

PentaMetric battery Monitor “System Sentry” data logging

How to graph and analyze renewable energy system performance using the PentaMetric data logging function.

Bogart Engineering

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A: Introduction. Why logged data is useful.

When a typical renewable energy system with battery storage is first installed the installer is going to be sure that it is working properly. But such systems, however reliable, are bound to eventually experience failures of some kind. A battery connection or solar connection could fail. Eventually a battery cell will short or open. After a period of time the user of such a system may notice that the system isn’t acting normally, but may not have the expertise to know what is wrong or how to fix the problem..

This document explains how to set up the PentaMetric battery system to continually log basic data about the system’s performance, and then analyze the system using Microsoft “Excel” spreadsheet program along with an Excel “template” which you can download from the www.bogartengineering.com website. When a possible failure is suspected, the user can easily download the logged data from the PentaMetric into his computer (assuming he has one with Windows operating system) and email the files to the original installer or other “expert” to be analyzed. The energy expert can usually diagnose the problem without having to go to the actual site. This can provide a valuable service to the user of the system at a cost that should be quite a bit less than if a site visit were always required. It could reduce the effort and cost required to provide a service warranty for the system.

B: Two possible system examples will be described in this document.

There are different ways that the PentaMetric could be set up to provide useful diagnostic data. In order to illustrate the possibilities, this document describes in detail two useful examples for how it can be done for typical renewable energy systems.

The first example is for a common “hybrid” system consisting of one renewable energy source, such as a set of solar panels together with storage batteries consisting of two or more series strings. (See figure 1)

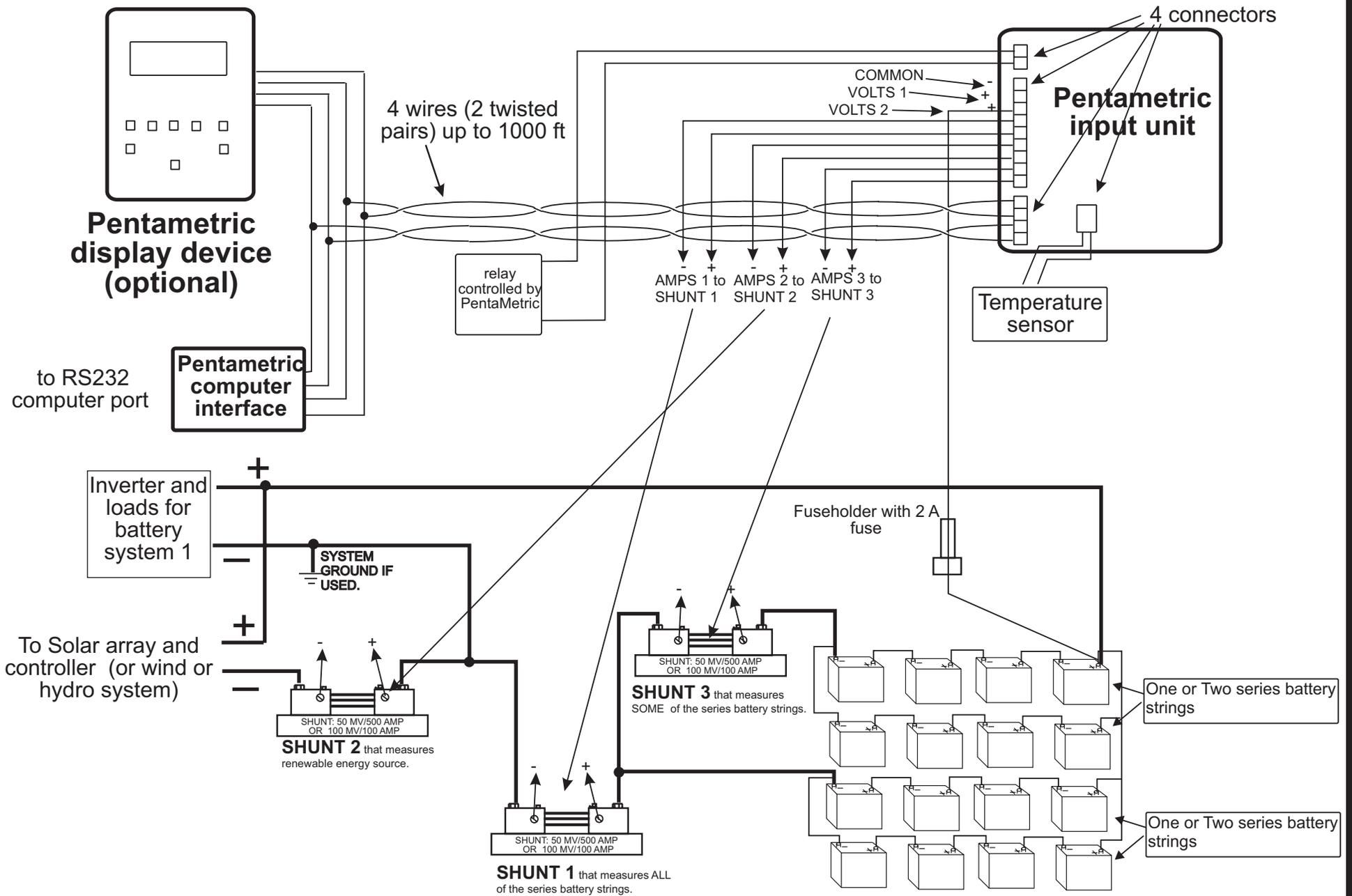


FIGURE 1: SHOWING A METHOD OF CONNECTING PENTAMETRIC FOR DATA LOGGING for systems with only one renewable energy source. One shunt is used to measure part of the total battery current when more than one battery series string is used..

