Solar USB Charger Design

This document is written to help you design a system to charge mobile devices via USB with energy from a solar panel.

We will start with how to choose a location for your solar build by using a Solar Pathfinder. Then we will use the data gathered to evaluate your location in RETScreen - an excel based program that will help you analyze your project and make decisions about supplies and set up. We will use RETScreen to determine what kind of power you will need for your project. You will also learn how to protect your equipment from the elements. The document will conclude with the list of monthly maintenance required for your solar charger and what to do if it stops working.

Contents:

Choosing A Location

You have chosen to construct a solar build and now you need to choose a location. This is a very important decision as you are going to use solar panels to collect energy. This energy will be stored in a battery and when required it will charge your mobile devices. If you choose a location that does not get a lot of sun you will not get enough energy to charge your battery and therefore cannot charge your devices. We will use the Solar Pathfinder to help us select a location that will provide enough solar power to charge your devices. Once we have used the solar pathfinder we can use our findings in RETScreen, a computer program to assist in energy projects. We will use the percentage of sun we find per month at our location to decide if it is a good location for a solar build.

Solar Pathfinder

The Solar Pathfinder is a low tech piece of equipment that is used for shade analysis. It helps the user to evaluate how much sun and shade a location will receive. Its specialized dome and sunpath diagrams will tell you how much solar energy you can get at a location any time of the year. With this information you can estimate approximately how much power you could get from setting up a solar system at a specific location.

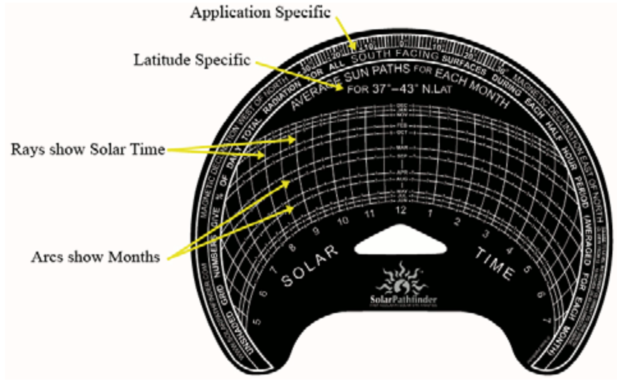
Supplies:

- Solar Pathfinder (includes base, dome, sunpath diagram)
- Camera for documenting
- Supplies to do calculations (pen and paper and or calculator or excel spreadsheet)

Set up

The Sunpath diagram:

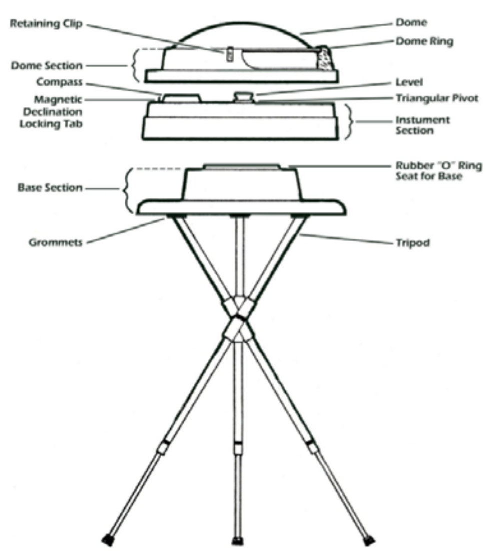
This piece of paper is what provides the basis for your analyses. It looks different for different latitudes around the world. As the latitude of the earth changes so does the angle of the sun. For example at the equator the sun is mostly directly overhead all year round you would see a very strait line on the pathfinder. As you move more north or south the sun is less and less directly overhead. The image below is an example of a sunpath diagram.



In the Halifax area we are at 45° North so we will select the sunpath diagram for 43° to 49° N Lat. The arched lines represent the path of the sun for that month. The shorter lines at the top of the image are the winter months. The longer ones that are more curved are the summer months. The rays are associated with the numbers below the lowest arch and tell the solar time. This can be used to tell the actual time as well with some calculations. The application specific angles at the top of the sunpath diagram allow you to ensure you are reading true south when you line up your pathfinder with the compass. You need to find the magnetic declination of your location, which changes. To get the most up to date declination check on the internet.

The month lines have small numbers through them, these numbers indicate how much solar power is available at that time of day and the total adds up to 100 per month (nice and easy to calculate percent). The highest numbers are clustered around noon time and lower numbers when the sun is closer to setting or rising as there is less solar energy available at those times. Due to the triangular hole on the sunpath diagram it will fit perfectly on the Solar Pathfinder.

The Base



Solar Pathfinder Parts Diagram from the SolarPathfinder Manual

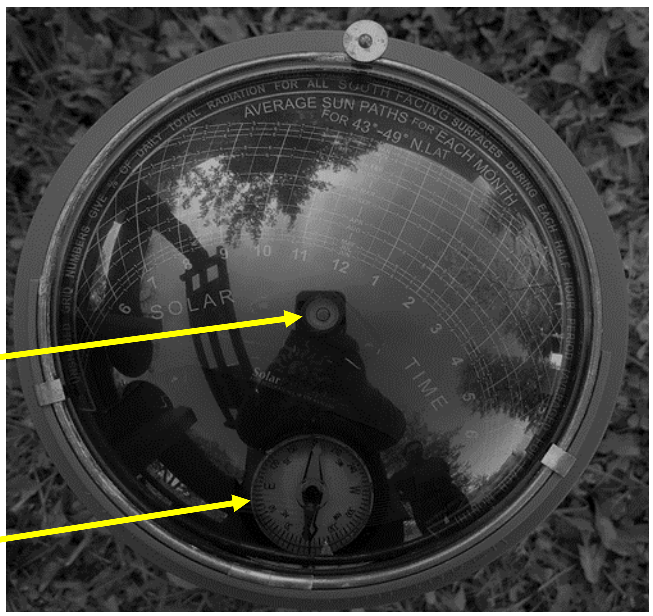
When you are at your location put your pathfinder together.

1) Connect the base section to the tripod.
2) Put the sunpath diagram on the instrument section
3) Adjust magnetic declination if required. The magnetic declination locking tab allows you to select the magnetic declination. The white dot on the outer ring of the instrument section should line up with your declination. Then you click the locking tab back into place.
4) Place the instrument section on the base section with the compass pointing south.
5) Adjust the base and tripod to get the pathfinder as flat as possible. Use the level bobble in the centre.
6) Place the dome on the instrument section.

You can now complete your shade analysis.

Documentation

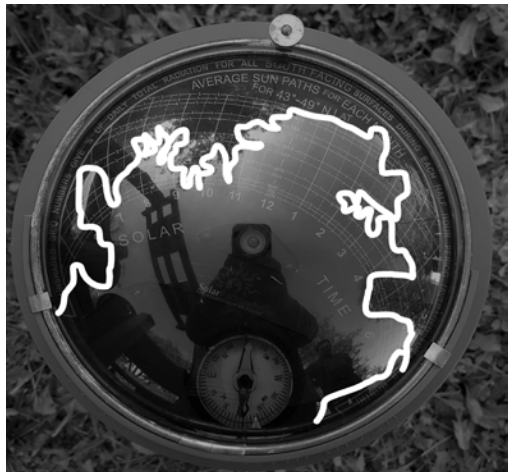
An easy way to capture your data is to take a picture. Ensure you are directly over the solar pathfinder and holding your camera parallel to the pathfinder. The image bellow is a good example.



Analysis

As you can see in the image above that there are some things at this location that cause shade. When you are doing your calculations do not use the shade cast by the photographer.

The trees in this space will cast shade on your solar panels but some light will still get through. Any shade on a solar panel does cause it to generate less energy. We will call the shade caused by the trees soft shade and we will include it in our analyses as shade. Any buildings or solid objects that block the sun will be called hard shade. They will stop the solar panel from generating a charge to the battery. To complete your analyses an easy way is to load your picture on the computer and draw over in with a bright colour using your preferred program like in the image below. Or you can print and it and use chalk to draw the outline.



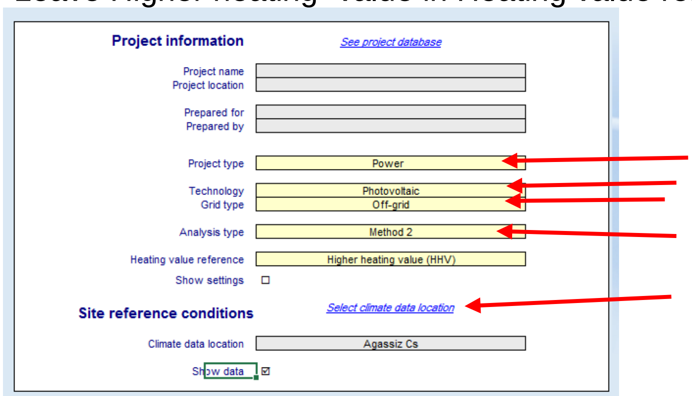
Now that you see the shade for all times of year you can add up the numbers in the month line that are not in the shaded areas. As the total number is equal to 100 it is easy to get the percentage of sun available for an average day in a particular month. We will use this data in RETScreen to help select our battery and the power of our solar panel. You can record it below.

Month	%
January	
February	
March	
April	
May	
June	
July	
August	
September	
October	
November	
December	

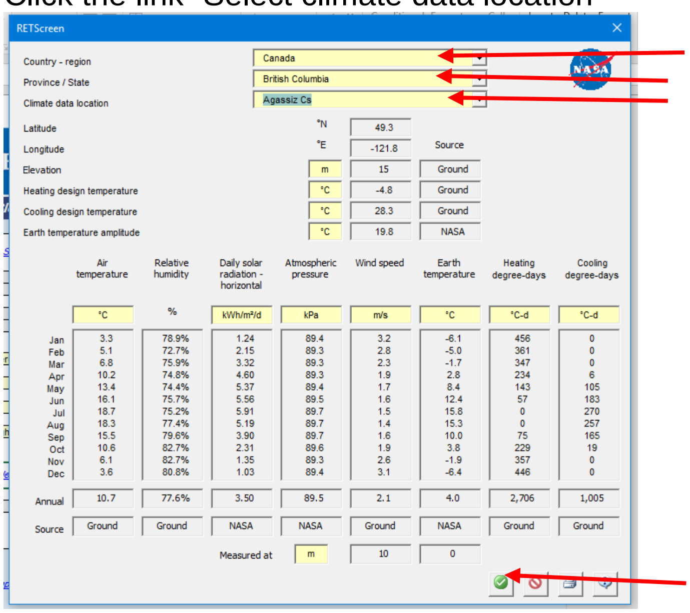
Work space

Using in RETScreen

1) Open the program
2) Select Enable
3) For Project type select “Power” from the drop down menu
4) Select “Photovoltaic” from the Technology menu. This is the technical name for the type of solar panel we will use on the solar bench.
5) Grid type is “Off-grid” as it will not be connected to any other power systems
6) Analysis type is “Method 2”
7) “Leave Higher heating” value in Heating value reference.

