

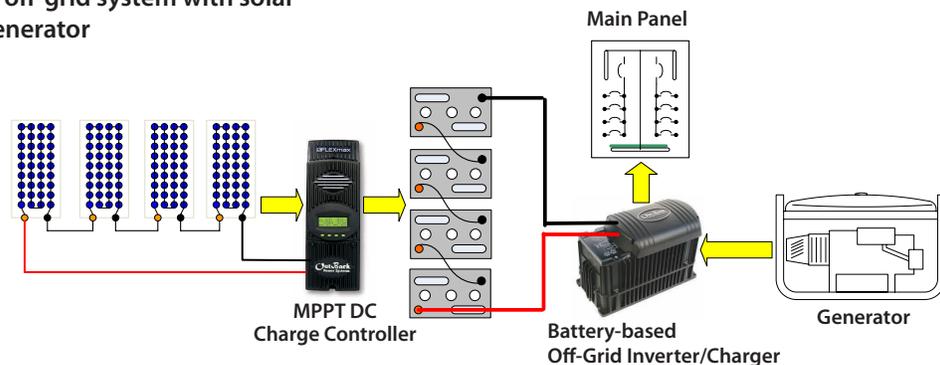
# AC Coupling in Renewable Energy Systems

*Most renewable energy systems are "DC coupled"*

Most renewable energy systems are based on DC current, yet these have certain scalability limitations. Higher currents and associated wiring of lower-voltage DC components' limits are particularly evident in micro-grid and single residences with multiple buildings.

DC coupled systems use either an off-grid or a grid interactive inverter/charger depending on whether the user is connected to a local utility or is completely self-sustaining. Off-grid users typically use battery banks to store energy for the times a renewable source isn't available. Grid-tie systems are designed with and without battery back-up. Those without batteries primarily sell power back to the utility to lower a user's power costs.

## Basic DC Coupled off-grid system with solar and backup AC generator



*Size matters*

Increasing the size of any DC system component—the solar array, battery bank, or the loads—often calls for an increase in the size of the system's electrical conductors. This can be unexpectedly expensive given the escalating cost of copper. An alternative to DC coupled systems based on *AC coupling* offers renewable energy users an alternative without compromising the quality or quantity of their electrical power.

*AC coupling basics*

Simply put, AC coupling combines batteryless and battery-based inverter/chargers in the same off-grid or grid-tied system, resulting in a system that is more easily upgraded and expanded than a DC coupled system. AC coupling accommodates multiple charging sources on the AC side of the system and does not require a charge controller to regulate DC power. For some applications, AC coupling has advantages over DC.

In a DC coupled battery-based system, current from a renewable energy source is used to either recharge batteries, run loads or sell back to the utility grid. A grid-tied system without a battery bank offers no back-up or stored power in the event of a utility outage. In a typical system with batteries, renewable energy passes through a charge controller and is then either stored in the batteries or passes through an inverter/charger to power loads or sell back.

AC coupling allows direct powering of AC loads through batteryless inverters and/or battery recharging through a battery-based inverter/charger. Backup generators can also be used to charge the batteries or power the loads through the battery based inverter/charger.