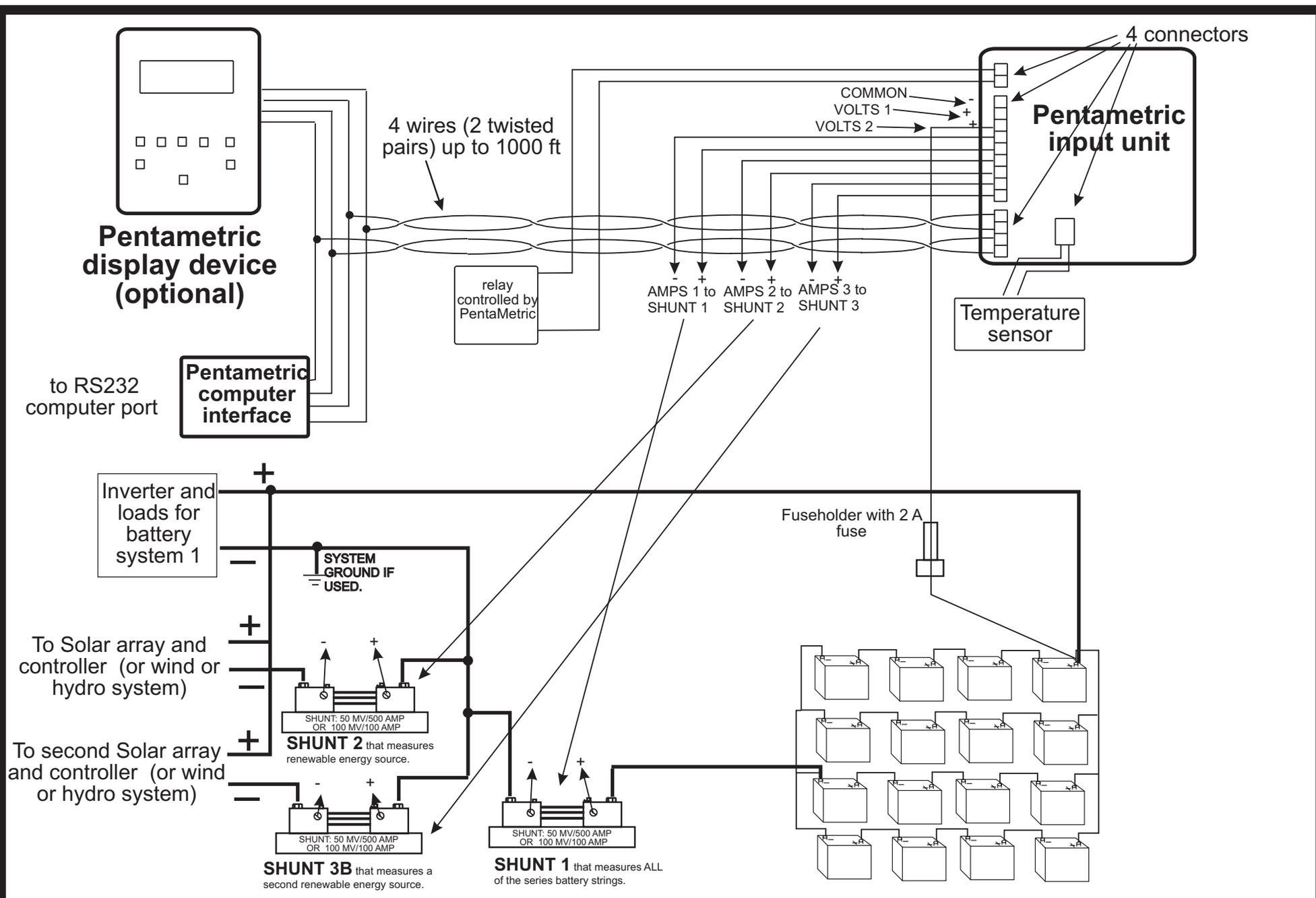


FIGURE 2: SHOWING A METHOD OF CONNECTING PENTAMETRIC FOR EFFECTIVE DATA LOGGING when there are two different renewable energy sources.

The second example (see figure 2) we show how the PentaMetric can be set up with a system that has two different renewable energy sources, such as one solar and one wind source. This example allows you to compare the two sources to estimate the most cost effective source for possible future expansion.

Of course there are other ways that systems could be connected depending on the imagination of the installer. . However this document is intended to show in step by step detail how it can be done for the two specific examples mentioned.

For both examples we show how to set up the meter and shunt connections, and show in some detail how to download the data, plot the data in a useful form using the “Excel” spreadsheet program, and then analyze the data to obtain useful data to analyze system operation and detect problems. To do the analysis you will need to have “Excel” already installed on your computer. You must also download the Excel “**ExcelPentaMetricDataTemplate**” files and the “**PMComm**” program which are available(including this document) without cost on the www.bogartengineering.com web site. (The cost of these programs is already included within the price of the PentaMetric computer interface.) This will enable you to make two types of graphs: one is a line graph showing hourly renewable energy production, battery voltage, net battery amp hours, and “state of battery charge”. The second is a bar graph which shows the daily total renewable energy production, load amp hours and generator amp hours. It is possible to choose how many days are shown on each graph. An example of the type of graphs that this makes is shown in figure A1-2 in the appendix to this document, in which 2 graphs with 6 total days are shown of hourly data, and figure A5 which shows daily system load amp hours, renewable input amp hours and approximate generator amp hours for 15 days. The example was recorded for a solar system in winter in California when there were some days of partly cloudy weather. The next pages (in the appendix) show some of the tabular data for this same system as it appears in the template program.

From this data we will describe how you can evaluate:

- Total daily solar production to spot problems with solar arrays or controllers. If insufficient to power the daily loads, the number of required additional amp hours/day of charging source can be estimated.,
- Total daily load amp hours, so charging source requirements can be estimated.
- Approximate generator charging amp hours by observing the data when the “load” (to inverter) becomes positive rather than negative.
- How frequently the battery system is fully charged, to see that batteries are being properly cared for.
- How deeply discharged the battery set typically becomes to see if battery systems are sized correctly.
- The charging “bulk” voltage settings to verify that they are the correct values for best battery life.
- The size of “Phantom loads” by observing the loads at early hours of the morning when the occupants are asleep.
- For example 1 mentioned above: How to identify battery problems or connection problems by observing the ratio of amp hours between the entire battery set to amp hours in a subset of the batteries.

- In addition, it is also possible using the “Charging cycle charge efficiency” log data, to determine the system “amp hour efficiency”: meaning the ratio in percent of the amp hours being put into the batteries (charging) compared to the amp hours taken out (discharging), for each charge cycle .

C: How to wire the PentaMetric to the battery system for log data monitoring for these examples:

Refer to Figure 1, which shows a system with a solar renewable energy system with shunts wired allowing measurement of “amps” (and amp hours) at three places: (1) Input of one renewable source, most commonly an array of solar panels. (2) The total “net” battery current through the entire battery set. (3) Another measurement of “amps” (and amp hours) which measures only *some* of the series battery strings which may be used. The purpose of the last measurement is to be able to compare the value of current in *part* of the series strings to the *total* battery current. If you have several “series strings” of batteries which are operating normally you would expect that the total current (“amps”) would divide approximately equally between the different strings. A shorted or open cell in one of the strings, or bad battery connection in a string would be expected to change the current balance of the strings, causing the ratio of amps between the partial strings and the total batteries to change, which can then be read in the log data record. For example, if 4 series strings of batteries are used and amps are monitored in just two strings (see illustration) one expects that the ratio between the total current and the “partial” current would be reasonably close to 2 to 1. —any deviation from this normal ratio would suggest a bad battery cell or poor connection in one of the battery series string connections. A similar logic applies if 3 strings are used, except the ratio would be 3 to 1 instead of 2 to 1

The second example, shown in figure 2, has more than one renewable input, (such as both wind and solar). Since the PentaMetric has only 3 “amps” channels available, two shunts are placed to measure two renewable inputs, and one is used to measure the total battery current. Thus a shunt is not available to record partial strings of the battery system. The method is similar to example 1, except that you will not have the ability to compare the currents in the different battery strings, thus limiting the ability to analyze individual battery performance. In trade for that you will be able to compare the relative effectiveness of the two separate renewable energy sources.

D: How to program the PentaMetric to record the data for these examples:

To do the analysis that we describe below you need to set up the log data programming as described here. If you do not collect data as described in this section you will not be able to use the Excel templates we have provided for this analysis, and you will be more “on your own” in doing the analysis with the Excel spreadsheet program.

The PentaMetric is capable of monitoring amp hours, watt hours, amps, volts and battery % full. Of these, the method suggested here does not use watt hours or amps, although it is possible to add these should you wish to. The “amp hour” measurements, however, show the average amps delivered for each hour, and, in our opinion, provide the most useful data for system analysis.

