

Sizing charge controllers

Array capacity in Short Circuit Amps

With MPPT charge controllers amp capacity is on the battery side

Plan for expansion if needed (it is always prudent)

Size disconnects

Appropriately for array

Size conductors Appropriately for array & Charge controller

Overcurrent = 125% + 125% on PV side

Conductors = Maximum capacity Of array and controller



Whizbang Jr. sold separately



Sizing Inverters:

Off grid – Maximum load, Maximum Surge

Grid-tied with battery backup – Maximum load, surge in critical load profile

and

Array capacity...

Choose the correct output voltage –
120

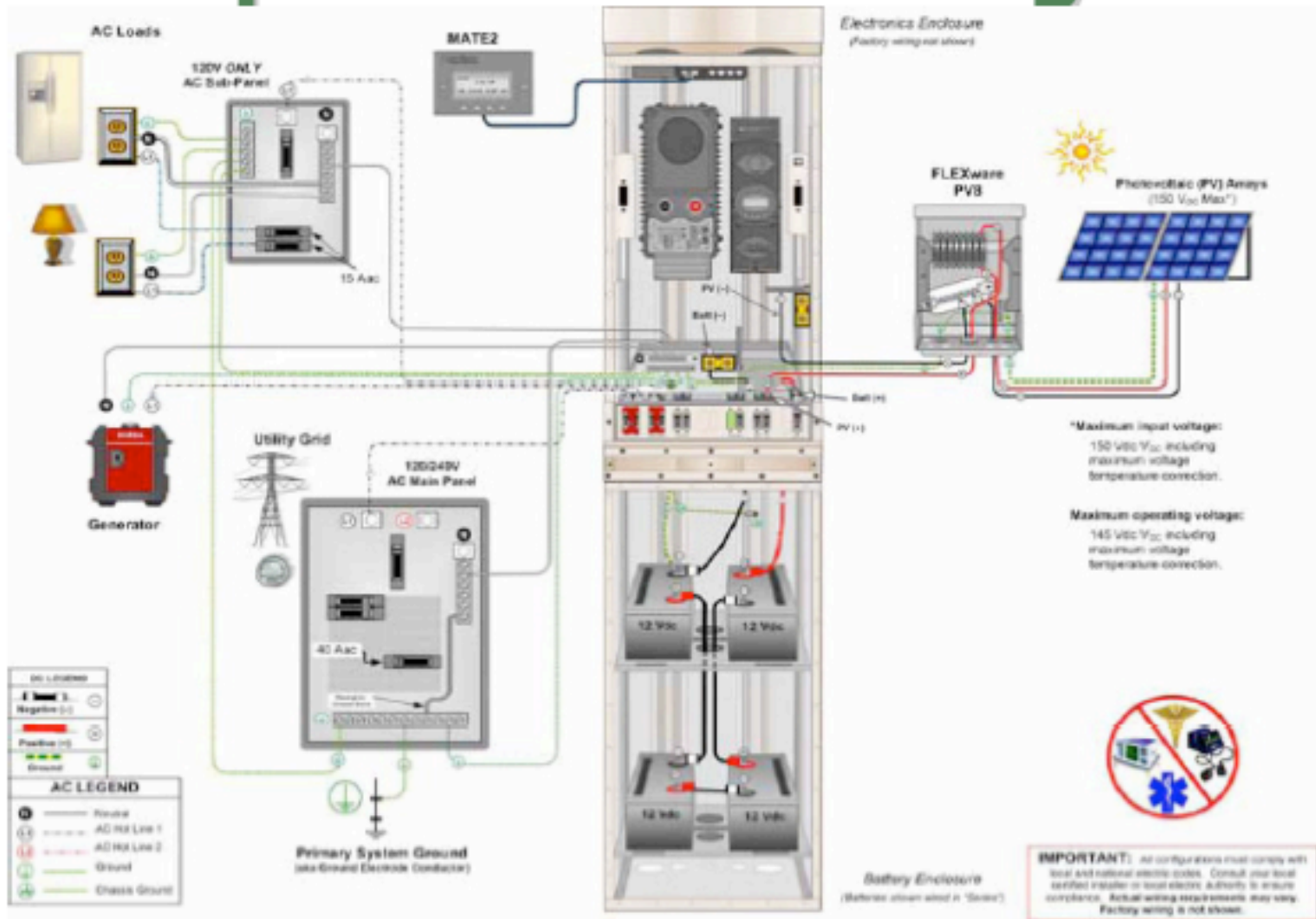
120/240 stacked

120/240 single

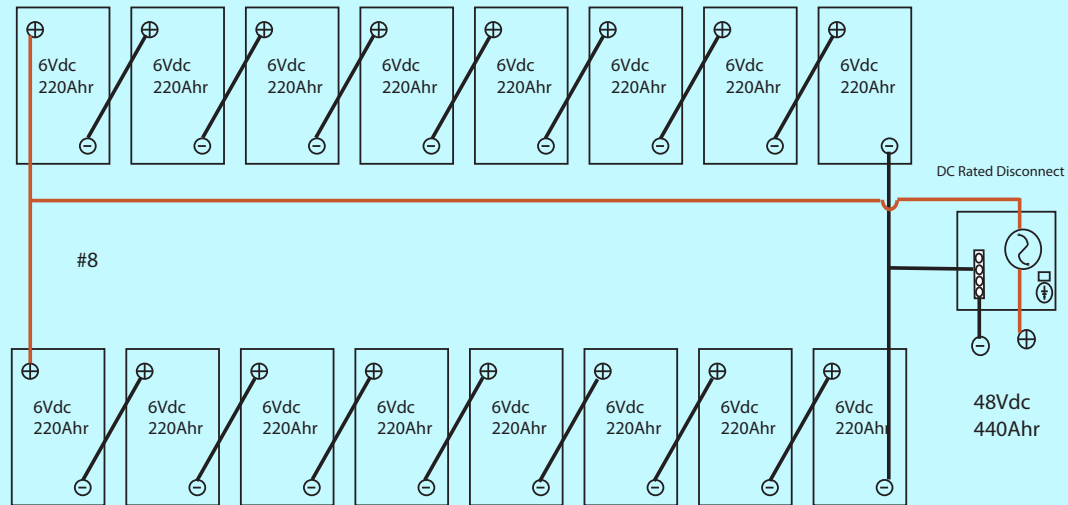
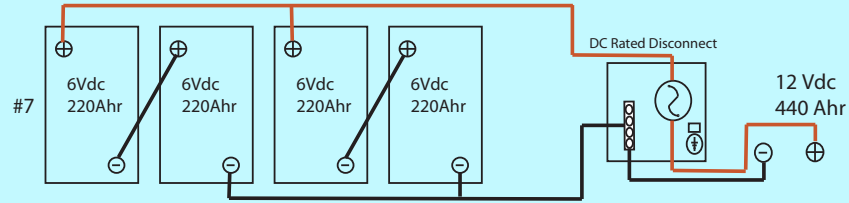
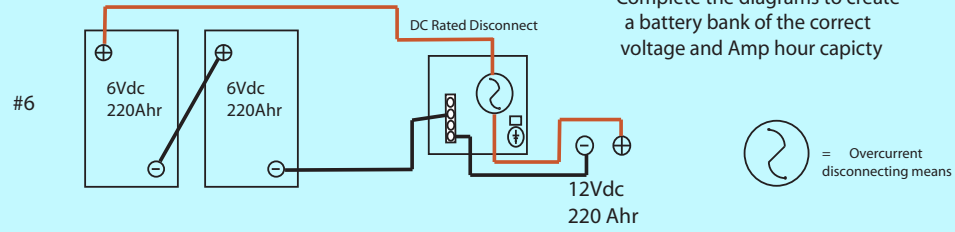
120 with boosting
Transformer...



