Introduction to "Solar on a Budget" Class

Instructor: Jonathan Surmi, Electronics Engineer

This class will cover power conservation, a solar power budget for your home, off-the-shelf solutions vs. a DIY solution, and finally, this class will introduce the DIY ***Simple Safe Solar,*** *home solar/battery backup system. This system is designed around 410Watts of solar panel power, a 4800Whr battery bank, and a 3500Watt 24VDC-110VAC modified sine wave inverter. This system costs a little over $2500 to put together in 2012, and is designed to be a long-term backup power resource for the average household. All class participants will receive the complete* ***System Wiring Diagram****,* ***Parts List****,* ***Power Conservation Guide****, and* ***Solar Power Budget Worksheet*** *for FREE. A complete walkthrough of the design including step-by-step video instructions of the system wiring and of the safety circuitry will be available on DVD for purchase after the class ($15, cash, check or credit). If you can't make it to the class but would still like to download the free resources and/or purchase the DVD (add $2 for shipping), just visit the following website: https://sites.google.com/site/diysolardvd .*

CLASS TOPICS:

Part 1: Power Conservation – How much power do you really need?

When the utilities go down for days, weeks or even months, your home solar/battery backup system will prove to be an invaluable resource for you and your family. However, **unless you are willing to conserve as much power as possible, your backup power resource won't be much of a resource at all**.

Part 2: What is a Solar Power Budget?

Developing an accurate solar power budget is critical to ensuring that your system will provide all your power needs during even the longest power outage.

Part 3: Off-the-Shelf Solutions vs. a DIY System

With the proper information and resources, the average do-it-yourselfer **CAN** build their own Solar Backup Power system safely and correctly. However, there are also some off-the-shelf solutions that you should at least consider before diving into the DIY project.

Part 4: Explaining the DIY, Comprehensive Step-by-step Resources

The goal for this class is to ensure that you leave with every resource you need to build your own Home Solar/Battery Backup System or purchase an off the shelf solution. The **DIY Solar DVD** is an invaluable resource for those of you who are serious about getting your DIY system built. Visit this YouTube video for a peak at what the **DIY Solar DVD** is all about: http://www.youtube.com/watch?v=GYmQqiwffyE

ABOUT the Simple Safe Solar Project

As an electronics engineer for the Department of Defense, I have worked on solar/battery backup systems for both the Marines and the Army. In early 2012, I realized that there was no good reason why the average DIY person could not build a simple and safe solar/battery backup system for their home as well. Unfortunately, I found that resources available on the web were extremely limited. No one was following the National Electric Code and the quality of instruction was severely lacking. No wonder so few DIY people were actually having success building their own backup power systems for their homes! This was the catalyst that brought about the **Simple Safe Solar** design. My requirements were simple:

- The system **MUST** follow the **National Electric Code** (I used the most current, which is NEC 2011).
- As long as a strict power conservation routine is followed, the system **MUST** be able to run a medium size chest freezer, compact refrigerator, power tools, LED or fluorescent lights, washing machine on cold cycles, microwave, and portable evaporative cooler.
- The system **MUST** be in the range of **$2500** (could be less, but not too much more).
- The system **MUST** be **simple enough to build for the average DIY person** who doesn't have very much electrical knowledge.

After many months of work, I finally produced a design that met all of the above requirements. And, I have made my diagram, parts list, and power conservation guide freely available to the DIY solar community. Once I completed the design, however, I realized that many DIY people might still look at the design and think it was too complicated for them to build. So, the next phase in my **Simple Safe Solar** project began: producing the **DIY Solar DVD**.

After literally spending hundreds of hours writing the script, shooting the video, and editing all the footage, I finally completed the **DIY Solar DVD** which includes over two hours of step-by-step video instruction. No, I didn't have a professional video crew doing the filming and the video is not in HD. But, I did my best to keep the camera as stationary as much as possible, and I went to great pains during editing to ensure that the viewing experience would be a good one. Also, I don't just **tell you** how to do the system wiring, I did my best to **show you exactly how to do it**.

