
P2 =	75
VT =	8.03E+00

Submittal Data Information

101-030

Model 005 Cartridge Circulator

Taco Comfort Solutions™ A Taco Group Company

Effective: June 1, 2011 **Supersedes:** June 15, 2009

Job: _____ Engineer: _____ Contractor: _____ Rep: _____

ITEM NO.	MODEL NO.	IMP. DIA.	G.P.M.	HEAD/FT.	H.P.	ELEC. CHAR.

Features

- Standard High Capacity Output-Compact Design
- Quiet, Efficient Operation
- Direct Drive-Low Power Consumption
- Unique Replaceable Cartridge Design-Field Serviceable
- Self Lubricating
- No Mechanical Seal
- Unmatched Reliability-Maintenance Free
- Universal Flange to Flange Dimensions
- Cast Iron or Stainless Steel Construction

Materials of Construction

Casing (Volute):	Cast Iron or Stainless Steel
Stator Housing:	Steel
Cartridge:	Stainless Steel
Impeller:	Non-Metallic
Shaft:	Ceramic
Bearings:	Carbon
O-Ring & Gaskets:	EPDM

Model Nomenclature

F – Cast Iron, Flanged

SF – Stainless Steel, Flanged

Variations:

Z – Zoning Circulator

VR – Variable Speed Outdoor Reset

VS – Variable Speed Set Point

VV – Variable Speed Variable Voltage

J – Bronze Cartridge with Cast Iron Casing

Performance Data

Flow Range: 0 – 19 GPM

Head Range: 0 – 9 Feet

Min. Fluid Temperature: 40°F (4°C)

Max. Fluid Temperature, Cast Iron: 230°F (110°C)

Max. Fluid Temperature, Stainless Steel : 220°F (104°C)

Max. Working Pressure: 125 psi

Connection Sizes: 3/4", 1", 1-1/4", 1-1/2" Flanged

c UL us LISTED

FOR INDOOR USE ONLY

NSF® ≤ .25% Lead

Complies with California Health and Safety Code Section 116875 / AB1953 and Vermont Act 193

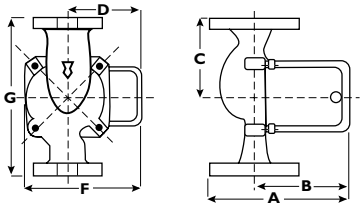
Application

- Hydronic Heating/Cooling
- Radiant
- Indirect Water Heaters
- Hydro-Air Fan Coils
- Domestic Water Recirculation
- Solar Thermal

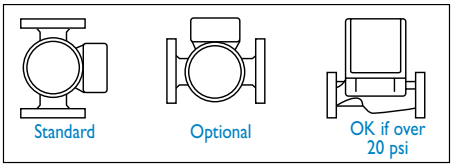
The Taco 005 is designed for a wide range of residential and light commercial water circulating applications. It's unique replaceable cartridge contains all of the moving parts and allows for easy service, instead of replacing the entire circulator. Compact, direct-drive, low power consumption design is ideal for high efficiency jobs.

Pump Dimensions & Weights

		A		B		C		D		F		G		Ship Wt.	
Model	Casing	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	lbs.	Kg
005-F2	Cast Iron	5-5/8	143	4	102	3-3/16	81	2-15/16	75	4-3/4	121	6-3/8	162	8.0	3.6
005-SF2	St. Steel	5-5/8	143	4	102	3-3/16	81	2-15/16	75	4-3/4	121	6-3/8	162	7.0	3.2



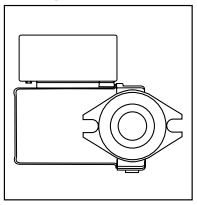
Mounting Positions



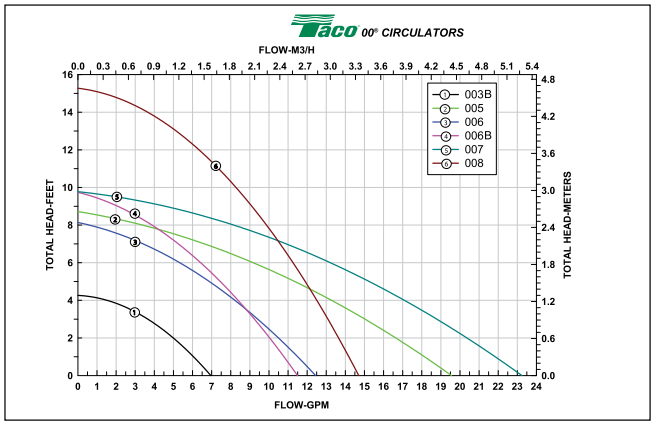
Electrical Data

Model	Volts	Hz	Ph	Amps	RPM	HP
005-F2	115	60	1	.52	3250	1/35
005-SF	115	60	1	.54	3250	1/35
Motor Type	Permanent Split Capacitor Impedance Protected					
Motor Options	220/50/1, 220/60/1, 230/60/1, 100/110/50/60/1					

Flange Orientation



Performance Field - 60Hz



Taco Comfort Solutions™ A Taco Group Company

TACO INC., 1160 Cranston Street, Cranston, RI 02920 Telephone: (401) 942-8000 Fax: 942-2360
TACO (Canada), Ltd., 6180 Ordan Drive, Mississauga, Ontario L5T 2B3 Telephone: (905) 564-9422 Fax: (905) 564-9436

SINCE 1908
wessels company

SUBMITTAL

NL-SERIES

HYDRONIC EXPANSION TANKS

Models: NL-15 thru NL-160VL
Submittal Sheet No. A-1102A Date: 1/19

Job Name	_____	Submitted By	_____	Date	_____
Location	_____	Approved By	_____	Date	_____
	_____	Order No.	_____	Date	_____
Engineer	_____	Notes	_____		
Contractor	_____		_____		
Sales Rep.	_____		_____		

Description

Wessels NL Tanks are non-ASME removable bladder type pre-charged expansion tanks. They are designed to absorb the expansion forces and control the pressure in heating/cooling systems. The system's expanded water (fully compatible with water/glycol mixtures) is contained in a full acceptance heavy-duty butyl bladder that prevents tank corrosion and waterlogging problems. All NL expansion tanks can be installed vertically or horizontally.

Construction

Shell: Carbon Steel
Bladder: Heavy Duty Butyl
System Connection: Carbon Steel
Finish: Baked Epoxy

Performance Limitations

Maximum Design Temperature: 240°F
Maximum Design Pressure: 150 PSIG

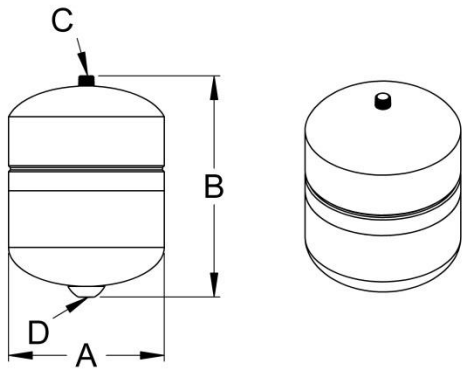
Model Number	Part Number	Tank Volume (Gallons)	Tagging Information	Quantity
NL-15	32051008	2.1		
NL-20	32051012	3.2		
NL-30	32051018	4.8		
NL-60	32051025	6.6		
NL-80L	32051035	10.6		
NL-90L	32051050	15.8		
NL-40VL	32051080	21.1		
NL-60VL	32051105	26.4		
NL-90VL	32051200	52.8		
NL-110VL	32051300	79.2		
NL-160VL	32051500	132.1		

Typical Specification

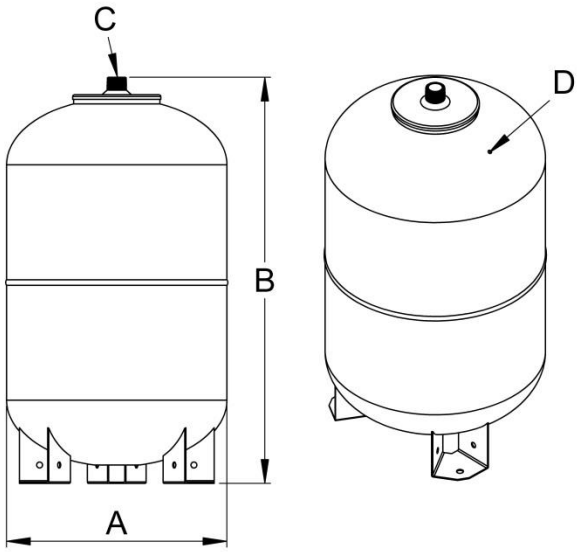
Furnish and install, as shown on plans, a _____ gallon _____" diameter X _____" (high) pre-charged steel expansion tank with heavy-duty butyl bladder. The tank shall have NPT system connections and a 0.302"-32 charging valve connection (standard tire valve) to facilitate the on-site charging of the tank to meet system requirements.

Each tank shall be Wessels model number NL_____ or approved equal.

101 TANK ST ● GREENWOOD, IN 46143 ● (317) 888-9800 ● (317) 888-9988 FAX ● www.westank.com



NL-15 thru NL-60



NL-80L thru NL160VL

Dimensions & Weights

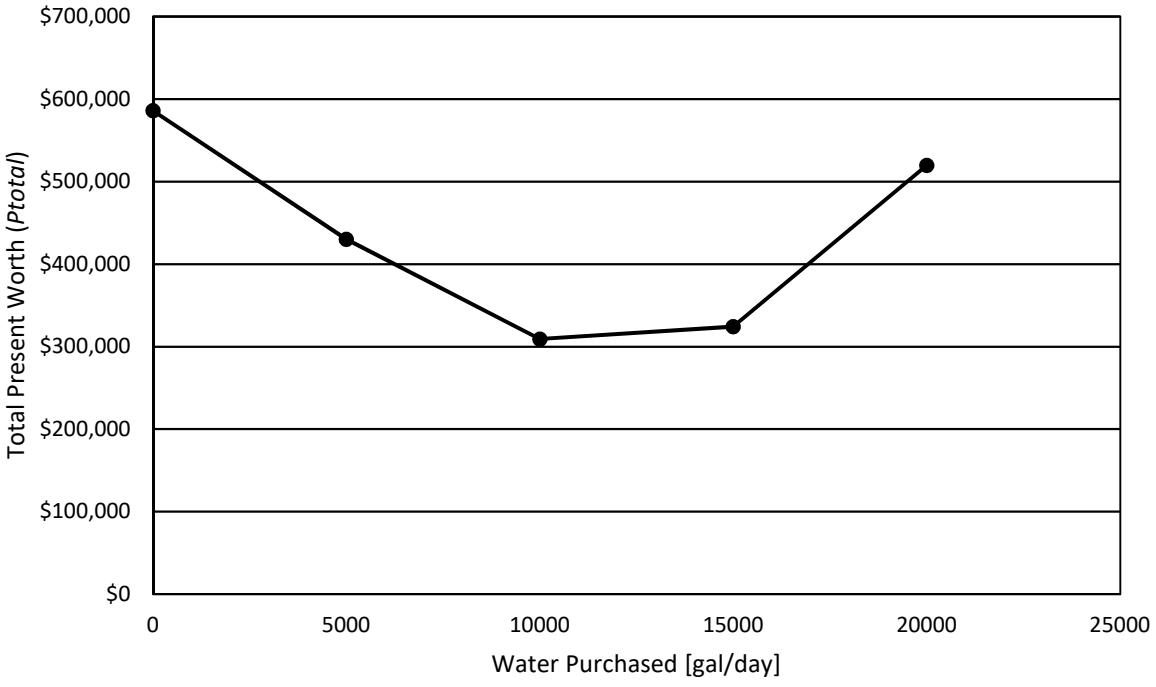
Model Number	Dimensions In Inches				Approx Shipping Weight (lbs)
	A	B	System Connection	Charging Valve	
			C	D	
NL-15	7.9	12.9	3/4	0.302" -32NC	6
NL-20	10.6	11.8			7
NL-30		16.2			9
NL-60	11.4	19.7			12
NL-80L	12.6	22.5	1		22
NL-90L	15	28.7			31
NL-40VL	17.7	28.9			35
NL-60VL		31.1			45
NL-90VL	21.6	42.5	1 1/2		84
NL-110VL	24.8	46.3			111
NL-160VL	30.7	50.5			217

Notes

- Tanks are factory pre-charged at 12 psi and field adjustable.
- Models NL80L thru NL160VL will have mounting legs.