Basics  
continued

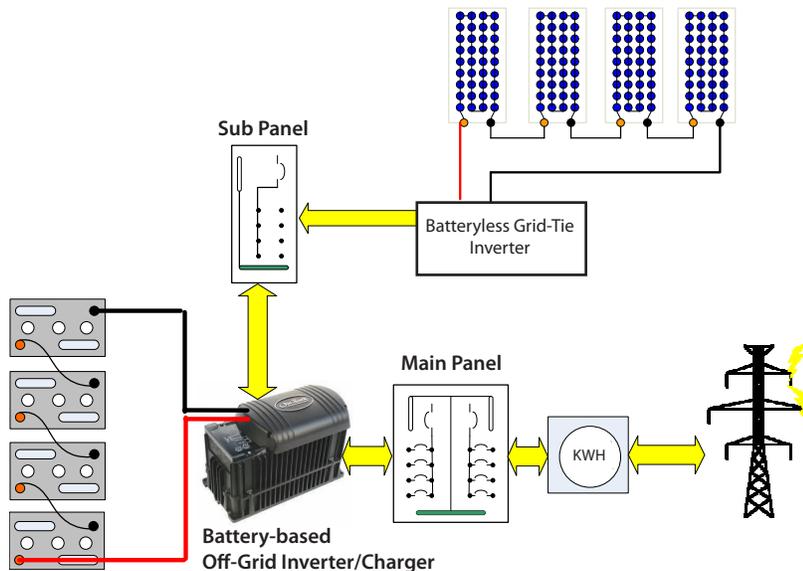
Although an AC coupled system requires the addition of a battery-based inverter/charger, some of this cost is offset by smaller conductor sizes and the absence of a DC charge controller.

Not every system design—for instance, small off-grid applications—will benefit from AC coupling. Those that will benefit include:

- A system whose solar panels, wind turbine, or other power generation source are a long distance from the loads it's powering
- Large grid-tie system owners wanting battery back-up not proportional to their power generating source (i.e. a 4 kW PV array with a 2 kW battery system)
- Multiple buildings and power generating locations off-grid
- Retrofitting battery back-up to an existing grid-tie system
- Systems using positively grounded modules, but desiring battery back-up

## BASIC SYSTEM DESIGN USING AC COUPLING

Power from the solar array powers the loads through a batteryless grid-tie inverter. Current passes through the load center to the battery-based inverter/charger to both recharge the battery bank with the remaining power selling back to the grid. It is important to note that power is only passing through the battery inverter/charger. The batteryless grid tie inverter is selling back.



The above system allows for multiple inverter/chargers for backing up large loads.

## OFF-GRID APPLICATIONS

### *Long distance to the array*

A prime home site on a larger property might not be the optimal site for solar power generation. This poses the problem of running very large conductors from the solar array to the battery bank. Today's Maximum Power Point Tracking DC charge controllers can help in some systems by allowing the solar array to operate at higher voltages than the nominal battery bank. This decreases the current for a given wattage and thus decreases conductor size for acceptable voltage drop.

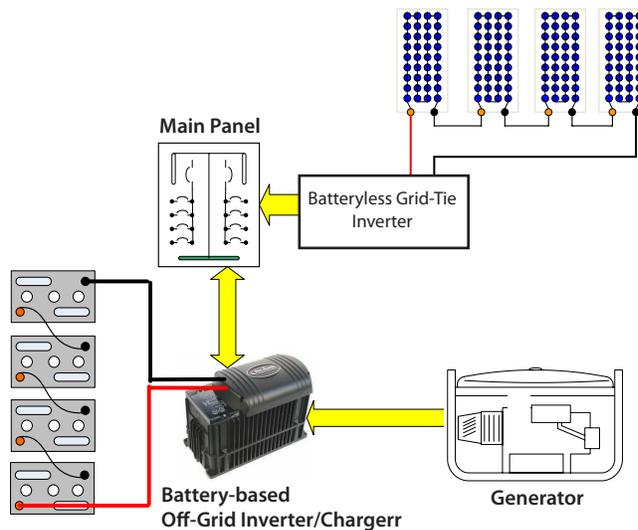
This has limitations for the size and distance between the battery bank and solar array. For very long distances, particularly with larger arrays, running the array at the higher voltages into a batteryless grid-tie inverter and running the output at higher voltages can cut copper costs considerably, as well as simplify the wiring.

### *Multiple building off-grid residential*

An off-grid residence with multiple buildings can be viewed as a micro-grid. The normal battery-based inverter/charger system provides the synchronizing node with multiple *grid-tie inverters* supplementing this micro-grid.