Finally, I have made this **DIY Solar DVD** available to the DIY solar community for a modest price ($15 + $2 shipping). If you're the kind of person that types in "free energy" into Google and is looking for someone to hand you a "free video" so you can build your "free energy machine", then obviously you won't be interested in this DVD. However, if you are serious about getting your family more prepared to weather the coming crisis in America, than this **DIY Solar DVD** will get you across the finish line.

Please email me at solardvd@hotmail.com with any questions you have about the **Simple Safe Solar** system or the **DIY Solar DVD**. I will respond as soon as I can. Get it done!

https://sites.google.com/site/diysolardvd .

Simple Safe Solar

Home Solar/Battery Backup System

Power Conservation during a Long-Term Crisis

*This handout is to be used in conjunction with the DIY **Simple Safe Solar,** home solar/battery backup system. This system is designed around 410Watts of solar panel power, a 4800Watt hr battery bank, and a 3500Watt 24VDC-110VAC modified sine wave inverter. A complete walkthrough of the design including step-by-step video instructions of the system wiring and of the safety circuitry is available on DVD for purchase at https://sites.google.com/site/diysolardvd . This system costs a little over $2500 to put together in 2012, and is designed to be a long-term backup power resource for the average household.*

When the utilities go down for days, weeks or even months, your home solar/battery backup system will prove to be an invaluable resource for you and your family. However, **unless you are willing to conserve as much power as possible, your backup power resource won't be much of a resource at all**. Think of your power backup system just like your backup water supply. If you drain your 55 gallon water barrel faster than you are filling it back up, then you will eventually run out of water. So too, if you consistently use more power than your solar panels can provide, you will drain your batteries, and your backup power system will be worthless.

In order for your home solar/battery backup system to provide your family's power needs during a long-term crisis, you **MUST** follow these power conservation practices:

Food Refrigeration and Freezing:

Having electricity available to keep food well preserved and free from bacteria growth is the most compelling reason to have a home solar/battery backup system. However, your refrigerator and freezer will be a significant drain on your system because these appliances have a steady on and off cycle every day and throughout the night. In order for your home solar/battery backup system to meet the power demands of your refrigerator/freezer you **MUST** adopt the following power conservation instructions:

- During an **extended** power outage, **be prepared to empty out your full-size refrigerator** and **migrate all your food to a stand-alone freezer and smaller, compact refrigerator** (probably located in your garage). Our modern day, full-size refrigerators waste a lot of energy, even the "energy efficient" ones. Why? **Because we don't need that much refrigerator space!** Take a look at what you're keeping in your refrigerator: days-old leftover casserole, a to-go container with the other half of yesterday's sandwich, old salad dressing bottles that no one really uses; then there's food items that could be frozen like bags of shredded cheese and sandwich deli meat; finally, there's some things that don't really need refrigeration like soda cans and water bottles. At the end of your inventory you should find that a smaller compact refrigerator ($180 range) will meet your crisis food refrigeration needs (milk, eggs, cheese, juice, vegetables, and a few other foods that you may want to thaw out from your freezer).

- **Or, Convert a chest freezer to a refrigerator**! For those of you that want to drastically reduce the power usage of your refrigerator, but you want more space than a compact refrigerator can provide - there is a solution! Simply buy a chest freezer to refrigerator conversion kit. Read all the details on the "Free Downloads" page on my website. **Pros**: saves an incredible amount of power and gives you more refrigerator space than a compact refrigerator. **Cons**: you will need to buy a second chest freezer.

- **Keep your chest freezer full!** A full freezer will stay colder longer, thus using less energy to maintain the ideal freezer temperature. Once frozen, foods should be grouped together to help keep each other cold. It takes less energy to keep frozen foods cold than to cool the air in the freezer. You can keep your freezer full by adding ice, flour, dry beans, rice or other pantry items when you have extra space. Remember, those solid masses will help keep your freezer more energy efficient.

- During the winter and other periods of limited sunlight, you can actually **turn off your freezer at night**. **Only do this if your freezer is fully packed!** A freezer full of frozen food will keep for about two days, a half full freezer will only stay frozen for about half a day. Also, **plug your freezer into a timer** ($15) that you can program to turn it off when the sun goes down and turn it back on when the sun comes up in the morning.