The PentaMetric computer interface should be used to make the choices of data, (rather than the PentaMetric Display Unit) as this provides more choices for recording logged data as compared with the PentaMetric Display Unit. Use program mode P39-42 to select the following:

1. Record data once per hour to yield 24 measurements per day
2. Record the following data:
 - Battery volts
 - Battery amp hours (probably Amp hours 1)
 - Each renewable input amp hours (possibly Amp hours 2 and/or 3)
 - Partial amp hours (if recorded) Amp hours 2 or 3
 - Battery %Full ,which will also record whether or not during each (one hour) sample time the batteries received a “full charge” as determined by the PentaMetric “charged volts and amps” criteria. (The charged criteria may be chosen by program mode P32 or P33).

When the PentaMetric is set up to record data in this way it will record continuously for 19 days. After that it will continue to record data by writing over the oldest data, thus always retaining the most recent 19 days of data. In a typical system the PentaMetric would be left by itself to record this data, but it would only be necessary to download the data into a file and send it by email for analysis if a system problem were suspected. Two weeks is ordinarily enough data to sufficiently analyze a system—however if it is desired to have a complete historical record of all data it will be necessary to download the data and save it at intervals not exceeding 19 days. Of course if data is recorded less often than once per hour it will record proportionally more number of days before overwriting old data. However you will not be able to use the templates we have provided for doing the graphing of data.

The installer should also connect the PentaMetric “computer interface” to a Windows PC and insure that it can properly communicate with the PentaMetric using the PMComm program (as described in the PentaMetric instructions). The “PMComm” program is available as a free download from the bogartengineering.com website. Of course the computer does not have to be left on while the log data is being recorded—it only need be on when the user wants to download the logged data, or in case the user wishes to use the computer for observing “real time” data on the PentaMetric or for observing or changing some programmed value for the PentaMetric system.

E: Getting the data from PentaMetric into a computer file suitable for analysis which could be emailed to another location.

This is a simple process which any user who is familiar with “Windows” should be able to do. When it is desired to analyze the data the first step is to download the data from the PentaMetric into the computer. The user should turn on the computer, then invoke the “PMComm” program by clicking on the icon. The first step should be to push the “display” button and observe the data momentarily. The reason for this is that this will enable the proper descriptions for the data in the download file. (Otherwise although the data will be downloaded, the downloaded file may not be produced with names that make it easy to identify the different types of data.) Then turn off the “display” data button and choose the “download data” button. The user is given the option as to where

the file should go in the computer. The “desktop” of the Windows program could be chosen, for example. After up to five files have been automatically downloaded, which takes several minutes, the data can be analyzed as described below, or these 5 files can be emailed as attachments to someone else who can do the analysis. The files are named starting with “PM” then followed by the date that the download was done, and finally a description of the file contents. Here are typical file names. Of course the date shown will be the current date of the download: The document will describe how you use the “Periodic data” and the “Cycle efficiency” files.

PM_Sep_11_2005_PeriodicData.csv
PM_Sep_11_2005_Batt1CycleEfficy.csv
PM_Sep_11_2005_Batt2CycleEfficy.csv
PM_Sep_11_2005_Batt1DischProfile.csv
PM_Sep_11_2005_Batt1DischProfile.csv

F: Step by step method using “Excel” to graph the “periodic” data (first file shown above). It is assumed that you have already downloaded from the PentaMetric the “PeriodicData.csv” file shown above.

Before beginning you must download the “ExcelPentametricDataTemplate” from the website at www.bogartengineering.com, and you must have Microsoft’s “Excel” on your computer.

1. Open the “Excel” program. From Excel, go to “file” menu and open the template file “Pentametric periodic data template.xls” that you downloaded from the website. If you get a message about macros on the screen, be sure to allow the macros to be used. If necessary you may need to go to the “Tools” menu, then “options”, then “security”, and finally check the box that says “macro security”. Then choose a setting that will allow you to run macros.
2. Note the tabs at the bottom left of the computer screen. One says “hourly data” and the other says “daily data”. Be sure that the “hourly data” tab is selected. Then go to the top of the screen and look for the button that says :”Import Data”. Click on that button, and select the file “PM_[Date_]PeriodicData.csv” which contains the data you wish to analyze that was downloaded from the PentaMetric.
3. If the program is happy with the data, a window will appear that says “Import Logged Data”. If an error message is indicated: **“The selected data is not a valid PentaMetric data file”** you will need to look at the data carefully to find out what is wrong, and correct it, and then try step 2 again.

Correcting the input PentaMetric data. First go the “file” menu of Excel and choose “open”. Find the problematic file (which has a .csv file extension) and open it. If the above error occurred it is because there is something wrong with the “Date/time” column, which is the leftmost column. If the first (date)

column looks like “#####” then you will first need to widen the first (left) column so you can read the dates properly.

Check the date/time column of the data. It is best to use Excel to sort the dates in order: select the “data” tab (at the top), then “sort”, and arrange the data in ascending date order. Check that there is one data point per hour—24 per day. If part of the file consists of data not spaced by one hour, edit it out and save the part that has data recorded every hour. (This program will only work with data that has been recorded once per hour.) Then check for unreasonably high or low dates, which after the sorting done above, should be at the top or bottom of the file, and delete them.

Then try to import the file again described in step 2.

4. If the above step went OK you should see a window labeled “Import Logged data”. The next task is to match the names of the downloaded PentaMetric data with the data names understood by the “PentaMetric data template file” in order to properly graph the data. While doing this you may want to examine more closely the spreadsheet data which is the PentaMetric logged data that you see “behind” the “Import Logged data” window.

NOTE: It is important that the column labels at the top of the columns (in the original “**PeriodicData.cvs**” file) all be different for the data columns that you wish to graph, otherwise the task in the next paragraph will not be possible. (The columns you don’t intend to graph don’t matter.) If two columns are named the same, or if some that you want to graph say “no label” it will be necessary to edit these label names so they are descriptive, and different. You can do this by using Excel to open the file—then edit the file so they have unique descriptive names, then save the file, and start again at step 1.

In the “import Logged data” window the names *outside* the boxes are the names that the Excel template understands. The selections *inside* the boxes represent the names of the data designated in the downloaded PentaMetric data file. It is your next task to select the names inside the box to match the template descriptions, so the graphing will be done correctly. Typically there will be six types of data on the left column that will need to be specified. Some of these are self explanatory. Note that the “partial amp hours” is data from a shunt which measures amp hours in only *some* of the series battery strings making up the battery system. If you have other data that you wish to graph that was recorded besides the ones we suggested above, it is possible to use the columns on the right to choose this data. (This has not yet been well tested.) Be sure not to overlook the “Batt reached charged setpoint” box, which is at the bottom right. This box needs to match up the column of PentaMetric data that tells whether the battery has been “charged” during any measurement hour. You can identify this data on the spreadsheet by noting that it consists (usually) mostly “0’s”, and an occasional “1.” When the “1” appears that indicates that the battery

reached the “charged setpoint” parameters during that hour. When finished click on the “OK” button.

