Michael Worry, CEO

Grace Pratt, Policy Analyst

Maximo Torres, CEO

Welcome

Webinar

AC AND DC COUPLED ENERGY STORAGE

NUVATION ENERGY

CESA CALIFORNIA ENERGY STORAGE ALLIANCE

MAXIMO SOLAR INDUSTRIES

Michael Worry, CEO

Grace Pratt, Policy Analyst

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Introductions

Webinar

AC AND DC COUPLED ENERGY STORAGE

NUVATION ENERGY

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MAXIMO SOLAR INDUSTRIES

Poll questions

1. Does your organization work directly on solar and/or energy storage projects?
2. Will you be developing a new market solution or working on a project within the next 6 months?

Agenda

Presenters and topics

- CESA
  - California Markets for Microgrids
- Nuvation Energy
  - AC & DC Coupling
  - Power Conversion
  - Architecture
- Nuvation Energy and Maximo Solar
  - Project Example
- Q&A

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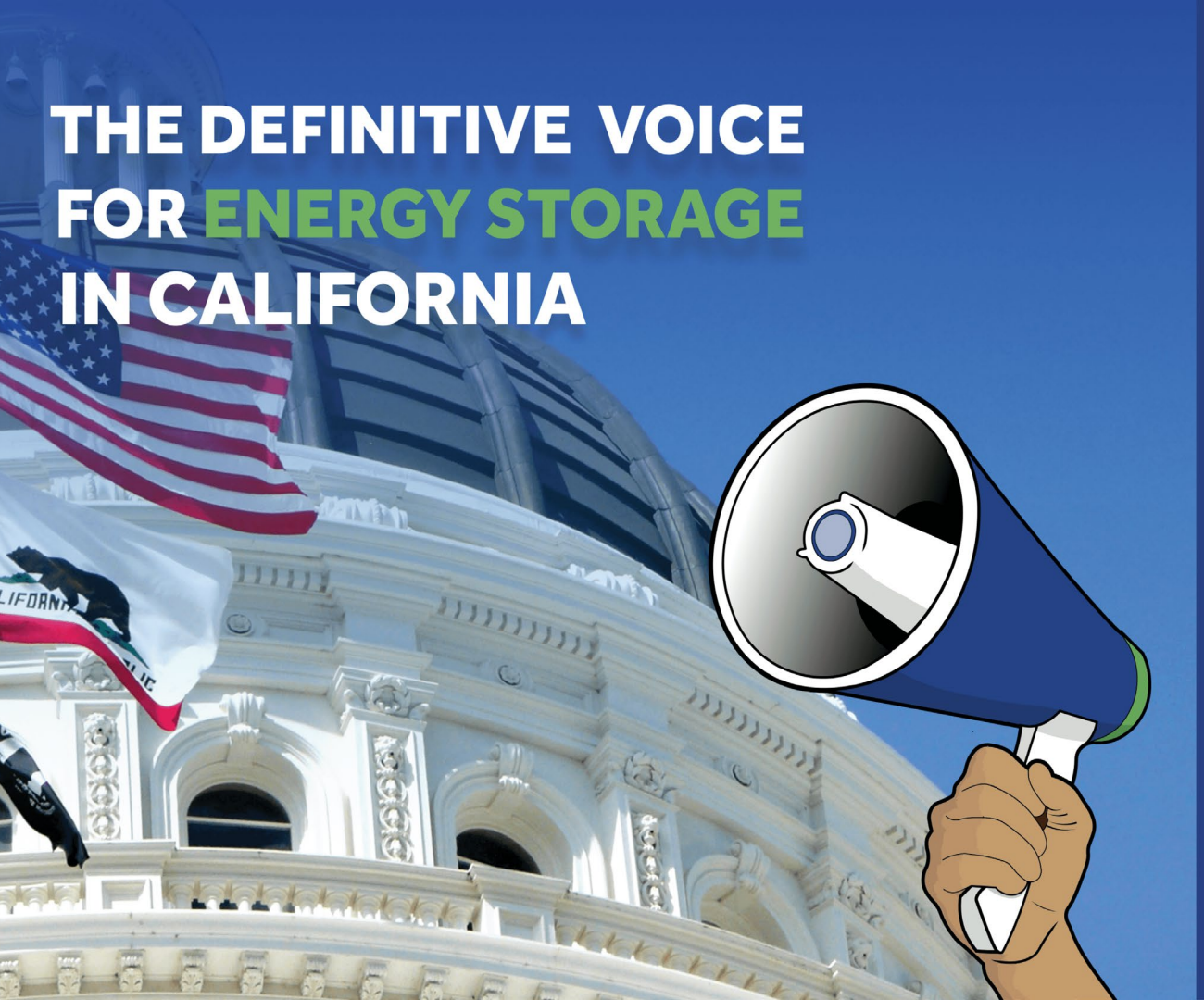
Presented by CESA

California Markets

CESA CALIFORNIA ENERGY STORAGE ALLIANCE

THE DEFINITIVE VOICE FOR ENERGY STORAGE IN CALIFORNIA



CESA creates and builds energy storage markets and networks to support the grid in CA. CESA members help drive our advocacy, build relationships with our 100+ members, gain insight, and connect with energy storage policy-makers and buyers such as IOUs, CCAs, Munis, and more.