Appendix F

Description	Cost	Unit	Quantity	Total Cost
2" Copper Pipe & Insulation	$62.65	L.F.	295	$22,178.10
1.5" Copper Pipe & Insulation	$19.25	L.F.	19.25	$444.68
1.25" Copper Pipe & Insulation	$37.30	L.F.	234.25	$10,485.03
1" Copper Pipe & Insulation	$37.10	L.F.	241.8	$10,764.94
1" Ball Valve	$122.00	Ea.	10	$1,464.00
2" Ball Valve	$470.00	Ea.	2	$1,128.00
1" Elbow	$71.00	Ea.	4	$340.80
2" Elbow	$122.00	Ea.	4	$585.60
1.25" Elbow	$79.50	Ea.	2	$190.80
2" Reducing Tee	$199.00	Ea.	2	$477.60
1.5" Reducing Tee	$162.00	Ea.	2	$388.80
1.25" Reducing Tee	$138.00	Ea.	4	$662.40
Heat Exchangers	$292.00	Ea.	5	$1,752.00
Pumps	$229.94	Ea.	5	$1,379.64
Expansion Tank	$256.00	Ea.	1	$307.20
Associated Cost	$15,000.00	Ea.	1	$15,000.00
		Installation Cost:		$67,549.58



Water Cost ($/yr)	provided (gal/day)	Heat Exchanger flow rate (gpm)	Heat Exchange Rate (Btu/hr)	Heat exchange/day	L_{yr_elect} (Whr)
500	5000	5	43,256.18	720936	2.76E+07
	# Days	Total Heat Exchange (Btu)	L_{heat}	L_{heat} - HE_{TOT}	L_{backup}
January	31	22349026	7.374E+07	5.139E+07	51390974
February	28	20186217	5.913E+07	3.894E+07	38943783
March	31	22349026	5.043E+07	2.808E+07	28080974
April	30	21628090	2.890E+07	7.272E+06	7271910
May	31	22349026	1.442E+07	-7.929E+06	0
June	30	21628090	5.170E+06	-1.646E+07	0
July	31	22349026	9.527E+05	-2.140E+07	0
August	31	22349026	1.147E+06	-2.120E+07	0
September	30	21628090	8.482E+06	-1.315E+07	0
October	31	22349026	2.393E+07	1.581E+06	1580974
November	30	21628090	4.578E+07	2.415E+07	24151910
December	31	22349026	6.435E+07	4.200E+07	42000974
				Total L_{backup} (Btu):	193421497
				A_{energy} ($) =	2.67E+04
				P_{energy} =	3.63E+05

Water Cost ($/yr)	provided (gal/day)	Heat Exchanger flow rate (gpm)	Heat Exchange Rate (Btu/hr)	Heat exchange/day	L_{yr_elect} (Whr)
10000	15000	5	43,256.18	2162809	2.76E+07
	# Days	Total Heat Exchange (Btu)	L_{heat}	L_{heat} - HE_{TOT}	L_{backup}
January	31	67047079	7.374E+07	6.693E+06	6692921
February	28	60558652	5.913E+07	-1.429E+06	0
March	31	67047079	5.043E+07	-1.662E+07	0
April	30	64884270	2.890E+07	-3.598E+07	0
May	31	67047079	1.442E+07	-5.263E+07	0
June	30	64884270	5.170E+06	-5.971E+07	0
July	31	67047079	9.527E+05	-6.609E+07	0
August	31	67047079	1.147E+06	-6.590E+07	0
September	30	64884270	8.482E+06	-5.640E+07	0
October	31	67047079	2.393E+07	-4.312E+07	0
November	30	64884270	4.578E+07	-1.910E+07	0
December	31	67047079	6.435E+07	-2.697E+06	0
				Total L_{backup} (Btu):	6692921
				A_{energy} ($) =	1.89E+04
				P_{energy} =	2.57E+05

Water Cost ($/yr)	provided (gal/day)	Heat Exchanger flow rate (gpm)	Heat Exchange Rate (Btu/hr)	Heat exchange/day (Btu/day)	L_{yr_elect} (Whr)
2500	10000	5	43,256.18	1441873	2.76E+07
	# Days	Total Heat Exchange (Btu)	L_{heat}	L_{heat} - HE_{TOT}	L_{backup}
January	31	44698053	7.374E+07	2.904E+07	29041947
February	28	40372435	5.913E+07	1.876E+07	18757565
March	31	44698053	5.043E+07	5.732E+06	5731947
April	30	43256180	2.890E+07	-1.436E+07	0
May	31	44698053	1.442E+07	-3.028E+07	0
June	30	43256180	5.170E+06	-3.809E+07	0
July	31	44698053	9.527E+05	-4.375E+07	0
August	31	44698053	1.147E+06	-4.355E+07	0
September	30	43256180	8.482E+06	-3.477E+07	0
October	31	44698053	2.393E+07	-2.077E+07	0
November	30	43256180	4.578E+07	2.524E+06	2523820
December	31	44698053	6.435E+07	1.965E+07	19651947
				Total L_{backup} (Btu):	75707227
				A_{energy} ($) =	1.78E+04
				P_{energy} =	2.42E+05

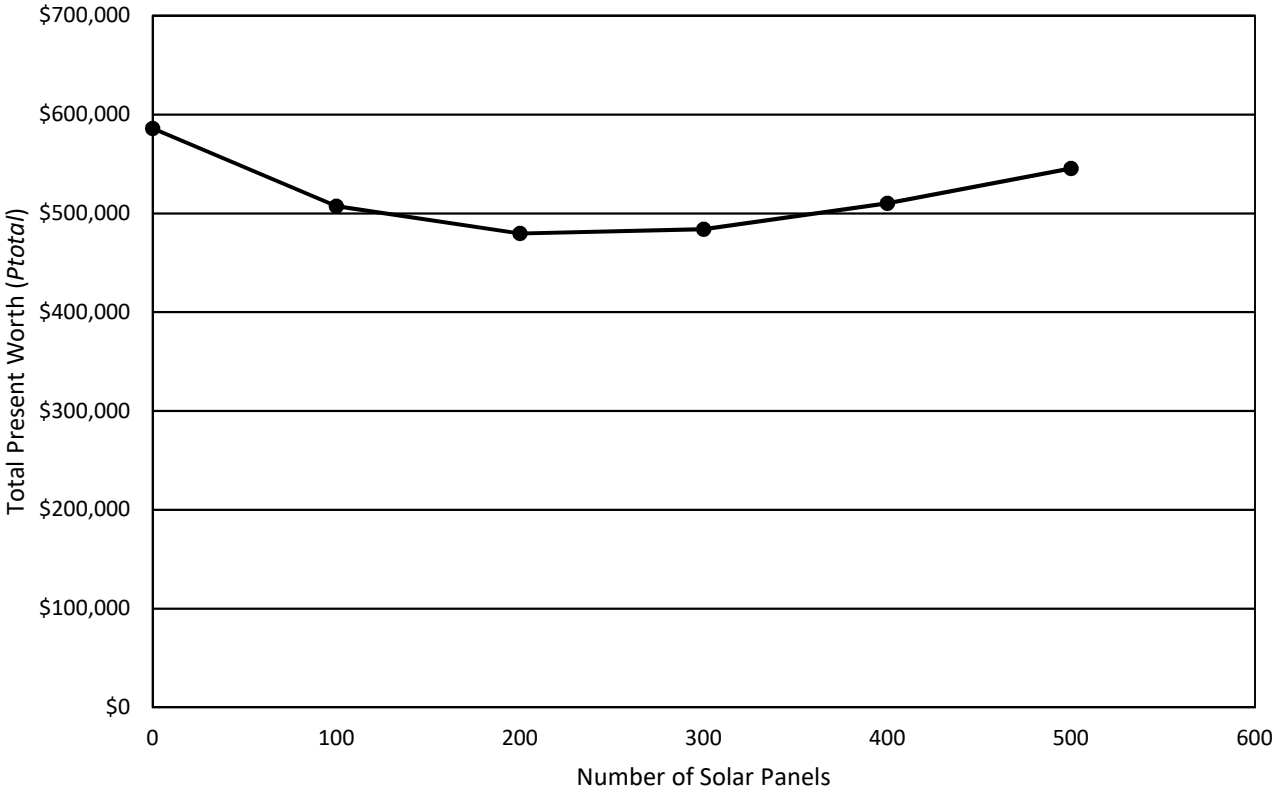
Water Cost ($/yr)	provided (gal/day)	Heat Exchanger flow rate (gpm)	Heat Exchange Rate (Btu/hr)	Heat exchange/day (Btu/day)	L_{yr_elect} (Whr)
25000	20000	5	43,256.18	2883745	2.76E+07
	# Days	Total Heat Exchange (Btu)	L_{heat}	L_{heat} - HE_{TOT}	L_{backup}
January	31	89396105	7.374E+07	-1.566E+07	0
February	28	80744869	5.913E+07	-2.161E+07	0
March	31	89396105	5.043E+07	-3.897E+07	0
April	30	86512360	2.890E+07	-5.761E+07	0
May	31	89396105	1.442E+07	-7.498E+07	0
June	30	86512360	5.170E+06	-8.134E+07	0
July	31	89396105	9.527E+05	-8.844E+07	0
August	31	89396105	1.147E+06	-8.825E+07	0
September	30	86512360	8.482E+06	-7.803E+07	0
October	31	89396105	2.393E+07	-6.547E+07	0
November	30	86512360	4.578E+07	-4.073E+07	0
December	31	89396105	6.435E+07	-2.505E+07	0
				Total L_{backup} (Btu):	0
				A_{energy} ($) =	3.33E+04
				P_{energy} =	4.52E+05

Water Cost ($/yr)	provided (gal/day)	Heat Exchanger flow rate (gpm)	Heat Exchange Rate (Btu/hr)	Heat exchange/day (Btu/day)	L_{yr_elect} (Whr)
0	0	5	43,256.18	0	2.76E+07
	# Days	Total Heat Exchange (Btu)	L_{heat}	L_{heat} - HE_{TOT}	L_{backup}
January	31	0	7.374E+07	7.374E+07	73740000
February	28	0	5.913E+07	5.913E+07	59130000
March	31	0	5.043E+07	5.043E+07	50430000
April	30	0	2.890E+07	2.890E+07	28900000
May	31	0	1.442E+07	1.442E+07	14420000
June	30	0	5.170E+06	5.170E+06	5170000
July	31	0	9.527E+05	9.527E+05	952741
August	31	0	1.147E+06	1.147E+06	1147000
September	30	0	8.482E+06	8.482E+06	8482000
October	31	0	2.393E+07	2.393E+07	23930000
November	30	0	4.578E+07	4.578E+07	45780000
December	31	0	6.435E+07	6.435E+07	64350000
				Total L_{backup} (Btu):	376431741
				A_{energy} ($) =	4.31E+04
				P_{energy} =	5.86E+05

Water Purchased (gal/day	P_{total}
0	$585,876.82
5000	$430,092.99
10000	$309,252.32
15000	$324,396.85
20000	$519,835.64

Appendix G

Number of solar panels	Solar Panel Area [m^2]	Total solar power [W]	Solar Installation Cost [$]	E_{total}
0	0	0	0	$585,925.10
100	169	29500	113500	$507,167.04
200	338	59000	202000	$479,655.25
300	507	88500	290500	$483,933.60
400	676	118000	379000	$510,065.30
500	845	147500	467500	$545,678.83



100 Solar Panels				
Month	G(total)	L_{heat}	L_{elec}	P_{backup}
January	18580	7.37E+07	2.34E+06	2.20E+07
February	22419	5.91E+07	2.12E+06	1.66E+07
March	30719	5.04E+07	2.34E+06	1.27E+07
April	30106	2.89E+07	2.27E+06	6.09E+06
May	33767	1.44E+07	2.34E+06	1.08E+06
June	32469	5.17E+06	2.27E+06	0.00E+00
July	34613	9.53E+05	2.34E+06	0.00E+00
August	33336	1.15E+06	2.34E+06	0.00E+00
September	31075	8.48E+06	2.27E+06	0.00E+00
October	24372	2.39E+07	2.34E+06	5.61E+06
November	18272	4.58E+07	2.27E+06	1.33E+07
December	17484	6.44E+07	2.34E+06	1.92E+07

P_{yr_backup}	9.66E+07
A_{backup}	$28,967
E_{backup}	$393,667
E_{total}	$507,167

300 Solar Panels			
Month	G(total)	L_{heat}	L_{elec}
January	18580	7.37E+07	2.34E+06
February	22419	5.91E+07	2.12E+06
March	30719	5.04E+07	2.34E+06
April	30106	2.89E+07	2.27E+06
May	33767	1.44E+07	2.34E+06
June	32469	5.17E+06	2.27E+06
July	34613	9.53E+05	2.34E+06
August	33336	1.15E+06	2.34E+06
September	31075	8.48E+06	2.27E+06
October	24372	2.39E+07	2.34E+06
November	18272	4.58E+07	2.27E+06
December	17484	6.44E+07	2.34E+06

P_{yr_backup}	
A_{backup}	
E_{backup}	
E_{total}	

200 Solar Panels				
Month	G(total)	L_{heat}	L_{elec}	P_{backup}
January	18580	7.374E+07	2342726	1.88E+07
February	22419	5.913E+07	2116010	1.28E+07
March	30719	5.043E+07	2342726	7.52E+06
April	30106	2.890E+07	2267154	1.01E+06
May	33767	1.442E+07	2342726	0.00E+00
June	32469	5.170E+06	2267154	0.00E+00
July	34613	9.527E+05	2342726	0.00E+00
August	33336	1.147E+06	2342726	0.00E+00
September	31075	8.482E+06	2267154	0.00E+00
October	24372	2.393E+07	2342726	1.49E+06
November	18272	4.578E+07	2267154	1.02E+07
December	17484	6.435E+07	2342726	1.63E+07