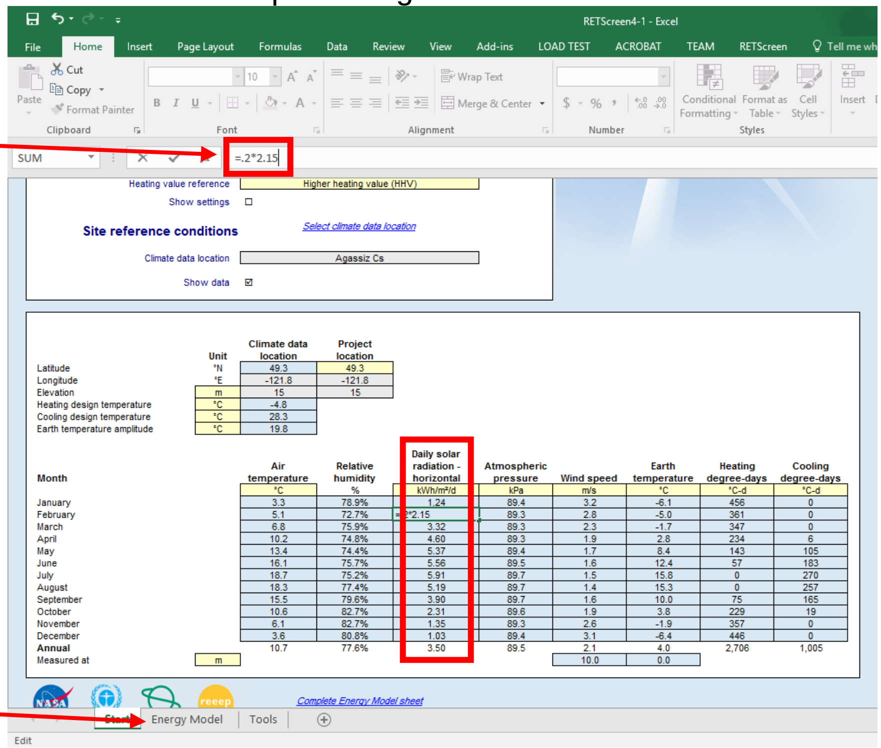


8) Click the link “Select climate data location”



9) From the drop downs select the nearest and most appropriate location for you. Select your country, province and Location. Then click the green arrow to continue.

10)Click “show data” box to see the monthly values. This is where we will be able to use the percentage we found from the SolarPathfinder.



11)You can change the values that are in blue. Click on the box you want to change and make your edit in the text box.

The values we want to adjust are in the daily solar radiation column. The numbers provided are 100% of solar captured but if there is shade at your location that is not accurate.

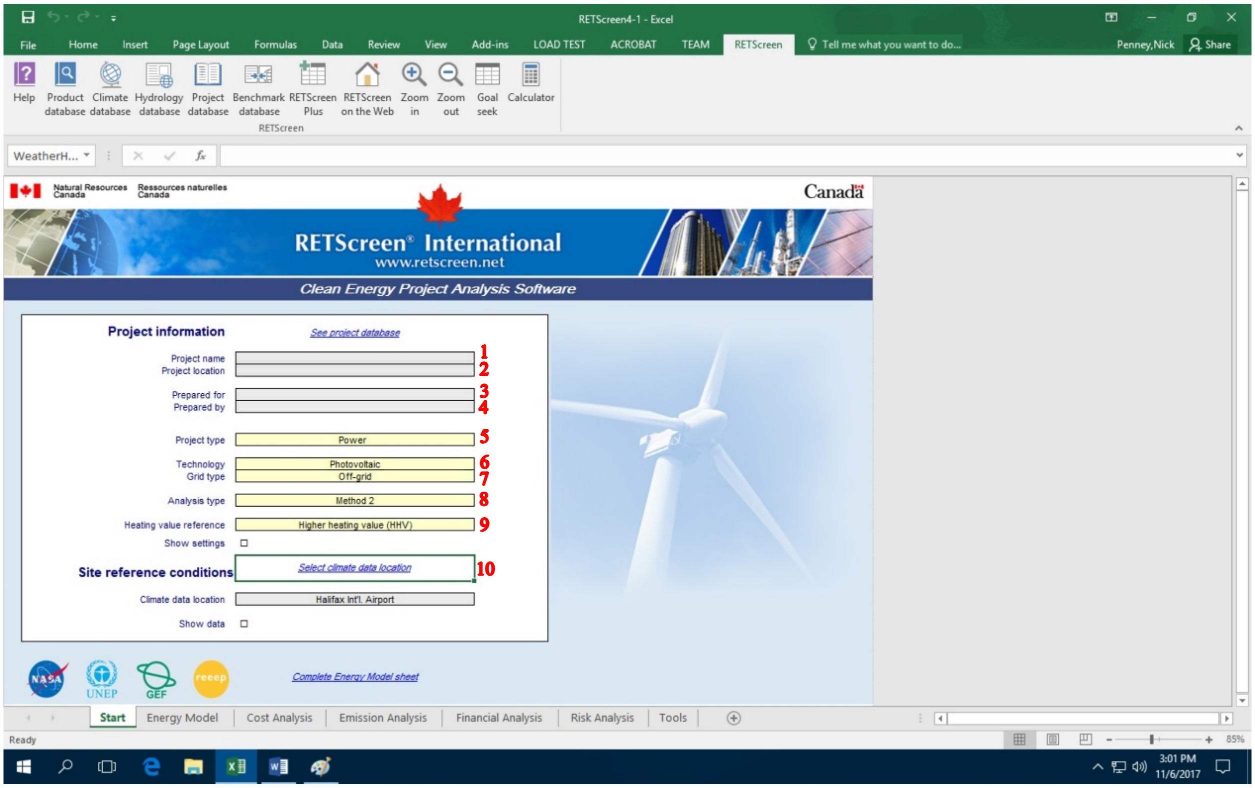
This is how the calculation should be typed “=.8*2.15” See image above.

Excel will do the math for you. The “.8” is an example of the percent of sun the location you chose has for that month. If you calculated 14% then you would use “.14”. The “*” signifies multiplication. ‘2.15” is the 100% solar radiation value provided in the chart.

Once you have completed the adjustments to this chart you can continue to the second tab: Energy Model.

How-To RETScreen

After opening RETScreen you will be presented with this screen asking for basic information. Fill out the fields as follows:



1. **Project name**

   The user enters the project name for reference purposes only.

2. **Project location**

   The user enters the project location for reference purposes only.

3. **Prepared for**

   The user enters the name of the person or organisation for which the RETScreen analysis is prepared. This information is for reference purposes only.

4. Prepared by

The user enters the name of the person or organisation who prepared the RETScreen analysis. This information is for reference purposes only.

5. Project type

The user selects the proposed project type considered from the ten options in the drop-down list: "Power," "Power - multiple technologies," "Heating," "Cooling," "Combined heating & power," "Combined cooling & power," "Combined heating & cooling," "Combined cooling, heating & power," "Energy efficiency measures" or "User-defined." Note that the use of the word "power" means "electricity generation" in the RETScreen Model.

For our purposes we will select Power from this list.

6. Technology

The user selects the technology from the drop-down list.

For our purposes we will select Photovoltaic from the drop-down list.

7. Grid type

The user selects the grid type considered from the drop-down list. For central-grid and isolated-grid systems, the user also selects whether or not there is an internal load.

For our purposes we will select Off-grid from the drop-down list.

8. ## Analysis type

The user selects the type of analysis from the drop-down list. If "Method 1" is selected, less detailed information is required (i.e. most of the worksheets close) while if "Method 2" is selected, more detailed information is required. Typically, Method 1 is used first to determine if a Method 2 analysis is warranted.

For our purposes select Method 2 analysis as this provides us with more information.

9. ## Heating value reference

The user selects the heating value reference from the drop-down list. The user should not change this selection once the analysis has started.

Heating value is a measure of energy released when a fuel is completely burned. Depending on the composition of the fuel (amount of hydrogen) the amount of steam in the combustion products varies. Higher heating value (HHV) is calculated assuming the combustion product is condensed and the steam is converted to water. Lower heating value (LHV) is calculated assuming the combustion product stays in a vapour form.

Higher heating value is typically used in Canada and USA, while lower heating value is used in the rest of the world.

For this option select Higher Heating Value (HHV).