5. Now you should see the spreadsheet containing the PentaMetric logged data, with identifying labels on the top. Examine the data to see that the various numbers are reasonable. For example, you would expect to see “solar amp hours” equal to 0 during night hours, but positive only during the day. “Battery net” amps hours can be either positive or negative. “Partial amp hours” should be less and hopefully some relatively constant fraction of “battery amp hours” (assuming this data was in the PentaMetric data file.) Battery % full should be mostly between 0 and 100 and perhaps occasionally over that. If some column of numbers is unreasonable, you may have done step 4 wrong—the wrong data may have been assigned to the wrong column. If this is the case import the data again according to step 2 and correct the error by repeating step 4 with corrections.
6. The green horizontal lines mark every 24 hours of the data. The column labeled “load amp hours” on the right should show the system loads. It is obtained by taking the “Batt A-hr” data column and subtracting the “Solar A-hr”, “Wind A-r” and “Hydro A-hr” columns. (If some of these three have no data, they are treated as “0” amp hours.) Also note that when the “load” amp hours become positive the data in the “load” column is colored orange. This alerts you to periods of not “load” amp hours, but indicates when the inverter is acting as a charger, usually when running a generator to charge the batteries.

Note also that when a cell containing the “Battery % full” data is colored blue, this signifies that during the preceding hour the PentaMetric “battery charged” criteria (specified in program mode P32 or P33) were met. If the meter is properly set up this should typically take place only when the “Battery % full” readings are at or near 100% . When this happens the “Battery % full” is typically reset to 100%.

G: Making the “hourly data” charts

7. At the lower left of the screen be sure that the “Hourly data” tab is selected. Go to the top of the screen and look for the button that says “Create hourly chart”. The default choice there allows you to start with day 0 (the first day) and will show 3 days total. You can change these to select how many days you want and when the data should begin, provided the data is valid for the choices you make. Often 4 days is a reasonable number to print without overcrowding the data. Then select “OK” to produce the chart.
8. You can now edit the chart a little if you like. If you find the graph too crowded with data you can delete some of the graphs by placing the mouse pointer on the graph you wish to delete and right clicking with the mouse. Then choose the “clear” option. To make the “volts” readings more readable you may want to get the vertical scale numbers on the right to line up with the horizontal measurement lines, to more easily read the “voltage” readings on the graph. You can change the vertical scale on the right (or left, for that matter) by “right clicking” on the (vertical) scale numbers (the numbers on the right) and then choose “format axis”. When the box opens select the

“scale” tab. You can change the scale by putting in your own values such that the scale numbers on the graph are accurately aligned with the horizontal measurement lines. To do this uncheck the “auto” box for “minimum” and “maximum”, and then choose suitable values for “minimum” and “maximum” such that the intermediate values line up with the horizontal lines. It might take a few tries to get it right. Then for analysis it is very useful to print out each graph, much preferably using a color printer for easier readability.

9. Now you can produce another graph for a different period by selecting at the bottom left with the mouse the “Hourly data” tab. and then repeat from step 7 for another section of the data.

H: Making the “daily charts”

10. The other chart that the template helps you make is a bar chart that shows the daily proportion of “load” , “green” and “generator” energy. Use the mouse to select (at the lower left of the screen) the “hourly data” tab. Then go to the top of the screen to select “create daily chart”. You will be able to select the number of days over which you wish the chart to cover. The “green” energy is the sum of amp hours from the “solar”, “wind” and “hydro” inputs. The “load” energy represents the energy measured in the “load” column of data when the data in this column is negative, (and therefore not colored in orange) indicating that the inverter/charger was powered by the generator. The “generator” energy is the sum of amp hours when the “load” is positive, (therefore the data colored orange) indicating that the generator was on .

The “load” and “generator” energies are only approximate because these “load” measurements do not include the load while the generator is on. Similarly, the measured generator amp hours doesn’t include the energy supplied to the loads at the time of the generator running. So the “generator energy” is lower than actual, and the “load” currents are greater than actual when both show on the same bar graph. These errors, however should not be large assuming that the generator is only on for a short time, and the generator charging current is much higher than the loads.

I: Analyzing the data:

•Total daily solar production to spot problems with solar arrays or controllers.

One way to find out what the daily solar amp hour potential is to look at the hourly chart to quickly determine which days had maximum sun, or solar production. Then look at the “daily electric usage” for those days to estimate this—preferably on a day upon which the system did not become fully charged.. Or you can look at the spreadsheet directly and add the daily amp hours for those days. However remember that if the system has reached a full charge that day then it is likely that the solar controller had curtailed the input when fully charged, so that the actual solar potential could be greater than this sum. So first choose a day in which the sun shone the entire day, and possibly where the battery did not reach full charge. This can be easily seen by looking at the graphs to identify such a day. Then go to that day on the spreadsheet data and add the solar amount for that day.

- **Total daily load amp hours .**

This was mentioned above, in the “step 10” above. To find the daily load usage you can examine the “Daily electric usage” chart. Look at days where no generator usage is shown and examine the “load” values.

As mentioned in step 10, when the generator is running it is not possible to view load amps since the loads during generator usage are being supplied by the generator, and doesn't get measured by the shunt. Often, however, the loads during that time can be estimated by looking at the values they had just before and just after the period of generator usage.

- **Approximate generator charging amp hours by observing the data when the “load” (to inverter) becomes positive rather than negative.**

This can be judged by adding the data in the spreadsheet load column that are colored orange. Similarly, the time that the generator was on can be estimated.

- **How frequently the battery system is fully charged**

- **How deeply discharged the battery set typically becomes**

These last two are easily evaluated using the hourly electric usage chart by looking at the graph of Battery % full..

- **The charging “bulk” voltage settings to verify that they are the correct values.**

This can be seen by locating times that the battery is showing at or near 100%, when the battery voltage is highest. It is often easiest to look at the spreadsheet data directly to get this information most precisely.

- **The size of “Phantom loads” by observing the loads at early hours of the morning when the occupants are asleep.**

Easily observed on either the hourly chart or the spreadsheet data typically in the early hours AM when occupants are not using many loads..

- **(In the case of example 1): Battery problems or connection problems by observing the ratio of amp hours between the entire battery set to amp hours in a subset of the batteries.**

This can be seen by looking at the graphed hourly data, or even more precisely by scanning the spreadsheet data. The “partial battery” amp hours should be some correct percentage of the “battery net amp hour” column, depending on what percentage of battery strings the “partial battery” amp hours is measuring. For example, if the system has 3 battery strings and one is being measured as the “partial” battery amps, then the ratio of current should be about 3 to 1. Discrepancies from that could suggest a bad string—caused by a bad cell or bad connection in one of the strings.

- **J: Measuring “system efficiency” using the “Cycle Efficiency” logged data.**

- **In addition, it is also possible using the “Charging cycle charge efficiency” log data, to determine the system “amp hour efficiency”: meaning the ratio in percent of the amp hours being put into the batteries (charging) compared to the amp hours taken out (discharging), for each charge cycle .**

You don't need the PentaMetric template to do this. Just use Excel to open the "PM_(Date)_2005_Batt1CycleEfficy.csv" file, which is another of the files that gets downloaded by the PMComm program. Page 13 shows what this data looks like on the spreadsheet for one system that may be beginning to show some signs of reduced efficiency due to age. Keep in mind that this measures *charge* efficiency, not overall energy efficiency, which would be somewhat lower than charge efficiency. The data is somewhat self explanatory. **The PentaMetric instruction manual explains in section 6.C.3 in considerable detail exactly how it is measured.** "Cycle hours" is the time between two successive "full charge" events. The "discharge" amp hours refers to the total of amp hours recorded between full charges measured *only* when the "amps" was negative (discharging). The "charge" amp hours is similar, except recorded only when "charging". "Net" amp hours is the difference between these last two values. "Charge efficiency" is the discharge amp hour total divided by the charge amp hours, so it describes the overall efficiency (in amp hour terms) of the battery system, including the inefficiency resulting from gassing when the battery is fully charged. The "self discharge" current is the net amp hours divided by the number of Cycle hours, so represents the average current (in amps) lost over the entire charge cycle, expressed in amperes. Finally the "efficiency factor" and "discharge current" are expressed as averaged over several cycles, for a number indicated at the top of the column. The number of cycles over which the data is averaged may be specified in the "options" in the PMComm program before the downloading the data from the PentaMetric. The averaged values are more useful because temperature changes from one cycle to another can influence the apparent efficiency of one or two cycles. However this effect of temperature difference will be averaged out when taken over several cycles so will give a more realistic value for system efficiency.

