Hartley Solar and Storage Retrofit… Case Study -

Design and specification, installation and commissioning of the Hartley Nature Center Solar Electric Retro-fit PV+Storage system…

Christopher LaForge

IREC Certified Master Trainer

NABCEP Certified Photovoltaic Installation Professional

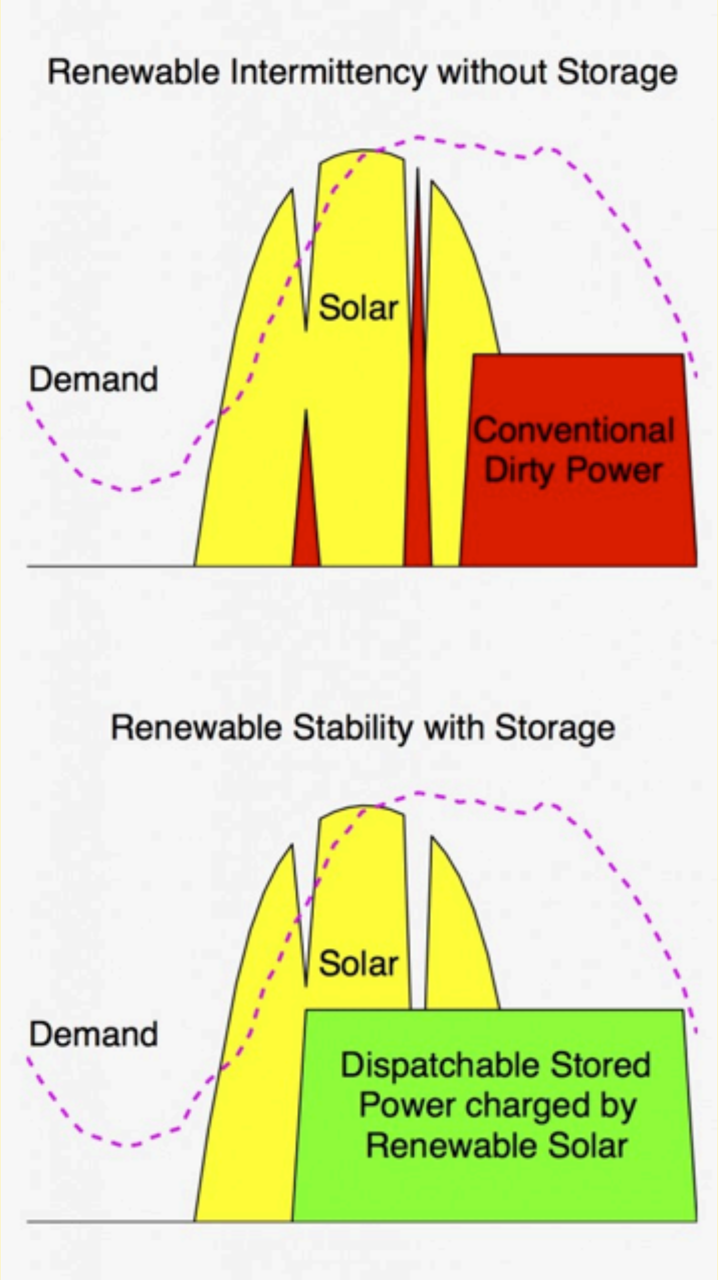
30 years Operating Great Northern Solar

26 years Training with MREA and other organizations

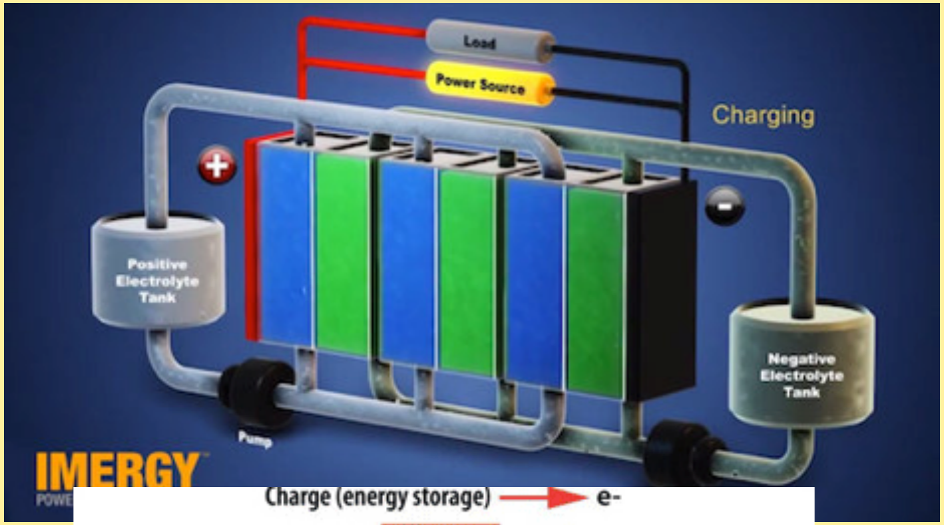
Emeritus

The development of LiOn batteries, first for electric cars, has stimulated the market for battery use in PV + Storage systems…

The benefits of dispatchable Solar Energy stored in quick reacting batteries appeals to Utilities (energy time shift, load following and frequency regulation, renewable capacity continuity, transmission congestions relief) as well as end users such as businesses (peak load shaving) and home owners (time of use metering options and resiliency).



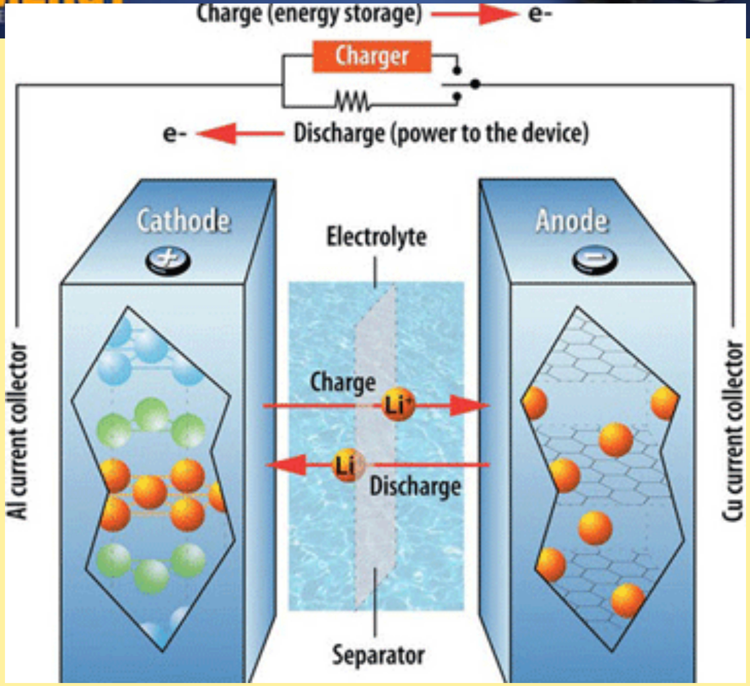
Two primary new battery types are dominating the PV = Storage market



Flow batteries

and

LiOn batteries

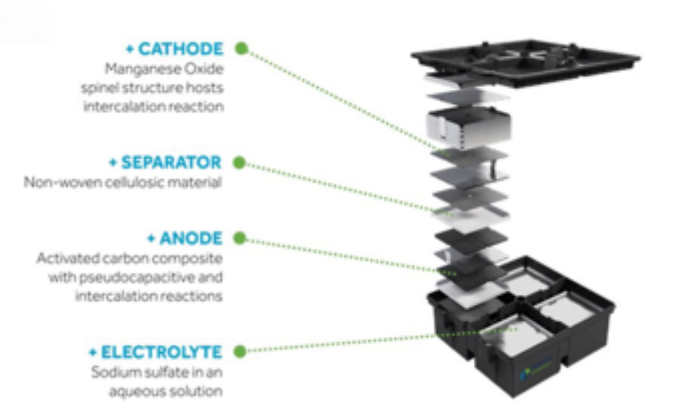


Sustainable - Aqueous Hybrid Ion (AHI™)

AHI batteries have an environmentally-friendly electrochemical design that contains no heavy metals, toxic chemicals, inorganic solvents, or other noxious materials.

AHI batteries rely on no heavy or toxic metals, such as lead, or caustic materials such as sulfuric acid or lithium hexafluorophosphate.

AHI batteries are safe enough to be disposed via traditional waste streams (always follow local regulations regarding disposal of any product).



The batteries are completely sealed and do not require maintenance. They are self-balancing and do not require an equalizing charge or a battery management system (BMS).