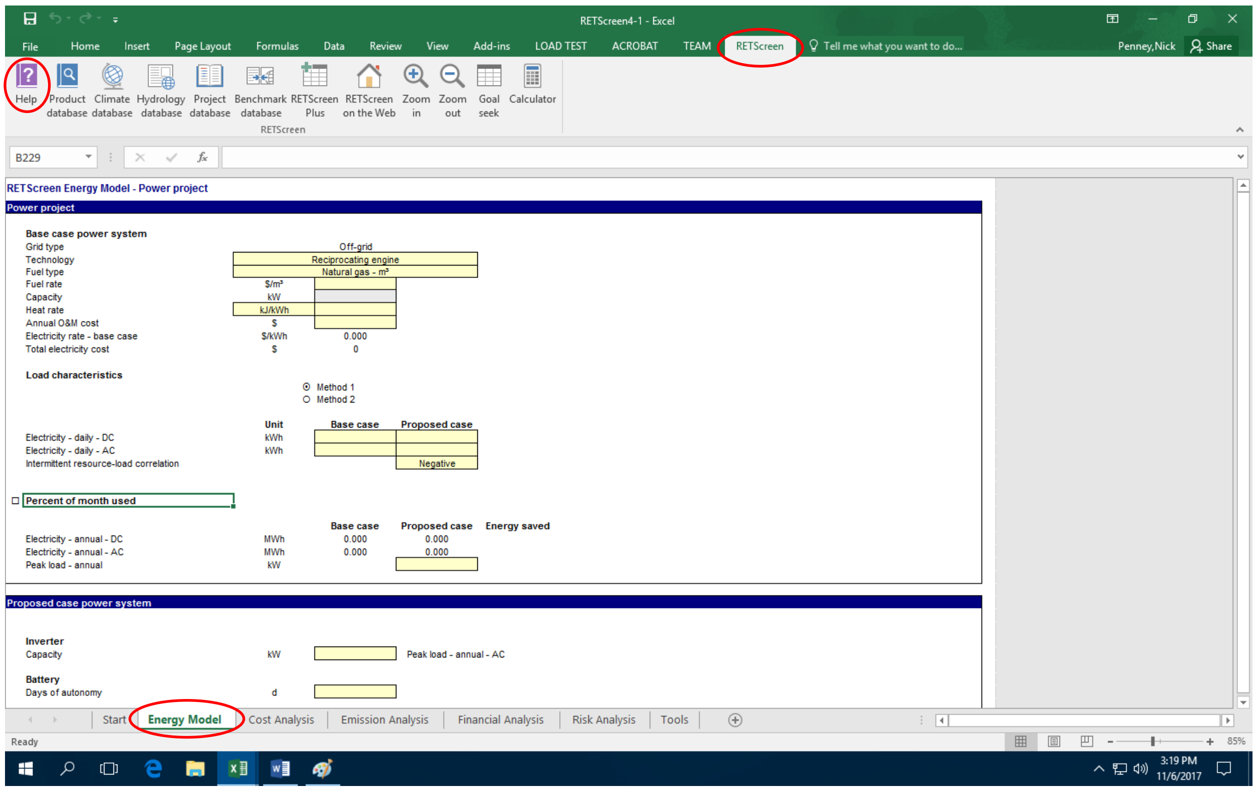
10. ## Climate data location

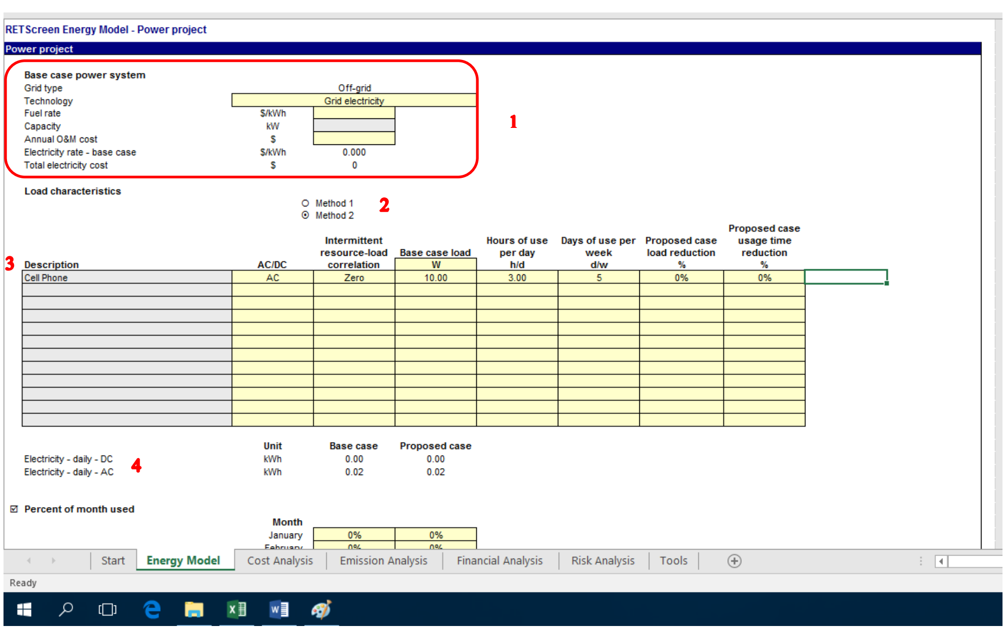
The user enters the climate data location with the most representative climate conditions for the project. This is for reference purposes only. The user should consult the RETScreen Climate Database for more information.

Note that the user has to either select a climate data location via the climate database and paste the data to the worksheet or enter the climate data manually in the yellow and blue cells displayed when clicking on the "Show data" arrow.

Select the location nearest you. See page 6 for more detailed information on this part. In this example we have selected Halifax Int'l. Airport.

Once you have filled in all the required information on the "Start" tab select the "Energy Model" tab at the bottom of the program to continue. A helpful tool in RETScreen is the help button. Which can be found by selecting the RETScreen tab at the start of the page and selecting the help button on the far left of the page. If you select any part of the spreadsheet and then click the help button RETScreen will give you a detailed description of what that part means or advice on what information should be entered there.





1. This section is used if you are comparing your RETScreen design to an existing installation, but since we are putting in a new installation this section can be ignored.
2.

Load characteristics

The user specifies what method of analysis to perform by clicking on the appropriate radio button. If "Method 1" is selected, the user must enter global estimates of the loads. If "Method 2" is selected, the detailed load calculator can be used to specify the load on an item-by-item basis.

Select "Method 2" for our purposes as this gives us access to more information.

3.

Description

The user enters a description of the load. This is for reference purposes only. For example if the load in question is an electric vacuum cleaner the user might enter "Vacuum cleaner."

AC/DC

The user selects whether the load is direct current (DC) or alternating current (AC). For example if the load is a standard electric vacuum cleaner the user would select AC.

Photovoltaic solar panels run off DC, for our purposes select DC in this column.

Intermittent resource-load correlation

The user selects the intermittent resource-load correlation. The three options from the drop-down list are: "Negative," "Zero" and "Positive." The intermittent resource load correlation is a qualitative estimate of how the load is correlated with an intermittent resource, for example the solar energy in the case of a photovoltaic (PV) system.

"Negative" (i.e. negative correlation) corresponds to cases where the load is very irregular or occurs mostly when the resource is not available (e.g. at night in the case of a PV system). In this case, the model considers that the load is always met from the battery. A light used exclusively at night, for the PV system example, falls into this category. "Zero" (i.e. zero correlation) corresponds to steady loads. The model considers that the load is constant throughout the day and is met partly from the battery, partly directly by the power system without going through the battery. A cathodic protection system would fall into this category. "Positive" (i.e. positive correlation) corresponds to loads that are turned on only when there is enough electricity produced by the resource to power them directly. In this case, the model then considers that the load is met directly by the power system and the battery does not play a role. A direct fan would fall into this category. In most cases the intermittent resource-load correlation will be "Negative." Only in very particular cases, such as the ones given in the example, will the intermittent resource-load correlation be "Zero" or "Positive." In the vacuum cleaning example the user will likely enter "Negative."

For our solar bench project select “Zero” in this column. As the bench will most likely be used during sunlight hours.

Base case load

The user enters an estimate of the load. The Typical Loads in a Household table can be used as a guideline for estimating loads encountered in a household. In the vacuum cleaning example the user would enter 800 W.

In our example we are selecting 10 Watts in this column as an average of the wattage of two cell phone chargers plugged in.

Hours of use per day

The user enters an estimate of the number of hours that the load is used during a typical day (h/d). For example, if it takes one half-hour to vacuum the house the user would enter 0.5.

In this column enter the estimated amount of hours you think the solar bench would be used per day. In our example we have selected 3 hours of use per day.

Days of use per week

The user enters an estimate of the number of days during which the load is used per week (d/wk). In the vacuum-cleaning example, if vacuuming is done on Mondays, Wednesdays and Fridays the user should enter 3.

Based on a Monday-Friday school week we would predict that the solar bench would be in use 5 days a week.

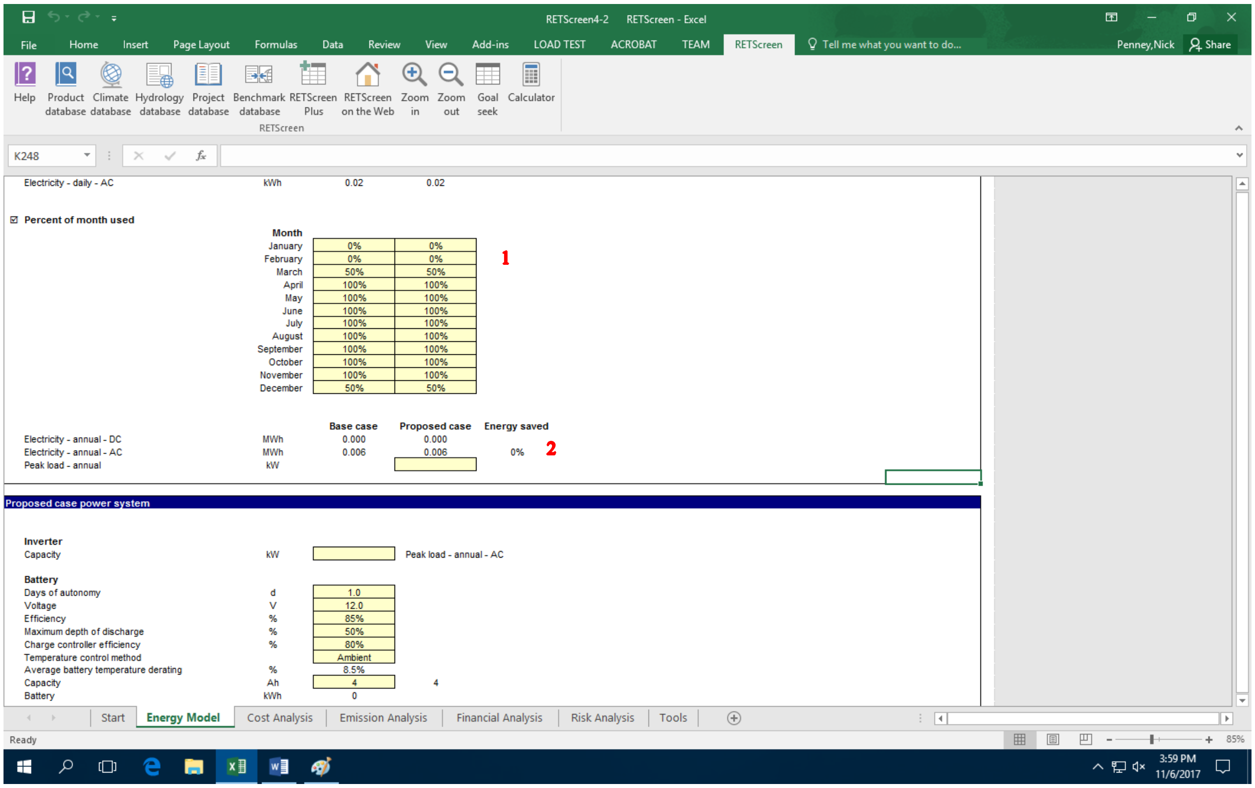
Proposed case load reduction & proposed case usage time reduction

These columns are used to estimate the load reduction from a current system. Because we are building a new installation these columns can be set to 0% and ignored.