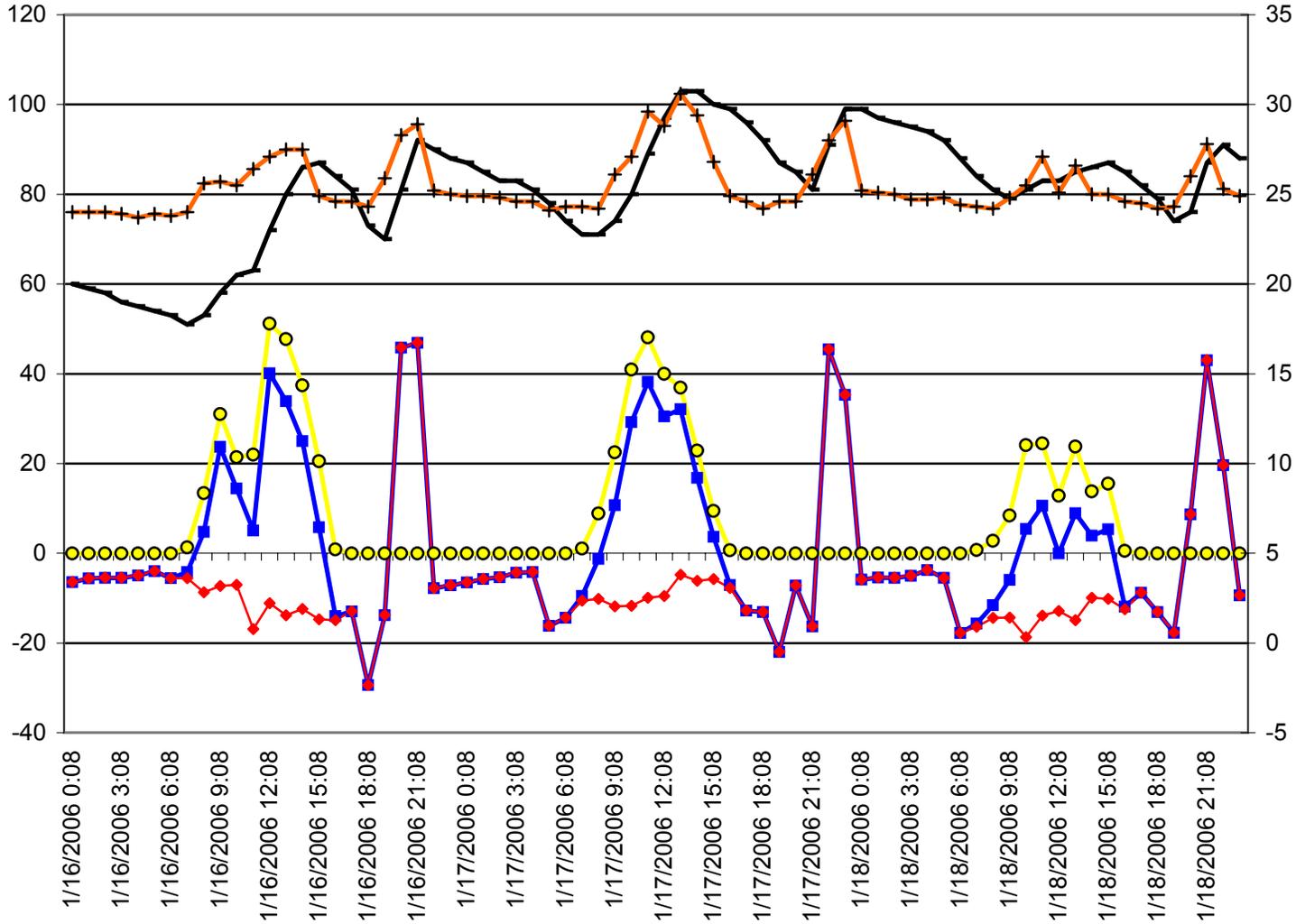
Date Time	Valid	Cycle Hrs	Dis AHrs	Chrg AHrs	Net AHrs	Chrg Eff	Self DisChrg	5 Cycle Chrg Eff	5 Cycle Self DisChrg
9/22/2008 2:01	FALSE	0	0	0	0	0.00%	0	0.00%	0
9/23/2008 2:28	TRUE	24.45	-185.96	206.95	20.99	89.86%	0.86	0.00%	0
9/24/2008 2:23	TRUE	23.92	-173.66	195.46	21.8	88.85%	0.91	0.00%	0
9/25/2008 2:31	TRUE	24.13	-200.14	215.75	15.61	92.76%	0.65	0.00%	0
9/26/2008 2:25	TRUE	23.9	-195.61	214.79	19.18	91.07%	0.8	0.00%	0
9/27/2008 2:31	TRUE	24.1	-185.22	206.29	21.07	89.79%	0.87	90.51%	0.82
9/28/2008 2:14	TRUE	23.72	-134.78	153.05	18.27	88.06%	0.77	90.26%	0.8
9/29/2008 2:24	TRUE	24.17	-229.81	240.5	10.69	95.56%	0.44	91.77%	0.71
9/30/2008 2:57	TRUE	24.55	-170.26	187.59	17.33	90.76%	0.71	91.37%	0.72
10/1/2008 1:36	TRUE	22.65	-196.09	209.12	13.03	93.77%	0.58	91.93%	0.67
10/2/2008 2:37	TRUE	25.02	-205.86	212.54	6.68	96.86%	0.27	93.42%	0.55
10/3/2008 2:01	TRUE	23.4	-187.35	191.85	4.5	97.65%	0.19	94.99%	0.44
10/5/2008 2:39	TRUE	48.63	-431.85	404.34	-27.51	106.80%	-0.57	98.84%	0.1
10/6/2008 3:10	TRUE	24.52	-192.8	233.14	40.34	82.70%	1.65	97.04%	0.26
10/7/2008 3:05	TRUE	23.92	-263.69	277.14	13.45	95.15%	0.56	97.16%	0.26
10/8/2008 3:34	TRUE	24.48	-196.8	220.51	23.71	89.25%	0.97	95.89%	0.38
10/9/2008 2:58	TRUE	23.4	-179.54	194.89	15.35	92.12%	0.66	95.09%	0.45
10/10/2008 3:16	TRUE	24.3	-186.83	205.71	18.88	90.82%	0.78	90.12%	0.93
10/11/2008 3:03	TRUE	23.78	-116.13	134.82	18.69	86.14%	0.79	91.28%	0.75
10/12/2008 3:38	TRUE	24.58	-146.52	164.2	17.68	89.23%	0.72	89.75%	0.78
10/13/2008 3:25	TRUE	23.78	-153.3	170.35	17.05	89.99%	0.72	89.92%	0.73
10/14/2008 3:12	TRUE	23.78	-163.93	177.86	13.93	92.17%	0.59	89.89%	0.72
10/15/2008 3:23	TRUE	24.18	-181.09	197.05	15.96	91.90%	0.66	90.13%	0.69
10/16/2008 3:47	TRUE	24.4	-194.46	211.63	17.17	91.89%	0.7	91.12%	0.68

This shows a section of “Efficiency data” that has been downloaded from a solar electric system (with batteries) during a period of clear weather, in which the system got fully charged on most days. The “Cycle Hrs” is the number of hours during the interval between one time that the batteries were “fully charged” until the next time that they are fully charged. Note that on 10/5/2008 the charge efficiency showed a seemingly impossible value of “106.8%”. This happened because the temperature dropped during that period, so the battery would not accept as many amp hours as was withdrawn the day before—so it appeared that the battery was recharged with less energy than was removed before. Similarly, the efficiencies can appear low when the temperature rises. The 5 day average eliminates these anomalies. The “Self DisChrg” columns show the current (in amperes) averaged over the entire cycle.