- Finally, if you can, **adjust the temperature settings to the highest safe level** on both your compact refrigerator and chest freezer: Your compact refrigerator should be between 38 and 42 degrees. Your freezer should be between 0 to 5 degrees.

Cooking:

If you have an electric oven, you should **NOT** use it with your solar/battery backup system because the power draw is much too large. However, you would be amazed at how much cooking you can get done with a **microwave oven**. Check out this Washington Post article about how to cook an entire thanksgiving meal using only a microwave oven (http://voices.washingtonpost.com/campus-overload/2010/11/cooking_a_thanksgiving.html). Just being able to heat water quickly in your microwave oven in order to re-hydrate your emergency food supply will be a huge advantage over all the other heating methods (wood fire, sun oven, propane, etc.).

A microwave oven runs at about 1000W but you only need to run it for maybe 15-20 minutes a day depending on what you need to cook. Most microwave ovens also come with power settings so you can cook your food at a lower power setting for a longer length of time. This will enhance the quality of the food cooked using the microwave oven and will still use about the same energy from your solar/battery backup system.

Invest in some good microwave safe dishes (avoid the plastic ones even if they say "microwave safe"; stick with glass and ceramic, if you can). Of course, you can still use your solar oven for baking and a few other things that may not cook as well in a microwave oven. However, spend some time searching on the web and you will be surprised to find microwave oven recipes for all kinds of things, even bread (http://www.wikihow.com/Make-a-Microwave-Simple-Bread).

A microwave oven offers several key benefits that make it a valuable resource to have during a crisis:

1) Can be used with a home solar/battery backup system
2) Food preparation time is decreased significantly
3) Does not require a consumable fuel source (wood, propane, etc.)
4) Can be used during all times of the day and night
5) Can be used to cook most kinds of foods
6) Fast way to heat water for re-hydration of long-term food supplies

Lighting:

- Invest in **Light Emitting Diode (LED)** and **Compact Fluorescent Lights (CFL)**. If you only use your lights a couple hours at night and you keep lights off when you're not using them, then you won't be putting a significant strain on your battery bank. **Avoid using incandescent bulbs**.

- **Buy electric lanterns with rechargeable batteries**. Charge the batteries during the clearest and brightest time of the day because your panels will be producing more power than you are using. Then, use the lanterns in your house at night. Doing this will keep you from using precious power from the batteries when they are not getting any re-charge from the sun. Yes, your house won't be as bright at night as it used to be, but three or four lanterns should still keep your night life pretty alive. **Important note**: charge your re-chargeable batteries as often as possible (on clear, sunny days of course)! This will extend the life of your re-chargeable batteries dramatically. Also, if you let your re-chargeable batteries expend all their energy you will be requiring larger power draws from your solar backup system to charge your lantern batteries up again.



Standard Electric Power Tools and other Small Appliances (non-heat generating):

- **Most of your standard power tools and small appliances (drill, saw, weed cutter, vacuum, mixer, etc.) can be used with your home solar/battery backup system**. Again, when at all possible, use your tools and small appliances during the day time when your solar panels can produce plenty of power to run your tools or small appliances and keep your battery bank fully charged. **Do not use heat generating appliances** that are used for longer lengths of time like hair dryers and space heaters.

Washing Clothes

- Being able to use your washing machine during an extended power outage will be a huge labor saver – and **your home solar/battery backup system can run a standard washing machine provided that you use it without the internal boiler**. Some of the older washing machines don't have an internal boiler to heat up the water. Many of the newer ones do (some newer washing machines always use the internal boiler because they only have a cold water connection). Some of the newer machines have a "quick cycle" setting and will take the water directly from the hot water connection (from your water heater) without any internal heating. There are many different models of washing machines, so you will have to experiment with this one. Chances are, during a severe crisis you will not have natural gas to heat the water in your hot water tank anyway, and you don't want your washing machine's internal boiler to drain your battery bank when it heats up the cold water. The best solution is to simply run your washing machine on cold cycles and maybe augment with a pail or two of hot water that you heated on an outside fire or left in a solar hot water bag for a few hours (like a solar shower water bag). And remember, only run your washing machine during the middle of bright, sunny days when your solar panels can produce plenty of power.