4. Electricity - daily - DC

The daily DC electricity is the weekly averaged daily amount of DC electricity required by all the individual loads. If Method 1 is selected, the user enters this value for the base case and the proposed case. If Method 2 is selected, the model calculates this value for the base case and the proposed case. Values can range from zero (if the entire load is AC) to a few tens of kWh or more.

This value is calculated for you automatically based on the information entered into the chart in step 3.



1.

Percent of month used

The user indicates by ticking the box whether or not the load varies on a monthly basis, from the daily average values entered above. If the user ticks the box, monthly values can be adjusted up or down. For example, a cottage might only be open during the summer, so the winter months would be entered as 0% indicating that there is no load during those months. If the user does not tick this box then the model assumes that all months equal 100%.

Check this box then enter your estimated usage percent by month. For example as the weather gets colder in the fall and into winter the bench would probably see less usage. Where 100% usage would be the usage amount entered in the chart above.

2.

Electricity - annual - DC

The model calculates the annual DC electricity, which is the weekly averaged annual amount of DC electricity required by all the individual loads, for the base case and the proposed case.

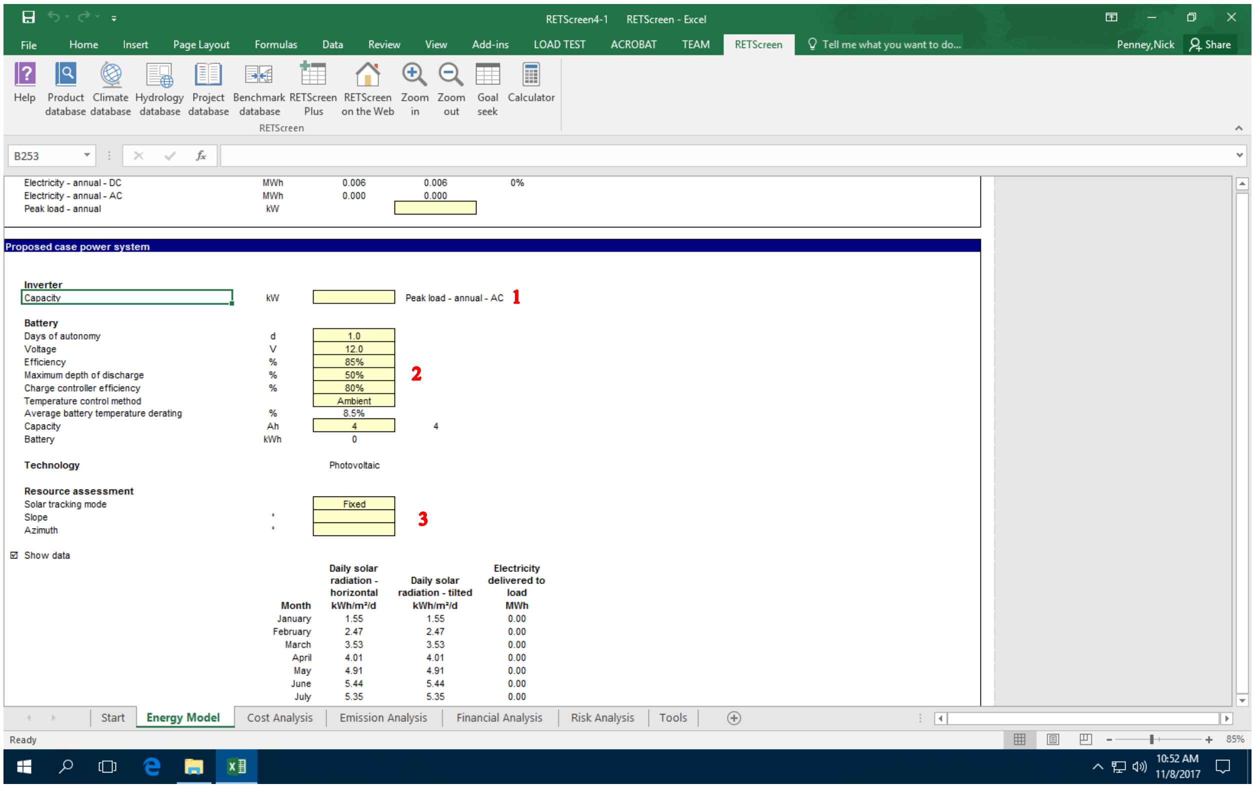
If Method 1 is selected as the "Analysis type" in the *Start* worksheet, the user should enter the incremental initial costs or credits (negative value) as a result of implementing the proposed case end-use energy efficiency measures (e.g. proposed case load and/or usage time reduction). Note that if the incremental costs are nil, i.e., the costs for the proposed case are equal to those that would have been spent for the base case, the user should enter 0. If Method 2 is selected as the "Analysis type" in the *Start* worksheet, then the user would enter these incremental costs in the *Cost Analysis* worksheet under the "Energy efficiency measures" cost item.

This value is calculated for you automatically based on the information entered above.

Peak load - annual

The user enters the annual peak load for the proposed case system, which is the maximum power drawn at any time during one day by the load. This value is used to help determine the capacity of the proposed case power system required to meet the load. If all AC and DC loads occur simultaneously, this value corresponds to the sum of all AC and DC loads. However, in practice, some of the loads will be on at varying times, thus reducing the maximum power required from the power system. If this is the case, the user might want to enter a lower value.

This is the max power load required by the system at one time. For our solar bench project enter the number calculated for you in the “Electricity – annual – DC” cell.



1. Inverter

This section refers to what size inverter is needed when converting from DC to AC. Since our solar panel produces DC and we are running a DC charger there is no conversion going on. So this section can be ignored.

2. **Days of autonomy**

The user enters the size of the battery, expressed in days of autonomy (d). In other words this is the number of days that the system, starting from a state of full charge, would be able to meet the load using the batteries only.

Depending on site conditions and system characteristics, values usually range from a couple of days to 10 days. Systems with a few days of autonomy will have a poor availability or rely more on the peak load power system, if there is one. Systems with many days of autonomy will have greater availability or use the peak load power system (if there is one) less often.

This is the amount of days you want the system to run with no sun coverage (no charging happening). For our example we have selected one day of autonomy.

Voltage

The user enters the nominal voltage of the batteries to be used, in V.

Typical battery voltages are 6, 12, 18, 24, 36, 48, or 72 Volts. The nominal battery voltage has no influence on the energy predictions of the model; it is simply used to convert battery capacity from Ah to Wh, according to the relationship: Wh = V x Ah.

This is the nominal voltage level of the batteries you are using. Our batteries are 12V. For our example we have selected 12V.

Efficiency

The user enters the average efficiency (%) of the battery, as specified at the nominal temperature of 25°C. In the absence of information from the battery supplier, an efficiency of 85% may be used.

This is how efficient your batteries are. This can be obtained from your batteries manual. Or in the absence of that you can use an average efficiency of 85%.

Maximum depth of discharge

The user enters the percentage of the rated battery capacity that can be withdrawn repeatedly without abnormal loss of battery life.

The maximum depth of discharge depends on the size and type of the battery. In the absence of additional information (for example from manufacturer's data) the user can refer to the values in the Maximum Depth of Discharge for Rechargeable Batteries table.

This is how far between fully charged and empty you want your batteries to drain. Some batteries are not designed to drain close to empty while others are. What you enter here will depend on the batteries you are using. In our example we have selected 50% discharge.

Charge controller efficiency

The user enters the average efficiency of the charge controller, in %. A default value of 95% is suggested. Because controllers often draw a fixed current from the system - regardless of its size, controller efficiency tends to be higher in larger systems and lower in smaller systems.

This is the efficiency of your charge controller, which can be found in your charge controller's manual. If this data is not available you can use an average efficiency of 95%.

Temperature control method

The user enters the type of temperature control applied to the battery. The options from the drop-down list are: "Ambient," "Constant" and "Minimum." This is used to derate the battery capacity according to the temperature conditions it experiences.

The user may select "Ambient" if the battery is subject to fluctuations in outdoor temperature, for example if the battery is located in a non-insulated shed. If the battery is kept at a constant temperature, for example if it is located in the basement of a house, the user may select "Constant." The user may select "Minimum" if the battery follows the fluctuations of outdoor temperature except when it falls below a certain level, for example if the battery is located inside a phase-change box or if the battery is heated.

This is what the temperature of the battery is, you may select “Constant” if the battery is an area with controlled heat. “Ambient” if the battery is located outside, like in a solar bench. “Minimum” can be selected if the battery is operating constantly at its lowest operating limit.

Average battery temperature derating

The model calculates the loss of nominal (25°C) battery capacity resulting from temperature conditions experienced by the battery. This value is averaged over the season of use.

Battery derating depends mainly on the temperature at which the battery operates. Lower temperatures result in a larger temperature derating.

If the battery is kept at a constant temperature of 25°C year round, the battery temperature derating is zero. It can reach as high as 30% or more if the battery operates part of the year at very low temperatures.

This cell auto-fills based upon your entered temperature control method. The percentage displayed is how far below 100% max efficiency your battery is working based on the temperature it's subjected to (ex: 8.5% displayed indicates the battery is working at 92.5% efficiency.)

Capacity

The user enters the actual nominal capacity of the battery bank, in Ah.

The model calculates the suggested nominal capacity of the battery bank, in Ah. This value is displayed in the cell to the right of the input cell. This is the capacity that would provide the system with the autonomy specified by the user in the "Days of autonomy required," given the temperature conditions experienced by the battery. Values can range from less than one hundred Ah for small systems (e.g. on board electricity for recreational vehicles) to several thousand Ah for large systems requiring high availability (e.g. radio repeaters).