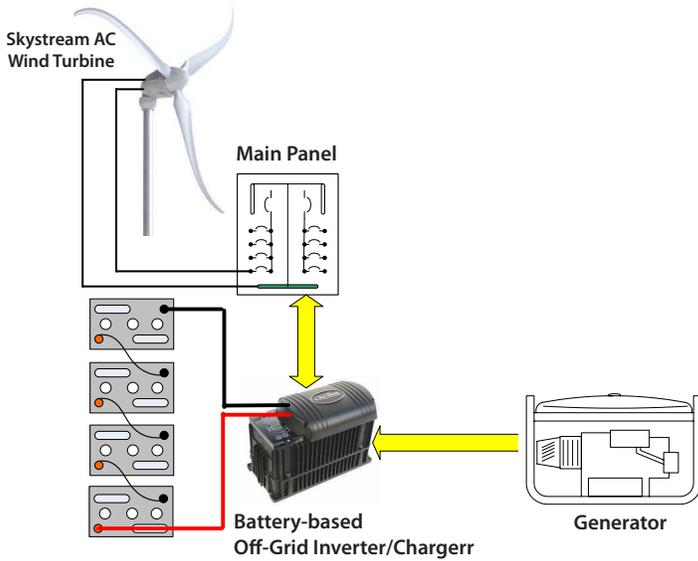
The advantage to this system is that buildings with minimal electrical usage can contribute to other buildings in the compound with larger electrical loads. Also, a large fossil fuel generator can be used to provide backup power in times of insufficient solar or wind resource.

### Off-grid system with a main panel and supplemental generator.



The grid-tie inverter is not synchronized with the generator—when the generator is running, the batteryless grid tie inverter shuts off.

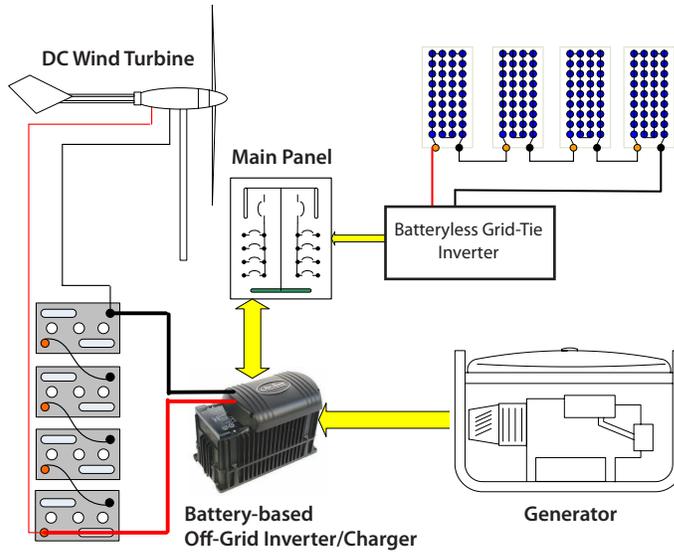
**Off-grid system with a main panel, supplemental generator, OutBack off-grid inverter/charger, and a Southwest Windpower Skystream wind turbine.**



The Skystream unit has an integral AC grid-tie, batteryless inverter. The connections in this system are very similar to a batteryless solar application. Please see the Skystream documentation, particularly regarding battery charging.

The Skystream has been approved by OutBack Power Systems as compatible with its inverter/chargers. Other AC wind generators *cannot* be substituted at this time.

**Off-grid system with a main panel, DC wind generator, a grid-tie inverter and an OutBack off-grid battery-based inverter/charger.**



## GRID-TIE APPLICATIONS

### *Positively grounded solar array*

Some solar modules require positive grounding. Batteryless grid-tie inverter manufacturers whose units have been specifically designed to work with these modules cannot provide back-up power. OutBack FX Series Inverter/Chargers can be damaged in a positive ground system. Note that positive grounding can be difficult to configure and still meet local electrical codes.

AC coupling positive ground inverters to an OutBack system yields a relatively simple highly efficient system, and is compliant with most local electrical codes.