Electric System Usage

Amp Hours - % Full

Volts

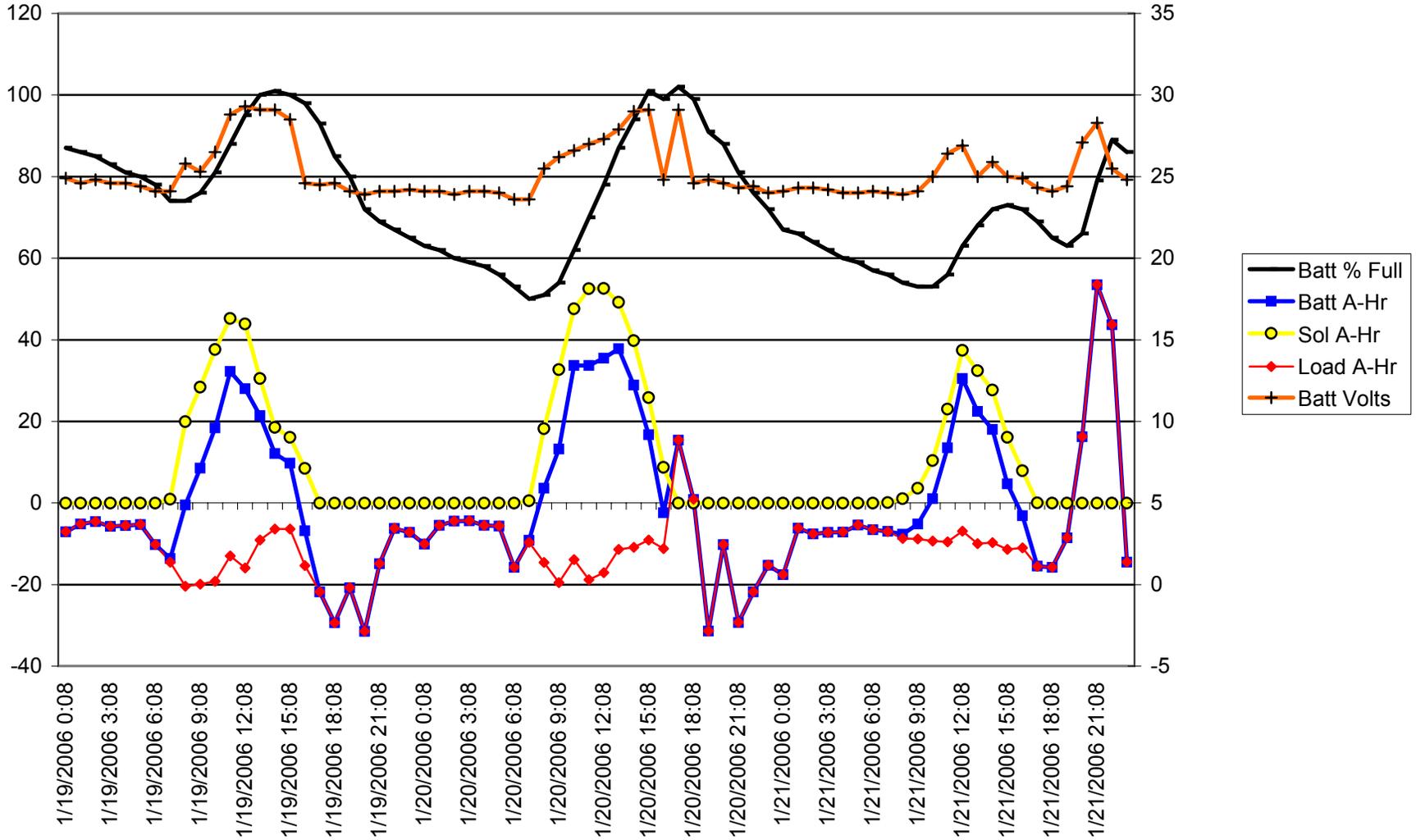


- Batt % Full
- Batt A-Hr
- Sol A-Hr
- ◆— Load A-Hr
- +— Batt Volts

Electric System Usage

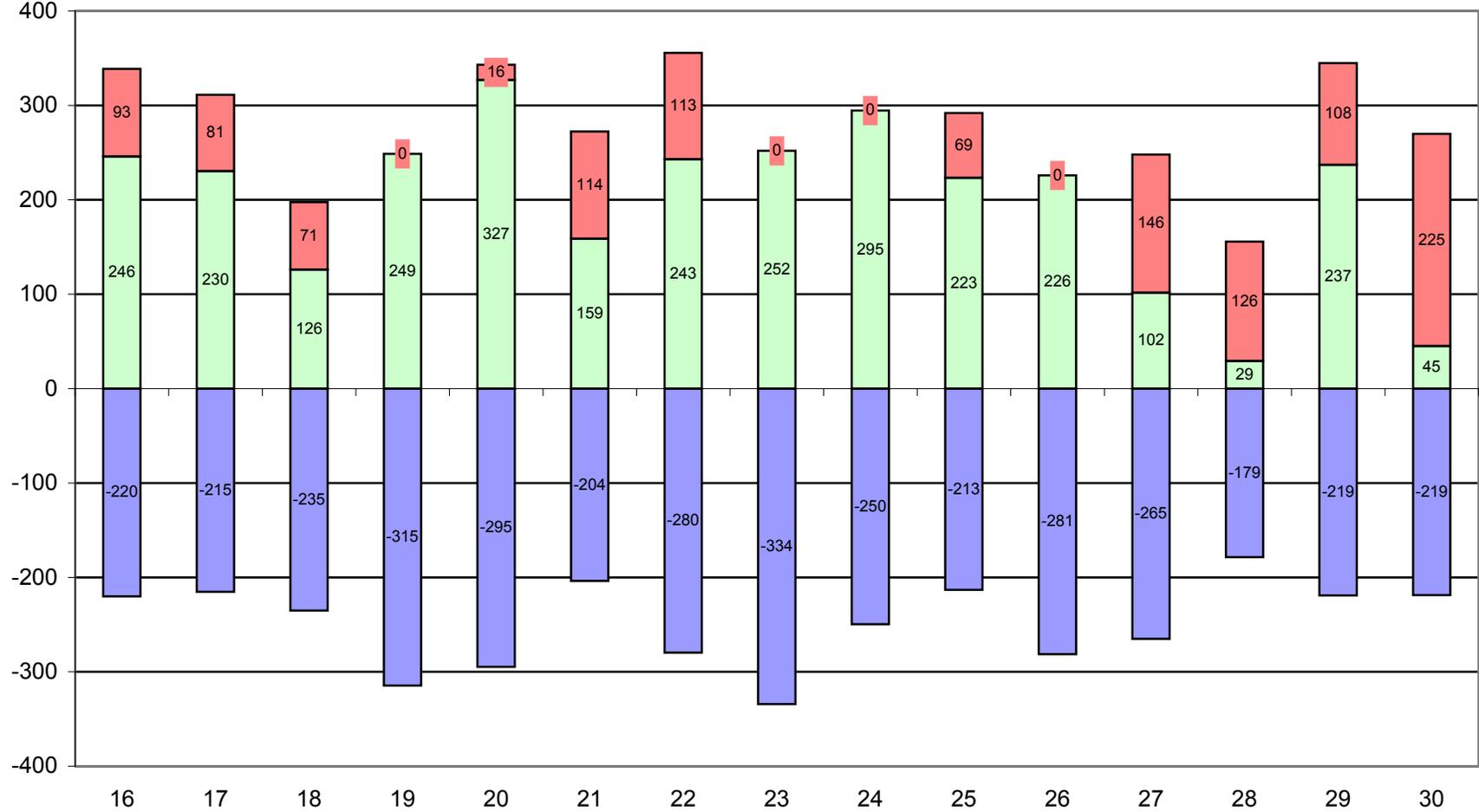
Amp Hours - % Full

Volts



Daily Electric Usage

Amp-Hours



Green A-Hrs Gen A-Hrs Load A-Hrs

Hourly Electric Usage Chart Data

Import Data

Create Hourly Chart

Date Time	Batt Volts	Batt % Full	Batt A-Hr	Partial Batt A-Hr
1/16/2006 0:08	24	60	-6.47	-4.1
1/16/2006 1:08	24	59	-5.59	-3.52
1/16/2006 2:08	24	58	-5.5	-3.45
1/16/2006 3:08	23.9	56	-5.48	-3.43
1/16/2006 4:08	23.7	55	-4.97	-3.11
1/16/2006 5:08	23.9	54	-4	-2.48
1/16/2006 6:08	23.8	53	-5.56	-3.52
1/16/2006 7:08	24	51	-4.24	-2.65
1/16/2006 8:08	25.6	53	4.74	3.61
1/16/2006 9:08	25.7	58	23.7	17.8
1/16/2006 10:08	25.5	62	14.4	10.4
1/16/2006 11:08	26.4	63	5.09	3.49
1/16/2006 12:08	27.1	72	40.1	26.8
1/16/2006 13:08	27.5	80	33.9	22
1/16/2006 14:08	27.5	86	25	16.4
1/16/2006 15:08	24.9	87	5.81	3.26
1/16/2006 16:08	24.6	84	-14	-11.8
1/16/2006 17:08	24.6	81	-13	-10.4
1/16/2006 18:08	24.3	73	-29.4	-19.7
1/16/2006 19:08	25.9	70	-13.8	-9.19
1/16/2006 20:08	28.3	81	45.8	31.9
1/16/2006 21:08	28.9	92	46.9	33.9
1/16/2006 22:08	25.2	90	-7.8	-7.15
1/16/2006 23:08	25	88	-7.13	-6.48
1/17/2006 0:08	24.9	87	-6.54	-5.71
1/17/2006 1:08	24.9	85	-5.74	-4.86
1/17/2006 2:08	24.8	83	-5.35	-4.34
1/17/2006 3:08	24.6	83	-4.31	-3.41
1/17/2006 4:08	24.6	81	-4.2	-3.25
1/17/2006 5:08	24.1	78	-16.2	-10.7
1/17/2006 6:08	24.3	74	-14.4	-9.24
1/17/2006 7:08	24.3	71	-9.5	-5.88
1/17/2006 8:08	24.2	71	-1.28	-0.69
1/17/2006 9:08	26.1	74	10.7	7.43
1/17/2006 10:08	27.1	80	29.2	21
1/17/2006 11:08	29.6	89	38.2	28
1/17/2006 12:08	28.8	97	30.5	21.4
1/17/2006 13:08	30.6	103	32.1	18.2
1/17/2006 14:08	29.4	103	16.8	8.9
1/17/2006 15:08	26.8	100	3.68	2.01
1/17/2006 16:08	24.9	99	-7.08	-6.12
1/17/2006 17:08	24.6	96	-12.8	-11.6
1/17/2006 18:08	24.2	92	-13.1	-11.3