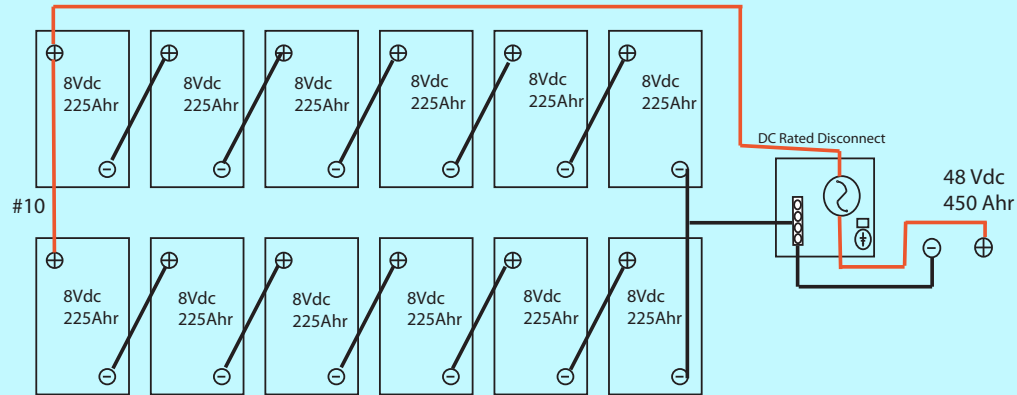
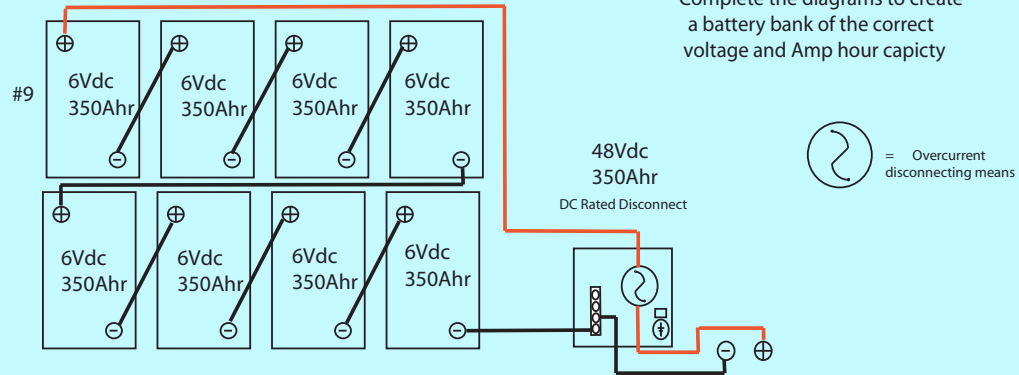
Simplified Install Diagram



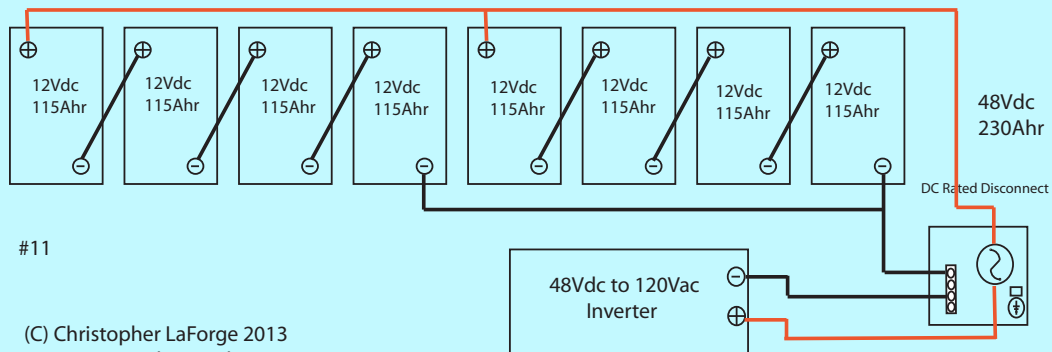
Complete the diagrams to create a battery bank of the correct voltage and Amp hour capacity



System Diagram Exercises: Page 4
 Complete the diagrams to create
 a battery bank of the correct
 voltage and Amp hour capacity



Add in the Inverter...



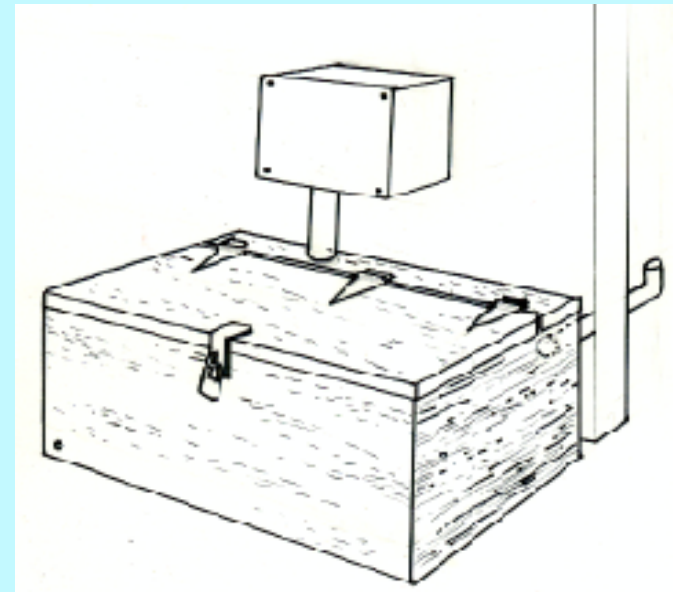
Battery Containment

© 2013 Christopher LaForge

For safe operation of systems with batteries an acid resistant battery containment (battery box) or battery room must be employed. Either type of containment must be vented to outside free air so that hydrogen sulfide gas and oxygen (an explosive mixture) are not allowed to build up in the battery containment. Ventilation can be active or passive but must allow the gasses to escape to the outside of the building. The containment must be acid resistant and provide for controlling accidental acid spills. Local codes may also specify fire resistant walls or other items for battery containment and therefore should be consulted before installation of the battery component of the system.

Battery containment should be able to be secured so that unauthorized persons cannot access the battery. A lock on the battery box or battery room door should be provided for this purpose.

Battery use is safe and simple if basic safety rules are followed. Failing to do so presents serious and even fatal conditions for people unfamiliar with battery operation.