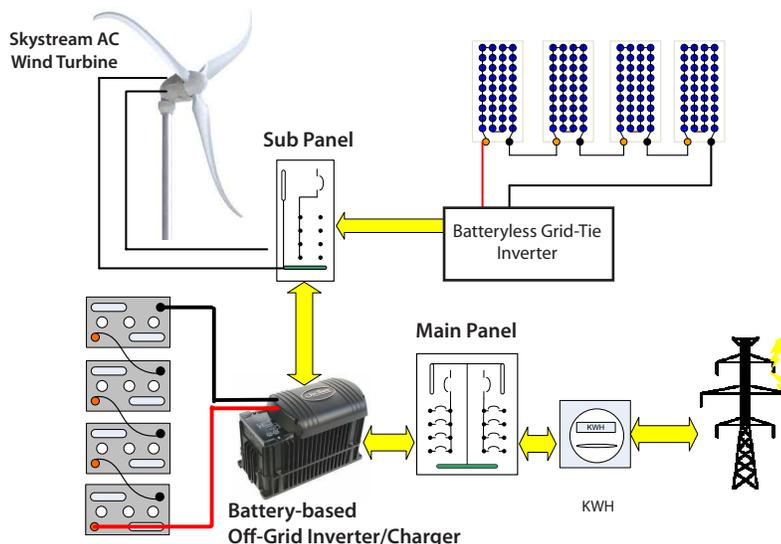
In some cases, offering small to moderate battery backup with a large grid-tie system can be the turning point in making a system sale. A conventional DC coupled approach can require a larger battery bank than the customer might want to have for backup. AC coupling allows for efficient use of a smaller battery bank for backing up limited, essential loads.

### *Offering battery back-up*

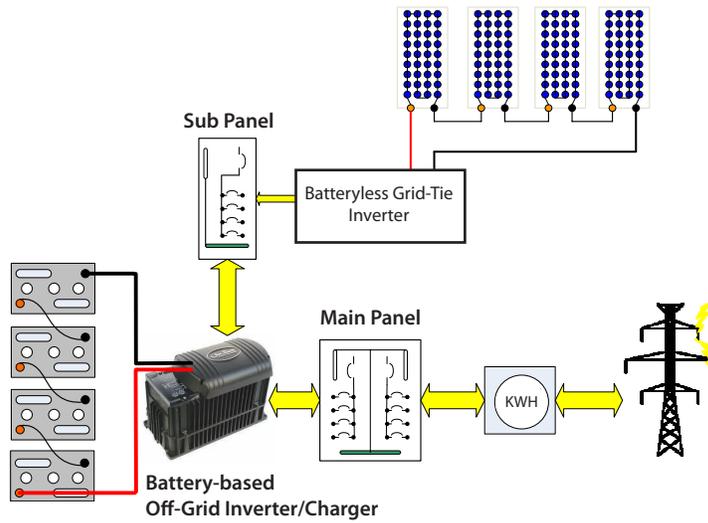
Many grid-tie installations are batteryless and only sell back to the grid. Often, customers will want to add battery backup some time after the initial installation of a grid-tie system. AC coupling provides a convenient and efficient method of retrofitting this functionality.

- The existing grid-tie inverter can remain in the installation without rewiring the solar array from typical higher voltages to the lower voltages associated with battery charging.
- A backup load panel is required as in a DC coupled grid-interactive installation.
- The grid-tie inverter will also have to be rewired from the main house panel to this backup sub panel. This is an easy task handled by a residential electrician.