1/17/2006 19:08	24.6	87	-22	-15.8
1/17/2006 20:08	24.6	85	-7.24	-5.44
1/17/2006 21:08	26.1	81	-16.3	-10.7
1/17/2006 22:08	28	91	45.4	32.7

1/17/2006 23:08	29.1	99	35.3	26.9
1/18/2006 0:08	25.2	99	-5.87	-5.3
1/18/2006 1:08	25.1	97	-5.42	-5.12
1/18/2006 2:08	25	96	-5.51	-5.07
1/18/2006 3:08	24.7	95	-5.06	-4.53
1/18/2006 4:08	24.7	94	-3.74	-3.41
1/18/2006 5:08	24.8	92	-5.52	-4.73
1/18/2006 6:08	24.4	88	-17.8	-12.5
1/18/2006 7:08	24.3	84	-15.7	-10.6
1/18/2006 8:08	24.2	81	-11.6	-7.57
1/18/2006 9:08	24.8	79	-5.95	-3.75
1/18/2006 10:08	25.5	81	5.41	4.09
1/18/2006 11:08	27.1	83	10.6	7.5
1/18/2006 12:08	25.1	83	-0.06	-0.02
1/18/2006 13:08	26.6	85	8.89	6.5
1/18/2006 14:08	25	86	3.9	2.81
1/18/2006 15:08	25	87	5.31	3.78
1/18/2006 16:08	24.6	85	-11.9	-9.09
1/18/2006 17:08	24.5	82	-8.81	-6.32
1/18/2006 18:08	24.2	79	-13.1	-8.57
1/18/2006 19:08	24.3	74	-17.7	-10.6
1/18/2006 20:08	26	76	8.64	6.57
1/18/2006 21:08	27.8	87	43	29.9
1/18/2006 22:08	25.3	91	19.6	13.2
1/18/2006 23:08	24.9	88	-9.38	-7.95
1/19/2006 0:08	24.9	87	-7.1	-5.79
1/19/2006 1:08	24.6	86	-5.18	-4.01
1/19/2006 2:08	24.8	85	-4.6	-3.45
1/19/2006 3:08	24.6	83	-5.77	-4.08
1/19/2006 4:08	24.6	81	-5.54	-3.77
1/19/2006 5:08	24.4	80	-5.27	-3.45
1/19/2006 6:08	24.1	78	-10.2	-6.27
1/19/2006 7:08	24.1	74	-13.6	-8.13
1/19/2006 8:08	25.8	74	-0.51	0.07
1/19/2006 9:08	25.3	76	8.5	6.07
1/19/2006 10:08	26.5	81	18.4	12.9
1/19/2006 11:08	28.8	88	32.2	22.6
1/19/2006 12:08	29.3	95	28	19.3
1/19/2006 13:08	29.1	100	21.4	13.6
1/19/2006 14:08	29.1	101	12.1	7.11
1/19/2006 15:08	28.5	100	9.73	5.25
1/19/2006 16:08	24.6	98	-6.86	-5.81
1/19/2006 17:08	24.5	93	-21.8	-17.6
1/19/2006 18:08	24.6	85	-29.4	-20.3
1/19/2006 19:08	24.1	80	-20.8	-13.7
1/19/2006 20:08	23.9	72	-31.5	-19.3
1/19/2006 21:08	24.1	69	-14.9	-9.16
1/19/2006 22:08	24.1	67	-6.28	-3.75
1/19/2006 23:08	24.2	65	-7.21	-4.23
1/20/2006 0:08	24.1	63	-10.1	-5.92
1/20/2006 1:08	24.1	62	-5.52	-3.15