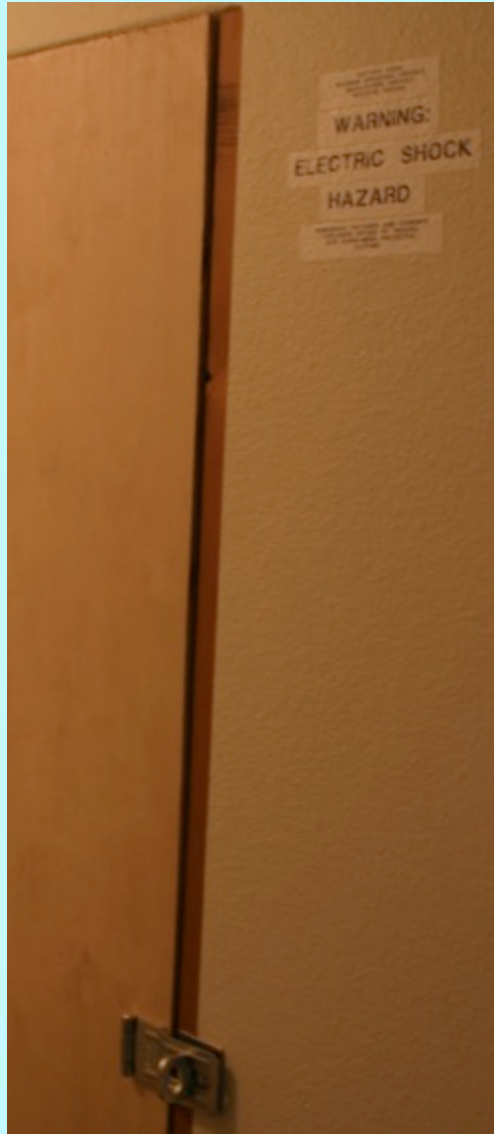


Commercial Battery Box Example - HDPE Plastic, available through most distribution...

Contains 8 – GC2 or L16 size batteries - 33” X 27” X 22.5”



Containment issues



Battery Room Safety Signage

My Safety Sign

www.mysafetysign.com

Enviroguard

www.enviroguard.com

Discussion:

Equipment choices –

Charge controllers

Batteries

Inverters

Schneider (formerly Xantrex) Offers the XW series for Battery based systems,

They also have other battery based equipment....



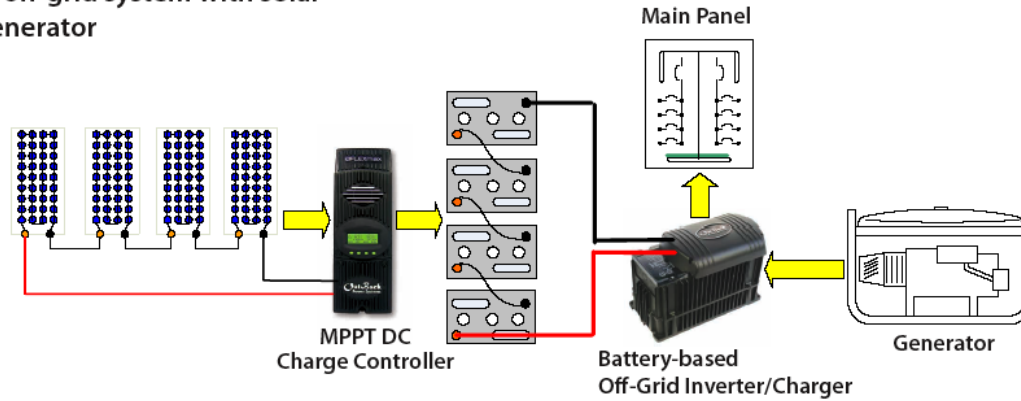
Grid intertie and Battery back-up and Straight grid intertie



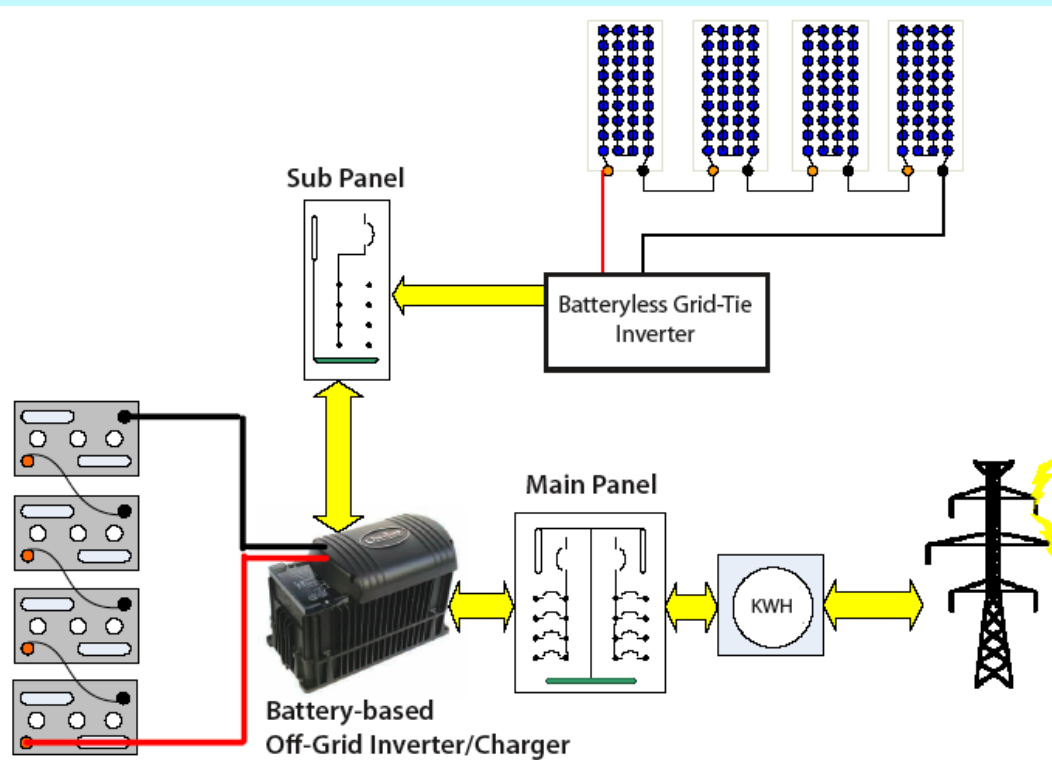
Two system designs allow for backing-up the grid during power outages-

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

DC Coupling -



AC Coupling -



The First design is the traditional way to allow for backing-up the grid during power outages-