P_{yr_backup}	6.81E+07
A_{backup}	$20,430
E_{backup}	$277,655
E_{total}	$479,655

400 Solar Panels			
Month	G(total)	L_{heat}	L_{elec}
January	18580	7.37E+07	2.34E+06
February	22419	5.91E+07	2.12E+06
March	30719	5.04E+07	2.34E+06
April	30106	2.89E+07	2.27E+06
May	33767	1.44E+07	2.34E+06
June	32469	5.17E+06	2.27E+06
July	34613	9.53E+05	2.34E+06
August	33336	1.15E+06	2.34E+06
September	31075	8.48E+06	2.27E+06
October	24372	2.39E+07	2.34E+06
November	18272	4.58E+07	2.27E+06
December	17484	6.44E+07	2.34E+06

P_{yr_backup}	
A_{backup}	
E_{backup}	
E_{total}	

P_{backup}
1.57E+07
8.99E+06
2.33E+06
0.00E+00
0.00E+00
0.00E+00
0.00E+00
0.00E+00
0.00E+00
0.00E+00
7.13E+06
1.33E+07
4.74E+07
$14,233
$193,434
$483,934

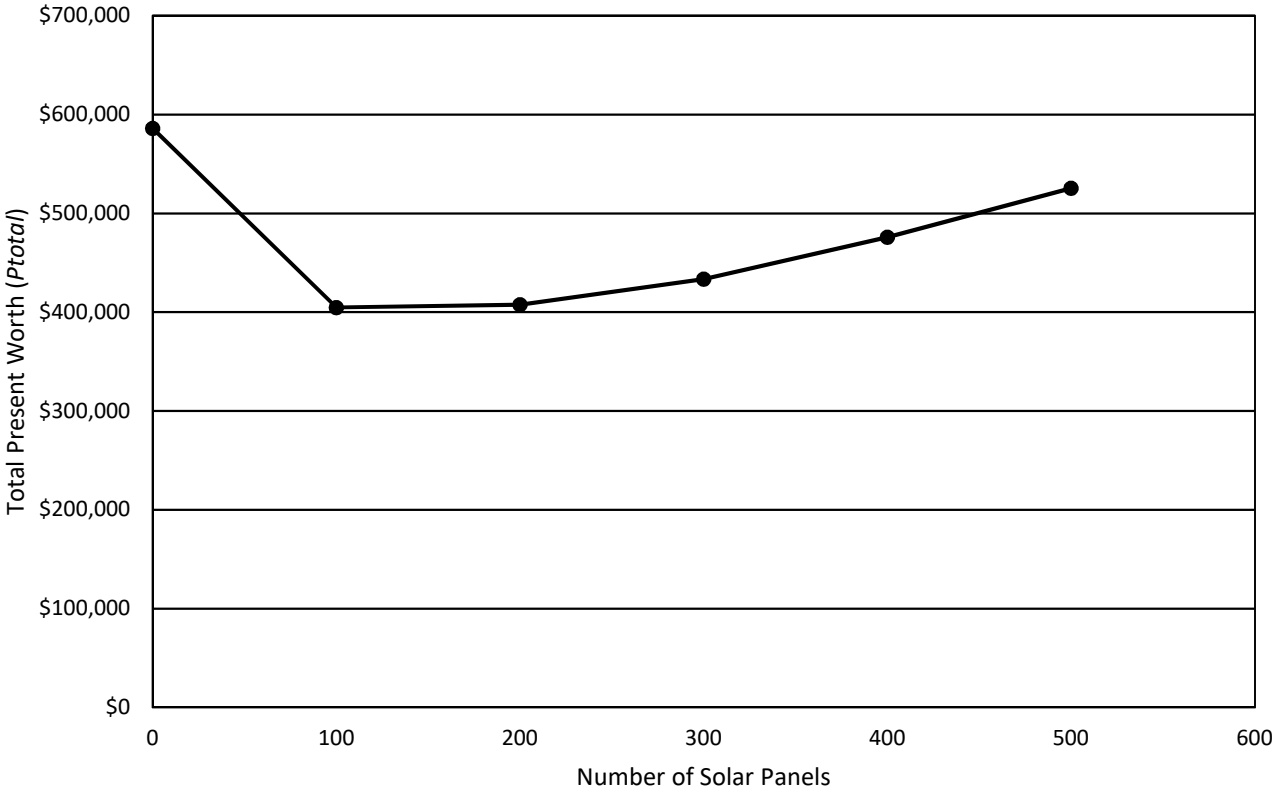
500 Solar Panels				
Month	G(total)	L_{heat}	L_{elec}	P_{backup}
January	18580	7.374E+07	2342726	9.39E+06
February	22419	5.913E+07	2116010	1.41E+06
March	30719	5.043E+07	2342726	0.00E+00
April	30106	2.890E+07	2267154	0.00E+00
May	33767	1.442E+07	2342726	0.00E+00
June	32469	5.170E+06	2267154	0.00E+00
July	34613	9.527E+05	2342726	0.00E+00
August	33336	1.147E+06	2342726	0.00E+00
September	31075	8.482E+06	2267154	0.00E+00
October	24372	2.393E+07	2342726	0.00E+00
November	18272	4.578E+07	2267154	9.50E+05
December	17484	6.435E+07	2342726	7.42E+06
			P_{yr_backup}	1.92E+07
			A_{backup}	$5,752.54
			E_{backup}	$78,178.83
			E_{total}	$545,678.83

P_{backup}
1.25E+07
5.20E+06
0.00E+00
0.00E+00
0.00E+00
0.00E+00
0.00E+00
0.00E+00
0.00E+00
0.00E+00
4.04E+06
1.04E+07
3.21E+07
$9,644
$131,065
$510,065

0 Solar Panels				
Month	G(total)	L_{heat}	L_{elec}	P_{backup}
January	18580	7.374E+07	2342726	2.51E+07
February	22419	5.913E+07	2116010	2.04E+07
March	30719	5.043E+07	2342726	1.79E+07
April	30106	2.890E+07	2267154	1.12E+07
May	33767	1.442E+07	2342726	6.79E+06
June	32469	5.170E+06	2267154	3.86E+06
July	34613	9.527E+05	2342726	2.64E+06
August	33336	1.147E+06	2342726	2.70E+06
September	31075	8.482E+06	2267154	4.88E+06
October	24372	2.393E+07	2342726	9.73E+06
November	18272	4.578E+07	2267154	1.64E+07
December	17484	6.435E+07	2342726	2.22E+07
			P_{yr_backup}	1.44E+08
			A_{backup}	$43,113.39
			E_{backup}	$585,925.10
			E_{total}	$585,925.10

Appendix H

Number of solar panels	Solar Panel Area [m^2]	Total solar power [W]	Solar Installation Cost [$]	E_{total}
0	0	0	0	$585,925.10
100	169	29500	113500	$404,813.61
200	338	59000	202000	$407,464.89
300	507	88500	290500	$433,640.87
400	676	118000	379000	$475,988.32
500	845	147500	467500	$525,352.34



100 Solar Panels				
Month	G(total)	L_{heat}	L_{elec}	P_{backup}
January	18580	7.37E+07	2.34E+06	2.20E+07
February	22419	5.91E+07	2.12E+06	1.66E+07
March	30719	5.04E+07	2.34E+06	1.27E+07
April	30106	2.89E+07	2.27E+06	6.09E+06
May	33767	1.44E+07	2.34E+06	1.08E+06
June	32469	5.17E+06	2.27E+06	0.00E+00
July	34613	9.53E+05	2.34E+06	0.00E+00
August	33336	1.15E+06	2.34E+06	0.00E+00
September	31075	8.48E+06	2.27E+06	0.00E+00
October	24372	2.39E+07	2.34E+06	5.61E+06
November	18272	4.58E+07	2.27E+06	1.33E+07
December	17484	6.44E+07	2.34E+06	1.92E+07

P_{yr_backup}	9.66E+07
A_{backup}	$21,435
E_{backup}	$291,314
E_{total}	$404,814

300 Solar Panels			
Month	G(total)	L_{heat}	L_{elec}
January	18580	7.37E+07	2.34E+06
February	22419	5.91E+07	2.12E+06
March	30719	5.04E+07	2.34E+06
April	30106	2.89E+07	2.27E+06
May	33767	1.44E+07	2.34E+06
June	32469	5.17E+06	2.27E+06
July	34613	9.53E+05	2.34E+06
August	33336	1.15E+06	2.34E+06
September	31075	8.48E+06	2.27E+06
October	24372	2.39E+07	2.34E+06
November	18272	4.58E+07	2.27E+06
December	17484	6.44E+07	2.34E+06

P_{yr_backup}	
A_{backup}	
E_{backup}	
E_{total}	

200 Solar Panels				
Month	G(total)	L_{heat}	L_{elec}	P_{backup}
January	18580	7.374E+07	2342726	1.88E+07
February	22419	5.913E+07	2116010	1.28E+07
March	30719	5.043E+07	2342726	7.52E+06
April	30106	2.890E+07	2267154	1.01E+06
May	33767	1.442E+07	2342726	0.00E+00
June	32469	5.170E+06	2267154	0.00E+00
July	34613	9.527E+05	2342726	0.00E+00
August	33336	1.147E+06	2342726	0.00E+00
September	31075	8.482E+06	2267154	0.00E+00
October	24372	2.393E+07	2342726	1.49E+06
November	18272	4.578E+07	2267154	1.02E+07
December	17484	6.435E+07	2342726	1.63E+07

P_{yr_backup}	6.81E+07
A_{backup}	$15,118
E_{backup}	$205,465
E_{total}	$407,465

400 Solar Panels			
Month	G(total)	L_{heat}	L_{elec}
January	18580	7.37E+07	2.34E+06
February	22419	5.91E+07	2.12E+06
March	30719	5.04E+07	2.34E+06
April	30106	2.89E+07	2.27E+06
May	33767	1.44E+07	2.34E+06
June	32469	5.17E+06	2.27E+06
July	34613	9.53E+05	2.34E+06
August	33336	1.15E+06	2.34E+06
September	31075	8.48E+06	2.27E+06
October	24372	2.39E+07	2.34E+06
November	18272	4.58E+07	2.27E+06
December	17484	6.44E+07	2.34E+06

P_{yr_backup}	
A_{backup}	
E_{backup}	
E_{total}	

P_{backup}
1.57E+07
8.99E+06
2.33E+06
0.00E+00
0.00E+00
0.00E+00
0.00E+00
0.00E+00
0.00E+00
0.00E+00
7.13E+06
1.33E+07
4.74E+07
$10,533
$143,141
$433,641

500 Solar Panels				
Month	G(total)	L_{heat}	L_{elec}	P_{backup}
January	18580	7.374E+07	2342726	9.39E+06
February	22419	5.913E+07	2116010	1.41E+06
March	30719	5.043E+07	2342726	0.00E+00
April	30106	2.890E+07	2267154	0.00E+00
May	33767	1.442E+07	2342726	0.00E+00
June	32469	5.170E+06	2267154	0.00E+00
July	34613	9.527E+05	2342726	0.00E+00
August	33336	1.147E+06	2342726	0.00E+00
September	31075	8.482E+06	2267154	0.00E+00
October	24372	2.393E+07	2342726	0.00E+00
November	18272	4.578E+07	2267154	9.50E+05
December	17484	6.435E+07	2342726	7.42E+06

P_{yr_backup}	1.92E+07
A_{backup}	$4,256.88
E_{backup}	$57,852.34
E_{total}	$525,352.34

P_{backup}
1.25E+07
5.20E+06
0.00E+00
0.00E+00
0.00E+00
0.00E+00
0.00E+00
0.00E+00
0.00E+00
0.00E+00
4.04E+06
1.04E+07
3.21E+07
$7,137
$96,988
$475,988

0 Solar Panels				
Month	G(total)	L_{heat}	L_{elec}	P_{backup}
January	18580	7.374E+07	2342726	2.51E+07
February	22419	5.913E+07	2116010	2.04E+07
March	30719	5.043E+07	2342726	1.79E+07
April	30106	2.890E+07	2267154	1.12E+07
May	33767	1.442E+07	2342726	6.79E+06
June	32469	5.170E+06	2267154	3.86E+06
July	34613	9.527E+05	2342726	2.64E+06
August	33336	1.147E+06	2342726	2.70E+06
September	31075	8.482E+06	2267154	4.88E+06
October	24372	2.393E+07	2342726	9.73E+06
November	18272	4.578E+07	2267154	1.64E+07
December	17484	6.435E+07	2342726	2.22E+07

