Index to *Home Power* Issues #89–94

This index lists the contents of all six of these *Home Power* issues, organized by subject. The two numbers at the end of each listing refer to the issue number and page number, respectively. Click directly on the entry to go to that article.

Photovoltaics

Systems

Data & Tools for RE System Design

It takes tools to design and install RE systems. Sometimes the tool for the job is a wrench, and sometimes it's a database, table, or spreadsheet. This section includes solar and wind resource data from the National Renewable Energy Laboratory. These averages from across North America will help you evaluate your specific site's energy resources. A step-by-step load analysis article and spreadsheet will help you determine how much energy your home or business is using. The Energy Master spreadsheet will assist you with RE system sizing and hardware selection. Finally, wire sizing tables and a spreadsheet will help you determine the appropriate transmission wire sizes. Use all these tools to help you design your system before you buy!

Solar Resource Data: 30 Year Average of Monthly Solar Radiation

Wind Resource Data: Wind Energy Resource Atlas of the United States

Load Analysis: Estimating Loads Article & Excel Spreadsheet

The Energy Master: RE System Design Excel Spreadsheet

Wire Sizing: Wire Sizing Tables for 12, 24, & 48 Volts & Excel Spreadsheet

Solar Resource Data

Determining the solar resource at a given location is a two-step process. The first step is to determine the solar resource for your location—how much does the sun shine? To help answer the first question, we're providing 30 years worth of solar resource data for the U.S. The data is courtesy of the Renewable Resource Data Center: http://rredc.nrel.gov. The second step is to determine the size and shape of the solar window for the proposed location of your solar collectors—how much sun versus shading by surrounding objects. A tool like a Solar Pathfinder will help you determine shading at the proposed position of your solar collector: http://www.solarpathfinder.com.

How to Use the Data: Instructions from the RReDC

Solar Resources in the U.S.: Bookmarked by state

Wind Resource Data

Wind speed changes on an instantaneous basis. Getting long term wind data for a given site is complicated and expensive. As a result, pre-installation wind monitoring is rarely carried out when a residential-scale wind system is being considered. This section includes long term wind data for locations around the U.S. Thanks to the National Climatic Data Center and National Renewable Energy Laboratory for collecting this incredible data.

Wind Resources in the U.S.: How hard & how much it blows at your site

Load Analysis

Analyzing your energy needs is the first step in planning a renewable energy system. Only once your energy needs are defined can you begin to design an RE system to meet those needs. You must measure each appliance or load and determine how much energy it takes to run that load. Long before you start comparing prices on photovoltaic modules you must first create a totaled list of loads called a “load profile.” This article goes through a step-by-step discussion of creating and using a load profile.

Load Analysis Article: How to create a load profile

Load Calculator: From the article, a working version of the load calculator spreadsheet in Excel format, with the file name “LOADS.XLS”

Energy Master

The Energy Master is an Excel spreadsheet for designing photovoltaic systems. It accepts user input as to appliances and appliance power consumption. Using this energy consumption data, the spreadsheet calculates the amount of PV, inverter, and battery required. It is open ended, and you can specify whatever brand and model of hardware you wish. The Energy Master will accept backup engine/generators as an energy input and calculate generator operating time and expenses.

Using the Energy Master

There are two versions of this spreadsheet—one in Excel version 5/95, and one in Excel version 8. The version 8 spreadsheet contains macros for sorting the Consumption and Cost tables. Other than this, there is no difference between the two versions. I suggest cloning (duplicating) the Energy Master spreadsheet and giving it another name—for example, “Joe’s PV System.” The sheet will perform regardless of its name. Cloning it will assure you a fresh, and unchanged version to use again.

When you first launch the Energy Master you will see that some cells are bordered in the color red. These red cells are where you should place your input data. The remainder of the cells, either bordered in black or without borders at all, contain Excel code and should not be used for your input.

The Energy Master is formatted for printing on a laser printer and on 8.5 inch by 11 inch paper. The spread already has a print area set to print on the essential pages. Other pages may be printed by redefining the print area in Excel.

Main Energy Master Features

This spreadsheet has three major components. The first component is the Consumption tables where the user inputs each and every appliance in the system. The second is the Controls panel. And the third is the Cost Estimate.

Energy Consumption Tables

The first page of the spreadsheet is called, “INVERTER SUPPLIED 120 VAC APPLIANCE POWER CONSUMPTION ESTIMATE” and this is where you tell the program all about the 120 VAC appliances to be used in the system. The only column which requires explanation is the column headed “P?” (cells C12:C46). This column specifies Priority appliances. Priority appliances are assumed to be always operational by the code, which sizes the inverter(s). Place a “1” (the

number one) here to indicate that an appliance is a Priority appliance, and a “0” (the number zero) to indicate that the appliance is not a Priority appliance. All appliances that automatically activate themselves (such as refrigerators, freezers, furnace fans, etc.) should be designated as Priority appliances.