DC Coupling –

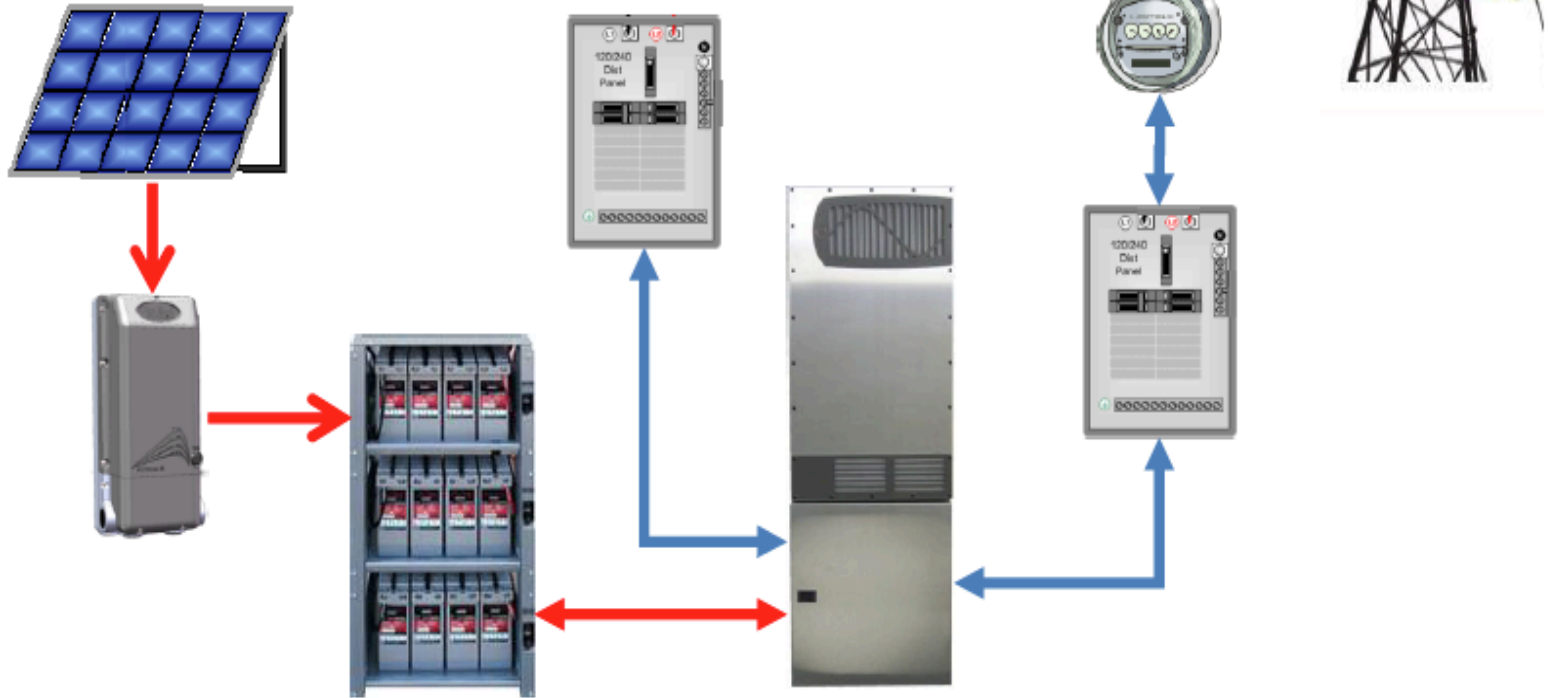
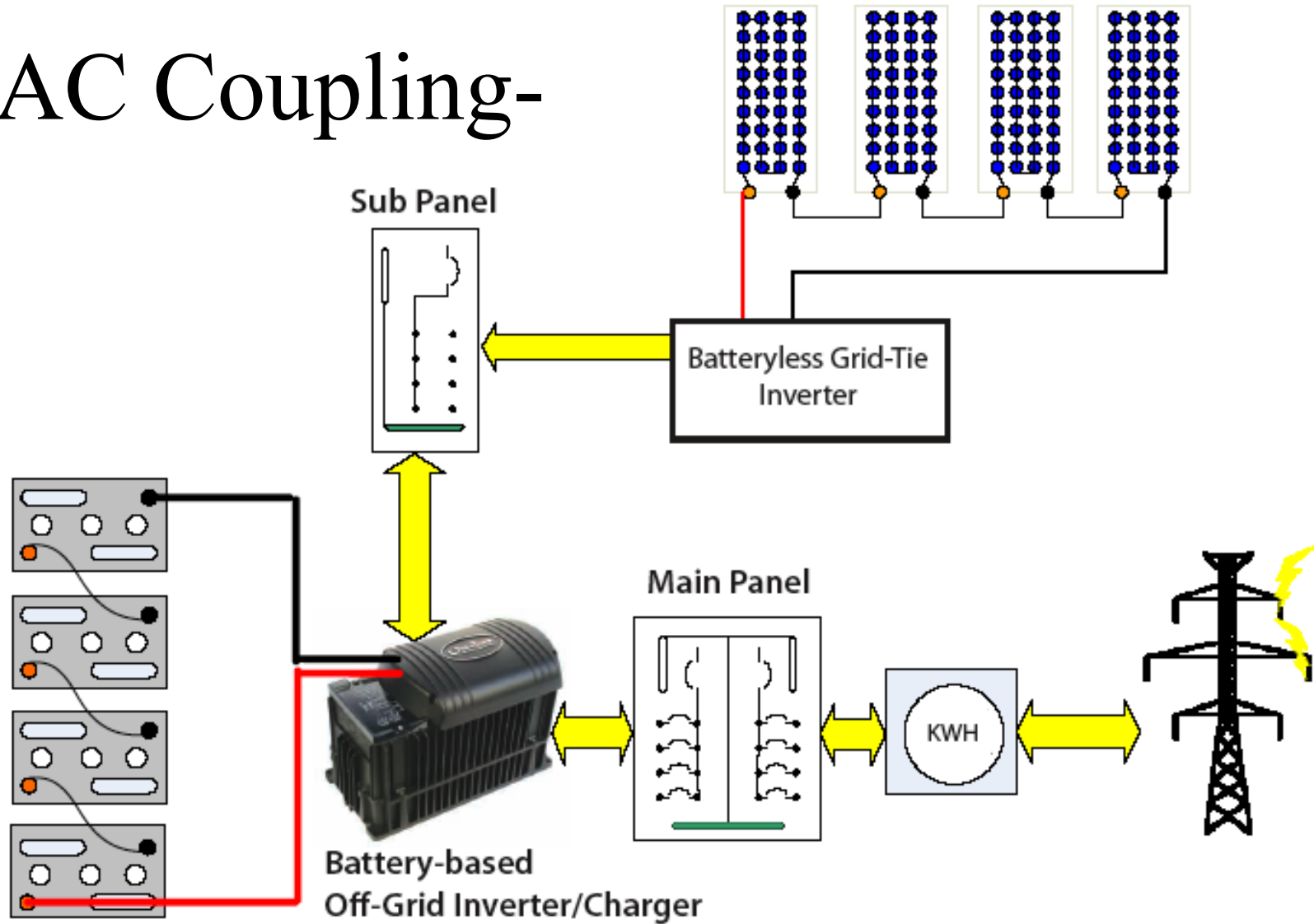