AHI batteries have no moving parts like flow batteries, complicated watering systems like some lead acid batteries, and do not require active cell balancing like lithium ion systems.

The aqueous electrolyte provides natural overcharge and over discharge protection and, along with the high impedance of the system, allows AHI batteries to self balance in string configurations.

Stone-edge-farm-microgrid-project

Fourteen 25 kWh Aquion M-Line Battery Modules providing approximately 350 kWh of energy storage capacity, connected to a 32 kW solar array using Ideal Power's 30 kW multi-port power conversion system.

The Ideal Power multi-port system architecture enables the direct DC-level connection of solar PV and energy storage in one compact, highly efficient, transformerless package, eliminating the complexities and redundancies of older, AC-coupled systems. Aquion's battery technology is a unique saltwater chemistry made from abundant, nontoxic materials. The batteries are designed for daily deep cycling in long duration (4+ hour charge/discharge) applications, making them ideal for solar installations.

https://prezi.com/cnbi98fvg3va/stone-edge-farm-microgrid-project/

The scale and cost of the Flow batteries directed our project toward LiOn batteries and a quick review of this technology was in order…

Lithium Ion (Li-ion): Li-ion batteries are a much newer technology, commonly used in the electric vehicle and stationary storage markets. Li-ion is used where light weight and high energy density are of prime importance, such as a building with space constraints. There are different types of Li-ion systems that are generally defined by various cathode chemistries that affect performance, longevity, safety, and cost (Battery University, 2015)

lithium iron phosphate (LFP)

lithium nickel manganese cobalt oxide (NMC)

lithium nickel cobalt aluminum oxide (NCA)

lithium manganese oxide (LMO)

lithium titanate (LTO)

Of the five Li-ion battery candidates, none show a significant advantage over the others. Focusing on one strong attribute like energy density may compromise another, like safety (which is the case with NCA). LTO is generally considered the safest chemistry system, but has the lowest energy density of the group.

Battery Comparison Table

Specifications	Battery Chemistries						
	Lead Acid	Lithium-Ion					Flow Batteries
	VRLA (Deep-Cycle)	LFP	NMC	NCA	LTO	LMO	Redox
Usage[1]	Resiliency, Grid Support, Peak load shifting, Intermittent energy smoothing, UPS	Resiliency, Grid Support, Peak load shifting, Intermittent energy smoothing, UPS					Resiliency, Grid Support, Peak load shifting, Intermittent energy smoothing, UPS, Bulk power management
Energy density (Wh/kg)	30-50	90-120	150-220	200-260	70-80	100-150	10-20
Lifetime cycles (80% depth of discharge)	50-100[7]	1000-2000	1000-2000	500	3000-7000	300-700	10,000+
Efficiency (%)	85-90[2]	90-95	90-95	90-95	90-95	90-95	65-85
Charge rate	8-16 hrs[1]	2-4 hrs	2-4 hrs	2-4 hrs	1-2 hrs	1-2 hrs	Depends on size of tanks & cell stack[5]
Cost	\$150-300/kWh[4, 7]	\$400/kWh[7]	\$428-750/kWh[3, 6]	\$240-\$380/kWh[3, 6]	\$2,000/kWh[7]	\$250-300/kWh[7]	\$680-800/kWh[6, 7]
Advantages	Well-known and reliable technology, able to withstand deep discharges, relatively low cost, and ease of manufacturing.	High energy density, able to withstand deep discharges, and long cycle lives.					Relatively safe, well suited for bulk storage, long cycle life (claim 10,000-20,000 cycles), and easy to scale up the amount of energy stored by simply making the tanks larger.

Battery Comparison Table

Specifications	Battery Chemistries						
	Lead Acid	Lithium-Ion					Flow Batteries
	VRLA (Deep-Cycle)	LFP	NMC	NCA	LTO	LMO	Redox
Disadvantages	Relatively low number of life cycles (must be replaced more often) and lower energy density (larger size for less energy storage).	More expensive than lead acid systems and may become thermally unstable. Overheating or short circuits in Li-ion cells may cause thermal run-away—a phenomenon where the internal heat generation in a battery increases faster than it can dissipate. This heat can damage or destroy the cells and is a potential source for fires. Electronic protection circuits are added to the battery pack to prevent thermal run-away.					Relatively high cost, low efficiency (less than 70%) and low energy density; high maintenance with pumps that often leak and precipitate out.
Safety (Thermal Run-away)[8]	Considered thermally safe	High thermal stability	Increased thermal stability	Thermal instability	Highest thermal stability	Increased thermal stability	Very safe since storage of electrolyte is separate from power generation unit

Sources: All information from Battery University unless otherwise noted.

Energy Storage and PV – current product offerings

Tesla began much of the buzz of smaller scale PV + Storage systems

The products vary widely as does their real availability…

The Product selection saga took considerable research and investigation…

Tesla was not a cost effective nor timely product line for this project, But we looked deeply into it.

Others included Balquon, Stem, Princeton, Sonnen, Juice Box and finally
Sunverge…

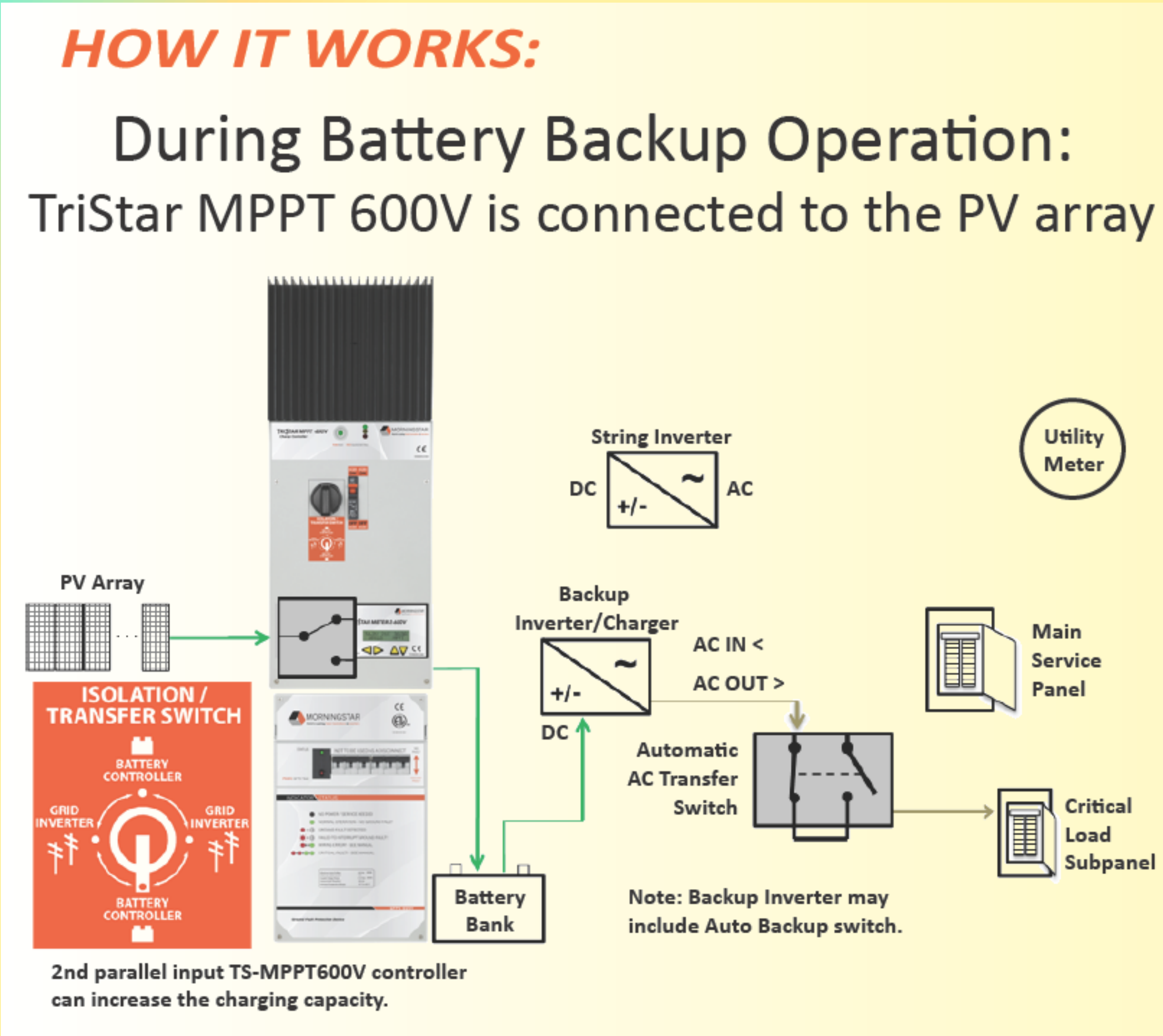
We review the offerings…

TESLA

Technology: Wall mounted, rechargeable lithium ion battery with liquid thermal control.
Models:10 kWh $3,500 For backup applications
7 kWh $3,000 For daily cycle applications
Warranty: 10 years
Efficiency: 92% round-trip DC efficiency
Power: 2.0 kW continuous, 3.3 kW peak
Voltage: 350 – 450 volts
Current: 5.8 amp nominal, 8.6 amp peak output
Compatibility: Single phase and three phase utility grid compatible.
Operating Temperature: -4°F to 110°F
Enclosure: Rated for indoor and outdoor installation.
Installation: Requires installation by a trained electrician. DC-AC inverter not included.
Weight: 220 lbs / 100 kg
Dimensions: 51.2" x 33.9" x 7.1”
Certification: NRTL listed to UL standards

Required re-wiring the sub-arrays with SolarEdge optimizers, using SolarEdge inverters, leading to high labor cost for retro-fit. The product was not readily available.