CESA
100+ MEMBERS
CALIFORNIA ENERGY STORAGE ALLIANCE

Our CESA Members

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What is a microgrid?

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Microgrid Definition in California (from SB 1339):

An interconnected system of loads and energy resources, including, but not limited to, distributed energy resources, ***energy storage***, demand response tools, or other management, forecasting, and analytical tools, *appropriately sized to meet customer needs*, within a *clearly defined electrical boundary* that can act as a *single, controllable entity*, and can *connect to, disconnect from, or run in parallel with*, larger portions of the electrical grid, or can be *managed and isolated* to withstand larger disturbances and maintain electrical supply to connected critical infrastructure

What is a microgrid?

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Customer Facility (Single User) Microgrid: Serving one entity or customer

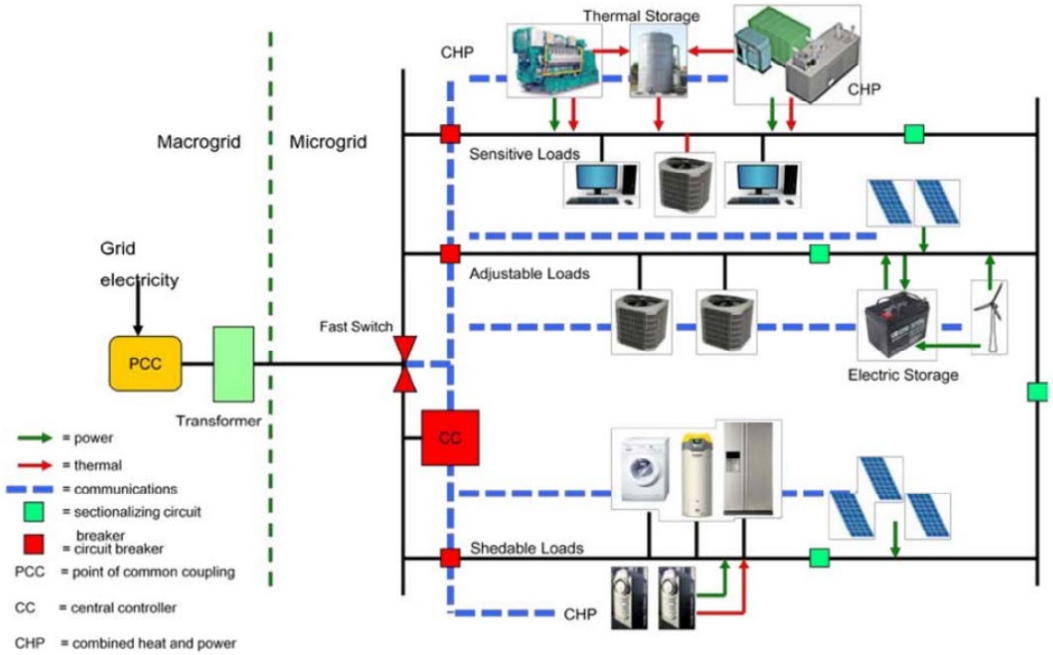

Image Source: CPUC

What is a microgrid?

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Community Microgrid: Serving multiple sites and customers