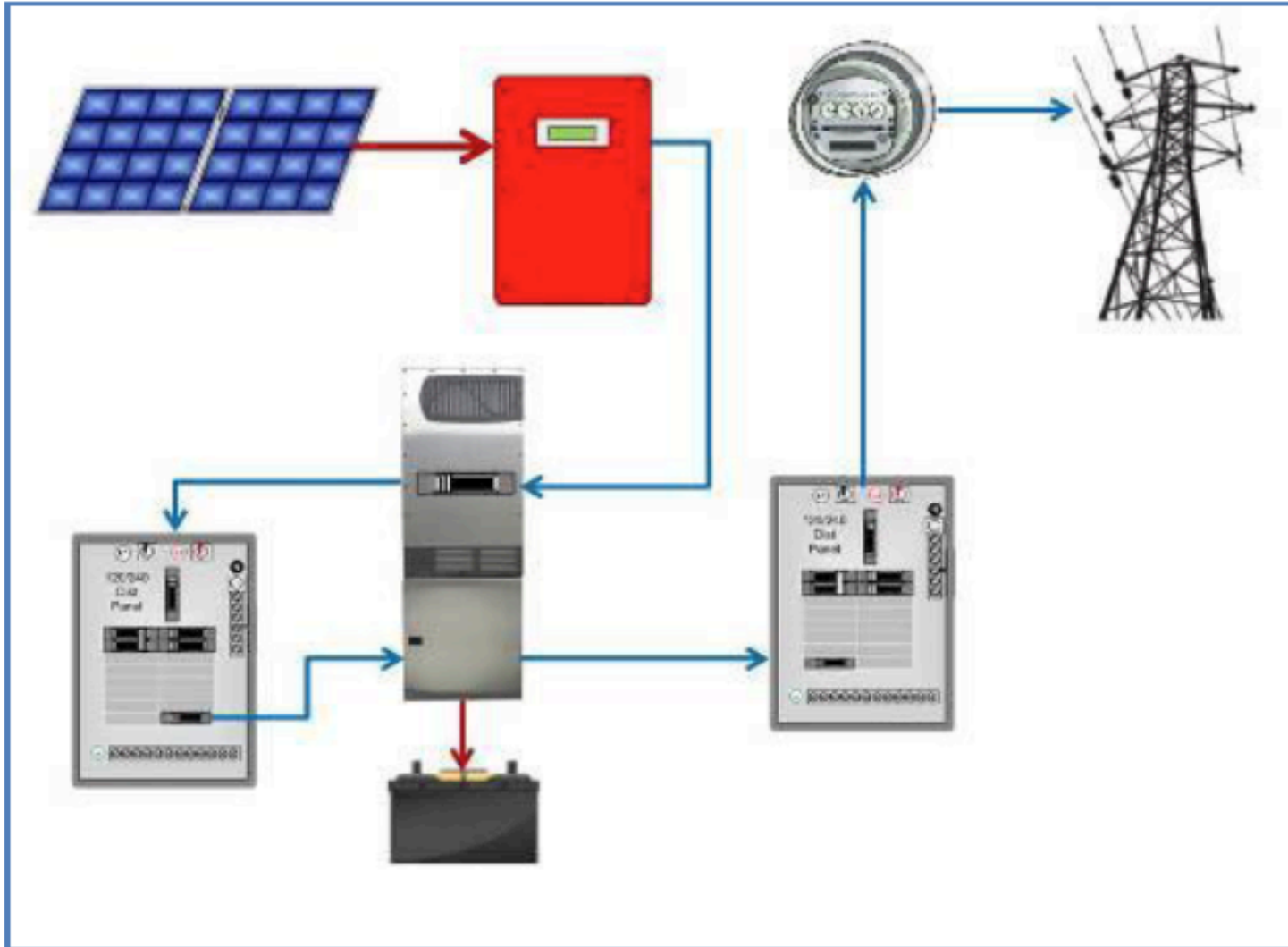
Figure 2 - Typical Grid/Hybrid System

The second design a newer way to allow for backing-up the grid during power outages. This allows battery-free systems to be retrofitted for battery back-up