- For a reliable source of hot water, you can also build a small Solar Water Heating system (~$1000). There are many good DIY web resources. Here is one that I found: http://www.builditsolar.com/Experimental/PEXColDHW/Overview.htm

Drying Clothes

- Sorry, **no clothes dryers allowed**. Get out your clothes line and start hanging.

Heating / Cooling

Your home solar/battery backup system is **NOT** designed to run any AC heating or cooling in your home. However, you should be able to use a portable evaporative cooler or a fan during the hottest summer months when you solar panels are providing plenty of power. There are many DIY small evaporative cooler ideas on the web. Here is one resource: http://www.instructables.com/id/DIY-baby-swampy-small-evaporative-cooler/

However, if you would rather just spend the $250, there are some pretty low power ones that should at least keep your main living area cool during the summer. You can search for portable evaporative coolers from www.homedepot.com. Here is one that they had in stock that looked promising: Port-A-Cool KuulAire 470 CFM 3-Speed Portable Evaporative Cooler for 350 sq. ft that doesn't use much power, has good customer reviews, and is only $219.

As for heating, invest in some warm clothing and good blankets. And, if you can afford it, having a pellet/wood stove, or a fire place will help raise your comfort level during the winter.

Computers, TV, and other Non-essential Electronics

Your home solar/battery backup system **may** be able to run some of these things, but not very efficiently (don't blame me if your X-Box stops working!). The inverter being used in the system is a modified sine wave inverter not a pure sine wave inverter. Computers, TVs, and other non-essential electronics often require cleaner power (from a pure sine wave inverter) in order to operate correctly. However, if you really need to turn the TV on for a few minutes to watch news updates, you may have better luck using an older TV. Otherwise, sit down, read a good book, and spend some time getting to know your neighbors.

The **Step-by-step Solar DVD** (available for purchase at https://sites.google.com/site/diysolardvd) will show you exactly how to monitor your backup power system so you know how much power you are using and how much you have available. **Make sure you experiment with your system before the crisis happens!** You need to understand the limitations of your system as well as the specific power requirements to keep your home operational.

Solar Power Budget

In the **DIY Solar DVD**, I demonstrate how to do a solar power budget using Amp hours instead of power (Watts). I did this as a visual way of showing that the current (Amps) leaving the battery bank must **NOT** be more than the current (Amps) recharging the battery bank from the solar panels. In the following **Solar Power Budget** worksheet, I use power instead of current because this is the standard way of doing it. Simply plug in your appliance, turn on your inverter and record the power that is shown on the display while you run your appliance (Run Watts). Sometimes the power will jump up and down (like with your washing machine). In that case, just average the best you can but always over estimate a little. Then, record how many hours a day your appliance will be running. If you want to be more accurate with the "hours per day" estimate of each appliance, purchase an energy meter (Amazon has them for $25). Then you can get the exact power usage of your appliances over a 24 hour period.

Solar Power Budget (during summer)

First, get the available peak sun hours (during summer) for your region. There are plenty of charts on the web that give you an estimate of average sun hours available each day for your location. Here is one "unofficial" reference that I used: http://www.bigfrogmountain.com/SunHoursPerDay.html. Note: There are many references that claim that in order to properly size your solar array you need to "de-rate" the power output of your solar panels (using several formulas) to account for:

- battery charging inefficiencies
- temperature of the solar panels
- how dirty the solar panels are
- voltage losses in the wiring
- age of the solar panels
- shading effects
- and, the effect of solar panel tilt and azimuth.

However, my experience has shown that if you live in a region that has plenty of peak sun hours (> 7 in the summer and > 5.5 in the winter) than "de-rating" according to certain formulas is unnecessary. Why? Because the "official" number of peak sun hours in a region does not take into account that there are a lot more than 7 hours of daylight in the summer and more than 5.5 hours in the winter. The official number of peak sun hours is measured according to the duration of "bright" sunlight. However, solar panels produce power **whenever** the sun is shining on them. So, that means your solar panels will be producing a decent amount of power for at least two or three hours beyond the measured "peak sun hours" in your location. That means this "extra" power being produced will make up for some of the power losses listed above, and we don't have to "de-rate" our power output according to more complex formulas. Now, I will go one step further just to make sure I've accounted for all the losses, and I will subtract one "peak sun hour" when I calculate my total available sun hours.