1/20/2006 2:08	23.9	60	-4.48	-2.53
1/20/2006 3:08	24.1	59	-4.39	-2.48
1/20/2006 4:08	24.1	58	-5.52	-3.18
1/20/2006 5:08	24	56	-5.7	-3.31
1/20/2006 6:08	23.6	53	-15.8	-9.28
1/20/2006 7:08	23.6	50	-9.12	-5.19
1/20/2006 8:08	25.5	51	3.6	2.61
1/20/2006 9:08	26.2	54	13.2	9.16
1/20/2006 10:08	26.6	62	33.7	22.4
1/20/2006 11:08	27	70	33.7	21.8
1/20/2006 12:08	27.3	78	35.5	22.6
1/20/2006 13:08	27.9	87	37.8	23.9
1/20/2006 14:08	29	94	28.9	17.9
1/20/2006 15:08	29.1	101	16.7	9.91
1/20/2006 16:08	24.8	99	-2.42	-2.93
1/20/2006 17:08	29.1	102	15.4	9.52
1/20/2006 18:08	24.6	99	0.85	-1
1/20/2006 19:08	24.8	91	-31.4	-23.4
1/20/2006 20:08	24.6	88	-10.2	-8.21
1/20/2006 21:08	24.3	81	-29.3	-19.1
1/20/2006 22:08	24.4	76	-21.8	-13.6
1/20/2006 23:08	24	72	-15.3	-9.28
1/21/2006 0:08	24.1	67	-17.6	-10.2
1/21/2006 1:08	24.3	66	-6.17	-3.47
1/21/2006 2:08	24.3	64	-7.58	-4.23
1/21/2006 3:08	24.2	62	-7.25	-4.02
1/21/2006 4:08	24	60	-7.18	-3.98
1/21/2006 5:08	24	59	-5.4	-2.96
1/21/2006 6:08	24.1	57	-6.55	-3.67
1/21/2006 7:08	24	56	-6.95	-3.95
1/21/2006 8:08	23.9	54	-7.69	-4.5
1/21/2006 9:08	24.1	53	-5.19	-3.05
1/21/2006 10:08	25	53	1.06	0.88
1/21/2006 11:08	26.4	56	13.5	9.42
1/21/2006 12:08	26.9	63	30.5	19.9
1/21/2006 13:08	25	68	22.4	13.9
1/21/2006 14:08	25.9	72	18	11.1
1/21/2006 15:08	25	73	4.7	2.38
1/21/2006 16:08	24.9	72	-3.1	-2.51
1/21/2006 17:08	24.3	69	-15.5	-10.2
1/21/2006 18:08	24.1	65	-15.8	-10
1/21/2006 19:08	24.4	63	-8.59	-5.31
1/21/2006 20:08	27.1	66	16.2	10.4
1/21/2006 21:08	28.3	79	53.5	34.3
1/21/2006 22:08	25.5	89	43.7	27.3
1/21/2006 23:08	24.8	86	-14.5	-11.7
1/22/2006 0:08	24.6	82	-13.7	-10.5
1/22/2006 1:08	24.6	78	-14.7	-10.3
1/22/2006 2:08	24.5	74	-15.7	-10
1/22/2006 3:08	24.5	73	-6.82	-4.22
1/22/2006 4:08	24.5	71	-6.67	-3.96

1/22/2006 5:08	24.3	70	-5.61	-3.22
1/22/2006 6:08	24.1	67	-12.1	-6.84
1/22/2006 7:08	24.3	65	-4.95	-2.67
1/22/2006 8:08	25.9	67	6.58	4.41
1/22/2006 9:08	26.6	71	18.8	12.3
1/22/2006 10:08	28.1	79	35.1	23.4
1/22/2006 11:08	29	89	40	26.3
1/22/2006 12:08	29.1	95	24.6	15.3
1/22/2006 13:08	29.1	99	15	8.79
1/22/2006 14:08	29.2	101	11.2	6.16
1/22/2006 15:08	27.1	100	7.03	3.77
1/22/2006 16:08	24.4	95	-21.8	-16.8
1/22/2006 17:08	24.1	87	-32.6	-23.1
1/22/2006 18:08	24.3	78	-35.4	-22.3
1/22/2006 19:08	24.3	72	-20.7	-12.5
1/22/2006 20:08	26.7	71	-4.19	-2.24
1/22/2006 21:08	26.8	82	44.5	29.1
1/22/2006 22:08	29.1	95	55.6	36.9
1/22/2006 23:08	25.1	99	12.3	7.53
1/23/2006 0:08	25.1	97	-8.04	-7.16
1/23/2006 1:08	25	96	-6.53	-5.69
1/23/2006 2:08	24.9	94	-6.49	-5.43
1/23/2006 3:08	24.8	93	-6.56	-5.23
1/23/2006 4:08	24.6	92	-4.88	-3.86
1/23/2006 5:08	24.8	90	-6.19	-4.58
1/23/2006 6:08	24.6	85	-18.4	-11.6
1/23/2006 7:08	24.4	83	-9.52	-5.65
1/23/2006 8:08	25	83	-1.86	-0.93
1/23/2006 9:08	25.6	83	2.44	1.75
1/23/2006 10:08	26.8	87	19.1	13.3
1/23/2006 11:08	28.4	94	29.5	21.5
1/23/2006 12:08	29.1	100	23.8	16.7
1/23/2006 13:08	29.1	101	12	7.43
1/23/2006 14:08	29.1	103	10.7	5.9
1/23/2006 15:08	29.1	101	9.42	5
1/23/2006 16:08	26.7	100	5.8	3.06
1/23/2006 17:08	24.9	97	-10.8	-9.15
1/23/2006 18:08	24.4	94	-14.8	-12.3
1/23/2006 19:08	24.6	88	-25	-17.3
1/23/2006 20:08	24.3	80	-28.8	-17.8
1/23/2006 21:08	24.1	74	-25.3	-14.9
1/23/2006 22:08	24.2	71	-12.3	-7.07
1/23/2006 23:08	24.1	69	-9.84	-5.49
1/24/2006 0:08	24.3	67	-8.02	-4.37
1/24/2006 1:08	24.3	65	-7.28	-3.9
1/24/2006 2:08	24.3	63	-5.7	-3
1/24/2006 3:08	24.3	62	-5.55	-2.91
1/24/2006 4:08	24.1	61	-4.23	-2.18
1/24/2006 5:08	24.2	60	-4.49	-2.33
1/24/2006 6:08	23.9	56	-15.3	-8.51
1/24/2006 7:08	24	53	-10.5	-5.9