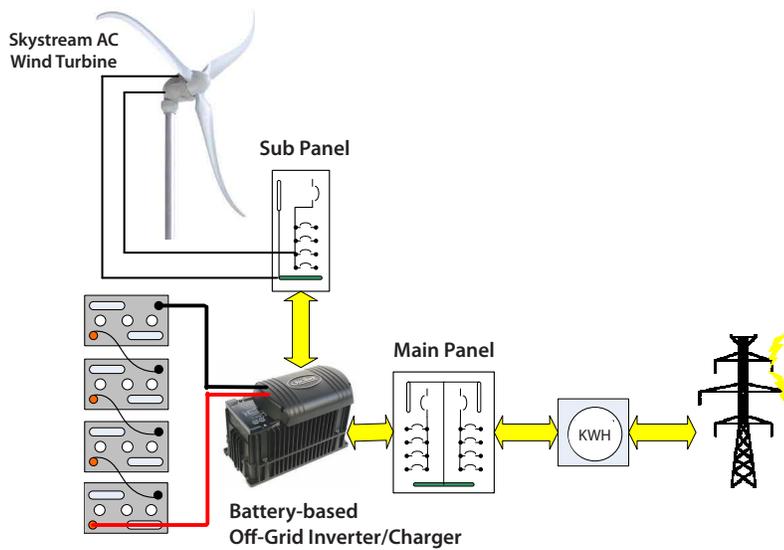
### **Grid-tie system with supplemental Skystream wind turbine, solar PV array and OutBack off-grid battery-based inverter/charger.**



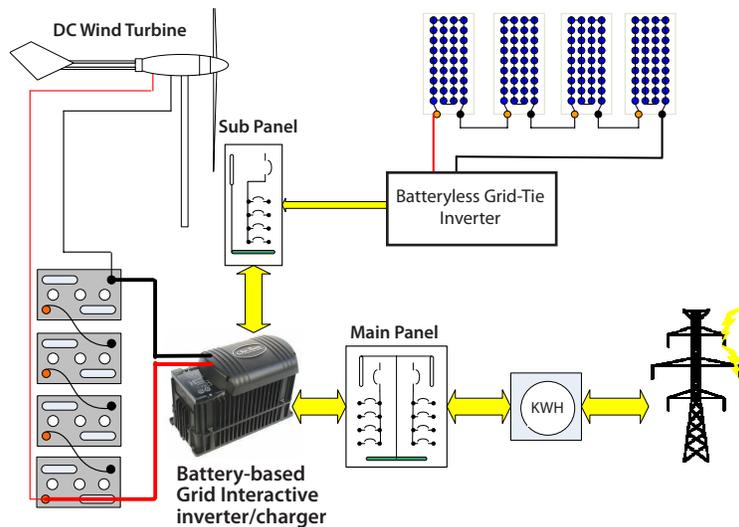
Grid-tie system with a sub-panel added. This is an example of retrofitting an existing grid tie solar system with an OutBack off grid, battery-based inverter/charger.



A grid-tie Skystream wind turbine and an OutBack off-grid, battery-based inverter/charger providing battery back-up.



## A system using a battery based grid interactive inverter charger and a batteryless inverter/charger.



A grid interactive inverter/charger is battery based and capable of selling power back to the grid. In this application power is being sold back from two power generating sources: a PV array and a DC wind turbine. Power from the PV array is sold by the batteryless grid tie inverter passing through the battery based grid interactive inverter/charger to the grid. Power from the DC wind turbine is also being sold back to the grid by the grid interactive inverter/charger.