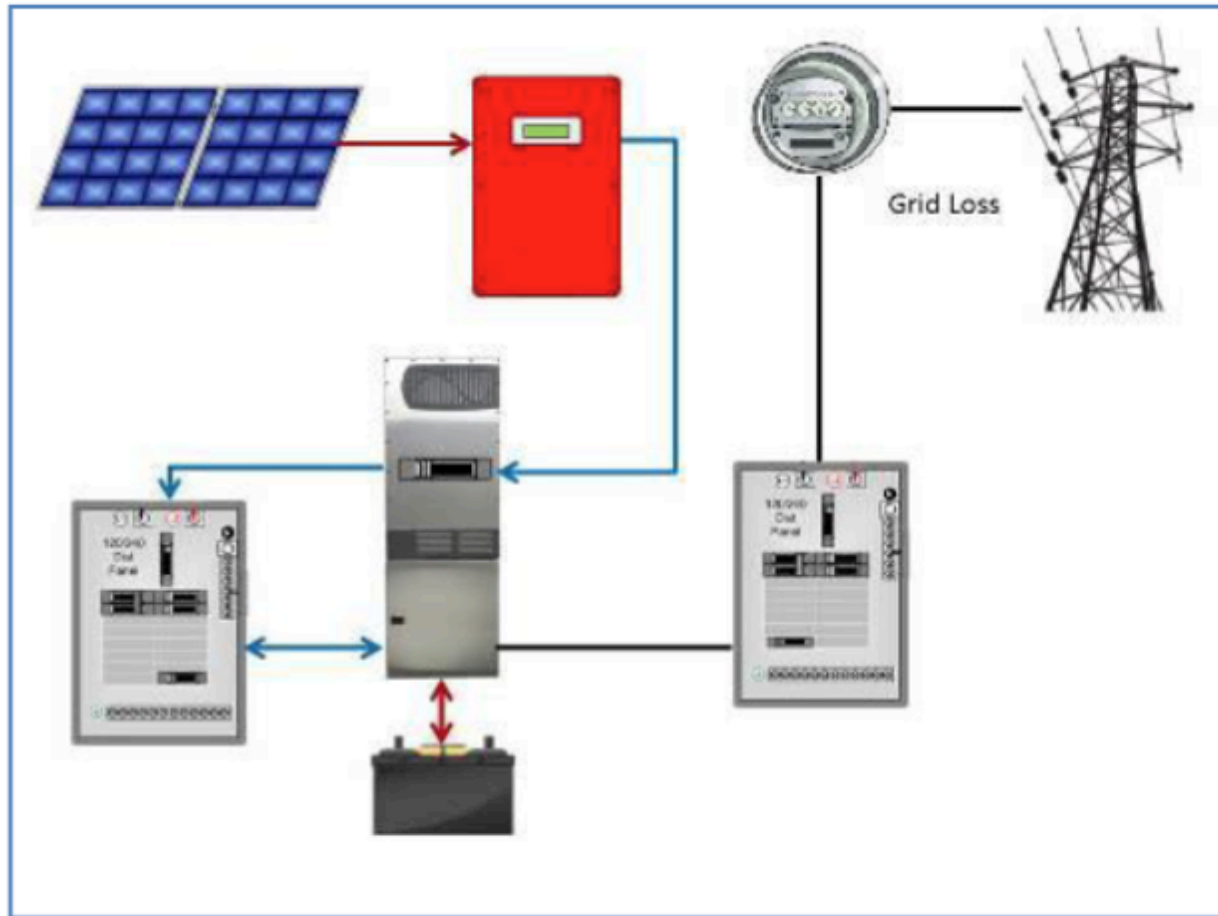
AC Coupling-



During normal grid-operation



During Grid power outages





SUNVERGE

DC –coupled design,
LiOn Battery with
Schneider BOS

The Choice for
deploying at Hartley
Nature Center – August
2016



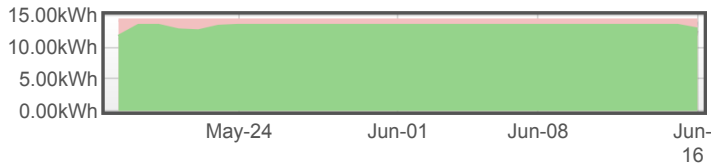
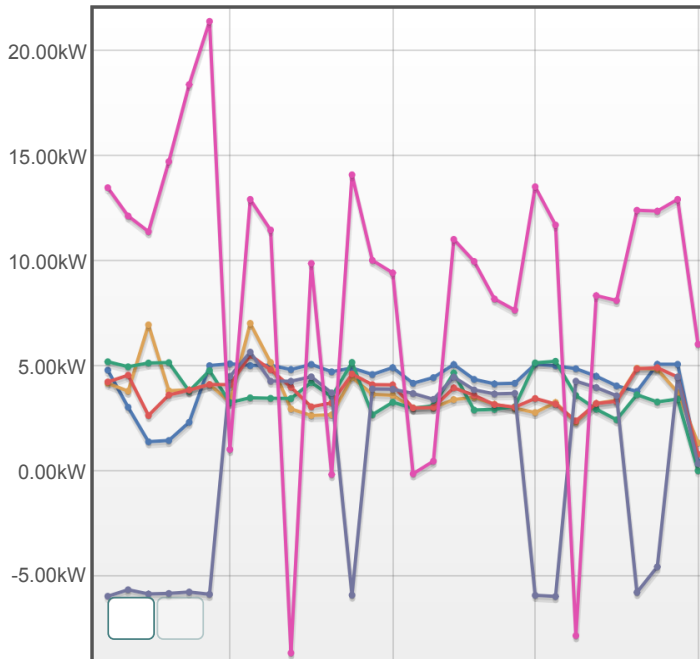
Dashboard Unit Details for HartleyNC01

Unit ID: **0e68b496-b87d-4e3b-8a09-81da463dcf38** Status: Control Mode:

Operational View

[View More](#)

One Month Chart



	W	V	A	Hz	VA
PV DC	448.00	266.70	1.68		
Grid 1 In	255.00	122.04	3.60	59.97	391.00
Grid 2 In	171.00	121.36	2.13	59.97	247.00
Load 1 Out	271.00	121.88	2.76	0.00	336.39
Load 2 Out	176.00	121.88	1.70	0.00	187.70
Grid 1 Out	0.00	122.04	0.00	59.97	0.00
Grid 2 Out	0.00	121.36	0.00	59.97	0.00
Site Line 1	-39.00	121.84	1.76		214.37
Site Line 2	-836.00	121.84	7.04		911.36
Battery	340.00	55.90	6.10		
Capacity	14250.00 Wh				
Stored	12540.00 Wh				



Hartley Nature Center eGauge

[View](#) | [LAN Access](#) | [Tools](#) | [Settings](#) | [Help](#)

6/15/2017 7:26am - 6/16/2017 7:26am

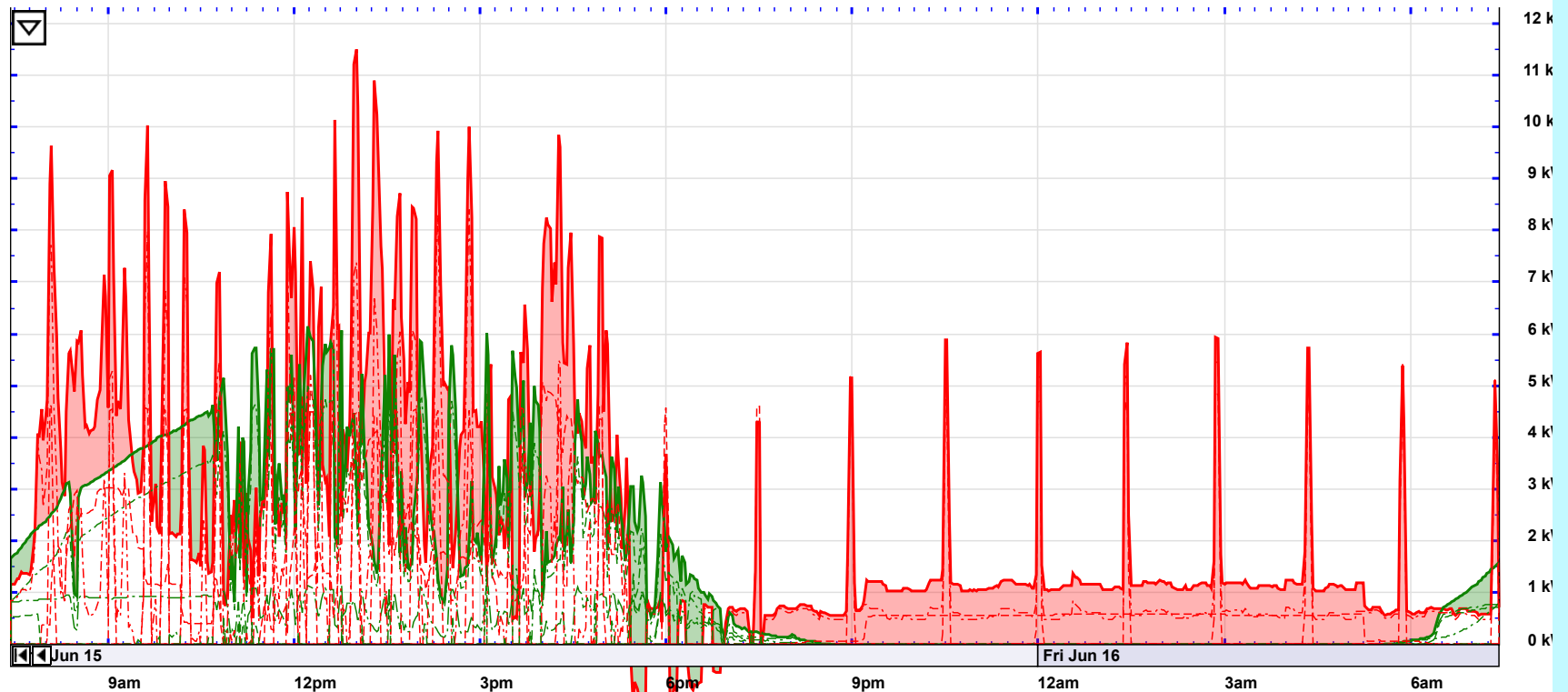
Summary for time-period shown in graph

Energy Used 60.8 kWh (approx. \$7.90 used)
 Energy Generated 37.1 kWh (approx. \$4.82 saved)
 Net 23.7 kWh bought (approx. \$3.08 spent)

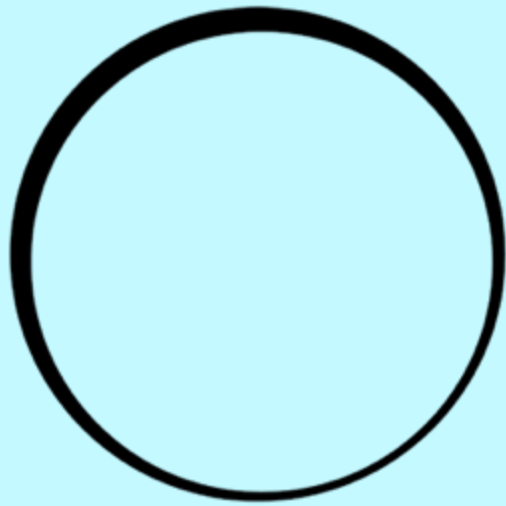
Summary over last 30 days

Energy Used 1.80 MWh (approx. \$234.47 used)
 Energy Generated 924 kWh (approx. \$120.17 saved)
 Net 879 kWh bought (approx. \$114.30 spent)