The second page of the spreadsheet is called, “DC APPLIANCE POWER CONSUMPTION ESTIMATE,” and this is where you tell the program all about each and every DC-powered appliance in the system. Both consumption tables already have a sample of appliances entered into them. Feel free to modify any of these to suit the system you are designing.

The Control Panel

The third page of the spreadsheet is called, “THE CONTROL PANEL.” The Control Panel has three major parts.

1. THE FACTS OF THE MATTER details the energy consumption, battery voltage, inverter size, and other system parameters. All this data is program determined and this is not the place for user input.

2. USER INPUT—THE CONTROLS is the place for your input. Place the number of days of battery storage you wish in cell S16, labeled “Battery Storage.” If the system has a 120 VAC engine/generator, place its wattage in cell S17, labeled “AC Generator.” If the system uses a DC generator, then place its wattage in the cell V16, labeled “DC generator.” Place the number of PV modules in the system in cell V17, labeled “Solar.” If the system uses a PV tracker place a “1” (the number one) in cell V18, labeled “Tracker?”

3. THE BOTTOM LINE section contains computer determined energy data. This data will change with changes in either of the Consumption tables, or in the User Input—The Controls section. I suggest changing such user inputs as number of days of battery storage and number of PV modules and watching the derived data in this section change. With a little experience it is easy to model the most effective and least expensive system required to meet the user specified energy demands.

Hardware Specification List

In Excel, on page three, directly below The Control Panels, is an area for user input of what brands, sizes, and types of hardware are to be used in the system. Once again, place your selections in the cells bordered in red. The program will accept PV data, battery data, inverter data, and PV tracker data.

Below the Hardware Specification List is a section called, Parameter Entry. Here’s where you tell the program your average number of solar hours per day. This information for your location is available via NREL and is also published on this CD-ROM. You can also enter the maximum allowable depth of battery discharge in the Parameter Entry area.

Cost Estimate

The fourth page of the spreadsheet is called, “RENEWABLE ENERGY SYSTEM HARDWARE COST ESTIMATE,” and

this is where to enter the costs for the hardware. User input cells are once again bordered in red. The cells bordered in black are computer determined.

Getting the most out of the Energy Master

Use the spreadsheet to model different system scenarios. The main cell to keep an eye on is in the Control Panel—cell V24, labeled “Energy Cost.” This cell gives you the energy cost in dollars per kilowatt-hour over a ten-year basis. Design the system for a minimum figure here. This cell is all inclusive and reflects generator usage.

I have left the code on this spreadsheet wide open. There are no locked cells. For Excel adepts, feel free to modify my code, I’m sure you can improve it. All I ask is that you send me your improvements so Home Power can share them with others. I’ve been working on the Energy Master for over ten years now (it started in an Excel precursor called Multiplan) and I can always find things to improve and polish. I welcome your input.

While I don’t have time to teach folks how to use Excel, I will answer specific questions about the Energy Master via e-mail: richard.perez@homepower.com. Please put “Energy Master” in the subject line.

Happy PV System Designing!

Richard Perez

Energy Master: System sizing and design in an Excel spreatsheet format; file name “EMASTER.XLS”

Energy Master: Same as above, but in version 97 of Excel; file name “EMAST97.XLS”

Wire Sizing Table & Spreadsheet

Calculating correct transmission wire sizes is an important part of designing any renewable energy system. Because many PV systems operate at relatively low voltages (under 48 VDC nominal), even *National Electric Code* guidelines may result in unacceptable voltage drop. Voltage drop results in lost power, day after day, year after year. Included are wire sizing tables for 12, 24, and 48 VDC nominal systems.

12 Volt Nominal: Wire sizing table for 12 volts DC

24 Volt Nominal: Wire sizing table for 24 volts DC

48 Volt Nominal: Wire sizing table for 48 volts DC

Also included is a wire sizing spreadsheet to help you calculate appropriate wire sizes. Clicking this link or bookmark will launch Microsoft Excel and open the spreadsheet where you may enter the variables to calculate wire size.