The model assumes discharge rates typical of renewable energy systems, i.e. C/20 or slower. The user should note that a faster than normal discharge rate will reduce the actual battery capacity.

By default the user will likely enter the suggested nominal capacity calculated in the model. However, if the user has a specific battery model in mind, the user should enter a multiple of the nominal capacity specified by the manufacturer.

Here you enter the nominal Amp Hours (Ah) of your battery bank. RETScreen displays a suggested Ah rating to the right of the cell, this is calculated on the values you've entered in this section. It's recommended to enter the suggested Ah rating. You could enter a higher number if you desire more battery capacity is required.

3.

Solar tracking mode

The user selects the type of sun tracking device upon which the solar collector is mounted. The options from the drop-down list are: "Fixed," "One-axis," "Two-axis" and "Azimuth." If the solar collector is mounted on a fixed structure the user may select "Fixed." The remaining choices may be selected if the solar collector is mounted on a tracker.

A tracker is a device supporting the solar collector which moves the collector in a prescribed way to minimise the angle of incidence of beam radiation on the collector's surface. Hence incident beam radiation (i.e. solar energy collected) is maximized. Solar trackers may be classified as follows:

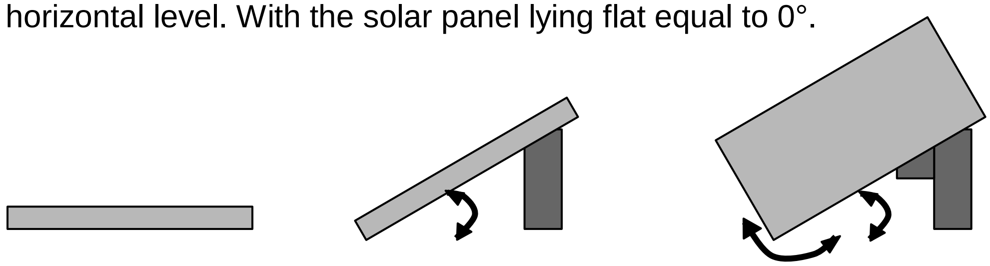
- **One-axis trackers** track the sun by rotating around an axis located in the plane of the collector. The axis can have any orientation but is usually horizontal east-west, horizontal north-south, or parallel to the earth's axis;
- **Azimuth trackers** have a fixed slope and rotate about a vertical axis; and
- **Two-axis trackers** always position their surface normal to the beams of the sun by rotating about two axes.

Here you enter your tracking mode. For our solar bench the solar panel will be in fixed position. Enter "fixed" here.

Slope

The user enters the angle between the solar collector or the tracking axis and the horizontal, in degrees.

In this section you will enter the angle of your solar panel compared to horizontal level. With the solar panel lying flat equal to 0°.

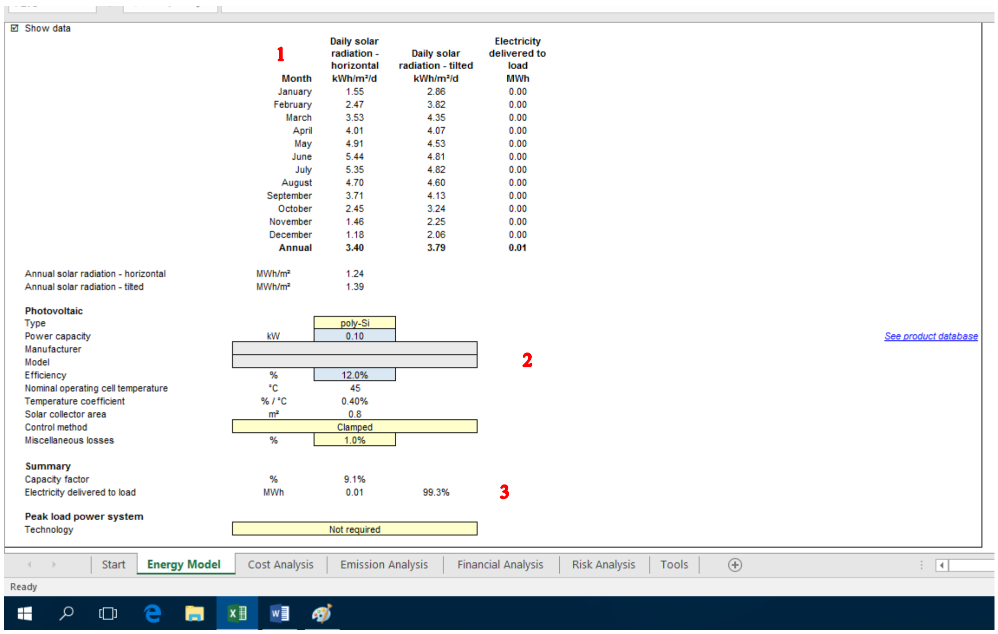


Slope 0° Azimuth (n/a) | Slope 30° Azimuth 0° | Slope 30° Azimuth 30°

Azimuth

The user enters the angle between the projection, on a horizontal plane, of the normal to the surface and the local meridian, with zero due south (for the purpose of this model, the sign has no importance).

In this section you will enter how far in degrees the solar panel is facing from due south. With due south being 0°.


Show data

1

Month	Daily solar radiation - horizontal kWh/m²/d	Daily solar radiation - tilted kWh/m²/d	Electricity delivered to load MWh
January	1.55	2.86	0.00
February	2.47	3.82	0.00
March	3.53	4.35	0.00
April	4.01	4.07	0.00
May	4.91	4.53	0.00
June	5.44	4.81	0.00
July	5.35	4.82	0.00
August	4.70	4.60	0.00
September	3.71	4.13	0.00
October	2.45	3.24	0.00
November	1.46	2.25	0.00
December	1.18	2.06	0.00
Annual	**3.40**	**3.79**	**0.01**

Annual solar radiation - horizontal	MWh/m²	1.24	
Annual solar radiation - tilted	MWh/m²	1.39	
Photovoltaic			
Type		poly-Si	
Power capacity	kW	0.10	
Manufacturer			
Model			
Efficiency	%	12.0%	
Nominal operating cell temperature	°C	45	
Temperature coefficient	% / °C	0.40%	
Solar collector area	m²	0.8	
Control method		Clamped	
Miscellaneous losses	%	1.0%	
Summary			
Capacity factor	%	9.1%	
Electricity delivered to load	MWh	0.01	99.3%
Peak load power system			
Technology		Not required	

2

See product database

3

1. **Data**

This section shows the average daily solar radiation received by your solar panel for each month of the year. The two columns list the tilted daily solar radiation which is based on your slope and azimuth entered in the previous step. And the horizontal solar radiation which is if the panel was laying at a horizontal level.

2 Type

The user selects the type of PV module considered for the application. The seven options from the drop-down list are: "mono-Si," "poly-Si," "a-Si," "CdTe," "CIS," "spherical-Si" and "Other." The Nominal Efficiencies of PV Modules table presents a comparative summary of the different types of modules.

The PV module type selected will depend on a number of factors, including: price from suppliers, product availability, warranties, efficiencies, etc.

Power capacity

The user enters the power capacity. The percentage of the power capacity over the proposed case power system peak load is calculated.

Here you enter the power capacity of your solar panel in Kw. In our example we have a 100W panel so we enter 0.1Kw.

Manufacturer and model

Here you can enter the manufacturer and model of your solar panel. This is just for reference purposes and has no impact on the calculations.

Efficiency

The user enters the nominal efficiency (%) of the PV module under consideration.

Here you enter the efficiency of your solar panel. This information can be obtained from your solar panel's manual.

Nominal operating cell temperature

The model calculates the Nominal Operating Cell Temperature (NOCT), in °C. NOCT is defined as the module temperature that is reached when the PV module is exposed to a solar radiation level of 800 W/m^2, a wind speed of 1 m/s, an ambient temperature of 20°C, and no load.

This value is generated automatically based upon what was entered as your solar panel type.

Temperature coefficient

The model calculates the PV temperature coefficient for module efficiency.

In the case where the user selects "Spherical-Si" or "Other" under PV module type, the user enters the temperature coefficient of the PV module efficiency. (Note that, if the temperature coefficient of the PV module efficiency is not available, the user can enter the temperature coefficient for the maximum power.) The efficiency of photovoltaic cells varies with their operating temperature. Most cell types exhibit a decrease in efficiency as their temperature increases.

This value is calculated for the user automatically based upon what type of solar panel was selected.

Solar collector area

The model calculates the area that will be covered by the PV array. This is simply the PV array power capacity divided by the nominal module efficiency. The user should verify the value calculated by the model. If the PV array is mounted on a wall, the required array area should not exceed the surface available on the wall. For roof-mounted systems, the size should not exceed approximately half the total roof area. For ground-mounted systems, the size is limited only by the available land area.

This value is calculated automatically and gives the user the approximate size of the required PV array. This is good if you have limited space available and need to fit your PV array in a small area.

Control method

The user selects from the drop-down list the type of PV array controller that is used to interface the PV array to the rest of the system. A Maximum Power Point Tracker (MPPT) is an electronic device used to maintain the operating voltage of the array at a value that maximises array output, regardless of changes in load impedance or changes in array operating conditions due to variations in temperature or insolation. If the user selects "MPPT," the efficiency of the array will be optimal. A "Clamped" PV array controller is a direct connection between the array and the batteries; in this configuration the array operates at the voltage set by the battery. This may not be the optimal voltage for the array and therefore its efficiency will be lower.

Here you select what type of charge controller you have for your PV array, either “clamped” or “Maximum Power Point Tracker”. You can obtain this information from your charge controller’s manual.

Miscellaneous losses

The user enters array losses (%) from miscellaneous sources not taken into account elsewhere in the model. This includes, for example, losses due to the presence of dirt or snow on the modules, or mismatch and wiring losses. Typical values range from a few percent to 15%. In some exceptional circumstances (e.g. very harsh environment) this value could be as high as 20%.

In this section you enter any other losses not taken into account. In our example we have entered 1%.

3. Capacity factor

The model calculates the capacity factor, which represents the ratio of the average power produced by the power system over a year to its rated power capacity. Typical values for photovoltaic system capacity factor range from 5 to 20%.

This value is calculated for you automatically for you by RETScreen.

Electricity delivered to load

The model calculates the electricity delivered to the load by the power system.

The percentage of the electricity delivered to the load over the proposed case power system electricity use is also calculated.