Here is how I did it: My region has over 8 peak sun hours during the summer. So, I am going to subtract one hour from the peak sun hours available:

7 sun hours X **410 Watts** from the solar panels = a total of **2870 Watt hours**.

Now I can do my solar budget:

2870 Watt hours per day from the solar panels

AC Load Description	Run Watts	Hours/Day	Total Watt hours per day
Compact refrigerator	80	10	800
Chest freezer (5 cu feet, turn off at night, and kept completely full)	100	6	600
Compact fluorescent light	20	2	40
Washing machine (cold cycle only, and one load per day)	90	.75 (45 mins)	68
Microwave	1140	.33 (20 mins)	377
Assortment of power tools and other kitchen appliances	150	.25 (15 mins)	38
Portable Evaporative Cooler (350 sq ft space)	180	5	900

2823 Watt hours being used per day

2870 - 2823 Watt hours = +47

I am within my budget!

Solar Power Budget (during winter)

My region has over 6.5 peak sun hours available during the winter. So, I am going to subtract one hour from the peak sun hours available:

5.5 sun hours X **410 Watts** from the solar panels = a total of **2255 Watt hours**.

2255 Watt hours per day from the solar panels

AC Load Description	Run Watts	Hours/Day	Total Watt hours per day
Compact refrigerator	80	10	800
Chest freezer (7 cu feet, turn off at night, and keep completely full)	100	6	600
Compact fluorescent light	20	5	100
Washing machine (cold cycle only, and one small load per day)	90	.75 (45 mins)	68
Microwave	1140	.33 (20 mins)	377
Assortment of power tools and other kitchen appliances	150	.25 (15 mins)	38

1983 Watt hours being used per day

2255 - 1983 Watt hours = +272

I am within my budget!

Let me say this again: this is **NOT** the standard way of estimating the daily Watt hours that your solar panels will produce. If you would rather use the common "de-rating" methods used in the professional solar industry, here is one standard formula used by solar system designers to calculate the "de-rating" factor: **(battery charging efficiency) X (PV array efficiency) X (total solar resource factor) = "De-rating" factor**

Here are some numbers that many professionals arbitrarily plug into this "de-rating" factor equation: (0.85) X (0.75) X (0.9) = **0.57**

The estimate of available solar power would be: **(average peak sun hours) X (solar panel power) X ("de-rating" factor) = Watt hours per day**

And, if I plug in my numbers: (7.66 average sun hours) X (410 Watts) X (0.57) = **1790 Watt hours per day**

Again, my experience has shown that using the standard formula **almost always** results in a system that is **over-sized** for most of the year especially in regions that have lots of sun hours. Why do solar system designers over-size their customers systems? Two reasons: they don't take the time to understand their customer's power needs, and the installers make more money installing more panels. It's that simple.

I've given you all the information you need to calculate the available Watt hours per day that are coming from your solar panels. Now it's time to do your own solar budget!

Solar Power Budget (during summer)

_____ Watt hours per day from the solar panels

AC Load Description	Run Watts	Hours/Day	Total Watt hours per day

_____ Watt hours being used per day

Solar Power Budget (during winter)

_____ Watt hours per day from the solar panels

AC Load Description	Run Watts	Hours/Day	Total Watt hours per day

_____ Watt hours being used per day

Solar/Battery Backup Power Solutions

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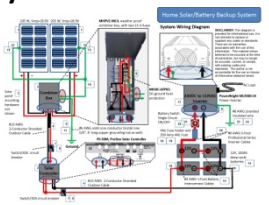
https://sites.google.com/site/diysolardvd