- All
- 1y
- 6M
- 3M
- 1M
- 3w
- 1w
- 3d
- 1d
- 12h
- 6h
- 3h
- 1h
- 10m
- Auto
- 500kW
- 100kW
- 50kW
- 10kW
- 5kW
- 1kW
- 500W



<input checked="" type="checkbox"/> Power used	<input checked="" type="checkbox"/> Energy from grid	<input checked="" type="checkbox"/> Power generated	<input checked="" type="checkbox"/> Energy to grid
<input type="checkbox"/> Grid gen./use	<input checked="" type="checkbox"/> GSHP gen./use	<input checked="" type="checkbox"/> Electric Boiler gen./use	<input checked="" type="checkbox"/> Roof Solar gen./use
<input type="checkbox"/> Roof Solar+ gen./use	<input checked="" type="checkbox"/> Solar Tracker gen./use	<input checked="" type="checkbox"/> Electric Water Heater gen./use	<input type="checkbox"/> ERV1 gen./use
<input type="checkbox"/> ERV2 gen./use	<input type="checkbox"/> ERV3 gen./use	<input checked="" type="checkbox"/> LP1 Main gen./use	<input checked="" type="checkbox"/> LP2 Main gen./use
<input type="checkbox"/> Toggle all/none			



“You can get easily to 60-70% of the cost [of a Sonnen system] through TOU arbitrage over the lifetime,” he said, “and then if you add tax credits and all, you can achieve a breakeven, even if you are on net metering and time of use in those markets.”

s o n n e n

AC –coupled design,
LiOn Battery



AC Coupling Issues:

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.

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.

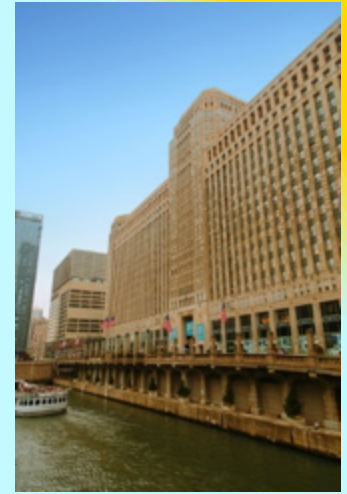
Not every system design—for instance, small off-grid applications—will benefit from AC coupling. Those that will benefit include:

- 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

Commercial/Industrial Systems:

Johnson Controls is a strong player in a busy field of energy-storage system vendors that includes other large players such as ABB, Tesla and Bosch competing with an array of startups in the commercial and industrial market, such as Stem, AMS, Geli and Greensmith.

Johnson Controls is offering its lithium-ion batteries that range from 500 kilowatts to 2 megawatts for large commercial and industrial customers, as well as 50-kilowatt to 250-kilowatt systems for commercial customers that want to put the energy storage systems within their building's electrical room.



One of Johnson Controls' first projects is in Chicago's Merchandise Mart, owned by Vornado Realty Trust. The 4.2-million-square-foot building was already using Johnson Controls for demand response.

With energy storage, the building can now play in PJM's frequency regulation market. The expanded platform will provide the storage capabilities enabling the Mart to participate in advanced fast response programs that adjust demand to changing conditions on the electric grid. Such active load Management strategies, when coupled with the distributed energy management system, can reduce a facility's annual expenditure for electricity by as much as 35 percent. Johnson Controls said that its energy management platform coupled with storage could save buildings up to 35 percent in electricity costs.



EaglePicher Crossroads Facility

System Size: 1MW/2MWh

Components: Four (4) 45 ft. ISO Containers consisting of several GTIB-100 Inverters, multiple advanced Lead-Acid and/or Lithium-Ion batteries, PPS Site Controller, PV, Wind Renewable Energy Resource, and EaglePicher Power Pyramid Controller.

Loads: EaglePicher Crossroads Facility Installation Date: February 2012

Location: Joplin, MO

The system charges at low-cost energy times, such as overnight, and discharges selected battery banks at peak times to reduce power demand, and to manage local loads. The system can operate as a microgrid when disconnected from the utility service.

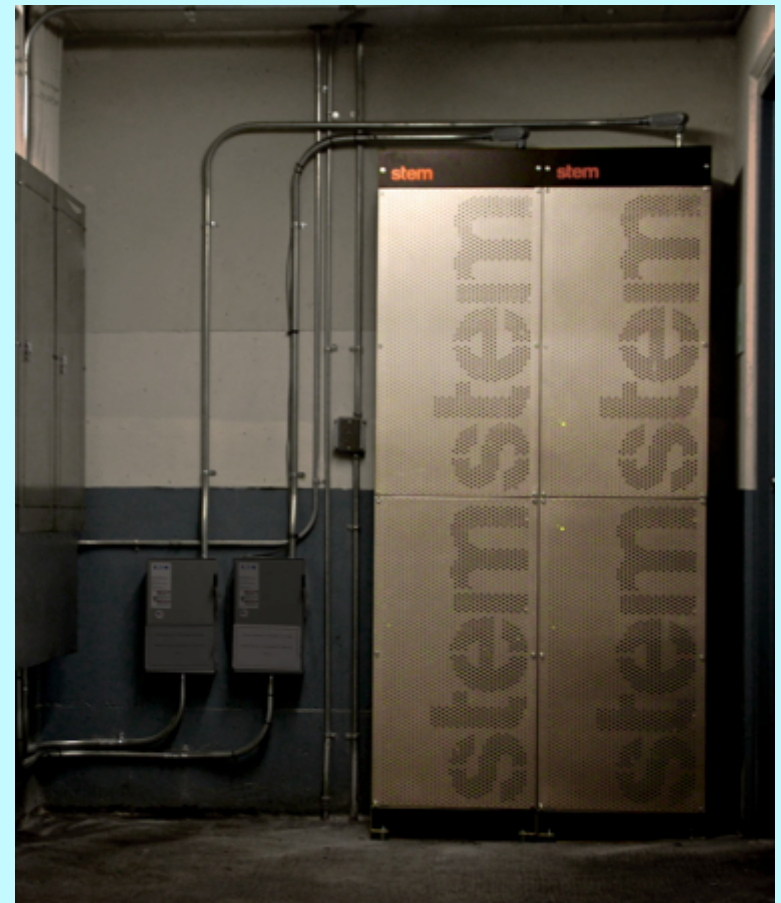


stem

data
analytics
power

Stem creates innovative solutions that are changing the way energy is distributed and consumed. Stem combines powerful learning software and advanced energy storage, simultaneously helping businesses better manage energy costs while creating a more efficient electrical grid.

1.3 MW of intelligent energy storage from California-based firm, Stem, will be deployed at Park Place to reduce energy bills and strengthen the Southern California grid



CODE LABELING ISSUES:

Off-Grid Stand Alone systems must also have a plaque or marking at a readily accessible location (such as the building entrance) indicating that the building contains a Stand alone battery based electrical system and it should indicate where the disconnecting means is located at.