Wire Sizing Calculator: Wire sizing calculator in Excel spreadsheet format, with file name “WIRE.XLS”

Wire Size for 12 Volts Nominal

15 Specification Voltage is 15.00 VDC
1 Wiring is specified for a power efficiency of 97.5% and/or correct ampacity

PV ARRAY CURRENT IN AMPERES

ROUND TRIP WIRE LENGTH IN FEET

	6	12	15	18	21	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120
25	13	10	10	9	8	7	6	6	5	4	4	4	3	3	2	2	2	1	1	0	0	0
30	13	10	9	8	7	7	6	5	4	4	3	3	2	2	2	1	1	1	0	0	0	0
35	12	9	8	7	7	6	5	4	4	3	3	2	2	1	1	1	0	0	0	0	-1	-1
40	11	8	7	7	6	5	4	4	3	2	2	1	1	1	0	0	0	-1	-1	-1	-1	-1
45	11	8	7	6	6	5	4	3	3	2	1	1	1	0	0	0	-1	-1	-1	-2	-2	-2
50	10	7	7	6	5	4	4	3	2	1	1	1	0	0	-1	-1	-1	-1	-2	-2	-2	-2
60	10	7	6	5	4	4	3	2	1	1	0	0	-1	-1	-1	-2	-2	-2	-3	-3	-3	-3
70	9	6	5	4	4	3	2	1	1	0	0	-1	-1	-2	-2	-2	-3	-3	-3	-3		
80	8	5	4	4	3	2	1	1	0	-1	-1	-1	-2	-2	-3	-3	-3					
90	8	5	4	3	3	2	1	0	0	-1	-2	-2	-2	-3	-3	-3						
100	7	4	4	3	2	1	1	0	-1	-1	-2	-2	-3	-3								
125	7	4	3	2	1	1	0	-1	-2	-2	-3	-3										
150	6	3	2	1	0	0	-1	-2	-3	-3												
175	5	2	1	0	0	-1	-2	-3	-3													
200	4	1	1	0	-1	-1	-2	-3														
225	4	1	0	-1	-1	-2	-3															
250	4	1	0	-1	-2	-2	-3															
275	3	0	-1	-2	-2	-3																
300	3	0	-1	-2	-3	-3																
325	2	-1	-2	-2	-3																	
350	2	-1	-2	-3	-3																	
375	2	-1	-2	-3																		
400	1	-1	-2	-3																		
425	1	-2	-3																			
450	1	-2	-3																			
475	1	-2	-3																			
500	1	-2	-3																			
600	0	-3																				
700	-1																					

Specification Voltage 15 VDC
for 12 VDC PV Applications

Wiring is specified for a power efficiency of 97.5%
and/or correct ampacity

Codes
The body of the table contains the Wire Gauge Number
0 Wire is designated by 0
00 Wire is designated by -1
000 Wire is designated by -2
0000 Wire is designated by -3

Wiring power efficiency is specified at 68°F
If ambient temperature is > 90°F, use the next gauge larger wire

Wire Size for 24 Volts Nominal

30 Specification Voltage is 30.00 VDC
1 Wiring is specified for a power efficiency of 97.5% and/or correct ampacity

PV ARRAY CURRENT IN AMPERES

ROUND TRIP WIRE LENGTH IN FEET	6	12	15	18	21	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120
25	14	13	12	12	10	8	6	6	6	6	6	6	4	4	4	2	2	2	2	0	0	0
30	14	13	12	11	10	8	6	6	6	6	6	6	4	4	4	2	2	2	2	0	0	0
35	14	12	11	10	10	8	6	6	6	6	6	5	4	4	4	2	2	2	2	0	0	0
40	14	11	10	10	9	8	6	6	6	5	5	4	4	4	3	2	2	2	2	0	0	0
45	14	11	10	9	9	8	6	6	6	5	4	4	4	3	3	2	2	2	2	0	0	0
50	13	10	10	9	8	7	6	6	5	4	4	4	3	3	2	2	2	1	1	0	0	0
60	13	10	9	8	7	7	6	5	4	4	3	3	2	2	2	1	1	1	0	0	0	0
70	12	9	8	7	7	6	5	4	4	3	3	2	2	1	1	1	0	0	0	0	-1	-1
80	11	8	7	7	6	5	4	4	3	2	2	1	1	1	0	0	0	-1	-1	-1	-1	-1
90	11	8	7	6	6	5	4	3	3	2	1	1	1	0	0	0	-1	-1	-1	-2	-2	-2
100	10	7	7	6	5	4	4	3	2	1	1	1	0	0	-1	-1	-1	-1	-2	-2	-2	-2
125	10	7	6	5	4	4	3	2	1	1	0	0	-1	-1	-2	-2	-2	-2	-3	-3	-3	-3
150	9	6	5	4	3	3	2	1	0	0	-1	-1	-2	-2	-2	-3	-3	-3				
175	8	5	4	3	3	2	1	0	0	-1	-1	-2	-2	-3	-3	-3						
200	7	4	4	3	2	1	1	0	-1	-1	-2	-2	-3	-3								
225	7	4	3	2	2	1	0	-1	-1	-2	-3	-3	-3									
250	7	4	3	2	1	1	0	-1	-2	-2	-3	-3										
275	6	3	2	1	1	0	-1	-2	-2	-3	-3											
300	6	3	2	1	0	0	-1	-2	-3	-3												
325	5	2	1	1	0	-1	-2	-2	-3													
350	5	2	1	0	0	-1	-2	-3	-3													
375	5	2	1	0	-1	-1	-2	-3														
400	4	1	1	0	-1	-1	-2	-3														
425	4	1	0	-1	-1	-2	-3															
450	4	1	0	-1	-1	-2	-3															
475	4	1	0	-1	-2	-2	-3															
500	4	1	0	-1	-2	-2	-3															
600	3	0	-1	-2	-3	-3																
700	2	-1	-2	-3	-3																	
800	1	-1	-2	-3																		