	Goal Zero Yeti 1250 Solar Generator Kit 	**Northern Arizona Off-grid Solar Power System** 	**Simple Safe Solar DIY Solar/Battery Backup System** 
Solar Panel Power	**120 Watts**	**630 Watts**	**410 Watts**
Solar Panel Watt hours for 6 peak sun hours	120 Watts X 6 hours = **720 Watt hours**	630 Watts X 6 hours = **3780 Watt hours**	410 Watts X 6 hours = **2460 Watt hours**
Battery Storage Capacity	**12 Volts @ 100 Ah = 1200 Watt hours**	**24 Volts @ 395 Ah = 9480 Watt hours**	**24 Volts @ 200 Ah = 4800 Watt hours**
Inverter Power	**1200 Watt** pure sine wave	**2500 Watt** pure sine wave	**3500 Watt** modified sine wave
Short-term backup-up power solution	**Good-.** This system can provide power for a medium sized chest freezer for **3 to 4 days or a refrigerator for 1 day** only if you don't run too many other things.	**Excellent.** This system can provide power for a full size refrigerator **for several days** and you can run several other tools and/or appliances.	**Good+.** This system can provide power for a full size refrigerator **for a couple days** and you can run several other tools and/or appliances.
Long-term back-up power solution	**Poor.** This system will only provide long-term power for smaller electronics like computers, power tools, and other small appliances.	**Good+.** This system can provide power for a medium sized chest freezer, compact refrigerator, and other small tools/appliances during long-term power outages. However, you will have to follow power conservation practices.	**Good.** This system can provide power for a medium sized chest freezer, compact refrigerator, and other small tools/appliances during long-term power outages. However, you will have to follow power conservation practices.
Portable	**Yes**	**No**	**No.** However, since this is a DIY solution, it could easily be put together in a more portable configuration.
Cost	**$2567**	**$6688**	**$2546**
Summary	This system is great for 1 to 2 day power outages. It also has the advantage of being fairly portable and requires minimal assembly. However, it won't be able to run the larger appliances like your freezer/refrigerator during long-term power outages.	This is an excellent home solar/battery backup power system for short and long-term power outages. However, it does require some assembly and the cost may break your budget.	This is a good home solar/battery backup power system for short and long-term power outages. Also, the cost is very reasonable. However, it does require a significant amount of assembly time since it is a complete DIY solution; and sensitive electronics may have some issues with the AC power.

Simple Safe Solar

Home Solar/Battery Backup System

TOTAL COST: $2,546

Parts List and Purchasing Information

Estimate based on 2012 prices

*This **Parts List** is for the DIY **Simple Safe Solar,** home solar/battery backup system. This system is designed around 410Watts of solar panel power, a 4800Watt hour battery bank, and a 3500Watt 24VDC-110VAC modified sine wave inverter. Complete step-by-step video instructions for wiring up the system (including all safety circuitry) are available on DVD for purchase at https://sites.google.com/site/diysolardvd . This system costs a little over $2500 to put together in 2012, and is designed to be a long-term backup power resource for the average household. The Part #'s correspond to the system diagram (a free download on the website).*

PART #	DESCRIPTION	QTY	TOTAL COST	PURCHASING INFORMATION
	SOLAR PANEL INSTALLATION			
1	**Solar Panels**, 28Vmp, 205W up to 230W	2	$492	Multiple manufacturers; mine were CS6P-205 solar panels, 205W, Vmp=28.9V, Manufacturer: Canadian Solar ($246 ea); purchased from http://www.sunelec.com (**See instructional DVD for further information regarding the purchase of your solar panels**)
2	**PS-30M, ProStar Solar Controller**, Manufacturer: MorningStar	1	$130	Purchased from: http://www.sunelec.com 
	Shipping and handling from Sun Electronics		$149	
3	**Mounting hardware for solar panels** using pre-existing wooden structure(i.e. shed or kid's play house)		$40	Home Depot or other building supply store (**See instructional DVD for further information regarding the mounting of your solar panels**)
4	**#10 AWG 2-Conductor Stranded Outdoor Cable, Waterproof & Sunlight Resistant** (110ft); actual length will be measured according to the distance from the solar panels to the battery bank	1	$119	Purchased from: Northern Arizona Wind & Sun Item link: http://www.solar-electric.com/10-2-tc.html 