This percentage is how much of the maximum load required is being generated by the solar panel. This value should be as close to 100% as possible. Most likely you will only reach 99% at the most. If this value is too low you will have to increase your power capacity by choosing a higher wattage solar panel.

Power Requirements

There is an important thing to know when designing a charger. How much power do we need to charge? In an electronic device, the part that uses power is known as the load. Here we will figure out how much power our load (mobile device) requires.

What are our load requirements?

- Charge 1 USB cellphone
- 3 Hours of use per day
- Use 5 days of the week

How much power does a cellphone charger use?

Phone chargers are USB devices with a nominal voltage of 5 volts direct current

To determine how much power we need, we'll have to guess how much current the average phone might use while charging. Different phones have different charging capabilities, but the newest USB charging standard is 1.5 amps. While 1.5 amps is the standard, many phones are capable of charging at 2 amps. For example, the standard charging current of a new apple device is 2.1 amps.

Since most devices can charge at 2 amps, we will use a charger capable of that. There is no need to worry about harming the device we are charging, since it will only draw as much current as it can handle. To calculate how much power our charger will use we just need to use a simple formula:

$$P = V \times I$$

Where:

P = Power, **V** = Voltage, **I** = Current

So, if we are charging at 5 volts at a current of 2 amps, we can find our total power in watts:

$$5\,Volts \times 2\,Amps = 10\,Watts$$

RETScreen Load Characteristics

Now that we know how much power our load will be using we can enter our information into RETscreen. Doing this will allow RETscreen to tell us how large our battery should be and how many watts our PV panel will have to produce. Here's how:

1. Go to the "Energy Model" page
2. In "Power Project" section, select method 2 under Load characteristics
3. We will call our first and only load entry "5V USB charge" in the description box
4. Since USB chargers use DC voltage, select DC in the "AC/DC" selection box
5. For "Intermittent resource-load correlation" select zero
6. Now enter the total load power into the "Base case load" (The result we found with the power formula on the last page)
7. We plan on running the bench for 3 hours a day, enter this value into to "Hours of use per day"
8. The bench should run for 5 days of the week, so we enter this into "Days of use per week"
9. Enter 0 into "Proposed case load reduction" and "Proposed case usage time reduction". These values are used to compare power systems, something we are not concerned with
10. Our last step is to indicate what time of year the bench will be in use check the box that says "Percent of month used" under the load characteristic list
11. Since we expect no use in the winter we will enter these values into our monthly use percentages. Be sure to put the listed value in both boxes next to the month

    January = 0%
    February = 0%
    March = 50%
    April = 100%
    May = 100%
    June = 100%
    July = 100%
    August = 100%
    September = 100%
    October = 100%
    November = 100%
    December = 50%

Here’s what our final load characteristics should look like

Load characteristics

○ Method 1
◉ Method 2

Description	AC/DC	Intermittent resource-load correlation	Base case load W	Hours of use per day h/d	Days of use per week d/w	Proposed case load reduction %	Proposed case usage time reduction %
5V USB Charge	DC	Zero	10.00	3.00	5	0%	0%

	Unit	Base case	Proposed case
Electricity - daily - DC	kWh	0.02	0.02
Electricity - daily - AC	kWh	0.00	0.00

☑ **Percent of month used**

Month		
January	0%	0%
February	0%	0%
March	50%	50%
April	100%	100%
May	100%	100%
June	100%	100%
July	100%	100%
August	100%	100%
September	100%	100%
October	100%	100%
November	100%	100%
December	50%	50%

Start | **Energy Model** | Cost Analysis | Emission Analysis | Financial Analysis | Risk Analysis | Tools

Supplies and Component Layout

Materials:

Safety Glasses

Battery

Charge Controller (We recommend one that will control the power to the load)

Solar Panel

Marretes (twist on connectors), and or other electronic connectors as required

Wire strippers

Various screwdrivers

Battery:

The battery we are using for our solar build is a Lead Acid type. Lead Acid type batteries have been around for over 100 years.

In our design an AGM (Absorbed Glass Mat) is used. The advantage for using an AGM type is that there is not fluid to spill and they are maintenance free.

The battery is rated in volts (in our case 12) and in Ahr (Amp hours).

12 volts is a common standard voltage and easily found.

The Ahr rating is based on a 20 hour time period where the battery will deliver the rated Amps.

If the battery is rated at 10Ahr, it will deliver 10Amps for 20 hours. At that time the battery will have started at 100% charge and end at 0% charge.

Charge Controller:

A charge controller is a piece of equipment that takes the energy from the solar panel and gives it to a battery.

Charge controllers are matched to the correct range of solar panel voltage and amperage, to the correct battery type and voltage.

It also takes the battery’s energy in this case, to the charge controller’s output to supply energy to our 12 volt USB charger.

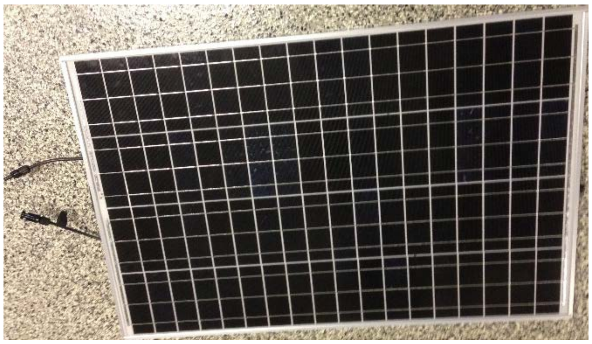
SAFETY:

Some safety guidelines and practices when working with the AGM battery for the solar build:

- Keep metal objects including jewelry away from the battery terminals.
- Wear safety glasses.
- Make sure meat objects including tools do not fall or touch both of the battery terminals.
- Ensure wires that are being connected to the battery are already connected to the desired location on their other ends before connecting to the battery.
- Inspect wire ends for frayed strands, and connectors for broken edges.
- Use proper wrench or screwdriver when tightening battery terminals.
- Inspect wire ends for frayed strands, and connectors for broken edges.
- Do not use excessive force when tightening battery terminals.

Circuit Diagram

Connect the components in your circuit to the negative and positive side of your battery. Draw the positive and negative connections. Remember: In this case the charge controller's uses the battery voltage to power the load (USB ports).