P_{yr_backup}	1.44E+08
A_{backup}	$43,113.39
E_{backup}	$585,925.10
E_{total}	$585,925.10

```
"Function to determine incident radiation on panel"
Function g_panel(Hr,psi,SIGMA,LAT,LON,LSM,Lookup$)

"Input parameters"
"Hr: Hour of Year (1 to 8760)"
"psi: Surface azimuth"
"SIGMA: Surface tilt"
"LAT: Latitude of location"
"LON: Longitude of location"
"LSM: Longitde of Standard Meridian, LSM= -120 for Pacific Time Zone"
"Lookup: Lookup Table Name"

"Ground reflectivity"
rho_g=0.2

"Day of Year (1 to 365)"
n=trunc(Hr/24)+1

"Equation of time (min)"
GAMMA=360*(n-1)/365
ET=2.2918*(0.0075+0.1868*cos(GAMMA)-3.2077*sin(GAMMA)-1.4615*cos(2*GAMMA)-4.089*sin(2*GAMMA))

"Declination angle"
delta=23.45*sin(360*(n+284)/365)

"Local Standard Time"
LST=Hr-(n-1)*24

"Apparent solar time (hr)"
AST=LST+ET/60+(LON-LSM)/15

"Hour angle"
H=15*(AST-12)

"Altitude angle"
beta=arcsin(cos(LAT)*cos(delta)*cos(H)+sin(LAT)*sin(delta))

"Azimuth angle"
If (sin(H)*cos(delta)/cos(beta)<0) Then
    phi=-arccos((cos(H)*cos(delta)*sin(LAT)-sin(delta)*cos(LAT))/cos(beta))
Else
    phi=arccos((cos(H)*cos(delta)*sin(LAT)-sin(delta)*cos(LAT))/cos(beta))
Endif

"Angle of incidence"
theta=arccos(cos(beta)*cos(phi-psi)*sin(SIGMA)+sin(beta)*cos(SIGMA))

"Global Horizontal Irradiance"
GHI=interpolate1(Lookup$,'Hour','GHI',Hour=Hr+0.5)

"Direct Normal Irradiance"
DNI=interpolate1(Lookup$,'Hour','DNI',Hour=Hr+0.5)

"Diffuse Horizontal Irradiance"
DHI=interpolate1(Lookup$,'Hour','DHI',Hour=Hr+0.5)

"Surface irradiance"
Y=max(0.45,0.55+0.437*cos(theta)+0.313*(cos(theta))^2)
g_panel=DNI*cos(theta)+DHI*(Y*sin(SIGMA)+cos(SIGMA))+GHI*rho_g*(1-cos(SIGMA))/2
End

"Function to determine the heat load for the office"
Function load(Hour,T_out)
```

```
"Input variables"
"Hour: Hour of year"
"T_out: Ambient air temperature in deg F"

"Function variables"
"K_tot: Office loss coefficient"
"tstat_occ: thermostat setting for occupied periods"
"tstat_unnocc: thermostat setting for unoccupied periods"
"on1: time turned on for weekday"
"off1: time turned off for weekday"
"on2: time turned on for weekend"
"off2: time turned off for weekend"

"User parameters"
K_tot=206012/(70+5.5)"Btu/hr*F"
tstat_occ=70 "F"
tstat_unocc=62 "F"
Gain_occ=30000 "Btu/hr"
Gain_unocc=1000 "Btu/hr"
on1=7
off1=18
on2=0
off2=0
Sat=6 "Set Saturday as 6th day of Week"
Sun=7 "Set Sunday as 7th day of Week"

n=trunc(Hour/24)+1
TimeOFDay=Hour-24*(n-1)

"Check if Weekday or Weekend, whether Occupied or Unoccupied, Calculate load"
If (mod(n,Sat)=0) OR (mod(n,Sun)=0) Then
  If ((TimeOFDay>=on2) AND (TimeOFDay<off2)) Then
    load=K_tot*(tstat_occ-T_out)-Gain_occ
  Else
    load=K_tot*(tstat_unocc-T_out)-Gain_unocc
  Endif
Else
  If ((TimeOFDay>=on1) AND (TimeOFDay<off1)) Then
    load=K_tot*(tstat_occ-T_out)-Gain_occ
  Else
    load=K_tot*(tstat_unocc-T_out)-Gain_unocc
  Endif
Endif
If load<0 Then load=0

End


"Main Equations Window"

"User parameters"
Tilt=45.81 "Panel tilt from horizontal"
phi_p=0 "Panel azimuth"
LAT=45.81 "Latitude of location"
LON=-108.54 "Longitude of location"
LSM=-105 "Longitude of standard meridian"

"Month$='January'"
"Table$='Table 1'"
"Month$='Feburary'"
"Table$='Table 2'"
"Month$='March'"
"Table$='Table 3'"
```

```
"Month$='April'"
"Table$='Table 4'"
"Month$='May'"
"Table$='Table 5'"
"Month$='June'"
"Table$='Table 6'"
"Month$='July'"
"Table$='Table 7'"
"Month$='August'"
"Table$='Table 8'"
"Month$='September'"
"Table$='Table 9'"
"Month$='October'"
"Table$='Table 10'"
"Month$='November'"
"Table$='Table 11'"
Month$='December'
Table$='Table 12'

TimeEnd=744 "Total number of hours in simulation"

"Set Hour for table lookups"
Hour=Time

"Evaluate ambient air temperature"
T_a=interpolate1(Month$,'Hour','Temp',Hour=Hour)
TdegF_a=(T_a*9/5)+32

"Evaluate incident radiation converted to electricity"
G_solar=g_panel(Hour,phi_p,Tilt,LAT,LON,LSM,Month$)
E_conv=0.17 "Electricity conversion factor of the solar panel"
f_temp=-0.004 "Temperature coefficient of the solar panels"
G=G_solar*E_conv*(1+((G_solar*30/1000+T_a)-25)*f_temp)


"Evaluate heating load"
q_load=load(Hour,TdegF_a)

"Summations"
$DOLAST
G_total=sumparametric(Table$,'G') "W.hr/m^2"
L_heat=sumparametric(Table$,'q_load') "BTU"
$ENDDOLAST
```

Parametric Table: Table 12

	Time	G	q_{load}
Run 1	8017	*0*	*100014*
Run 2	8018	*0*	*106890*
Run 3	8019	*0*	*114258*
Run 4	8020	*0*	*121625*
Run 5	8021	*0*	*113766*
Run 6	8022	*0*	*102470*
Run 7	8023	*1.537*	*87440*
Run 8	8024	*9.699*	*82038*
Run 9	8025	*24.12*	*79091*
Run 10	8026	*42.05*	*79091*
Run 11	8027	*54.26*	*76635*

Parametric Table: Table 12

	Time	G	q_{load}
Run 12	8028	*71.76*	*68285*
Run 13	8029	*82.47*	*62883*
Run 14	8030	*74.95*	*46184*
Run 15	8031	*59.26*	*46184*
Run 16	8032	*27.75*	*52077*
Run 17	8033	*4.384*	*57480*
Run 18	8034	*0*	*67107*
Run 19	8035	*0*	*72509*
Run 20	8036	*0*	*72509*
Run 21	8037	*0*	*75456*
Run 22	8038	*0*	*72509*
Run 23	8039	*0*	*75456*
Run 24	8040	*0*	*75456*
Run 25	8041	*0*	*72509*
Run 26	8042	*0*	*72509*
Run 27	8043	*0*	*72509*
Run 28	8044	*0*	*72509*
Run 29	8045	*0*	*75456*
Run 30	8046	*0*	*77912*
Run 31	8047	*0.5834*	*80859*
Run 32	8048	*6.397*	*75456*
Run 33	8049	*19.88*	*77912*
Run 34	8050	*36.21*	*61704*
Run 35	8051	*53.56*	*59248*
Run 36	8052	*77.57*	*53354*
Run 37	8053	*100.2*	*47952*
Run 38	8054	*81.06*	*40093*
Run 39	8055	*37.16*	*37146*
Run 40	8056	*11.69*	*40093*
Run 41	8057	*2.27*	*47952*
Run 42	8058	*0*	*53354*
Run 43	8059	*0*	*59248*
Run 44	8060	*0*	*61704*
Run 45	8061	*0*	*67107*
Run 46	8062	*0*	*72509*
Run 47	8063	*0*	*75456*
Run 48	8064	*0*	*77912*
Run 49	8065	*0*	*80859*
Run 50	8066	*0*	*86262*
Run 51	8067	*0*	*86262*
Run 52	8068	*0*	*86262*
Run 53	8069	*0*	*86262*
Run 54	8070	*0*	*89209*
Run 55	8071	*2.753*	*84494*
Run 56	8072	*30.79*	*84494*
Run 57	8073	*84.01*	*79091*
Run 58	8074	*122.2*	*70741*
Run 59	8075	*143.4*	*65339*
Run 60	8076	*150.5*	*59936*
Run 61	8077	*144.5*	*59936*
Run 62	8078	*124.7*	*57480*
Run 63	8079	*89.7*	*57480*
Run 64	8080	*37.35*	*65339*

Parametric Table: Table 12

	Time	G	q_{load}
Run 65	8081	4.566	70741
Run 66	8082	0	80859
Run 67	8083	0	97067
Run 68	8084	0	89209
Run 69	8085	0	89209
Run 70	8086	0	77912
Run 71	8087	0	75456
Run 72	8088	0	77912
Run 73	8089	0	77912
Run 74	8090	0	77912
Run 75	8091	0	75456
Run 76	8092	0	77912
Run 77	8093	0	75456
Run 78	8094	0	72509
Run 79	8095	1.049	62883
Run 80	8096	10.42	62883
Run 81	8097	29.55	65339
Run 82	8098	49.86	59936
Run 83	8099	58.93	59936
Run 84	8100	64.11	57480
Run 85	8101	83.46	52077
Run 86	8102	87.04	49130
Run 87	8103	61.06	43728
Run 88	8104	23.54	49130
Run 89	8105	2.824	57480
Run 90	8106	0	67107
Run 91	8107	0	77912
Run 92	8108	0	83806
Run 93	8109	0	86262
Run 94	8110	0	89209
Run 95	8111	0	94611
Run 96	8112	0	91664
Run 97	8113	0	102470
Run 98	8114	0	105417
Run 99	8115	0	91664
Run 100	8116	0	91664
Run 101	8117	0	91664
Run 102	8118	0	77912
Run 103	8119	1.394	62883
Run 104	8120	10.48	57480
Run 105	8121	23.2	57480
Run 106	8122	50.86	46184
Run 107	8123	68.16	29975
Run 108	8124	48.99	24573
Run 109	8125	35.25	21626
Run 110	8126	31.8	21626
Run 111	8127	25.73	21626
Run 112	8128	11.43	29975
Run 113	8129	1.832	24573
Run 114	8130	0	40093
Run 115	8131	0	37146
Run 116	8132	0	45496
Run 117	8133	0	42549

Parametric Table: Table 12

	Time	G	q_{load}
Run 118	8134	0	31744
Run 119	8135	0	42549
Run 120	8136	0	37146
Run 121	8137	0	42549
Run 122	8138	0	40093
Run 123	8139	0	37146
Run 124	8140	0	45496
Run 125	8141	0	40093
Run 126	8142	0	37146
Run 127	8143	1.252	21626
Run 128	8144	12.39	21626
Run 129	8145	46.62	16223
Run 130	8146	82.28	5418
Run 131	8147	101.5	2962
Run 132	8148	90.41	14.99
Run 133	8149	81.07	0
Run 134	8150	74.06	0
Run 135	8151	48.7	0
Run 136	8152	21.75	5418
Run 137	8153	2.694	10820
Run 138	8154	0	20938
Run 139	8155	0	34691
Run 140	8156	0	37146
Run 141	8157	0	45496
Run 142	8158	0	47952
Run 143	8159	0	56301
Run 144	8160	0	64651
Run 145	8161	0	64651
Run 146	8162	0	61704
Run 147	8163	0	72509
Run 148	8164	0	64651
Run 149	8165	0	61704
Run 150	8166	0	67107
Run 151	8167	1.22	57480
Run 152	8168	9.492	62883
Run 153	8169	31.71	62883
Run 154	8170	82.21	54533
Run 155	8171	129	46184
Run 156	8172	115.2	38325
Run 157	8173	97.24	24573
Run 158	8174	106.5	24573
Run 159	8175	82.77	32922
Run 160	8176	27.49	24573
Run 161	8177	1.732	40781
Run 162	8178	0	59248
Run 163	8179	0	42549
Run 164	8180	0	50899
Run 165	8181	0	50899
Run 166	8182	0	56301
Run 167	8183	0	64651
Run 168	8184	0	64651
Run 169	8185	0	64651
Run 170	8186	0	67107

Parametric Table: Table 12

	Time	G	q_{load}
Run 171	8187	*0*	*64651*
Run 172	8188	*0*	*77912*
Run 173	8189	*0*	*77912*
Run 174	8190	*0*	*80859*
Run 175	8191	*1.278*	*77912*
Run 176	8192	*8.291*	*80859*
Run 177	8193	*19.33*	*75456*
Run 178	8194	*29.2*	*72509*
Run 179	8195	*41.79*	*67107*
Run 180	8196	*88.35*	*53354*
Run 181	8197	*93.96*	*47952*
Run 182	8198	*47.43*	*47952*
Run 183	8199	*30.34*	*45496*
Run 184	8200	*14.63*	*50899*
Run 185	8201	*1.653*	*56301*
Run 186	8202	*0*	*61704*
Run 187	8203	*0*	*72509*
Run 188	8204	*0*	*75456*
Run 189	8205	*0*	*77912*
Run 190	8206	*0*	*77912*
Run 191	8207	*0*	*80859*
Run 192	8208	*0*	*80859*
Run 193	8209	*0*	*91664*
Run 194	8210	*0*	*91664*
Run 195	8211	*0*	*97067*
Run 196	8212	*0*	*97067*
Run 197	8213	*0*	*94611*
Run 198	8214	*0*	*100014*
Run 199	8215	*1.05*	*100014*
Run 200	8216	*15.8*	*102470*
Run 201	8217	*43.89*	*94611*
Run 202	8218	*73.07*	*91664*
Run 203	8219	*78.3*	*80859*
Run 204	8220	*78.83*	*64651*
Run 205	8221	*91.72*	*67107*
Run 206	8222	*67.37*	*56301*
Run 207	8223	*33.7*	*56301*
Run 208	8224	*10.72*	*59248*
Run 209	8225	*1.427*	*56301*
Run 210	8226	*0*	*61704*
Run 211	8227	*0*	*59248*
Run 212	8228	*0*	*59248*
Run 213	8229	*0*	*70054*
Run 214	8230	*0*	*59248*
Run 215	8231	*0*	*31744*
Run 216	8232	*0*	*37146*
Run 217	8233	*0*	*37146*
Run 218	8234	*0*	*31744*
Run 219	8235	*0*	*37146*
Run 220	8236	*0*	*37146*
Run 221	8237	*0*	*37146*
Run 222	8238	*0*	*20938*
Run 223	8239	*0.6768*	*19170*