5	**MNPV2-MC4**, weather proof combiner box, includes two 15A fuses	1	$130	Purchased from: Northern Arizona Wind & Sun Item link: http://www.solar-electric.com/misomnsoarco3.html 
6	**Midnight Solar 63 amp 150VDC Ground Fault Protector**	1	$50	Purchased from: Northern Arizona Wind & Sun Item link: http://www.solar-electric.com/mndc-gfp.html 
	Shipping and handling from Northern Arizona Wind & Sun		$26	
7	**Blue Sea 7181 30Amp Circuit Breaker Surface Mount 285 Series** ($39.95 ea)	2	$80	www.amazon.com free shipping 
8	**#12-10 AWG, ¼" ring terminal** (15 pack)	1	$3	Home Depot or other building supply store 

	SOLAR PANEL GROUNDING			
9	**5/8", 8' long, copper ground rod**	1	$12	Home Depot or other building supply store
10	**#6 AWG, solid core, copper ground wire** (20 to 25ft), $1.02/foot	1	$25	Home Depot or other building supply store
11	**5/8" ground rod clamp**	1	$2	Home Depot or other building supply store 
12	**#8 – 2 AWG copper grounding lug** (2 pack)	1	$3	Home Depot or other building supply store 
13	**¼"-20 X 2-1/2" hex bolt, washer, lock washer and nut** (galvanized)		$2	Home Depot or other building supply store
	BATTERY BACKUP INSTALLATION			
14	**Trojan SCS150 12V 100Ah Group 24 Deep Cycle Battery** ($169.95 each). These batteries have the longest life and the least cost per amp-hour. However, in order to enjoy these advantages, they require regular maintenance in the form of watering, equalizing charges and keeping the top and terminals clean (this is standard information available on the web; **it is not covered in the DIY Solar DVD**)	4	$680	Multiple vendors; these particular batteries were found on www.ebay.com 
	The cost for shipping by freight depends on your location. ***This is only an estimate!***		$108	

15	**4 AWG, 12” length, battery interconnect cables with 3/8” lugs** that should fit standard 3/8” battery terminals (verify the terminal size on your batteries before purchasing these cables)	4	$31	Purchased from: Northern Arizona Wind & Sun Item link: http://www.solar-electric.com/bainca4awgx11.html 
	Shipping and handling from Northern Arizona Wind & Sun		$14	
16	**#12-10 AWG, 5/16”-3/8” ring terminal** (15 pack)		$3	Home Depot or other building supply store 
	INVERTER INSTALLATION			
17	**Power Bright ML3500-24 3500 Watt 24 Volt DC To 110 Volt AC Power Inverter**. This is a modified sine wave inverter NOT a pure sine wave inverter. Some electronic devices like TVs and computers may not work very well with a modified sine wave inverter. However, if you really can’t go without your computer or TV, you can also buy the Power Bright APS600-24 True Sine Wave inverter from Amazon ($209). Using a second inverter with this system is very simple: Turn the battery-to-inverter disconnect switch OFF. Then switch the Red(+) and Black(-) inverter cables from the first inverter to the second pure sine wave inverter. **This is not covered in the DIY Solar DVD**.	1	$350	www.amazon.com free shipping 

18	**DB Link ANLFH01 0-Gauge ANL Fuse Holder**	1	$12	www.amazon.com free shipping 
19	**Raptor RANL2002 200 Amp ANL Fuses, 24K Gold Plated, 2 Pack**	1	$5	www.amazon.com free shipping 
20	**Power Bright 0-AWG3 0 AWG Gauge 3-Foot Professional Series Inverter Cables**	1	$30	www.amazon.com free shipping 
21	**#1/0 AWG Red Battery Interconnect Cable 12" with 3/8" Lugs**	1	$13	www.amazon.com free shipping 

22	**Blue Sea Systems 6006 m-series (Mini) Battery Switch Single Circuit ON/OFF**	1	$27	www.amazon.com free shipping 
23	**#8 AWG stranded THHN wire**, 7 – 10 feet (length depends on the distance from the inverter to the nearest grounded electrical outlet), $0.69/ft	10	$7	Home Depot or other building supply store 
24	**Standard 3-prong plug**	1	$3	Home Depot or other building supply store 