DC Coupled Retro-fit



Unique retro-fit option, did not provide LiOn battery option, did not create benefits other than simple battery back-up for utility outages.

sonnen

Power Unit - Continuous output: (AC) 3,000 W – 8,000 W
Usable capacity:4 kWh - 16 kWh (in 2 kWh steps)
Dimensions (in) W/H/D 4 - 8 kWh:26/51/14Dimensions (in)
Maximum efficiency of inverter: 93 %
240 VAC / split phase / 60 Hz Certified to UL 1741 (inverter), UL 1973 (batteries) Warranty*Guaranteed lifetime of 10,000 cycles or 10 years. *Please observe our applicable warranty conditions

AC –coupled design, LiOn Battery… Need for GT inverters with AC-coupled design. Cost too high for Hartley Retro-fit.

SUNVERGE

DC –coupled design, LiOn Battery with Schneider BOS

Battery chemistry - nickel manganese cobalt - cycle life 7200 cycles to 80% DOD…
1 cycle/day for 20 years…

NO AFCI or RSD

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.

Example: 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.

Larger scale and higher cost than the Hartley project could support. Very advanced system with wide range of client and utility applications.

Example: 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 En- ergy 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.

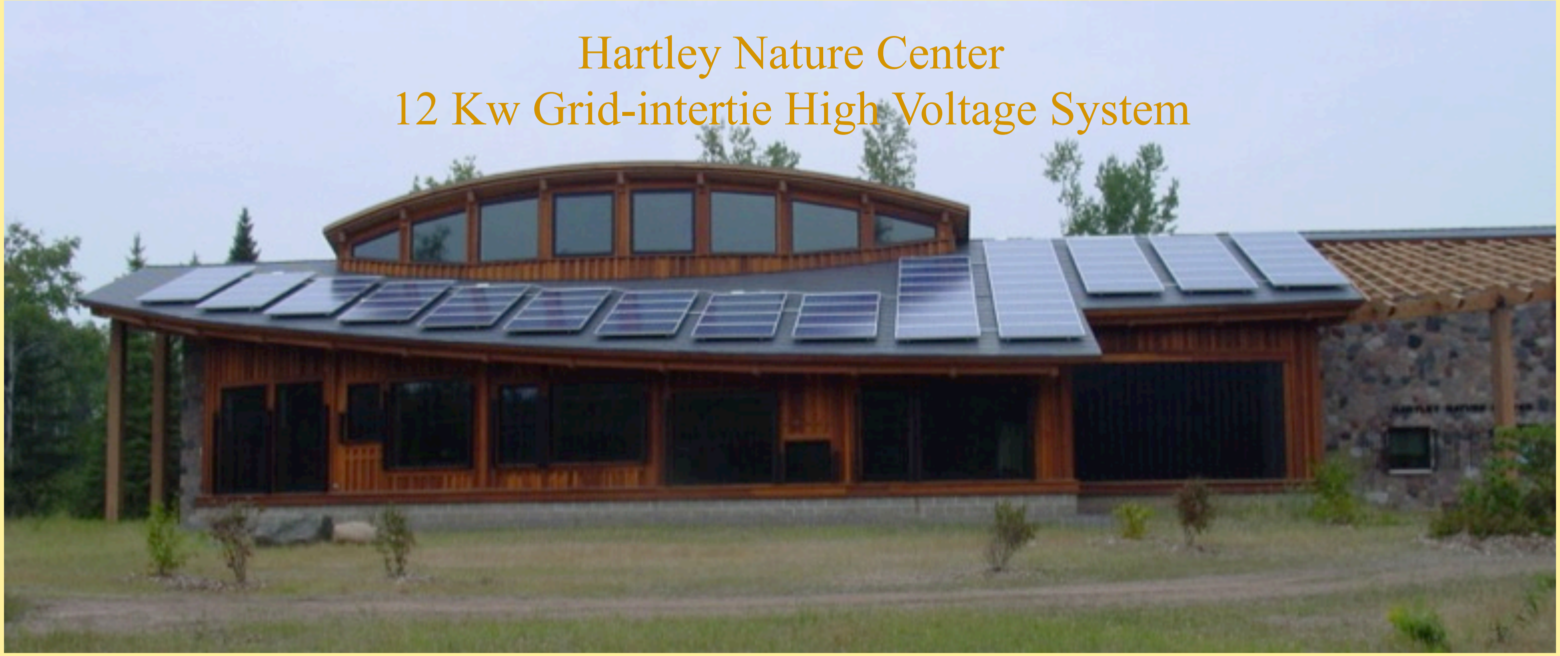
History of the Hartley Nature PV System:

Installation completed 2003

Installation supervised by C. LaForge under contract with RWE Schott Solar

The Hartley Nature Center contracted with RWE Schott Solar, to design and install the their 13.2Kw PV system. The system includes both roof mount and tracking arrays in a very robust building power system.

Peter Gravett was Director of Hartley Nature Center at that time.



This system, being a small commercial system installed early in the history of PV contracting, did not include a O&M Plan or contract…

The system owner was solely responsible for the Operation and Maintenance of the system.

With institutional turnover in personnel O&M can become a challenge for the ongoing operation of the system

Many Institutional systems become “Orphan Systems” that reduce output or stop operation completely.

The Two arrays make up the original system –

The 8 module tracking array in the parking area with an STC rated DC output of 1320w, and

The main roof array with 5 sub-systems for a total STC rated DC output of

Brett Amundson: Provided me with a time line of the operational status of the system:

August 2013-First of three inverters start failing

September 2013- Contacted Conservation Technologies (Energy Plus) re: diagnostic-No solution found and no response for a replacement bid request. I called SMA direct and they offered a discount on a new replacement as the error code and age required significant investment.

January 2014- Geothermal system starts reducing capacity. Second inverter starts showing problems, fuses regularly replaced. Difficulties with MN Power to get true billing that includes energy production/sell back.

Electrical billing increases significantly despite no new loads.

February 2014- Lighting energy audit performed.

July 2014- Full building energy audit performed.

October 2014- Second inverter fails completely. Geothermal completely offline.

February 2015- Conversations with Bret Pence (Ecolibrium3) begin on energy and efficiency solutions and funding.

June 2015- New E-gauge monitoring system is installed- old system is removed.

July 2015- Conversations begin with lighting consultant regarding full building energy efficiency retrofits begin.

October 2015- Third inverter fails completely.

February 2016- Early solar storage conversations and potential grant submission in the works. Project begins to take shape.

May 2016- Solar tracker down – trouble-shot and repaired by Great Northern Solar

July 2016- New Geothermal system installed.