Parametric Table: Table 12

	Time	G	q_{load}
Run 224	8240	20.01	21626
Run 225	8241	65.08	16223
Run 226	8242	101.7	5418
Run 227	8243	124.6	0
Run 228	8244	133.7	0
Run 229	8245	128.7	0
Run 230	8246	109.2	0
Run 231	8247	71.85	0
Run 232	8248	24.85	8365
Run 233	8249	2.205	29975
Run 234	8250	0	56301
Run 235	8251	0	61704
Run 236	8252	0	64651
Run 237	8253	0	64651
Run 238	8254	0	61704
Run 239	8255	0	61704
Run 240	8256	0	59248
Run 241	8257	0	64651
Run 242	8258	0	64651
Run 243	8259	0	64651
Run 244	8260	0	67107
Run 245	8261	0	70054
Run 246	8262	0	77912
Run 247	8263	1.268	73688
Run 248	8264	14	76635
Run 249	8265	37.11	79091
Run 250	8266	69.72	68285
Run 251	8267	101.1	68285
Run 252	8268	125.2	57480
Run 253	8269	133.2	46184
Run 254	8270	108.7	54533
Run 255	8271	82.93	54533
Run 256	8272	39.23	62883
Run 257	8273	5.033	68285
Run 258	8274	0	86262
Run 259	8275	0	86262
Run 260	8276	0	86262
Run 261	8277	0	91664
Run 262	8278	0	94611
Run 263	8279	0	100014
Run 264	8280	0	108364
Run 265	8281	0	110819
Run 266	8282	0	113766
Run 267	8283	0	116222
Run 268	8284	0	121625
Run 269	8285	0	119169
Run 270	8286	0	124572
Run 271	8287	0.8948	117401
Run 272	8288	15.55	117401
Run 273	8289	60.98	109051
Run 274	8290	109.3	106596
Run 275	8291	133.5	95299
Run 276	8292	141.6	82038

Parametric Table: Table 12

	Time	G	q_{load}
Run 277	8293	135.3	76635
Run 278	8294	112.1	65339
Run 279	8295	66.13	68285
Run 280	8296	20.86	76635
Run 281	8297	2.713	82038
Run 282	8298	0	97067
Run 283	8299	0	105417
Run 284	8300	0	108364
Run 285	8301	0	108364
Run 286	8302	0	110819
Run 287	8303	0	108364
Run 288	8304	0	110819
Run 289	8305	0	110819
Run 290	8306	0	113766
Run 291	8307	0	110819
Run 292	8308	0	113766
Run 293	8309	0	113766
Run 294	8310	0	113766
Run 295	8311	0.229	106596
Run 296	8312	9.19	111998
Run 297	8313	24.45	109051
Run 298	8314	51.23	106596
Run 299	8315	105.7	101193
Run 300	8316	133.3	98246
Run 301	8317	110.1	92843
Run 302	8318	65.68	95299
Run 303	8319	30.65	92843
Run 304	8320	11.76	95299
Run 305	8321	1.964	98246
Run 306	8322	0	105417
Run 307	8323	0	113766
Run 308	8324	0	113766
Run 309	8325	0	116222
Run 310	8326	0	116222
Run 311	8327	0	116222
Run 312	8328	0	116222
Run 313	8329	0	119169
Run 314	8330	0	119169
Run 315	8331	0	119169
Run 316	8332	0	116222
Run 317	8333	0	113766
Run 318	8334	0	113766
Run 319	8335	0.1534	113766
Run 320	8336	16.88	102470
Run 321	8337	44.41	83806
Run 322	8338	39.94	77912
Run 323	8339	77.14	72509
Run 324	8340	129.5	61704
Run 325	8341	125.9	37146
Run 326	8342	108.4	40093
Run 327	8343	78.49	45496
Run 328	8344	31.08	53354
Run 329	8345	2.981	61704

Parametric Table: Table 12

	Time	G	q_{load}
Run 330	8346	0	72509
Run 331	8347	0	72509
Run 332	8348	0	72509
Run 333	8349	0	72509
Run 334	8350	0	80859
Run 335	8351	0	94611
Run 336	8352	0	105417
Run 337	8353	0	119169
Run 338	8354	0	121625
Run 339	8355	0	121625
Run 340	8356	0	124572
Run 341	8357	0	129975
Run 342	8358	0	129975
Run 343	8359	0.2314	122804
Run 344	8360	3.835	119857
Run 345	8361	15	117401
Run 346	8362	31.65	117401
Run 347	8363	45.58	114454
Run 348	8364	50.76	111998
Run 349	8365	44.22	106596
Run 350	8366	33.01	106596
Run 351	8367	21.13	103649
Run 352	8368	8.235	98246
Run 353	8369	1.165	98246
Run 354	8370	0	105417
Run 355	8371	0	102470
Run 356	8372	0	105417
Run 357	8373	0	113766
Run 358	8374	0	116222
Run 359	8375	0	116222
Run 360	8376	0	113766
Run 361	8377	0	113766
Run 362	8378	0	116222
Run 363	8379	0	116222
Run 364	8380	0	119169
Run 365	8381	0	119169
Run 366	8382	0	116222
Run 367	8383	0.3434	116222
Run 368	8384	5.588	119169
Run 369	8385	20.76	119169
Run 370	8386	37.74	116222
Run 371	8387	63.34	116222
Run 372	8388	80.75	110819
Run 373	8389	78.88	105417
Run 374	8390	69.76	105417
Run 375	8391	45.84	108364
Run 376	8392	18.44	108364
Run 377	8393	2.784	105417
Run 378	8394	0	105417
Run 379	8395	0	108364
Run 380	8396	0	113766
Run 381	8397	0	113766
Run 382	8398	0	113766

Parametric Table: Table 12

	Time	G	q_{load}
Run 383	8399	0	119169
Run 384	8400	0	124572
Run 385	8401	0	129975
Run 386	8402	0	140780
Run 387	8403	0	146183
Run 388	8404	0	127028
Run 389	8405	0	129975
Run 390	8406	0	129975
Run 391	8407	0.7197	117401
Run 392	8408	22.77	119857
Run 393	8409	75.94	117401
Run 394	8410	119.3	114454
Run 395	8411	144.8	109051
Run 396	8412	154.3	103649
Run 397	8413	147.9	95299
Run 398	8414	127.3	92843
Run 399	8415	90.57	89896
Run 400	8416	36.97	89896
Run 401	8417	4.509	95299
Run 402	8418	0	108364
Run 403	8419	0	110819
Run 404	8420	0	110819
Run 405	8421	0	113766
Run 406	8422	0	113766
Run 407	8423	0	116222
Run 408	8424	0	116222
Run 409	8425	0	119169
Run 410	8426	0	121625
Run 411	8427	0	116222
Run 412	8428	0	113766
Run 413	8429	0	116222
Run 414	8430	0	110819
Run 415	8431	0.6518	103649
Run 416	8432	18.79	103649
Run 417	8433	64.32	98246
Run 418	8434	92.7	89896
Run 419	8435	117.2	87440
Run 420	8436	128.1	82038
Run 421	8437	91.4	79091
Run 422	8438	60.12	79091
Run 423	8439	43.14	79091
Run 424	8440	17.24	79091
Run 425	8441	2.064	84494
Run 426	8442	0	94611
Run 427	8443	0	97067
Run 428	8444	0	102470
Run 429	8445	0	108364
Run 430	8446	0	100014
Run 431	8447	0	100014
Run 432	8448	0	94611
Run 433	8449	0	91664
Run 434	8450	0	83806
Run 435	8451	0	86262

Parametric Table: Table 12

	Time	G	q_{load}
Run 436	8452	*0*	*89209*
Run 437	8453	*0*	*86262*
Run 438	8454	*0*	*91664*
Run 439	8455	*0.3565*	*79091*
Run 440	8456	*5.956*	*82038*
Run 441	8457	*18.37*	*76635*
Run 442	8458	*39.8*	*68285*
Run 443	8459	*52.14*	*57480*
Run 444	8460	*52.2*	*49130*
Run 445	8461	*53.48*	*40781*
Run 446	8462	*44.64*	*35378*
Run 447	8463	*38.98*	*40781*
Run 448	8464	*20.51*	*38325*
Run 449	8465	*2.854*	*38325*
Run 450	8466	*0*	*45496*
Run 451	8467	*0*	*47952*
Run 452	8468	*0*	*42549*
Run 453	8469	*0*	*45496*
Run 454	8470	*0*	*50899*
Run 455	8471	*0*	*45496*
Run 456	8472	*0*	*45496*
Run 457	8473	*0*	*45496*
Run 458	8474	*0*	*45496*
Run 459	8475	*0*	*45496*
Run 460	8476	*0*	*42549*
Run 461	8477	*0*	*50899*
Run 462	8478	*0*	*56301*
Run 463	8479	*0.2194*	*61704*
Run 464	8480	*6.25*	*61704*
Run 465	8481	*35.28*	*67107*
Run 466	8482	*87.69*	*64651*
Run 467	8483	*113.2*	*45496*
Run 468	8484	*100.6*	*53354*
Run 469	8485	*69.47*	*47952*
Run 470	8486	*47.89*	*42549*
Run 471	8487	*26.61*	*50899*
Run 472	8488	*7.076*	*50899*
Run 473	8489	*2.099*	*50899*
Run 474	8490	*0*	*64651*
Run 475	8491	*0*	*59248*
Run 476	8492	*0*	*64651*
Run 477	8493	*0*	*70054*
Run 478	8494	*0*	*75456*
Run 479	8495	*0*	*75456*
Run 480	8496	*0*	*72509*
Run 481	8497	*0*	*75456*
Run 482	8498	*0*	*77912*
Run 483	8499	*0*	*75456*
Run 484	8500	*0*	*77912*
Run 485	8501	*0*	*77912*
Run 486	8502	*0*	*75456*
Run 487	8503	*0.3908*	*76635*
Run 488	8504	*11.24*	*82038*

Parametric Table: Table 12

	Time	G	q_{load}
Run 489	8505	58.82	68285
Run 490	8506	113.5	57480
Run 491	8507	137.3	54533
Run 492	8508	137	52077
Run 493	8509	126.4	52077
Run 494	8510	119.4	59936
Run 495	8511	84.72	59936
Run 496	8512	33.05	65339
Run 497	8513	4.785	73688
Run 498	8514	0	94611
Run 499	8515	0	89209
Run 500	8516	0	91664
Run 501	8517	0	94611
Run 502	8518	0	94611
Run 503	8519	0	94611
Run 504	8520	0	97067
Run 505	8521	0	97067
Run 506	8522	0	97067
Run 507	8523	0	94611
Run 508	8524	0	94611
Run 509	8525	0	91664
Run 510	8526	0	100014
Run 511	8527	0.2246	87440
Run 512	8528	3.598	84494
Run 513	8529	14.56	92843
Run 514	8530	33.74	92843
Run 515	8531	44.6	89896
Run 516	8532	85.55	84494
Run 517	8533	118.2	79091
Run 518	8534	74.51	82038
Run 519	8535	59.57	87440
Run 520	8536	39.04	92843
Run 521	8537	4.922	101193
Run 522	8538	0	110819
Run 523	8539	0	108364
Run 524	8540	0	110819
Run 525	8541	0	108364
Run 526	8542	0	108364
Run 527	8543	0	105417
Run 528	8544	0	105417
Run 529	8545	0	110819
Run 530	8546	0	113766
Run 531	8547	0	108364
Run 532	8548	0	110819
Run 533	8549	0	110819
Run 534	8550	0	113766
Run 535	8551	0.174	119169
Run 536	8552	16.84	116222
Run 537	8553	63.9	116222
Run 538	8554	103.2	108364
Run 539	8555	122.5	108364
Run 540	8556	119.7	97067
Run 541	8557	97.99	89209