This **Parts List** does not cover common materials that most DIY people have lying around their garage like:

- wood screws
- RTV for sealing holes
- PVC pipe for burying the outdoor cable (optional and depends on where your panels are mounted)

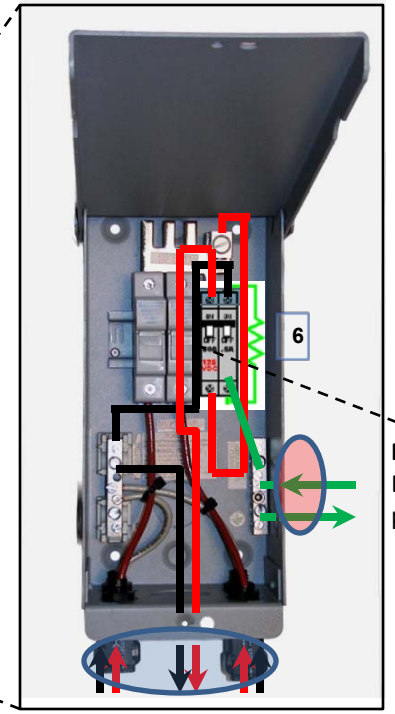
Home Solar/Battery Backup System

System Wiring Diagram

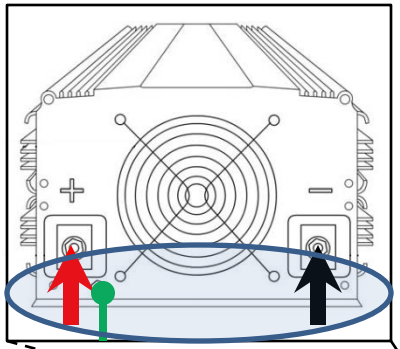
205 W, Vmp=28.9V

205 W, Vmp=28.9V

MNPV2-MC4, weather proof combiner box, with two 15 A fuses



MNDC-GFP63, DC-ground fault protection



DISCLAIMER: This diagram is provided for informational use; it is not intended to replace or supplant any codes or standards. There are no warranties associated with the use of this information. This material is/was believed to be accurate at the time of publication, but may no longer be accurate, current, or comply with existing codes and standards. The author is not accountable for the use or misuse of information obtained herein.

Solar panel mounting hardware not shown 3

Combiner Box 5

#10 AWG 2-Conductor Stranded Outdoor Cable 4

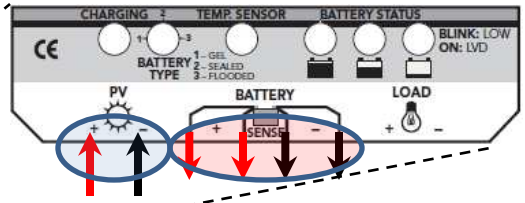
#6 AWG solid core conductor (install one 5/8", 8' long copper grounding rod as well) 9 11

Ground

Switch/30A circuit breaker 7 8

Solar Controller 2

PS-30M, ProStar Solar Controller



#10 AWG 2-Conductor Stranded Outdoor Cable 4

Switch/30A circuit breaker 7 8

24VDC to 110VAC Inverter 17

AC Load

PowerBright ML3500-24 Power Inverter

#8 AWG stranded insulated wire 23 24

Battery Switch Single Circuit ON/OFF 22 21

ANL Fuse holder and 200 Amp ANL Fuse 18 19

20

#0 AWG 3-Foot Professional Series Inverter Cables

12V, 100Ah deep-cycle batteries 14

#4 AWG 1-Foot Battery Interconnect Cables 15

16 16

System Specification	
Inverter Output	**3500 Watt** (Modified Sine Wave)
AC Volts	**110 to 120VAC**
Solar panels (2)	**410 Watts**
Deep cycle batteries (4)	**4800 Watt hour capacity**
Solar panel recharging Watts @ 6 peak sun hours	**2460 Watt hours**