Discussions begin at 2015 Energy Design Conference between C.LaForge and Bret Pence on Hartley inverter situation,…

Discussions continued with Bret Pence, Alison Hoxie, Brett Amundson and Clean Energy Group leading to PV + Storage options and the Resilient Power project assisting in planning…

RESILIENT POWER
A project of CleanEnergyGroup

Leading to the current plan to develop a retro-fit on a portion of the existing array with Lion storage…

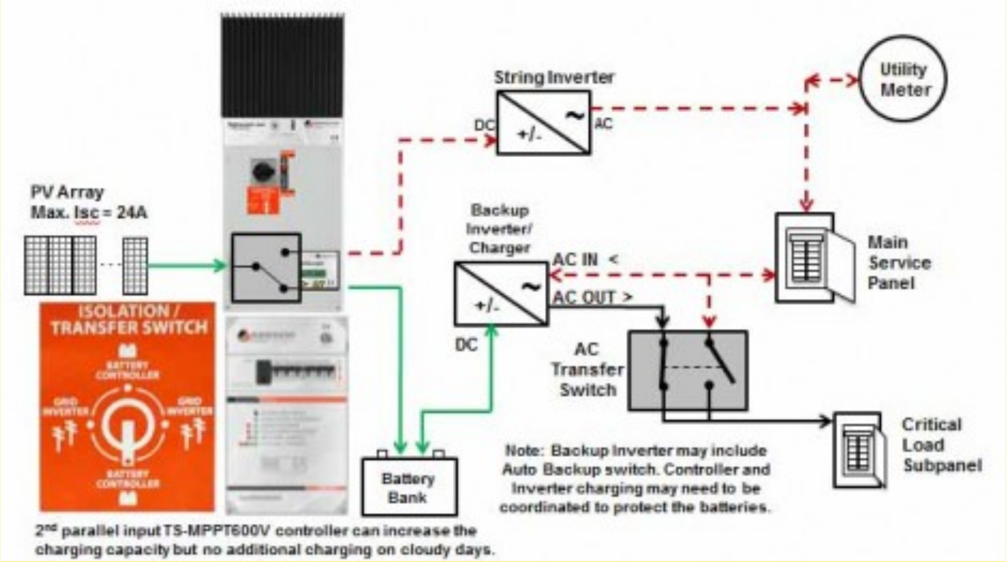
and the remaining 5 Kw to be dedicated to a standard grid-tied inverter without battery…