Parametric Table: Table 12

	Time	G	q_{load}
Run 542	8558	65.07	89209
Run 543	8559	28.66	89209
Run 544	8560	7.953	89209
Run 545	8561	1.622	91664
Run 546	8562	0	91664
Run 547	8563	0	94611
Run 548	8564	0	97067
Run 549	8565	0	100014
Run 550	8566	0	97067
Run 551	8567	0	102470
Run 552	8568	0	105417
Run 553	8569	0	105417
Run 554	8570	0	105417
Run 555	8571	0	105417
Run 556	8572	0	105417
Run 557	8573	0	105417
Run 558	8574	0	105417
Run 559	8575	0.2461	95299
Run 560	8576	10.95	95299
Run 561	8577	50.86	92843
Run 562	8578	88.78	84494
Run 563	8579	98.94	79091
Run 564	8580	100.2	70741
Run 565	8581	81.8	68285
Run 566	8582	53.03	65339
Run 567	8583	28.27	65339
Run 568	8584	8.569	70741
Run 569	8585	0.8862	73688
Run 570	8586	0	80859
Run 571	8587	0	80859
Run 572	8588	0	80859
Run 573	8589	0	80859
Run 574	8590	0	83806
Run 575	8591	0	83806
Run 576	8592	0	86262
Run 577	8593	0	83806
Run 578	8594	0	83806
Run 579	8595	0	83806
Run 580	8596	0	86262
Run 581	8597	0	89209
Run 582	8598	0	83806
Run 583	8599	0.2228	79091
Run 584	8600	5.512	79091
Run 585	8601	24.52	82038
Run 586	8602	49.89	73688
Run 587	8603	95.27	73688
Run 588	8604	115.3	62883
Run 589	8605	90.01	52077
Run 590	8606	60.82	49130
Run 591	8607	34.78	59936
Run 592	8608	14.69	65339
Run 593	8609	2	73688
Run 594	8610	0	75456

Parametric Table: Table 12

	Time	G	q_{load}
Run 595	8611	*0*	*80859*
Run 596	8612	*0*	*83806*
Run 597	8613	*0*	*80859*
Run 598	8614	*0*	*89209*
Run 599	8615	*0*	*89209*
Run 600	8616	*0*	*89209*
Run 601	8617	*0*	*97067*
Run 602	8618	*0*	*94611*
Run 603	8619	*0*	*102470*
Run 604	8620	*0*	*100014*
Run 605	8621	*0*	*94611*
Run 606	8622	*0*	*94611*
Run 607	8623	*0*	*94611*
Run 608	8624	*15.67*	*97067*
Run 609	8625	*60.62*	*100014*
Run 610	8626	*102.8*	*94611*
Run 611	8627	*125.8*	*77912*
Run 612	8628	*129.3*	*75456*
Run 613	8629	*95.87*	*75456*
Run 614	8630	*67.42*	*72509*
Run 615	8631	*39.19*	*75456*
Run 616	8632	*8.915*	*77912*
Run 617	8633	*1.904*	*86262*
Run 618	8634	*0*	*89209*
Run 619	8635	*0*	*86262*
Run 620	8636	*0*	*97067*
Run 621	8637	*0*	*100014*
Run 622	8638	*0*	*110819*
Run 623	8639	*0*	*94611*
Run 624	8640	*0*	*105417*
Run 625	8641	*0*	*105417*
Run 626	8642	*0*	*110819*
Run 627	8643	*0*	*110819*
Run 628	8644	*0*	*116222*
Run 629	8645	*0*	*116222*
Run 630	8646	*0*	*116222*
Run 631	8647	*0*	*109051*
Run 632	8648	*7.509*	*114454*
Run 633	8649	*45.56*	*106596*
Run 634	8650	*92.05*	*98246*
Run 635	8651	*116.9*	*95299*
Run 636	8652	*124.1*	*84494*
Run 637	8653	*113.1*	*79091*
Run 638	8654	*86.67*	*76635*
Run 639	8655	*40.49*	*76635*
Run 640	8656	*9.787*	*79091*
Run 641	8657	*1.683*	*89896*
Run 642	8658	*0*	*102470*
Run 643	8659	*0*	*97067*
Run 644	8660	*0*	*102470*
Run 645	8661	*0*	*116222*
Run 646	8662	*0*	*124572*
Run 647	8663	*0*	*135377*

Parametric Table: Table 12

	Time	G	q_{load}
Run 648	8664	0	140780
Run 649	8665	0	146183
Run 650	8666	0	146183
Run 651	8667	0	154532
Run 652	8668	0	159935
Run 653	8669	0	157479
Run 654	8670	0	162882
Run 655	8671	0	152764
Run 656	8672	5.881	155711
Run 657	8673	19.02	155711
Run 658	8674	41.98	152764
Run 659	8675	54.87	150308
Run 660	8676	52.4	147361
Run 661	8677	55.16	144414
Run 662	8678	47.59	144414
Run 663	8679	29.4	141959
Run 664	8680	12.21	139012
Run 665	8681	2.088	141959
Run 666	8682	0	149130
Run 667	8683	0	151585
Run 668	8684	0	149130
Run 669	8685	0	154532
Run 670	8686	0	162882
Run 671	8687	0	162882
Run 672	8688	0	168285
Run 673	8689	0	168285
Run 674	8690	0	168285
Run 675	8691	0	168285
Run 676	8692	0	168285
Run 677	8693	0	170740
Run 678	8694	0	179090
Run 679	8695	0	166516
Run 680	8696	15.72	171919
Run 681	8697	60.29	168972
Run 682	8698	105.9	158167
Run 683	8699	137.7	158167
Run 684	8700	140.3	155711
Run 685	8701	117.4	139012
Run 686	8702	72.69	147361
Run 687	8703	31.49	147361
Run 688	8704	13.04	150308
Run 689	8705	2.841	152764
Run 690	8706	0	159935
Run 691	8707	0	157479
Run 692	8708	0	157479
Run 693	8709	0	154532
Run 694	8710	0	154532
Run 695	8711	0	151585
Run 696	8712	0	143727
Run 697	8713	0	149130
Run 698	8714	0	146183
Run 699	8715	0	146183
Run 700	8716	0	143727

Parametric Table: Table 12

	Time	G	q_{load}
Run 701	8717	0	140780
Run 702	8718	0	140780
Run 703	8719	0	140780
Run 704	8720	4.347	135377
Run 705	8721	17.24	138324
Run 706	8722	32.86	127028
Run 707	8723	44.96	121625
Run 708	8724	53.84	116222
Run 709	8725	53.47	110819
Run 710	8726	48.71	110819
Run 711	8727	37.46	113766
Run 712	8728	14.72	119169
Run 713	8729	1.729	127028
Run 714	8730	0	129975
Run 715	8731	0	132921
Run 716	8732	0	135377
Run 717	8733	0	143727
Run 718	8734	0	146183
Run 719	8735	0	151585
Run 720	8736	0	146183
Run 721	8737	0	143727
Run 722	8738	0	140780
Run 723	8739	0	143727
Run 724	8740	0	135377
Run 725	8741	0	132921
Run 726	8742	0	129975
Run 727	8743	0	119857
Run 728	8744	9.261	119857
Run 729	8745	51.57	114454
Run 730	8746	106.8	114454
Run 731	8747	132.1	98246
Run 732	8748	121	95299
Run 733	8749	96.38	92843
Run 734	8750	74.4	84494
Run 735	8751	41	133609
Run 736	8752	12.22	144414
Run 737	8753	1.703	150308
Run 738	8754	0	162882
Run 739	8755	0	168285
Run 740	8756	0	170740
Run 741	8757	0	170740
Run 742	8758	0	176143
Run 743	8759	0	179090
Run 744	8760	0	179090

Lookup Table: June

	Hour	GHI	DNI	DHI	Temp
Row 1	3625	0	0	0	14.7
Row 2	3626	0	0	0	14.6
Row 3	3627	0	0	0	14.5
Row 4	3628	0	0	0	14.4

Lookup Table: June

	Hour	GHI	DNI	DHI	Temp
Row 5	3629	0	0	0	13.9
Row 6	3630	15	0	15	15.6
Row 7	3631	44	0	44	13.3
Row 8	3632	109	0	109	16.1
Row 9	3633	122	0	122	16.7
Row 10	3634	333	30	311	16.7
Row 11	3635	391	30	365	18.9
Row 12	3636	734	419	355	20
Row 13	3637	768	451	356	23.3
Row 14	3638	785	508	339	23.9
Row 15	3639	130	0	130	22.2
Row 16	3640	484	252	310	22.8
Row 17	3641	513	496	241	22.2
Row 18	3642	76	0	76	21.7
Row 19	3643	113	55	101	21.1
Row 20	3644	13	24	12	17.8
Row 21	3645	0	0	0	14.4
Row 22	3646	0	0	0	13.9
Row 23	3647	0	0	0	12.2
Row 24	3648	0	0	0	11.7
Row 25	3649	0	0	0	10.6
Row 26	3650	0	0	0	10
Row 27	3651	0	0	0	10
Row 28	3652	0	0	0	10
Row 29	3653	0	0	0	10
Row 30	3654	28	0	28	11.1
Row 31	3655	74	0	74	13.3
Row 32	3656	288	149	215	13.9
Row 33	3657	281	53	248	15
Row 34	3658	139	0	139	15
Row 35	3659	201	0	201	13.9
Row 36	3660	154	0	154	12.2
Row 37	3661	183	0	183	11.7
Row 38	3662	144	0	144	12.2
Row 39	3663	221	6	216	12.8
Row 40	3664	252	18	240	13.9
Row 41	3665	505	521	218	14.4
Row 42	3666	361	679	96	15
Row 43	3667	198	514	84	15
Row 44	3668	24	228	10	13.3
Row 45	3669	0	0	0	12.2
Row 46	3670	0	0	0	12.2
Row 47	3671	0	0	0	12.2
Row 48	3672	0	0	0	10.6
Row 49	3673	0	0	0	10.6
Row 50	3674	0	0	0	10
Row 51	3675	0	0	0	9.4
Row 52	3676	0	0	0	8.3
Row 53	3677	1	79	0	8.9
Row 54	3678	99	418	34	11.1
Row 55	3679	258	456	111	11.7
Row 56	3680	159	11	153	12.8
Row 57	3681	249	18	238	13.9

Lookup Table: June

	Hour	GHI	DNI	DHI	Temp
Row 58	3682	466	148	353	15
Row 59	3683	535	149	407	16.7
Row 60	3684	894	707	254	17.8
Row 61	3685	896	650	301	17.2
Row 62	3686	170	6	164	18.3
Row 63	3687	787	572	327	16.7
Row 64	3688	654	720	156	17.8
Row 65	3689	519	565	207	17.2
Row 66	3690	126	0	126	14.4
Row 67	3691	98	8	97	15.6
Row 68	3692	12	3	12	13.9
Row 69	3693	0	0	0	13.9
Row 70	3694	0	0	0	12.2
Row 71	3695	0	0	0	11.1
Row 72	3696	0	0	0	10.6
Row 73	3697	0	0	0	10
Row 74	3698	0	0	0	10
Row 75	3699	0	0	0	9.4
Row 76	3700	0	0	0	9.4
Row 77	3701	1	77	0	7.8
Row 78	3702	103	457	31	8.3
Row 79	3703	271	682	50	10
Row 80	3704	442	724	88	11.1
Row 81	3705	621	820	98	13.3
Row 82	3706	750	817	126	15.6
Row 83	3707	845	798	162	16.7
Row 84	3708	918	820	174	17.8
Row 85	3709	896	698	256	20
Row 86	3710	929	895	140	20.6
Row 87	3711	833	870	131	21.1
Row 88	3712	702	849	113	22.2
Row 89	3713	548	703	159	21.1
Row 90	3714	259	224	171	20.6
Row 91	3715	122	46	111	20
Row 92	3716	16	21	15	17.8
Row 93	3717	0	0	0	17.8
Row 94	3718	0	0	0	16.1
Row 95	3719	0	0	0	14.4
Row 96	3720	0	0	0	15
Row 97	3721	0	0	0	13.9
Row 98	3722	0	0	0	13.3
Row 99	3723	0	0	0	11.1
Row 100	3724	0	0	0	11.7
Row 101	3725	0	0	0	12.8
Row 102	3726	19	0	19	11.1
Row 103	3727	48	0	48	11.7
Row 104	3728	417	397	223	14.4
Row 105	3729	616	768	126	18.9
Row 106	3730	772	876	103	22.2
Row 107	3731	879	894	115	23.3
Row 108	3732	953	928	111	25.6
Row 109	3733	963	926	113	25.6
Row 110	3734	904	780	216	26.1