Solar Panel

IN

Charge Controller

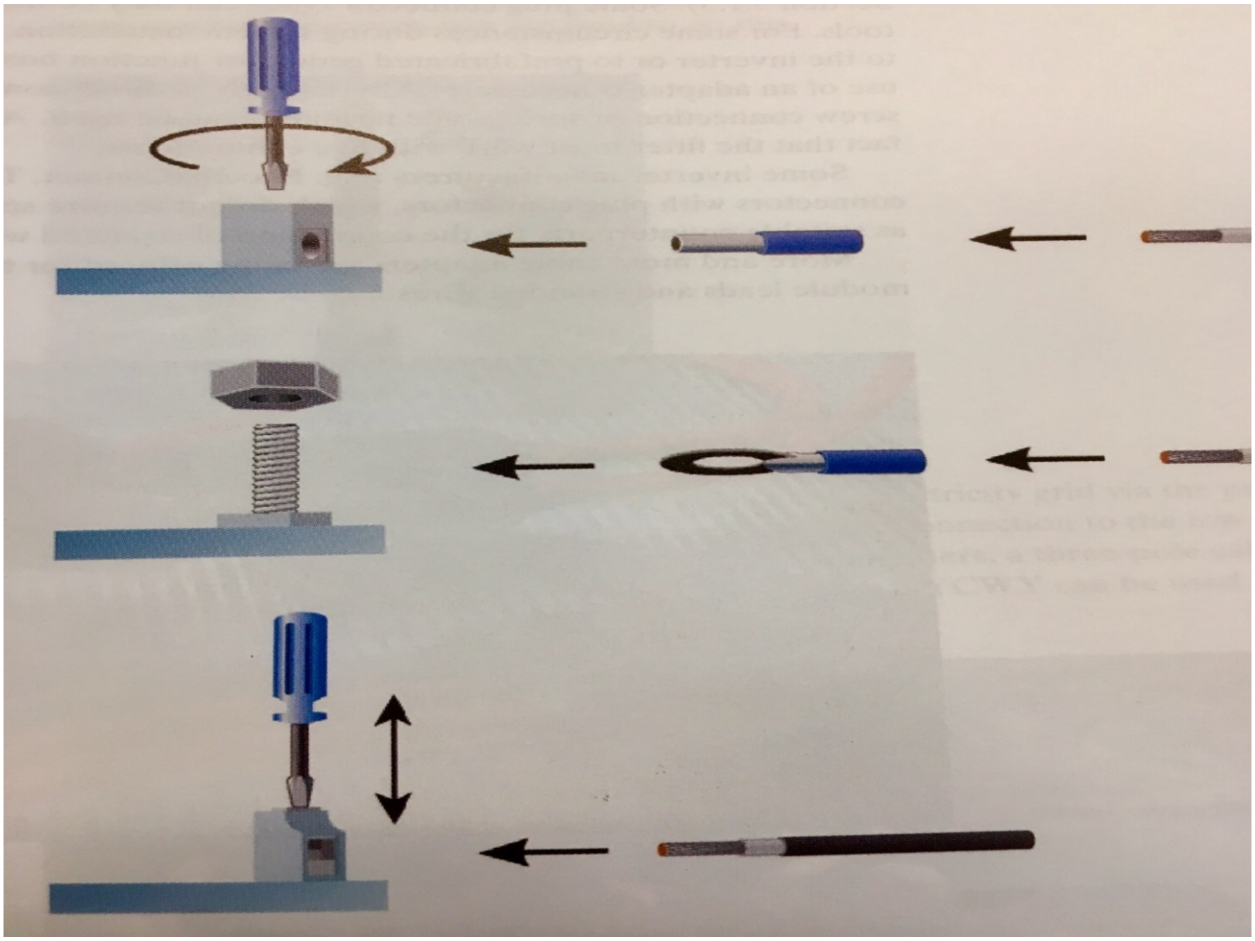
OUT

LOAD

USB Ports

Battery

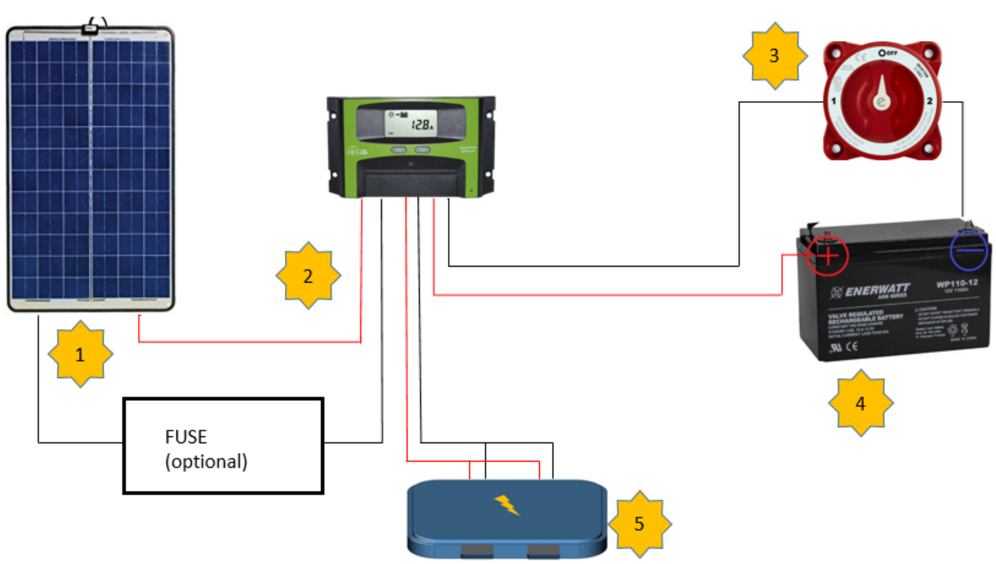
Note: Before we begin assembly, take a moment to identify the types of connectors used in your wiring layout, as some companies may differ in the type of materials provided. Depending on the connection, you may need a wrench, screwdriver, or some other component in able to make a secure connection.



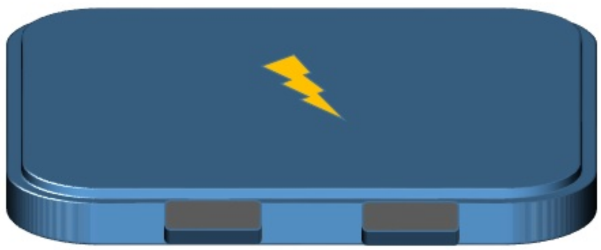
Assembly:

Please refer to your circuit schematic and make any corrections if required.

1. Attach either the red or black wire coming out of your solar panel to a compatible fuse box assembly. It can be either one, as long as it is part of the circuit. (Step optional; this is a low voltage project. Fuses will supply added protection to your equipment in case of over current)
2. Connect your red and black cables from the panel and the fuse box to the indicated points on your charge regulator. The connection points should be clearly indicated on the terminals.
3. It is not required, but adding an on/off switch to any circuit is a good idea, particularly if you need to stop the flow of power for any reason.
4. While the power switch is off, connect your battery terminals. Since these are outdoor batteries, applying a small amount of petroleum jelly (Vaseline) to the exposed metal terminals will help prevent corrosion.
5. A good charge controller will also be connected to the load and provide the batteries stored energy to power it. In this case connect the USB ports to the charge controller load outputs.



All-weather USB smartphone
charging interface



Weatherproofing your Charge Station:

Materials:

Hinged outlet box (these are usually of a suitable size to house two USB charging ports), length of rubber hose or similar material about 2mm in diameter, or optionally, a sheet of 2mm craft foam. You will also need an exact-o knife, epoxy or hot glue gun, silicone caulking, handheld drill or small set of cutting pliers, sponge or flexible craft foam material about 1 cm thick. You may also want Tremclad all-weather paint (optional), and will need 2 small magnets.

Discussion:

Some people may be able to source a ready-made charging box for their solar charging station. For those that don’t, here are some helpful instructions to make your own:

These solar charging stations will be outside seven days a week, 365 days a year. Like all things outside, they will be exposed to different sorts of weather all year, including the moisture from snow and rain.

Many electronics are sensitive to corrosion, which is the breaking down of a metal over time. Moisture can actually help to accelerate this process, so keeping your electronics away from as much moisture as possible is important. Corroded electronics do not function as efficiently as non-corroded ones, and may stop working altogether.

Our charging station will use several materials to help prevent this from happening. First, we will be using sealants, or materials that prevent moisture from getting in. Sealants prevent this by creating a barrier that water and moisture cannot get through easily. We will also use foam or some other spongy material to help keep more moisture out, thirdly we will have the option to create an additional barrier between the exterior metal and the air by painting some of the exposed surfaces. This will also create a barrier between metal and moisture.

We will also use a magnetic lock on this charging box. The small magnets will make it easy to keep the device closed, but won't make it difficult to open by hand. Leaving the box open will eventually undo any of the attempts made to weatherproof it, so having a magnetic latch on the front will help this to happen automatically.

Charging box selection.

First, select a hinged box that will comfortably accommodate the diameter of two USB charging jacks. You may choose to measure the diameter to see if you have a good fit, but it may be easier to place one inside the box to see if it closes comfortably. Also remember that you will be cutting holes in this box, so you may prefer to go with plastic instead of wood or metal.

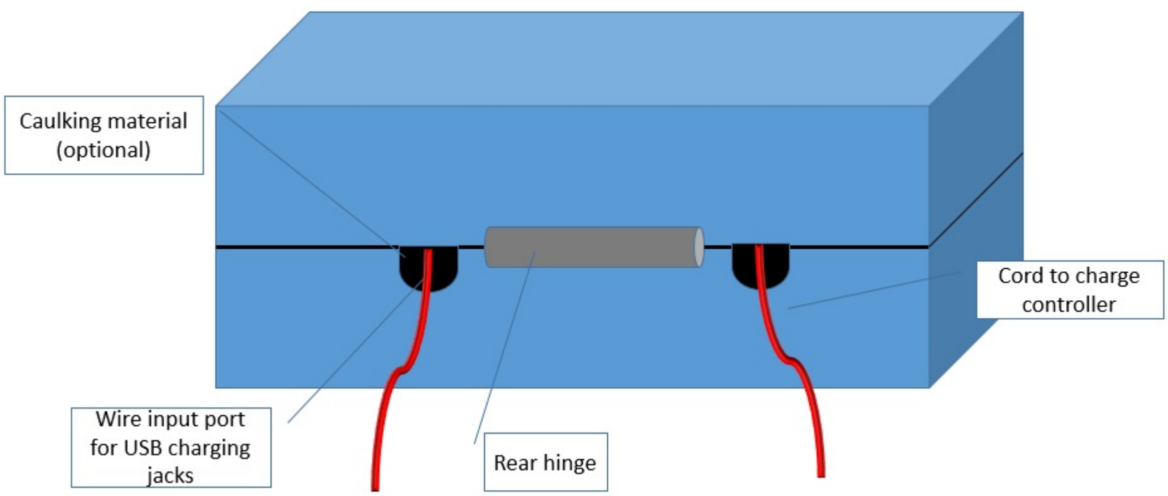
Wire ports:

There are going to be places for two pairs of wires to go into the charging box: two from the USB charging ports themselves, mounted in the rear, and two from the smartphones that can be connected for charging.

Rear ports -cutting:

Two holes will need to be made in the back of the box for installation of the wires that connect to the USB charging ports. With a marker, outline two circles about the diameter of a drinking straw (1.5 cm) along the lower half of the box where the top and bottom meet. Ideally, these will be centered at equal points from the center, but placed so that they won't interfere with the operation of the hinges. It is recommended that these marks only be made on the lower half of the box. Once you are satisfied with their position, take your cutting tool and cut along the line to create your holes.

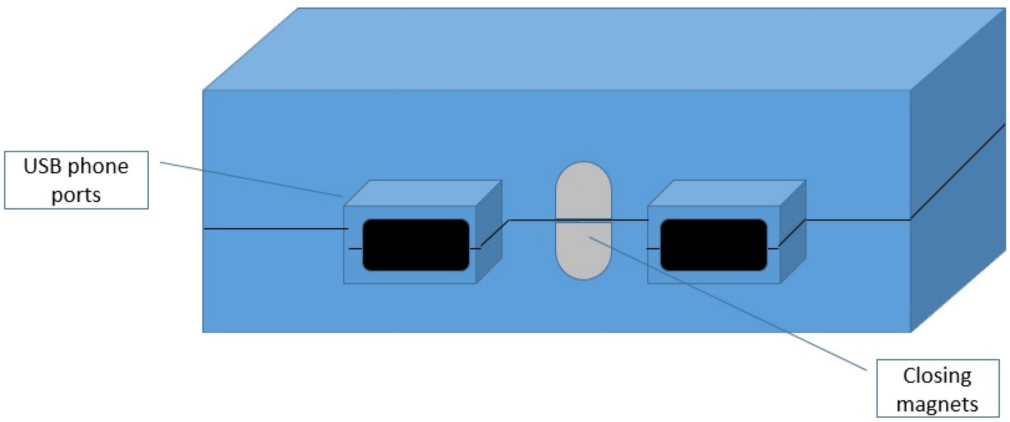
Charger interface – rear view



Front ports -cutting:

The front of your charging box will also require two holes for the smartphone charge cables. Again using the marker, outline two rectangles about 1.5 cm long by 1 cm deep along the lower edge of the box front, giving ample space for the center, where we will be attaching our magnetic lock. Once you are satisfied with location, again, make your cuts.