Specification Voltage 30 VDC
for 24 VDC PV Applications

Wiring is specified for a power efficiency of 97.5% and/or correct ampacity

Codes

The body of the table contains the Wire Gauge Number
0 Wire is designated by 0
00 Wire is designated by -1
000 Wire is designated by -2
0000 Wire is designated by -3

Wiring power efficiency is specified at 68°F

If ambient temperature is > 90°F, use the next gauge larger wire

Wire Size for 48 Volts Nominal

60 Specification Voltage is 60.00 VDC
1 Wiring is specified for a power efficiency of 97.5% and/or correct ampacity

PV ARRAY CURRENT IN AMPERES

ROUND TRIP WIRE LENGTH IN FEET	6	12	15	18	21	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120
25	14	14	12	12	10	8	6	6	6	6	6	6	4	4	4	2	2	2	2	0	0	0
30	14	14	12	12	10	8	6	6	6	6	6	6	4	4	4	2	2	2	2	0	0	0
35	14	14	12	12	10	8	6	6	6	6	6	6	4	4	4	2	2	2	2	0	0	0
40	14	14	12	12	10	8	6	6	6	6	6	6	4	4	4	2	2	2	2	0	0	0
45	14	14	12	12	10	8	6	6	6	6	6	6	4	4	4	2	2	2	2	0	0	0
50	14	13	12	12	10	8	6	6	6	6	6	6	4	4	4	2	2	2	2	0	0	0
60	14	13	12	11	10	8	6	6	6	6	6	6	4	4	4	2	2	2	2	0	0	0
70	14	12	11	10	10	8	6	6	6	6	6	5	4	4	4	2	2	2	2	0	0	0
80	14	11	10	10	9	8	6	6	6	5	5	4	4	4	3	2	2	2	2	0	0	0
90	14	11	10	9	9	8	6	6	6	5	4	4	4	3	3	2	2	2	2	0	0	0
100	13	10	10	9	8	7	6	6	5	4	4	4	3	3	2	2	2	1	1	0	0	0
125	12	10	9	8	7	7	6	5	4	4	3	3	2	2	1	1	1	1	0	0	0	0
150	12	9	8	7	6	6	5	4	3	3	2	2	1	1	1	0	0	0				
175	11	8	7	6	6	5	4	3	3	2	2	1	1	0	0	0						
200	10	7	7	6	5	4	4	3	2	1	1	1	0	0								
225	10	7	6	5	5	4	3	2	2	1	0	0	0									
250	10	7	6	5	4	4	3	2	1	1	0	0										
275	9	6	5	4	4	3	2	1	1	0	0											
300	9	6	5	4	3	3	2	1	0	0												
325	8	5	4	4	3	2	1	1	0													
350	8	5	4	3	3	2	1	0	0													
375	8	5	4	3	2	2	1	0														
400	7	4	4	3	2	1	1	0														
425	7	4	3	2	2	1	0															
450	7	4	3	2	2	1	0															
475	7	4	3	2	1	1	0															
500	7	4	3	2	1	1	0															
600	6	3	2	1	0	0																
700	5	2	1	0	0																	
800	4	1	1	0																		

Specification Voltage 60 VDC
for 48 VDC PV Applications

Wiring is specified for a power efficiency of 97.5% and/or correct ampacity

Codes

The body of the table contains the Wire Gauge Number
0 Wire is designated by 0
00 Wire is designated by -1
000 Wire is designated by -2
0000 Wire is designated by -3

Wiring power efficiency is specified at 68°F.
If ambient temperature is > 90°F, use the next gauge larger wire