Lookup Table: June

	Hour	GHI	DNI	DHI	Temp
Row 111	3735	611	286	380	26.7
Row 112	3736	572	400	294	27.8
Row 113	3737	548	696	161	26.7
Row 114	3738	375	730	86	26.1
Row 115	3739	205	555	79	22.8
Row 116	3740	28	258	11	20
Row 117	3741	0	0	0	20
Row 118	3742	0	0	0	21.1
Row 119	3743	0	0	0	18.9
Row 120	3744	0	0	0	19.4
Row 121	3745	0	0	0	18.3
Row 122	3746	0	0	0	17.2
Row 123	3747	0	0	0	16.1
Row 124	3748	0	0	0	13.9
Row 125	3749	1	78	1	13.9
Row 126	3750	104	449	32	13.9
Row 127	3751	272	677	52	16.1
Row 128	3752	457	782	74	19.4
Row 129	3753	605	768	115	21.7
Row 130	3754	777	852	126	22.2
Row 131	3755	891	816	192	23.3
Row 132	3756	782	515	314	24.4
Row 133	3757	938	788	215	24.4
Row 134	3758	804	562	307	25
Row 135	3759	819	803	170	25.6
Row 136	3760	701	836	118	25.6
Row 137	3761	547	809	97	25
Row 138	3762	382	618	137	23.9
Row 139	3763	144	161	107	21.1
Row 140	3764	20	76	15	19.4
Row 141	3765	0	0	0	17.8
Row 142	3766	0	0	0	16.1
Row 143	3767	0	0	0	14.4
Row 144	3768	0	0	0	13.3
Row 145	3769	0	0	0	12.2
Row 146	3770	0	0	0	11.7
Row 147	3771	0	0	0	11.1
Row 148	3772	0	0	0	10.6
Row 149	3773	1	78	1	10.6
Row 150	3774	104	450	32	11.1
Row 151	3775	268	650	56	12.8
Row 152	3776	447	742	84	14.4
Row 153	3777	621	844	82	16.1
Row 154	3778	766	864	105	16.7
Row 155	3779	885	906	109	18.9
Row 156	3780	953	928	109	20.6
Row 157	3781	981	914	141	21.1
Row 158	3782	885	743	227	22.2
Row 159	3783	682	468	303	22.2
Row 160	3784	605	535	232	22.8
Row 161	3785	547	690	162	22.2
Row 162	3786	299	309	176	21.7
Row 163	3787	202	390	112	21.1

Lookup Table: June

	Hour	GHI	DNI	DHI	Temp
Row 164	3788	29	186	16	19.4
Row 165	3789	0	0	0	17.2
Row 166	3790	0	0	0	17.8
Row 167	3791	0	0	0	17.2
Row 168	3792	0	0	0	15
Row 169	3793	0	0	0	13.9
Row 170	3794	0	0	0	13.3
Row 171	3795	0	0	0	11.7
Row 172	3796	0	0	0	11.7
Row 173	3797	0	0	0	11.7
Row 174	3798	19	0	19	12.8
Row 175	3799	48	0	48	13.9
Row 176	3800	214	40	194	14.4
Row 177	3801	101	0	101	16.1
Row 178	3802	122	0	122	11.1
Row 179	3803	477	101	390	9.4
Row 180	3804	764	437	366	12.8
Row 181	3805	298	30	271	13.9
Row 182	3806	251	0	251	15.6
Row 183	3807	195	6	190	16.1
Row 184	3808	292	25	275	17.2
Row 185	3809	277	31	259	17.8
Row 186	3810	207	52	186	17.2
Row 187	3811	106	8	104	16.7
Row 188	3812	0	0	0	13.9
Row 189	3813	0	0	0	12.8
Row 190	3814	0	0	0	12.2
Row 191	3815	0	0	0	11.7
Row 192	3816	0	0	0	11.1
Row 193	3817	0	0	0	10
Row 194	3818	0	0	0	10
Row 195	3819	0	0	0	8.9
Row 196	3820	0	0	0	8.9
Row 197	3821	0	0	0	8.3
Row 198	3822	16	0	16	8.9
Row 199	3823	44	0	44	8.9
Row 200	3824	104	0	104	9.4
Row 201	3825	133	0	133	9.4
Row 202	3826	189	0	189	8.9
Row 203	3827	241	0	241	8.9
Row 204	3828	284	6	279	10
Row 205	3829	207	0	207	10
Row 206	3830	207	0	207	11.1
Row 207	3831	169	0	169	11.1
Row 208	3832	116	0	116	11.1
Row 209	3833	131	0	131	10.6
Row 210	3834	116	0	116	10
Row 211	3835	117	53	105	9.4
Row 212	3836	0	0	0	9.4
Row 213	3837	0	0	0	9.4
Row 214	3838	0	0	0	9.4
Row 215	3839	0	0	0	8.9
Row 216	3840	0	0	0	9.4

Lookup Table: June

	Hour	GHI	DNI	DHI	Temp
Row 217	3841	0	0	0	8.3
Row 218	3842	0	0	0	7.2
Row 219	3843	0	0	0	7.2
Row 220	3844	0	0	0	6.7
Row 221	3845	1	39	1	6.1
Row 222	3846	89	240	50	7.2
Row 223	3847	229	375	106	7.8
Row 224	3848	437	621	132	9.4
Row 225	3849	520	440	239	11.1
Row 226	3850	722	645	228	11.7
Row 227	3851	741	489	322	13.3
Row 228	3852	622	263	382	14.4
Row 229	3853	920	710	266	15
Row 230	3854	621	254	396	14.4
Row 231	3855	422	85	353	13.9
Row 232	3856	197	6	193	13.3
Row 233	3857	284	44	259	11.7
Row 234	3858	231	125	181	11.7
Row 235	3859	58	0	58	10.6
Row 236	3860	0	0	0	8.9
Row 237	3861	0	0	0	8.3
Row 238	3862	0	0	0	8.3
Row 239	3863	0	0	0	7.8
Row 240	3864	0	0	0	6.7
Row 241	3865	0	0	0	7.2
Row 242	3866	0	0	0	7.2
Row 243	3867	0	0	0	7.2
Row 244	3868	0	0	0	6.7
Row 245	3869	1	40	1	6.7
Row 246	3870	76	96	61	8.3
Row 247	3871	202	171	146	9.4
Row 248	3872	398	460	172	12.2
Row 249	3873	584	645	171	13.9
Row 250	3874	744	776	150	15
Row 251	3875	822	649	264	16.1
Row 252	3876	728	383	379	16.1
Row 253	3877	670	295	398	16.7
Row 254	3878	878	719	240	16.7
Row 255	3879	799	797	151	16.1
Row 256	3880	679	701	187	17.2
Row 257	3881	451	370	243	15.6
Row 258	3882	371	635	114	15.6
Row 259	3883	209	545	79	13.3
Row 260	3884	0	0	0	11.7
Row 261	3885	0	0	0	11.1
Row 262	3886	0	0	0	11.1
Row 263	3887	0	0	0	10.6
Row 264	3888	0	0	0	10
Row 265	3889	0	0	0	10
Row 266	3890	0	0	0	9.4
Row 267	3891	0	0	0	8.9
Row 268	3892	0	0	0	8.3
Row 269	3893	2	100	1	8.3

Lookup Table: June

	Hour	GHI	DNI	DHI	Temp
Row 270	3894	108	476	31	11.1
Row 271	3895	273	672	53	11.1
Row 272	3896	447	759	74	13.3
Row 273	3897	621	774	126	17.2
Row 274	3898	705	551	283	17.8
Row 275	3899	195	6	190	19.4
Row 276	3900	213	6	208	18.9
Row 277	3901	542	126	425	18.3
Row 278	3902	533	121	426	20
Row 279	3903	519	164	386	20.6
Row 280	3904	190	6	186	20.6
Row 281	3905	269	31	251	20
Row 282	3906	189	26	179	18.9
Row 283	3907	161	181	118	17.2
Row 284	3908	0	0	0	15
Row 285	3909	0	0	0	13.3
Row 286	3910	0	0	0	12.2
Row 287	3911	0	0	0	11.1
Row 288	3912	0	0	0	12.2
Row 289	3913	0	0	0	8.3
Row 290	3914	0	0	0	7.2
Row 291	3915	0	0	0	8.9
Row 292	3916	0	0	0	8.3
Row 293	3917	2	74	1	8.3
Row 294	3918	105	442	34	8.3
Row 295	3919	268	645	57	10
Row 296	3920	452	765	77	12.2
Row 297	3921	632	844	91	15
Row 298	3922	777	888	97	17.8
Row 299	3923	885	906	107	18.3
Row 300	3924	971	910	141	19.4
Row 301	3925	956	872	152	20
Row 302	3926	928	919	112	20
Row 303	3927	844	906	106	21.1
Row 304	3928	719	873	105	21.7
Row 305	3929	559	820	95	21.1
Row 306	3930	386	739	86	21.1
Row 307	3931	218	587	77	20
Row 308	3932	0	0	0	18.3
Row 309	3933	0	0	0	16.7
Row 310	3934	0	0	0	17.2
Row 311	3935	0	0	0	14.4
Row 312	3936	0	0	0	14.4
Row 313	3937	0	0	0	13.9
Row 314	3938	0	0	0	12.2
Row 315	3939	0	0	0	10.6
Row 316	3940	0	0	0	9.4
Row 317	3941	2	74	1	9.4
Row 318	3942	105	442	34	10
Row 319	3943	268	645	57	11.1
Row 320	3944	452	776	71	14.4
Row 321	3945	611	803	96	16.7
Row 322	3946	772	841	128	19.4

Lookup Table: June

	Hour	GHI	DNI	DHI	Temp
Row 323	3947	896	929	98	21.7
Row 324	3948	970	952	102	22.2
Row 325	3949	980	950	104	23.9
Row 326	3950	934	931	107	23.9
Row 327	3951	844	906	105	25
Row 328	3952	719	836	130	25
Row 329	3953	537	733	122	24.4
Row 330	3954	369	621	116	23.9
Row 331	3955	217	541	86	22.8
Row 332	3956	0	0	0	20.6
Row 333	3957	0	0	0	19.4
Row 334	3958	0	0	0	16.7
Row 335	3959	0	0	0	15.6
Row 336	3960	0	0	0	16.7
Row 337	3961	0	0	0	14.4
Row 338	3962	0	0	0	12.2
Row 339	3963	0	0	0	11.7
Row 340	3964	0	0	0	11.7
Row 341	3965	2	100	1	11.7
Row 342	3966	108	476	31	13.3
Row 343	3967	277	700	48	12.2
Row 344	3968	447	742	83	15
Row 345	3969	621	844	81	18.3
Row 346	3970	761	847	112	21.1
Row 347	3971	890	882	133	22.8
Row 348	3972	970	952	102	24.4
Row 349	3973	980	950	103	25.6
Row 350	3974	940	779	247	25.6
Row 351	3975	461	97	381	25
Row 352	3976	231	6	226	24.4
Row 353	3977	145	0	145	24.4
Row 354	3978	90	0	90	24.4
Row 355	3979	216	323	138	23.9
Row 356	3980	0	0	0	21.1
Row 357	3981	0	0	0	20.6
Row 358	3982	0	0	0	18.3
Row 359	3983	0	0	0	16.7
Row 360	3984	0	0	0	17.2
Row 361	3985	0	0	0	15
Row 362	3986	0	0	0	13.9
Row 363	3987	0	0	0	12.2
Row 364	3988	0	0	0	11.7
Row 365	3989	2	74	1	11.7
Row 366	3990	102	404	37	12.2
Row 367	3991	259	584	68	15
Row 368	3992	447	742	83	20
Row 369	3993	627	826	97	23.3
Row 370	3994	783	900	94	25.6
Row 371	3995	896	929	98	27.2
Row 372	3996	947	910	117	29.4
Row 373	3997	980	950	103	30.6
Row 374	3998	940	937	106	31.1
Row 375	3999	837	821	166	32.2

Lookup Table: June

	Hour	GHI	DNI	DHI	Temp
Row 376	4000	624	541	242	31.7
Row 377	4001	377	200	263	30.6
Row 378	4002	123	0	123	28.9
Row 379	4003	215	322	137	26.7
Row 380	4004	0	0	0	25
Row 381	4005	0	0	0	24.4
Row 382	4006	0	0	0	23.3
Row 383	4007	0	0	0	20.6
Row 384	4008	0	0	0	19.4
Row 385	4009	0	0	0	18.9
Row 386	4010	0	0	0	17.8
Row 387	4011	0	0	0	16.1
Row 388	4012	0	0	0	15.6
Row 389	4013	2	74	1	15.6
Row 390	4014	102	404	37	16.1
Row 391	4015	255	562	71	18.3
Row 392	4016	402	535	140	18.9
Row 393	4017	589	645	177	21.1
Row 394	4018	633	456	284	23.9
Row 395	4019	879	798	193	25
Row 396	4020	947	910	116	25.6
Row 397	4021	961	914	118	27.8
Row 398	4022	921	755	249	27.8
Row 399	4023	298	43	264	27.8
Row 400	4024	115	0	115	26.1
Row 401	4025	101	0	101	21.1
Row 402	4026	65	0	65	21.7
Row 403	4027	68	0	68	21.1
Row 404	4028	0	0	0	20
Row 405	4029	0	0	0	18.9
Row 406	4030	0	0	0	18.3
Row 407	4031	0	0	0	16.7
Row 408	4032	0	0	0	15.6
Row 409	4033	0	0	0	15
Row 410	4034	0	0	0	15.6
Row 411	4035	0	0	0	15
Row 412	4036	0	0	0	15
Row 413	4037	1	0	1	14.4
Row 414	4038	44	0	44	14.4
Row 415	4039	110	6	108	13.9
Row 416	4040	214	29	200	15
Row 417	4041	462	258	297	16.1
Row 418	4042	683	568	248	17.8
Row 419	4043	804	614	277	18.9
Row 420	4044	964	850	189	18.9
Row 421	4045	876	571	349	21.1
Row 422	4046	150	0	150	21.1
Row 423	4047	642	334	368	21.1
Row 424	4048	481	190	346	22.2
Row 425	4049	340	131	265	22.8
Row 426	4050	90	0	90	14.4
Row 427	4051	79	0	79	12.8
Row 428	4052	0	0	0	12.8