Charger interface – front view



Magnetic lock:

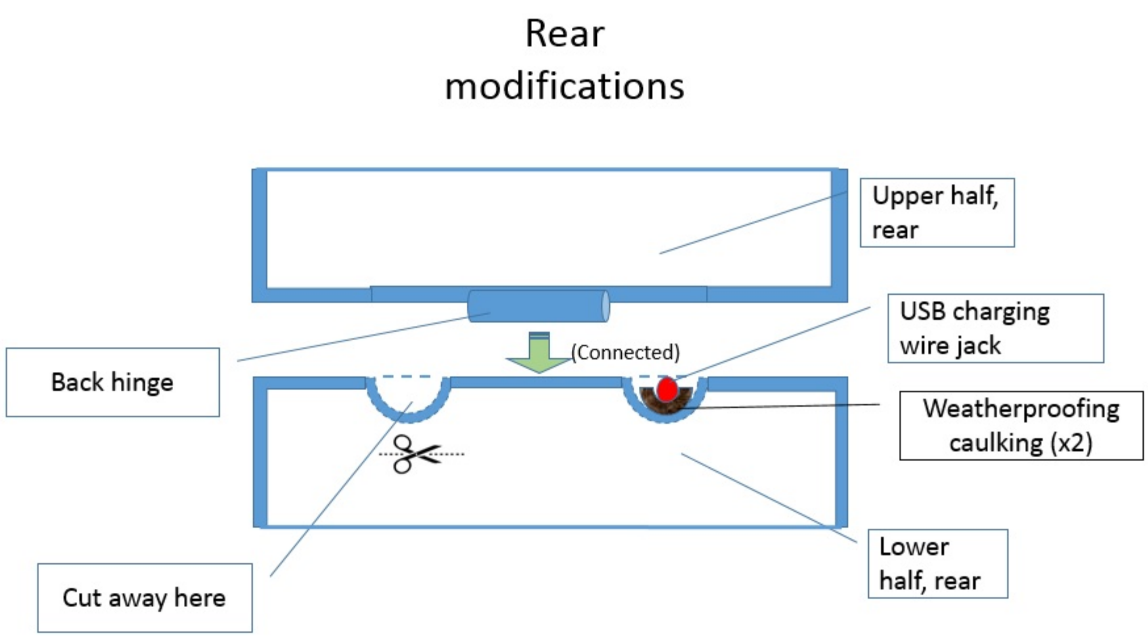
Take your two small magnets, and mount them with epoxy/glue on the inner upper and lower center of your box front. (Important! Before you finalize their positions, make sure that the magnets are oriented so that they attract each other. Repelling magnets will not work.)

USB charging ports (rear):

Set your two USB charging jacks inside of the lower box, seating the cord for each one in one of the newly cut holes in the back of the box near the hinge, allowing for about 2 cm of wire length inside, between the wall and the USB port housing.

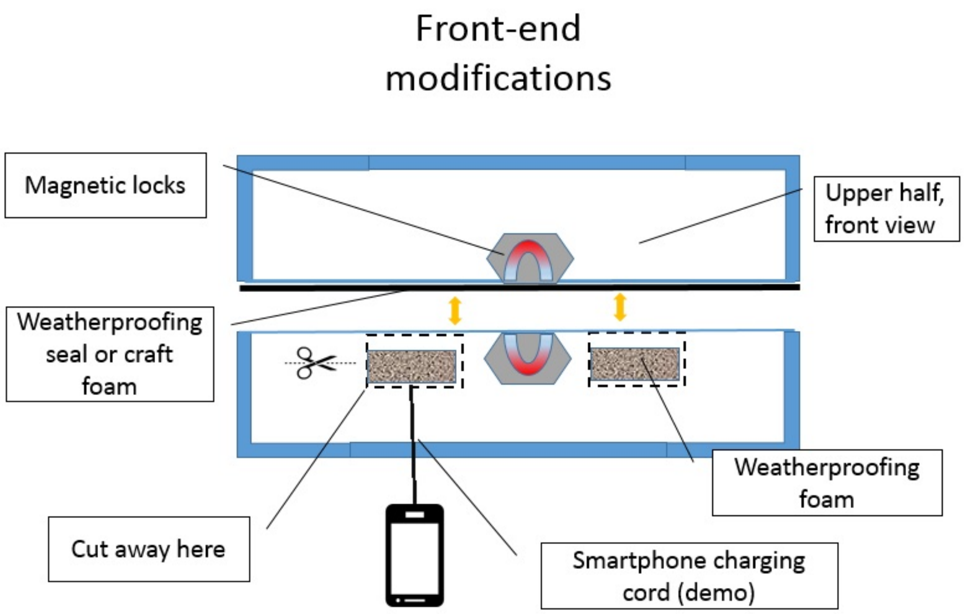
[NOTE: Should you chose to paint your USB outlets, you may paint everything except the metal surfaces inside the metal rectangles, as these must remain free of obstruction in order to operate properly.]

Once you are satisfied with how they are sitting, apply a small amount of silicone caulking to the hole, allowing it to fill any gaps between the wire and the wall of the charger box. Try to keep it level with the height of the lower box lid, and wait until it has set before you attempt to close the lid.



USB charging ports (front):

You now have two holes large enough to fit charging cables through, as set out in the previous segment, but now you will need to add some basic weather-proofing to your ports. At this point, cut two small segments of flexible craft foam or sponge to match the size of the holes cut in the front of the box. Attach them with epoxy, and allow them to set before moving them or attempting to close the box. The soft sponge will allow for the addition of wires through the ports, but will still provide basic weatherproofing.



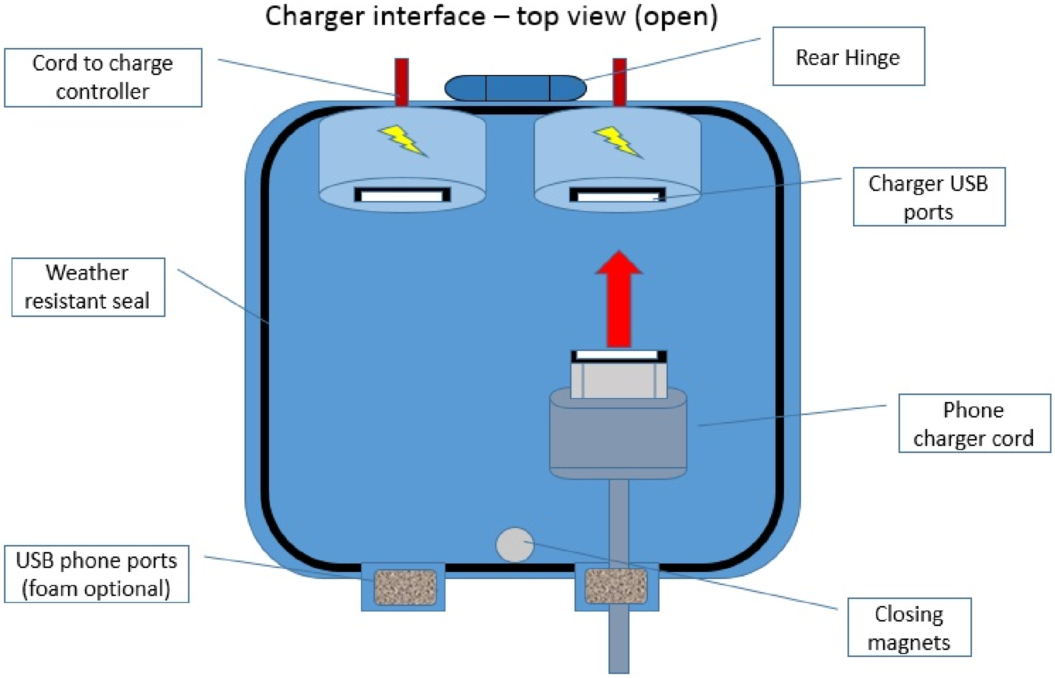
Final weatherproofing:

NOTE: Test fit either the craft foam or tubing before adding final epoxy, in order to ensure you have a good fit. If your seal is too thick, the box won't close properly.

Option A: Rubber tubing. Using your lid as a guide, lay the rubber tubing along the lip of your upper or lower box edge, routinely adding dabs of epoxy to anchor the tubing in place. Cut it to size with your epoxy knife, and allow it to set before closing the box.

Option B: Craft foam. Using the upper or lower half of the box as a guide, trace the outline of your box on the 2mm sheet of craft foam. Cut it to the desired shape to match the box ridge, and attach it in place with epoxy. Again, allow it to set before closing the box.

Charger interface – top view (open)



Solar Bench Maintenance Guide

This is a step by step maintenance guide for making sure your solar bench is running as intended. This guide will also be referred to if your solar bench were to ever fail in its operation. Keep this guide for instruction to use with the included troubleshooting flow chart.

STEP 1 – USB ports

- VISUAL INSPECTION - When looking at the USB ports they may develop rust over time, this normal. When looking at the physical wire connections to the USB ports there should be no corrosion. If there is this could lead to future problems and should be replaced.
- VOLTAGE – At the **soldered connection** to the USB port there should be a measured voltage of 12-15 Volts. If that is not the voltage measured, measure the voltage of the physical connection at the charge controller. If there is the right amount of voltage there and not at the USB connection there is an issue with that physical connection and that should be changed. If there is also no voltage at the charge controller connection this may indicate that the problem is before this connection.

STEP 2 – Charge Controller

- VISUAL INSPECTION – All physical connection points should have minimal corrosion and should be nice and tight. The **Power** LED should be lit and the charge controller should also indicate that it is **charging**. If the **Power** LED is not lit your charge controller is not getting any voltage (refer to step 3). If the Power LED is on but the Charging LED is not the batteries could be fully charged by the PV solar panel.
- VOLTAGE - To check this, measure the voltage at the battery inputs on the charge controller, you should measure a voltage around 11-15 Volts. This voltage indicates the batteries are at their max voltage and no longer need charging. If the voltage measured at the battery input connections is below 11 Volts there may be a problem between your charge controller and the PV panel (Refer to step 4).

STEP 3 – BATTERIES

- VISUAL INSPECTION – The batteries should have minimal corrosion and no damage. All connections should be tight and the 2 batteries should be in parallel.
- VOLTAGE – The voltage at the batteries should measure 15 Volts when fully charged. This voltage decrease overtime while the bench is being used until the voltage level gets to around 12 Volts. When the voltage drops to this level the battery will then begin charging again. If the voltage level is far below the batteries assumed minimum level, this could indicate that the batteries are not being charged correctly. (Refer to step 2 and 4).

STEP 4 – SOLAR PANEL

- VISUAL INSPECTION – The panel should have no cracks, fractures, dents or breaks on its hardware. The wires traveling from the panel to the charge controller should have no frays or cracks in the shielding. There should be minimal corrosion on the physical input and output connections and they should be kept nice and tight.
- VOLTAGE – For voltage rating on the solar panel, check the spec sheet for your type of solar panel being used.

TROUBLESHOOTING FLOW CHART

This flow chart is an easy to follow step-by-step guide to help you discover an issue with your Solar Bench. By flowing this guide answering YES or NO to each corresponding question you will be led to an end point with your Solar Bench's issue. At each end point you will be asked to refer to a step in the maintenance guide that is attached that will direct you to the section that contains information about your occurring problem. Use this flow chart and maintenance guide for help in any troubleshooting scenario.