Design Options – for Solar + Storage

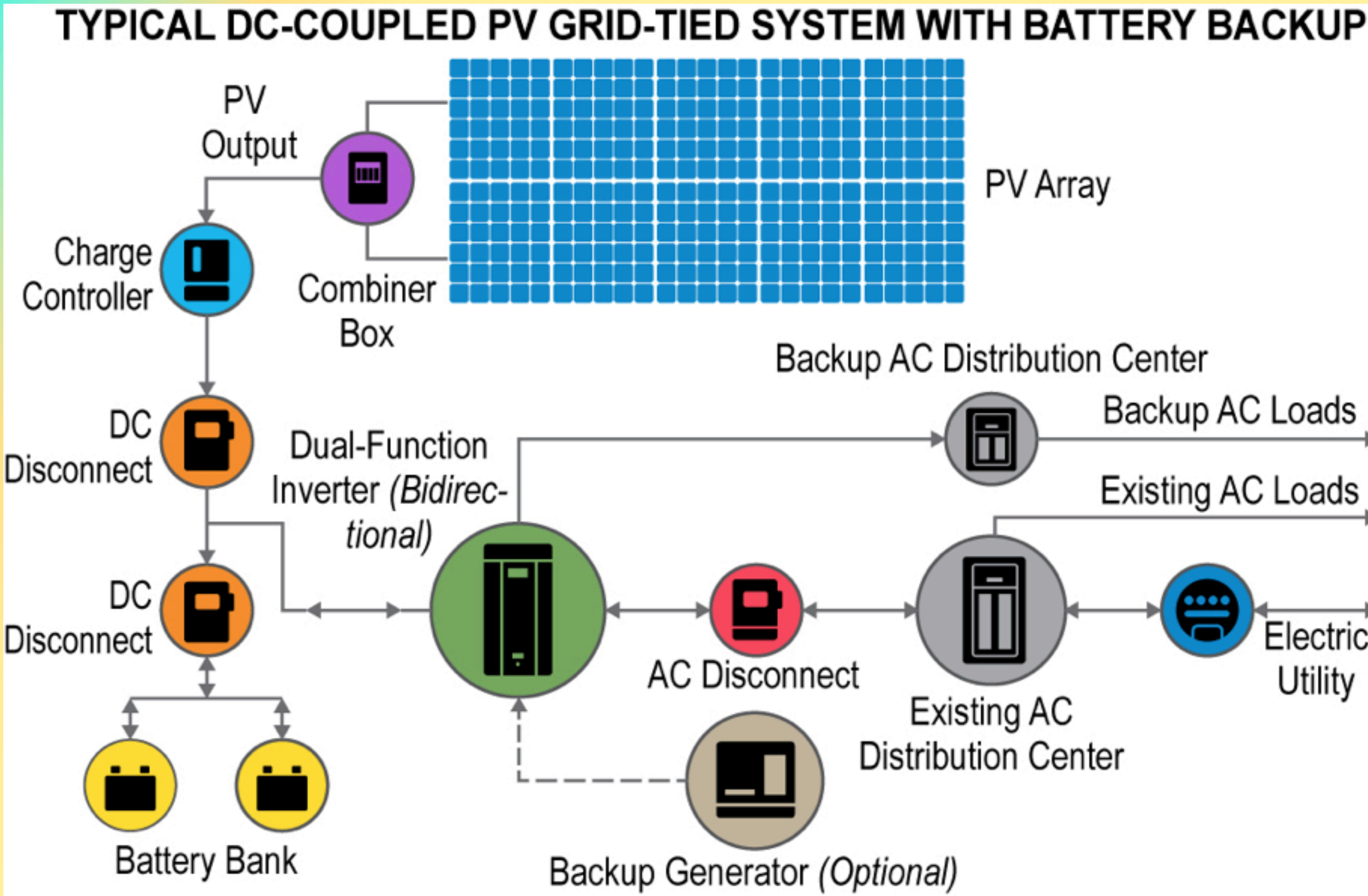
Two basic designs exist…

DC coupled

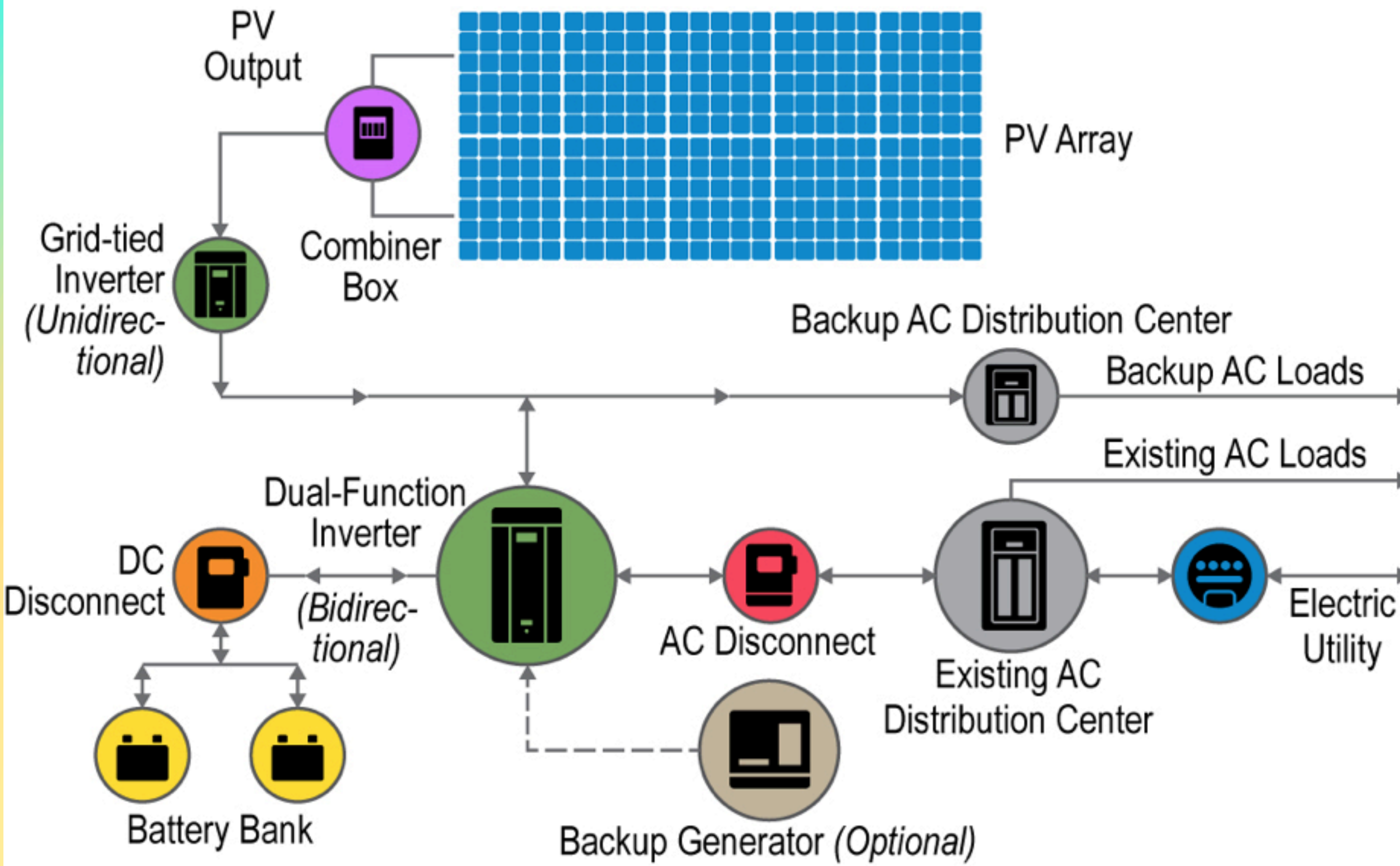
AC coupled



To understand the product choices we need first to define these basic designs…


TYPICAL DC-COUPLED PV GRID-TIED SYSTEM WITH BATTERY BACKUP
PV Output
PV Array
Charge Controller
Combiner Box
Backup AC Distribution Center
Backup AC Loads
DC Disconnect
Dual-Function Inverter (Bidirectional)
Existing AC Loads
DC Disconnect
AC Disconnect
Electric Utility
Existing AC Distribution Center
Battery Bank
Backup Generator (Optional)

TYPICAL AC-COUPLED PV GRID-TIED SYSTEM WITH BATTERY BACKUP



Getting the funds…

Hartley and Ecolibrium3 collaborated in raising funds and received support from –
Clean Energy Group (Educational support)
Minnesota Power (Equipment grant)
City of Duluth (Electrician support)
IBEW (project donation)
GNS (material and labor donations)

Others???

Decision Making Process for Choosing products for Hartley:

Non-Profit group with limited budget

City interested in building having back-up power for resiliency site

Hartley initial desires…

- Charge battery from Solar arrays and utility grid
- Feed excess energy to the utility grid
- Provide power from the solar modules and or battery when utility is down (critical load back-up)
- Provide peak demand management (Peak Shaving)
- Extend the onsite use of solar energy in a 24 hour period

Additional Goals of the project

- Provide Utility ancillary services as a small demonstration
- Provide a public communications shelter during utility outages and or emergency situations
- Educational demonstration project of benefits of a solar + Storage system

Design choices:

Each of the options provided for:

Charging battery from Solar arrays and utility grid

Feeding excess energy to the utility grid

Providing power from the solar modules and or battery when utility is down (critical load back-up)

Extend the onsite use of solar energy in a 24 hour period (Tesla not clear on this)

Stem, Princeton, Sonnen, and Sunverge could provide for:

Peak demand management (Peak Shaving)

Utility ancillary services as a small demonstration

A public communications shelter during utility outages and or emergency situations

Working with Great Northern Solar provided for:

Educational demonstration project of benefits of a solar + Storage system

Stem and Princeton were both too large scale/expensive and
Re-wiring requirements for the Tesla/SolarEdge option was much higher cost =

Sunverge became the best option for the Hartley project…

Design choices for Hartley upgrade

Product brand = Sunverge

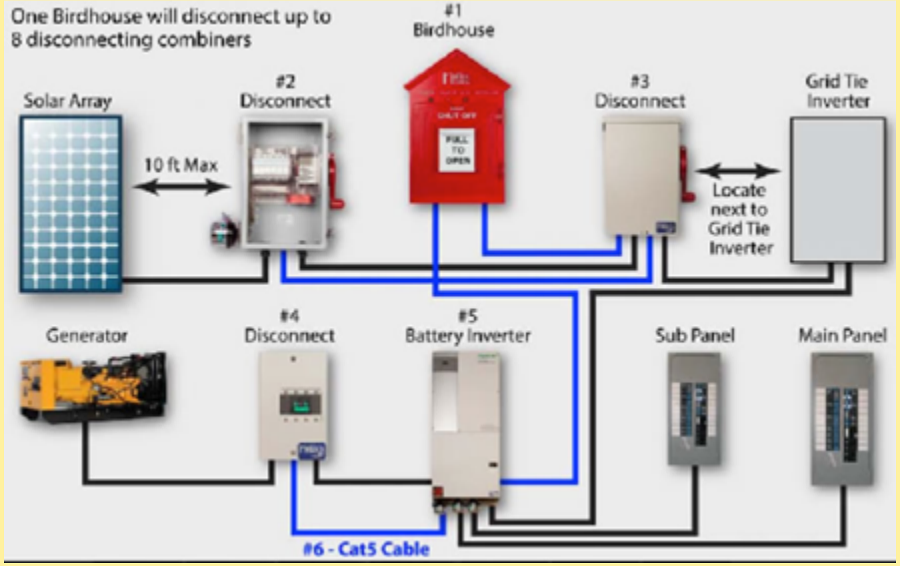
Array size for LiOn system

Choice of inverter replacement for remaining array

Retro-fit code issues:

AFCI

Rapid Shut Down



Array size for LiOn system:

Best fit was to use the arrays powering the 3 original SMA 1800/watt inverters… using 36 modules wired in 6 source circuit strings of 6 modules each… leaving the arrays that powered the 2 original SMA 2500/watt inverters…

Choice of inverter replacement for remaining array:

SMA offers a 5Kw inverter with a unique “secure power supply” – This option provides for a small amount of power from the array (~1500 watts) to be available at a dedicated outlet during Utility outages when adequate sun is present

This added to the value of the overall system for Provide a public communications shelter during utility outages.

Solutions for rapid shut down and Arc-fault detection and interruption (AFCI) are required for venues adopting the 2014 NEC… Minnesota has adopted 2014 NEC…

The SMA inverter has AFCI protection internally, but does not have Rapid Shut Down (RSD) on board and therefore would require a RSD unit…

The Sunverge SIS does not have AFCI or RSD and therefore would require a solution for both…

The industry has been challenged to achieve RSD protection and very few companies have provided for both AFCI and RSD as required by the Sunverge unit…

Lets review the offerings…

Available as of June 2016… not compatible with Sunverge SIS…

RAPID SHUTDOWN SYSTEMCOST-EFFECTIVE SYSTEM COMPLIANCE

Certified for Sunny Boy 5.0-US/6.0-US and TL-US inverter lines with multiple MPP tracking channels

Compatible with Secure Power Supply

Incorporated junction box reduces equipment and speeds installation time

Pre-wired MC4 connectors and snap terminals reduce materials and installation time