Battery containment or rooms (discussed in the last webinar) must be carefully labeled as well.

Adhesive fastened signs may be acceptable if properly adhered. Vinyl signs to be weather resistant. **FC 605.11.1.3**

The markings shall be of sufficient durability to withstand the environment involved. **NEC 110.21**

1 Breaker Panel / Pull Boxes

- WARNING** ELECTRICAL SHOCK HAZARD. EXPOSED TERMINALS OR BOTH LIVE AND DEAD CIRCUITS MAY BE EXPOSED. **FC 605.11.1.3**
- WARNING** PHOTOVOLTAIC POWER SOURCE. **FC 605.11.1.3**
- WARNING** PHOTOVOLTAIC AC DISCONNECT. TURN OFF PHOTOVOLTAIC AC DISCONNECT PRIOR TO WORKING INSIDE PANEL. **FC 605.11.1.3**
- WARNING** PHOTOVOLTAIC AC DISCONNECT. TURN OFF PHOTOVOLTAIC AC DISCONNECT PRIOR TO WORKING INSIDE PANEL. **FC 605.11.1.3**
- CAUTION** PHOTOVOLTAIC AC DISCONNECT. TURN OFF PHOTOVOLTAIC AC DISCONNECT PRIOR TO WORKING INSIDE PANEL. **FC 605.11.1.3**
- WARNING** PHOTOVOLTAIC AC DISCONNECT. TURN OFF PHOTOVOLTAIC AC DISCONNECT PRIOR TO WORKING INSIDE PANEL. **FC 605.11.1.3**

2 Combiner Box, Circuits / EMT / Conduit Combiner Box / Enclosures / Raceways

- WARNING** ELECTRICAL SHOCK HAZARD. EXPOSED TERMINALS OR BOTH LIVE AND DEAD CIRCUITS MAY BE EXPOSED. **FC 605.11.1.3**
- WARNING** PHOTOVOLTAIC POWER SOURCE. **FC 605.11.1.3**
- WARNING** PHOTOVOLTAIC AC DISCONNECT. TURN OFF PHOTOVOLTAIC AC DISCONNECT PRIOR TO WORKING INSIDE PANEL. **FC 605.11.1.3**
- CAUTION** SOLAR CIRCUIT. **FC 605.11.1.3**

3 Net Meter

- WARNING** ELECTRICAL SHOCK HAZARD. EXPOSED TERMINALS OR BOTH LIVE AND DEAD CIRCUITS MAY BE EXPOSED. **FC 605.11.1.3**

4 Building / Structure

- CAUTION** PHOTOVOLTAIC POWER SOURCE. **FC 605.11.1.3**

5 Main Service Disconnect

- MAIN PV SYSTEM AC DISCONNECT**. **FC 605.11.1.3**
- WARNING** ELECTRICAL SHOCK HAZARD. EXPOSED TERMINALS OR BOTH LIVE AND DEAD CIRCUITS MAY BE EXPOSED. **FC 605.11.1.3**
- SOLAR DISCONNECT**. **FC 605.11.1.3**
- WARNING** PHOTOVOLTAIC AC DISCONNECT. TURN OFF PHOTOVOLTAIC AC DISCONNECT PRIOR TO WORKING INSIDE PANEL. **FC 605.11.1.3**

6 Inverter

- WARNING** ELECTRICAL SHOCK HAZARD. EXPOSED TERMINALS OR BOTH LIVE AND DEAD CIRCUITS MAY BE EXPOSED. **FC 605.11.1.3**
- WARNING** PHOTOVOLTAIC AC DISCONNECT. TURN OFF PHOTOVOLTAIC AC DISCONNECT PRIOR TO WORKING INSIDE PANEL. **FC 605.11.1.3**

7 DC Disconnect / Breaker

- WARNING** PHOTOVOLTAIC DC DISCONNECT. TURN OFF PHOTOVOLTAIC DC DISCONNECT PRIOR TO WORKING INSIDE PANEL. **FC 605.11.1.3**
- WARNING** PHOTOVOLTAIC DC DISCONNECT. TURN OFF PHOTOVOLTAIC DC DISCONNECT PRIOR TO WORKING INSIDE PANEL. **FC 605.11.1.3**
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- WARNING** PHOTOVOLTAIC DC DISCONNECT. TURN OFF PHOTOVOLTAIC DC DISCONNECT PRIOR TO WORKING INSIDE PANEL. **FC 605.11.1.3**

8 AC Disconnect / Breaker / Points of Connection

- PHOTOVOLTAIC AC DISCONNECT**. **FC 605.11.1.3**
- WARNING** PHOTOVOLTAIC AC DISCONNECT. TURN OFF PHOTOVOLTAIC AC DISCONNECT PRIOR TO WORKING INSIDE PANEL. **FC 605.11.1.3**
- PHOTOVOLTAIC AC DISCONNECT**. **FC 605.11.1.3**

9 Battery Containment / Rooms

- WARNING** PHOTOVOLTAIC DC DISCONNECT. TURN OFF PHOTOVOLTAIC DC DISCONNECT PRIOR TO WORKING INSIDE PANEL. **FC 605.11.1.3**
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NEC 690.32(B)(2), FC 605.11.1.3
Labels shall appear at every section of the wiring system that is separated by enclosures, walls, partitions, ceilings or floors. Spacing between labels not to exceed 10 feet (3m).

NEC 690.35(F)
A PV power source shall be labeled at each junction box, combiner box or disconnect, and clearly where energized, ungrounded circuits may be exposed during service.

NEC 690.45
Where circuits are embedded in building, basement or membrane ceiling materials not covered by PV modules and associated equipment, the location of the circuits shall be clearly marked.

NEC 690.52
A label shall appear on the utility interactive inverter or be applied by the installer over the ground fault indicator at a visible location.

NEC 690.11(F)
Where all terminals of the disconnecting means may be energized in the open position, a marking shall be provided on or adjacent to the disconnecting means.

NEC 118.27(C)
Inverters, enclosures or other guarded locations that contain exposed live parts shall be marked with conspicuous warning signs for bonding unqualified persons to enter.

FC 605.11.1.3
Warning tags are used to represent a hazardous location between "Caution" and "Danger".

FC 605.11.1, FC 605.11.1.4 & NEC 690.11
If the equipment is energized from more than one source, the disconnecting means must be grouped and identified.

NEC 690.14(C)(3)
Each photovoltaic system disconnecting means shall be permanently marked to identify it as a photovoltaic system disconnect.

NEC 690.53
A permanent label for the direct-current PV power source shall be provided by the installer at the PV disconnecting means.

NEC 690.16(B)
Non-fault related disconnecting means shall be marked.

NEC 690.53(B)
Interaction current - Is a type that requires the use of a tool to open and be marked "Do Not Disconnect Under Load".

NEC 690.54
All interactive system points of interconnection with other sources shall be marked at its accessible location at the disconnecting means at the power source and with the rated AC, open-circuit and the nominal operating AC voltage.

NEC 690.55
PV power systems employing energy storage shall be installed at the maximum operating voltage, including any regulation voltage and polarity of the grounded circuit conductor.

Questions?