Lookup Table: June

	Hour	GHI	DNI	DHI	Temp
Row 429	4053	0	0	0	11.7
Row 430	4054	0	0	0	9.4
Row 431	4055	0	0	0	9.4
Row 432	4056	0	0	0	9.4
Row 433	4057	0	0	0	9.4
Row 434	4058	0	0	0	10
Row 435	4059	0	0	0	10
Row 436	4060	0	0	0	9.4
Row 437	4061	2	76	1	8.9
Row 438	4062	105	447	33	10
Row 439	4063	268	650	56	12.2
Row 440	4064	452	782	69	14.4
Row 441	4065	616	826	87	16.1
Row 442	4066	771	876	101	17.2
Row 443	4067	884	906	107	17.8
Row 444	4068	970	832	211	17.8
Row 445	4069	602	259	363	20
Row 446	4070	940	779	245	20
Row 447	4071	836	888	110	20
Row 448	4072	725	872	107	20.6
Row 449	4073	557	801	101	20.6
Row 450	4074	392	738	88	20.6
Row 451	4075	213	537	81	19.4
Row 452	4076	0	0	0	17.8
Row 453	4077	0	0	0	16.1
Row 454	4078	0	0	0	16.7
Row 455	4079	0	0	0	15
Row 456	4080	0	0	0	13.9
Row 457	4081	0	0	0	12.2
Row 458	4082	0	0	0	12.2
Row 459	4083	0	0	0	9.4
Row 460	4084	0	0	0	9.4
Row 461	4085	1	71	1	9.4
Row 462	4086	101	408	36	10
Row 463	4087	263	628	59	11.1
Row 464	4088	452	770	75	13.9
Row 465	4089	584	686	146	16.7
Row 466	4090	738	758	158	18.3
Row 467	4091	827	715	213	21.1
Row 468	4092	940	838	176	22.2
Row 469	4093	900	697	256	24.4
Row 470	4094	915	822	182	25
Row 471	4095	797	760	175	26.1
Row 472	4096	725	798	159	26.7
Row 473	4097	543	644	175	25.6
Row 474	4098	253	170	183	26.1
Row 475	4099	224	365	134	25
Row 476	4100	0	0	0	21.7
Row 477	4101	0	0	0	19.4
Row 478	4102	0	0	0	17.8
Row 479	4103	0	0	0	16.7
Row 480	4104	0	0	0	16.1
Row 481	4105	0	0	0	15.6

Lookup Table: June

	Hour	GHI	DNI	DHI	Temp
Row 482	4106	0	0	0	15.6
Row 483	4107	0	0	0	13.3
Row 484	4108	0	0	0	14.4
Row 485	4109	1	0	1	12.2
Row 486	4110	47	5	47	13.3
Row 487	4111	118	11	115	14.4
Row 488	4112	352	299	206	16.7
Row 489	4113	361	111	290	18.9
Row 490	4114	682	545	266	20.6
Row 491	4115	545	179	392	23.3
Row 492	4116	284	30	257	25
Row 493	4117	772	433	373	24.4
Row 494	4118	864	665	272	25
Row 495	4119	745	602	253	27.2
Row 496	4120	549	307	331	27.2
Row 497	4121	195	6	192	27.8
Row 498	4122	261	170	191	27.2
Row 499	4123	145	97	121	26.1
Row 500	4124	0	0	0	26.1
Row 501	4125	0	0	0	23.3
Row 502	4126	0	0	0	23.3
Row 503	4127	0	0	0	20.6
Row 504	4128	0	0	0	20
Row 505	4129	0	0	0	20
Row 506	4130	0	0	0	18.9
Row 507	4131	0	0	0	17.2
Row 508	4132	0	0	0	17.8
Row 509	4133	1	10	1	15.6
Row 510	4134	69	72	58	17.2
Row 511	4135	180	149	132	20.6
Row 512	4136	179	11	173	21.1
Row 513	4137	302	47	272	22.2
Row 514	4138	244	12	235	21.7
Row 515	4139	201	0	201	22.8
Row 516	4140	166	0	166	22.2
Row 517	4141	341	24	318	21.7
Row 518	4142	382	24	361	21.1
Row 519	4143	512	158	382	22.2
Row 520	4144	474	190	339	21.1
Row 521	4145	513	394	288	21.7
Row 522	4146	82	0	82	21.1
Row 523	4147	33	0	33	18.9
Row 524	4148	0	0	0	17.8
Row 525	4149	0	0	0	16.7
Row 526	4150	0	0	0	16.1
Row 527	4151	0	0	0	15
Row 528	4152	0	0	0	15
Row 529	4153	0	0	0	15.6
Row 530	4154	0	0	0	13.9
Row 531	4155	0	0	0	14.4
Row 532	4156	0	0	0	13.9
Row 533	4157	1	0	1	13.9
Row 534	4158	50	10	49	13.9

Lookup Table: June

	Hour	GHI	DNI	DHI	Temp
Row 535	4159	131	28	123	15
Row 536	4160	109	0	109	16.1
Row 537	4161	387	158	286	17.2
Row 538	4162	521	231	345	17.8
Row 539	4163	804	602	288	20.6
Row 540	4164	751	413	374	23.3
Row 541	4165	480	114	375	26.7
Row 542	4166	689	302	419	26.7
Row 543	4167	201	12	191	28.3
Row 544	4168	481	215	328	27.2
Row 545	4169	564	701	163	27.8
Row 546	4170	399	763	83	26.1
Row 547	4171	223	587	77	25
Row 548	4172	0	0	0	23.3
Row 549	4173	0	0	0	22.8
Row 550	4174	0	0	0	21.1
Row 551	4175	0	0	0	20.6
Row 552	4176	0	0	0	20
Row 553	4177	0	0	0	18.9
Row 554	4178	0	0	0	17.2
Row 555	4179	0	0	0	16.7
Row 556	4180	0	0	0	16.1
Row 557	4181	1	78	1	16.1
Row 558	4182	100	420	34	17.8
Row 559	4183	263	638	57	18.3
Row 560	4184	451	776	74	22.2
Row 561	4185	620	855	76	23.9
Row 562	4186	776	894	94	25.6
Row 563	4187	890	917	104	26.1
Row 564	4188	940	736	269	27.2
Row 565	4189	152	6	146	27.2
Row 566	4190	150	0	150	23.3
Row 567	4191	849	657	311	24.4
Row 568	4192	724	835	131	27.8
Row 569	4193	564	813	98	27.2
Row 570	4194	399	763	83	27.2
Row 571	4195	222	587	77	27.8
Row 572	4196	0	0	0	26.7
Row 573	4197	0	0	0	22.8
Row 574	4198	0	0	0	21.1
Row 575	4199	0	0	0	20.6
Row 576	4200	0	0	0	20.6
Row 577	4201	0	0	0	18.9
Row 578	4202	0	0	0	18.3
Row 579	4203	0	0	0	17.8
Row 580	4204	0	0	0	16.7
Row 581	4205	1	79	1	15.6
Row 582	4206	100	425	34	19.4
Row 583	4207	262	643	55	18.9
Row 584	4208	446	764	75	21.1
Row 585	4209	615	808	101	24.4
Row 586	4210	776	858	122	25.6
Row 587	4211	878	894	113	27.8

Lookup Table: June

	Hour	GHI	DNI	DHI	Temp
Row 588	4212	958	934	107	28.9
Row 589	4213	979	944	107	29.4
Row 590	4214	914	882	127	31.1
Row 591	4215	829	863	122	31.1
Row 592	4216	724	866	109	32.2
Row 593	4217	556	782	109	31.7
Row 594	4218	375	613	120	31.7
Row 595	4219	222	557	84	30.6
Row 596	4220	0	0	0	28.3
Row 597	4221	0	0	0	26.7
Row 598	4222	0	0	0	24.4
Row 599	4223	0	0	0	22.8
Row 600	4224	0	0	0	21.7
Row 601	4225	0	0	0	20.6
Row 602	4226	0	0	0	19.4
Row 603	4227	0	0	0	19.4
Row 604	4228	0	0	0	17.8
Row 605	4229	1	80	0	17.2
Row 606	4230	103	467	30	16.7
Row 607	4231	267	671	51	18.9
Row 608	4232	451	799	63	21.7
Row 609	4233	620	861	73	23.9
Row 610	4234	776	894	95	26.7
Row 611	4235	889	923	99	29.4
Row 612	4236	963	946	102	32.2
Row 613	4237	979	944	107	33.3
Row 614	4238	939	930	109	34.4
Row 615	4239	842	863	135	35.6
Row 616	4240	717	823	133	35.6
Row 617	4241	549	713	141	35.6
Row 618	4242	350	482	150	34.4
Row 619	4243	167	245	106	32.8
Row 620	4244	0	0	0	31.7
Row 621	4245	0	0	0	29.4
Row 622	4246	0	0	0	28.3
Row 623	4247	0	0	0	27.2
Row 624	4248	0	0	0	27.2
Row 625	4249	0	0	0	25.6
Row 626	4250	0	0	0	24.4
Row 627	4251	0	0	0	22.8
Row 628	4252	0	0	0	20
Row 629	4253	1	49	0	18.3
Row 630	4254	96	395	35	19.4
Row 631	4255	253	588	65	21.7
Row 632	4256	431	701	92	23.9
Row 633	4257	604	785	106	27.2
Row 634	4258	765	840	125	30
Row 635	4259	883	911	104	31.7
Row 636	4260	957	934	107	35
Row 637	4261	960	854	172	35.6
Row 638	4262	826	532	352	36.7
Row 639	4263	175	6	170	36.7
Row 640	4264	318	31	296	36.7

Lookup Table: June

	Hour	GHI	DNI	DHI	Temp
Row 641	4265	173	0	173	36.1
Row 642	4266	130	0	130	33.9
Row 643	4267	222	342	137	31.1
Row 644	4268	0	0	0	30
Row 645	4269	0	0	0	28.9
Row 646	4270	0	0	0	27.8
Row 647	4271	0	0	0	26.7
Row 648	4272	0	0	0	24.4
Row 649	4273	0	0	0	21.7
Row 650	4274	0	0	0	22.2
Row 651	4275	0	0	0	21.7
Row 652	4276	0	0	0	17.2
Row 653	4277	0	55	0	17.2
Row 654	4278	93	332	42	18.3
Row 655	4279	248	560	70	20
Row 656	4280	411	597	122	22.2
Row 657	4281	556	609	170	25.6
Row 658	4282	682	633	200	28.3
Row 659	4283	780	619	251	31.1
Row 660	4284	815	563	303	33.9
Row 661	4285	973	842	196	35
Row 662	4286	908	731	256	36.7
Row 663	4287	479	134	370	35
Row 664	4288	460	154	351	35.6
Row 665	4289	303	75	260	36.1
Row 666	4290	374	476	177	35.6
Row 667	4291	222	557	84	32.8
Row 668	4292	0	0	0	30
Row 669	4293	0	0	0	28.3
Row 670	4294	0	0	0	25
Row 671	4295	0	0	0	22.8
Row 672	4296	0	0	0	22.2
Row 673	4297	0	0	0	21.1
Row 674	4298	0	0	0	21.1
Row 675	4299	0	0	0	21.1
Row 676	4300	0	0	0	20.6
Row 677	4301	0	0	0	20
Row 678	4302	22	0	22	19.4
Row 679	4303	57	0	57	22.2
Row 680	4304	84	0	84	23.9
Row 681	4305	101	0	101	24.4
Row 682	4306	188	0	188	25
Row 683	4307	138	6	133	25
Row 684	4308	934	736	264	26.7
Row 685	4309	735	337	425	29.4
Row 686	4310	250	12	240	30.6
Row 687	4311	266	18	251	23.9
Row 688	4312	724	706	222	26.7
Row 689	4313	556	782	108	27.2
Row 690	4314	383	685	98	26.1
Row 691	4315	222	557	84	25.6
Row 692	4316	0	0	0	23.3
Row 693	4317	0	0	0	22.2

Lookup Table: June

	Hour	GHI	DNI	DHI	Temp
Row 694	4318	0	0	0	21.1
Row 695	4319	0	0	0	20
Row 696	4320	0	0	0	18.3
Row 697	4321	0	0	0	17.8
Row 698	4322	0	0	0	17.8
Row 699	4323	0	0	0	16.7
Row 700	4324	0	0	0	16.7
Row 701	4325	0	60	0	15
Row 702	4326	95	411	33	17.8
Row 703	4327	256	636	55	20
Row 704	4328	435	735	82	21.7
Row 705	4329	614	820	96	23.3
Row 706	4330	764	876	100	25
Row 707	4331	883	911	105	27.2
Row 708	4332	939	904	118	28.9
Row 709	4333	978	950	103	30.6
Row 710	4334	939	936	104	31.7
Row 711	4335	848	875	131	32.2
Row 712	4336	717	823	133	32.8
Row 713	4337	564	851	76	33.3
Row 714	4338	399	672	120	32.8
Row 715	4339	145	97	121	30.6
Row 716	4340	0	0	0	28.3
Row 717	4341	0	0	0	24.4
Row 718	4342	0	0	0	22.8
Row 719	4343	0	0	0	21.2
Row 720	4344	0	0	0	19.6