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

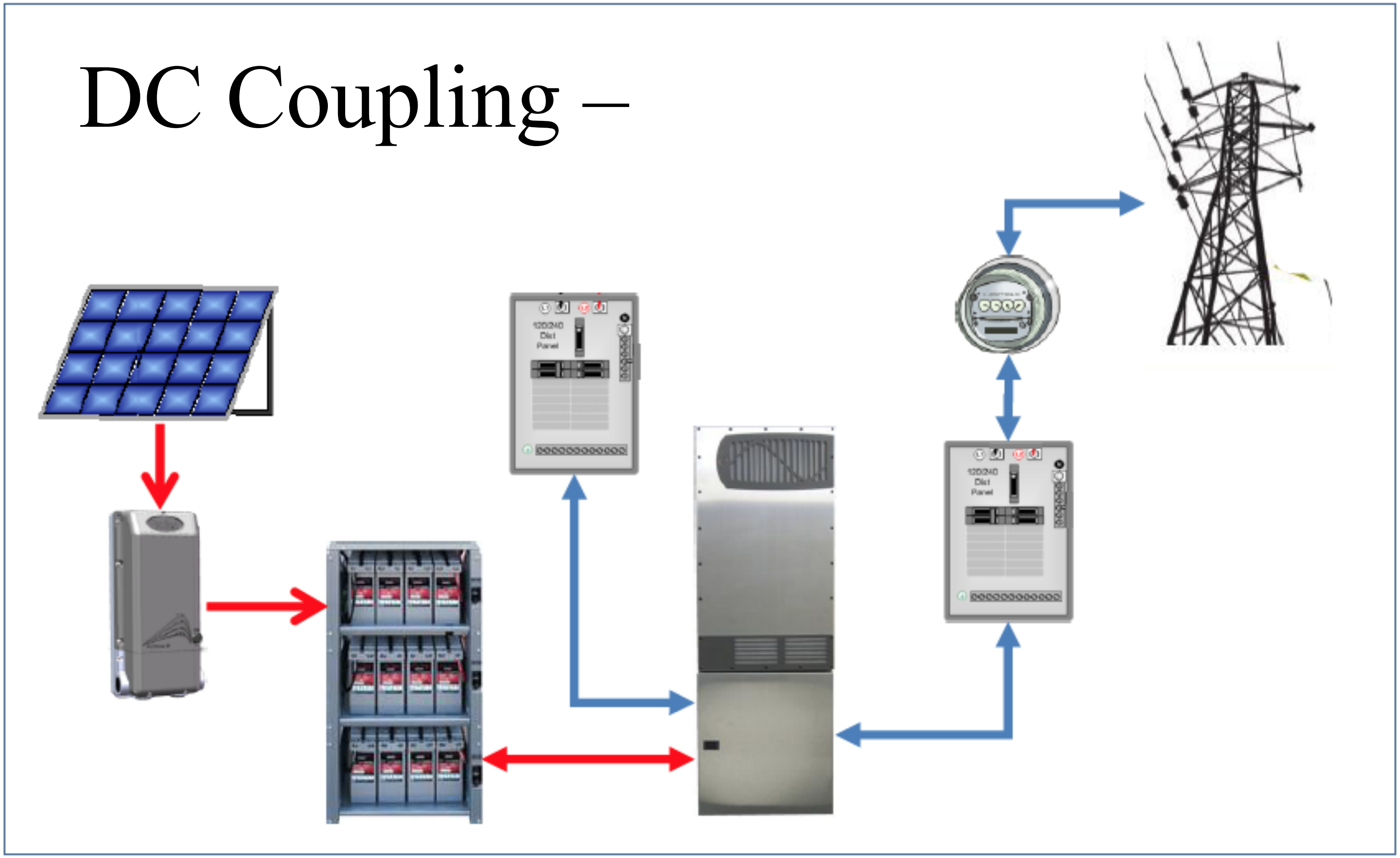
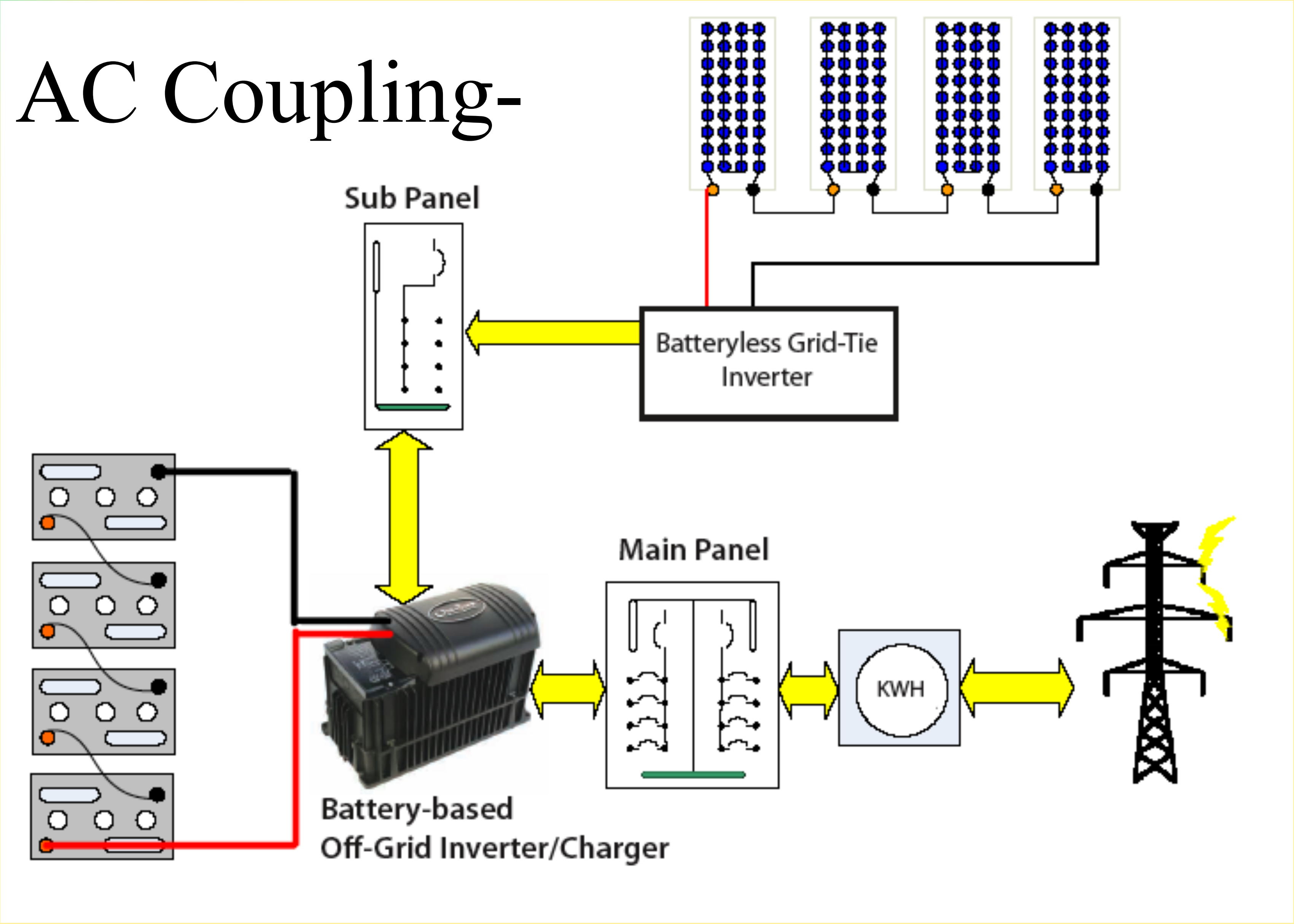


Figure 2 - Typical Grid/Hybrid System

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



Sunverge - NO AFCI or RSD

Innovative solar allowed for RSD with the SMA Inverter and RSD and AFCI with the Sunverge SIS…

This helped to create a single RSD that integrates with the Sunverge battery disconnect switch to de-energize the entire system with the throw of one switch located at the meter base of the Nature Center.

INNOVATIVE SOLAR INC

Product Information **2016**

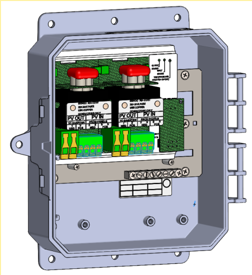
Rapid Shutdown

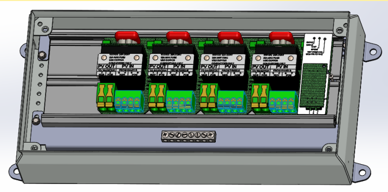
With Capacitor Discharge

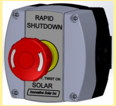
The First Universal Single Box Solution

Highlights:

- Discharges inverter capacitors in < 10 seconds.
- Three 600v versions included in initial release.
- (1000v UL1741 versions available on request).
- Auto-triggered with removal of grid power.
- NEC690.12 compliance in a single box.
- Available in the SolaDeck enclosure.
- Available in non metallic enclosure.
- Works with all grid-tied inverters.
- Scalable to all system sizes.
- TUV listed to UL1741.
- No additional conduit.







Differentiators

Innovative Solar Inc. offers **Capacitor Discharge** on every 600v string

A **Universal Solution** that works with all inverter manufacturers and types. No need to support multiple designs.

No Inverter Modifications are needed to achieve full compliance with 690.12.

No maintenance is required, no batteries to be maintained or replaced, and no PV wires to torque.

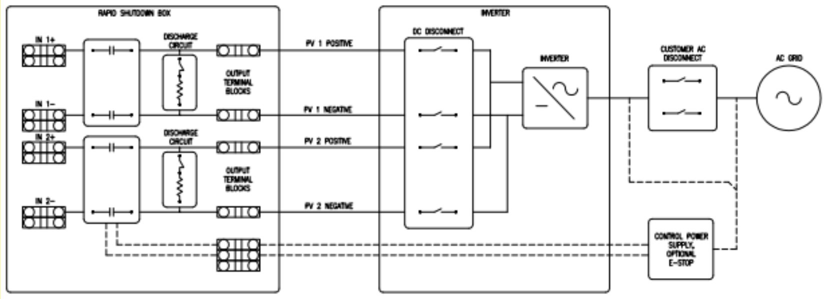
The system from Innovative Solar Inc. is rated for **Extreme temperatures**: -40°C to 70°C (-40°F to 158°F).

Innovative Solar Inc. is the only Rapid Shutdown system available in the popular **SolaDeck** enclosure.

Rapid Shutdown with Capacitor Discharge

Additional features:

- Can be triggered by Solar AC disconnect or optional E-stop.
- Control power can be daisy chained for larger systems.
- Both positive and negative legs are switched.
- Runs on nearly any low voltage source.