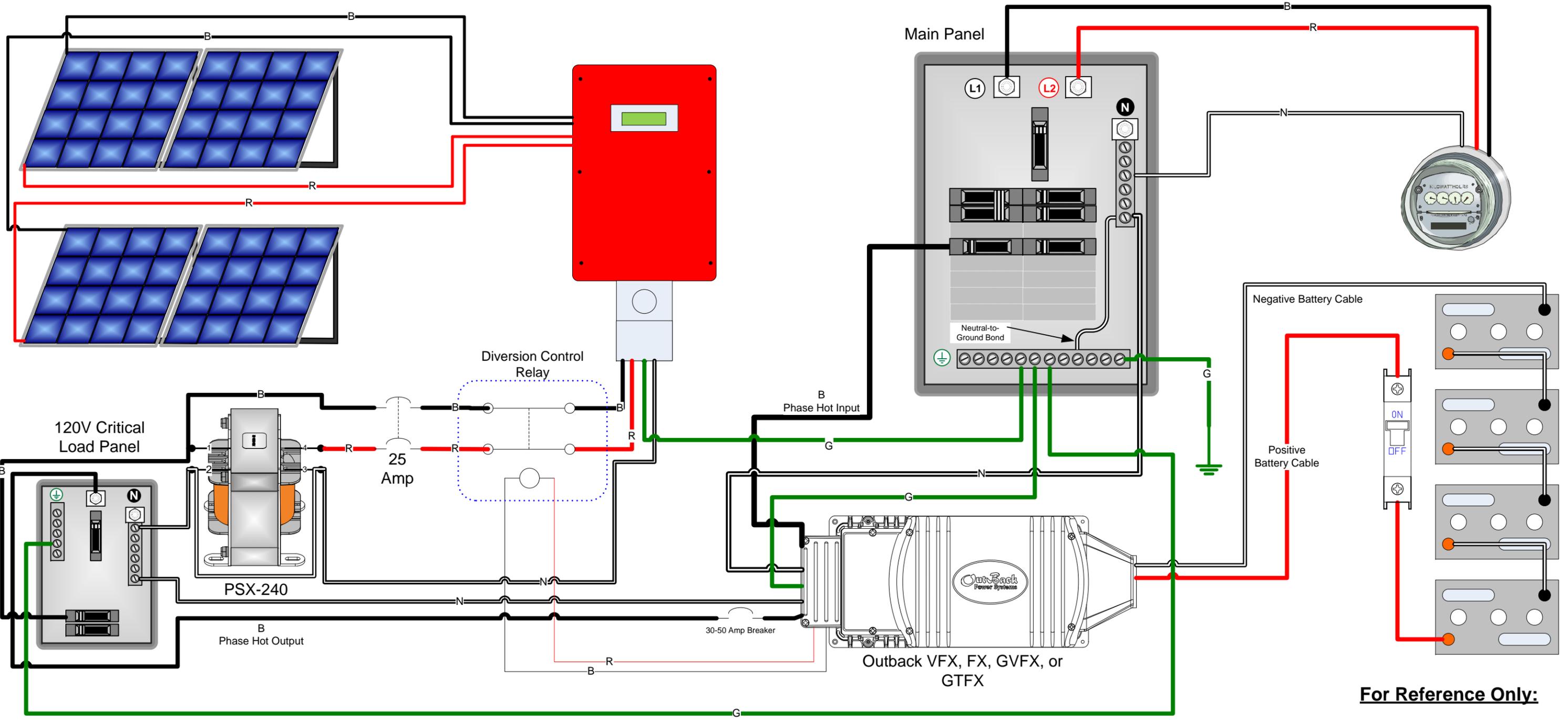
## PERFORMANCE MONITORING

### *Simplification*

Many PV installation incentive programs are based on the kilowatt hours produced by the solar array. Battery based grid-interactive systems have the challenge of monitoring the AC system output due to the power going both to the grid as well as the loads on the backup sub-panel. AC coupling the system using a batteryless grid-tie with a battery backup inverter system allows simple monitoring when installing a one-way kwh meter to the output of the grid-tie inverter.

### *Final Comments*

AC coupling greatly expands what you can do with your energy system. This integration method offers the possibility of combining multiple power generation sources or mixing power generation system pieces that would either be impossible or very inefficient to do in a traditional DC coupled system. In many ways, AC coupling allows you to maximize the benefits that many individual system pieces have to offer.



NOTE 1\*\*\*\*\* You can use any Outback inverter for this purpose. The G models can be used but will attempt to sell any excess battery voltage above the Sell RE voltage in conjunction of the SMA unit selling to the grid.

NOTE 2\*\*\*\*\* The OutBack Aux out is programmed for Diversion Control. When the battery gets too high the OutBack will open up the relay shutting off the SMA.

NOTE 3\*\*\*\*\* Not all Grounds shown for Clarity

NOTE 4\*\*\*\*\* In this Configuration with a possible input greater than the charger of the FX can deliver, over temping of the inverter could be an issue.

**For Reference Only:**

**All Electrical Designs should be presented to an PE for approval upon commencement of a Project.**

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