Contact Us

Give us a call for more information about our products

Innovative Solar Inc.
224 Airport Pkwy
Suite 190
San Jose, California 95110

Kevin Afshar
Sr. Business Development Mgr.

Phone Sales
1-408-914-8321

Specifications:

Version	SolaDeck 2 Channel RS6-D2-S1CAC	Polycarbonate 2 Channel RS6-D2-P1CAC	Powder Coated Steel 4 Channel RS6-D4-S2CAC
PV input			
Number of channels	2	2	4
Max number of input strings	4	4	8
Max input voltage	600vdc		
Max input current (per string)	12.5A		
Conductor size	14-10 awg (stranded)		
PV output			
Conductor size	14-6 awg (stranded or solid)		
Capacitor discharge	1000uf / RSD channel (discharge to <30v in <10sec)		
Surge protection (UL1449 certified)	20kA at single 8/20μS impulse		
Control power			
Power consumption	2.5w/contactor, pull-in 0.7w/contactor, holding		
Control voltage	15-30vdc		
Conductor size	18-12 awg (stranded or solid)		
Enclosure			
Type	CRS, flashing	Polycarbonate	CRS
Mounting angle (minimum)	14 deg > Horz 3/12 pitch	Any	Any horizontal orientation Derate 10C, if on end
Dimensions H x W x D (inches) without mounting flanges	8.7 x 10.4 x 2.6	9.5 x 8.5 x 3.5	15.7 x 7.9 x 3.1
Net weight (approx.)	10 lb.	3.5 lb.	13.1 lb.
Enclosure rating	NEMA 3R	NEMA 4X	NEMA 3R/4
Environmental			
Operating temperature range	-40°C to 70°C (-40°F to 158°F)		
Certifications	UL1741 , 690.12 compliant		
Warranty			
Standard Warranty	10 Year		

~ Contact Innovative Solar for Power Supply Options

Array sizing attempted to include the most PV into the Sunverge SIS possible…

The three sub-arrays that powered the 1800 watt SMA inverters led to a maximum array size – limited by the input requirements of the Schneider High Voltage Charge controller…

The Sunverge staff wanted fewer amps and more voltage – leading to a re-wiring of the 3 pairs of 6 module strings into 3 strings of 12 modules… this however led to a voltage exceeding 600Vdc at temperatures of -22 degrees F.

The arrays were re-wired leaving one module out in each string for 3 strings of 11 modules each…

The Schneider Conext design tool report was “Good”…

Geographic details: Insolation: 500 kWh/m2a Latitude: 30 °N Installation area: 100 m2

MPPT Charger details: Model name: XW MPPT 80 600 Battery Voltage(V): 48 V

Input(DC)

Max. open circuit DC voltage (V):	600 V
MPP range (V):	195-510V
Max. MPP Current(A)	24.34 A
Max. Array Isc(A):	28 A
No. of MPPT channels:	1

Output(DC)

Max. Output Power(W):	4800 W
Max. Charge Current(A):	80 A
Max. efficiency:	96.0%

Panel details: Manufacturer: Schott Solar AG Panel: SCHOTT POLY TM 165

Type:	poly	Temperature coefficient of open circuit voltage:	-0.33%
Peak output power (Wp):	165.00W	Temperature coefficient of short circuit current:	0.04%
MPP current (A):	4.70A	Short circuit current (A):	5.27A
Nominal Voltage (V):	35.10V	Open circuit voltage (V):	43.60V
No. of cells in the module:	72	Panel temperature:	Min -22 °F Max 104 °F

Installation type: Pitched-roof with poor back ventilation

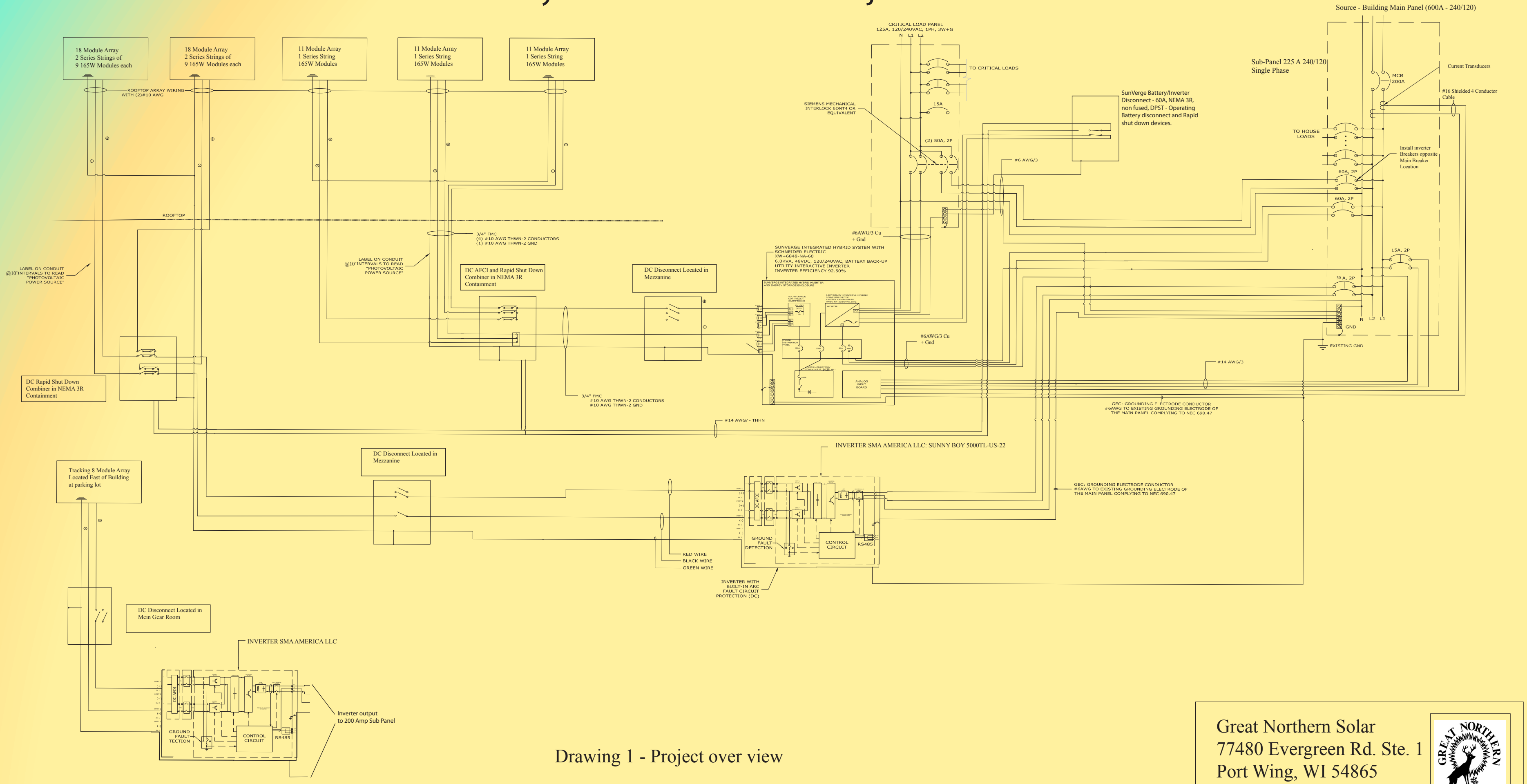
Panel configuration and output:

	MPPT1
Configuration	
Panels/String	11
No of Strings	3
Solar tracking	No
Inclination/ Tilt	22°
Azimuth/ Orientation	0°
Output	
PV generator output	5445 W
Suggestion	Warning
Suggested over-sizing factor	1.2
Over-sizing factor	1.08
Suggestion	Good

Min. MPP voltage of inverter	195 V
Min. MPP voltage of PV generator at 104 °F	366.98 V
Suggestion	Very good
Max. MPP voltage of inverter	510 V
Max. MPP Voltage of PV generator at -22 °F	456.17 V
Suggestion	Very good
Max. open-circuit voltage of inverter	600 V
Max. open-circuit voltage of PV generator at -22 °F	566.64 V
Suggestion	Acceptable
Max. DC current	24.34 A
Max. MPP current of PV installation	14.1 A
Suggestion	Good

Total PV generator output: 5445 W (Good)
Total no. of panels: 33

Hartley Nature Center O&M Project



Drawing 1 - Project over view

Great Northern Solar
77480 Evergreen Rd. Ste. 1
Port Wing, WI 54865
715 774 3374

Backing up building loads:

Critical load panels have the loads that need to run during Utility outages…

This load must:

1) not surpass the continuous or Surge capacity of the inverter in the back-up system
2) not be so large that the load consumes the battery too quickly
3) provide the services that the client requires for times of utility outage

Capacity:

Basic math – Amp hours X voltage = Watt-hours

Amp hour capacity based on

Daily watt hour consumption (DWC)

X required autonomy period (AP)

(hours–PV charge source adds capacity)

Amp hour capacity = DWC X AP / Voltage

Example: 1200 Whr X 3 /12 = 300 Ah

Begin with a Consumption Worksheet to detail Daily Watt-hour Consumption

INVERTER SUPPLIED 120 VAC APPLIANCE POWER CONSUMPTION ESTIMATE

Tutor example Date: 6/4/09

AC Watt-hrs. Used Daily 8641

1

Please note: this is an estimate and is only as good as the information supplied.

All Appliances on the list below are powered by 120 VAC from the inverter

No.	Inverter Powered Appliance	P?	Run Watts	Start Watts	Hours /Day	Days /Week	W-hrs/day	%
0	Refrigerator	1	125	500	6	7	0.0	0.0%
0	Well Pump	1	1800	3600	1	7	0.0	0.0%
0	Computer	1	60	100	2	7	0.0	0.0%
12	Washing Machine	0	800	2400	1.5	2	4114.3	47.4%
0	Lighting	1	20	25	6	7	0.0	0.0%
0	Incandescent Lights	0	30	30	2	7	0.0	0.0%
0	Vacuum Cleaner	0	700	2100	1	1	0.0	0.0%
1	Television Set	1	85	85	2	4	97.1	1.1%
0	Stereo	1	100	100	1	4	0.0	0.0%
0	Video Cassette Recorder	0	45	45	2	4	0.0	0.0%
1	Ni-Cad Battery Recharger	1	4	4	2	7	8.0	0.1%
1	Blender	1	350	700	0.05	2	5.0	0.1%
0	Power Tool	1	750	1500	0.2	2	0.0	0.0%
0	Microwave Oven	0	600	1200	0.1	3	0.0	0.0%
0	Computer Printer	1	60	60	0.5	7	0.0	0.0%
0	Shoplight	0	40	40	0.3	7	0.0	0.0%
1	Food Processor	0	400	800	0.05	2	5.7	0.1%
0	Kitchen Grater	0	150	150	0.1	2	0.0	0.0%
0	Kitchen Mixer	0	300	300	0.1	1	0.0	0.0%
0	Soldering Iron	0	100	100	0.1	2	0.0	0.0%
0	Makita Charger	0	10	10	0.5	3	0.0	0.0%
1	Clothes Dryer (motor only)	0	500	1500	0.25	7	125.0	1.4%
0	Electric Blanket	1	200	200	4	7	0.0	0.0%
0	Freezer	1	150	500	10	7	0.0	0.0%
0	Hair Dryer	0	750	750	0.2	7	0.0	0.0%
1	Heating Pad	1	250	250	2	7	500.0	5.8%
0	Radiotelephone RX	1	6	6	18	7	0.0	0.0%
0	Radiotelephone TX	1	70	70	0.5	7	0.0	0.0%
1	Satellite TV System	0	75	75	4	7	300.0	3.5%
0	Sewing Machine	0	80	160	0.1	7	0.0	0.0%
0	cieling fan	0	25	50	3	2	0.0	0.0%
1	Furnace pump	0	900	1800	3	7	2700.0	31.1%
0	Whatever Appliance	0	0	0	0	7	0.0	0.0%
0	Whatever Appliance	0	0	0	0	7	0.0	0.0%
0	Whatever Appliance	0	0	0	0	7	0.0	0.0%

Hartley critical loads-

1) Need load wattage and desired autonomy to be calculated

2) Was complicated by the existing wiring – multi-wire branch circuits

efficient wire use and less conduit fill – led to larger # of potential loads

3) Needs to be considered in terms of desired services and period of autonomy provided by the existing battery… How long do you need the loads powered

With many clients battery capacity can be added to the design for greater autonomy periods.

Hartley critical loads- Work in progress…

Sunverge System required a different RSD – SolarBos was delivered after snow made access to the array impossible…

The Battery element of the Sunverge system is in use currently for Peak Demand shaving trials…

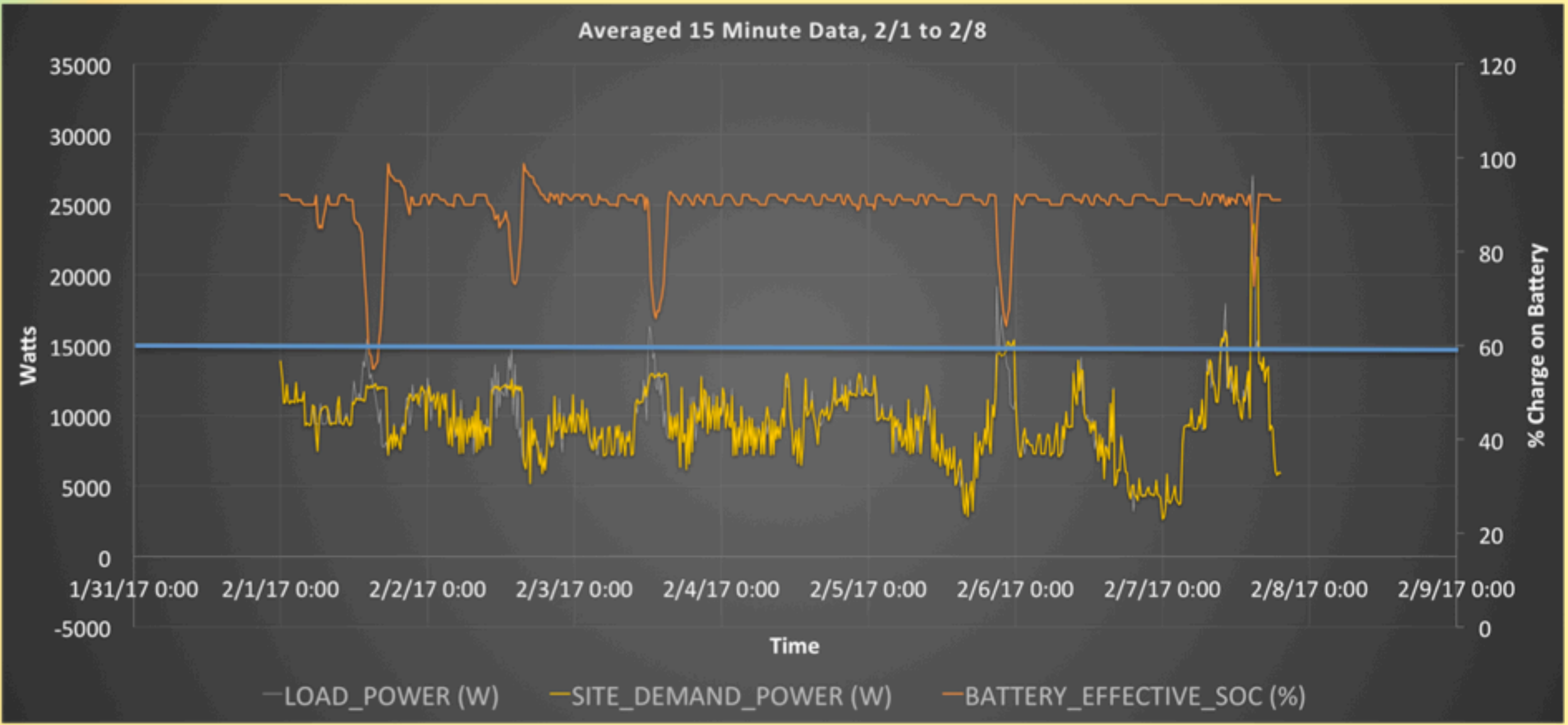
The Array is do to come on line early spring.

Sunverge System required a different RSD – SolarBos was delivered after snow made access to the array impossible…

The Battery element of the Sunverge system is in use currently for Peak Demand shaving trials…

The Array is do to come on line early spring.

Recent System data analysis by Alison Hoxie and her UMD students indicates positive results… "…battery is doing a good job of keeping the site demand below 15 kW over a 15 min averaged period! "



If time allows we can view the current monitoring at:

http://egauge18707.egaug.es

Thank you for your participation in this Solar + Storage Seminar

Christopher LaForge

IREC Certified Master Trainer

NABCEP Certified Photovoltaic Installation Professional - Emeritus

Emeritus