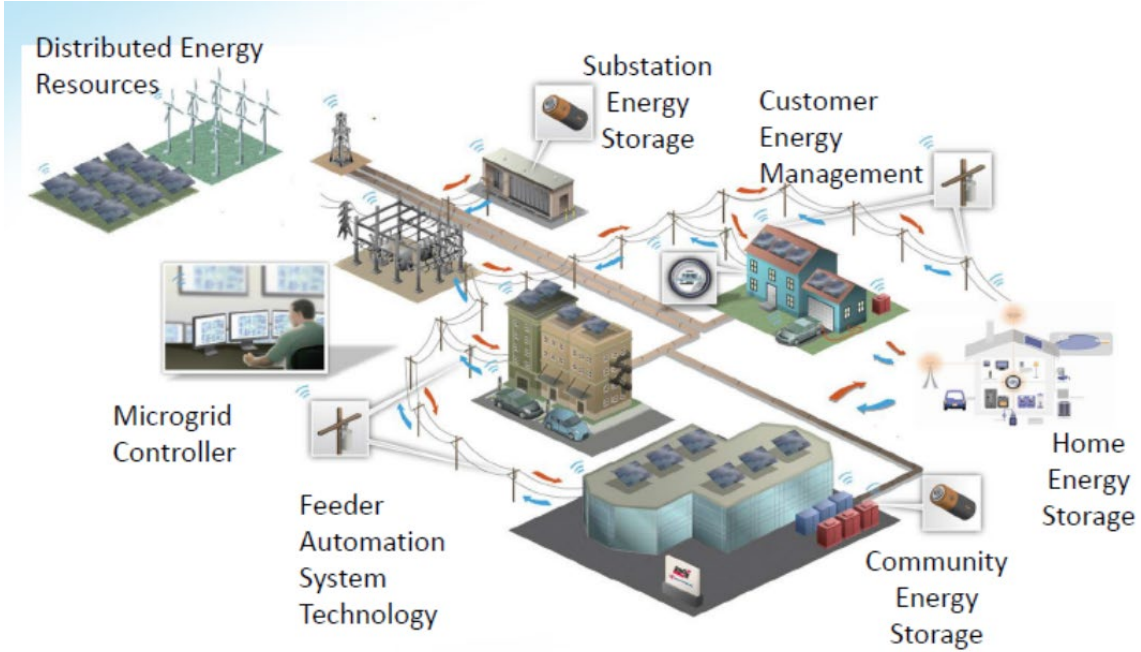

Image Source: CPUC

Why do people want microgrids in California?

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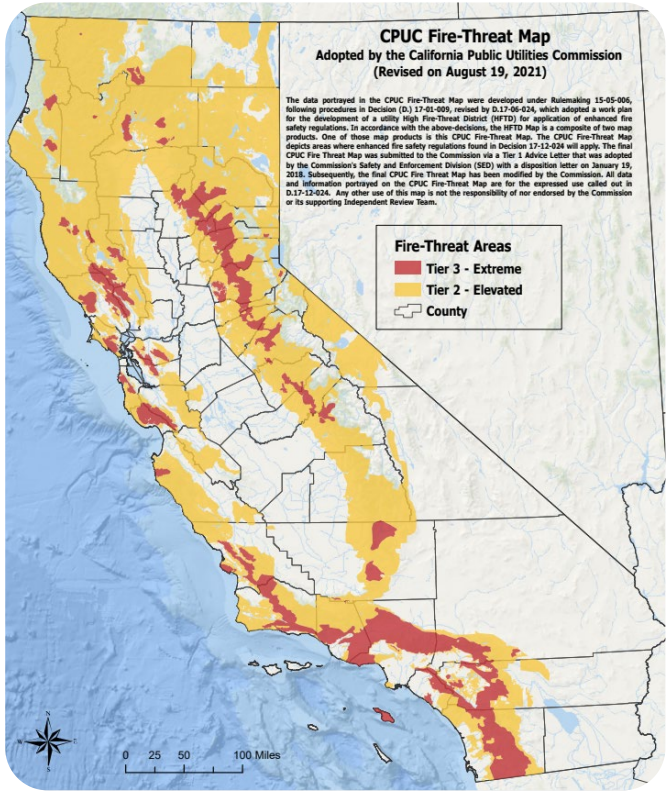

Image Source: CPUC

Local resiliency: Outages are prevalent in CA due to

- Public Safety Power Shutoffs (PSPS)
- Enhanced Powerline Safety Settings (EPSS)
- Other extreme weather

Electric bill savings:

- Time-of-use arbitrage
- Demand charge management

Clean energy goals

Microgrid Challenges - Incentives

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Self Generation Incentive Program (SGIP), supporting energy storage and microgrids, is running low on funding

- SGIP has been a key incentive for the deployment of behind-the-meter storage
- Potential funding to be added next year - limited to residential systems
- Provides $0.15 - $1.00/Wh incentives

New Microgrid Incentive Program launch has been delayed

- $15M will be available per project to support front-of-meter equipment for multi-customer microgrids
- PG&E Community Microgrid Enablement Program providing some funding for islanding equipment

Microgrid Challenges

New microgrid isolation technologies don't have a streamlined approval process with the utilities

- Hampering the ability for industry to design and install low-cost islanding technologies

Multi-customer microgrids do not have access to a multi-customer microgrid tariff

- Currently being discussed at the CPUC in the microgrids proceeding

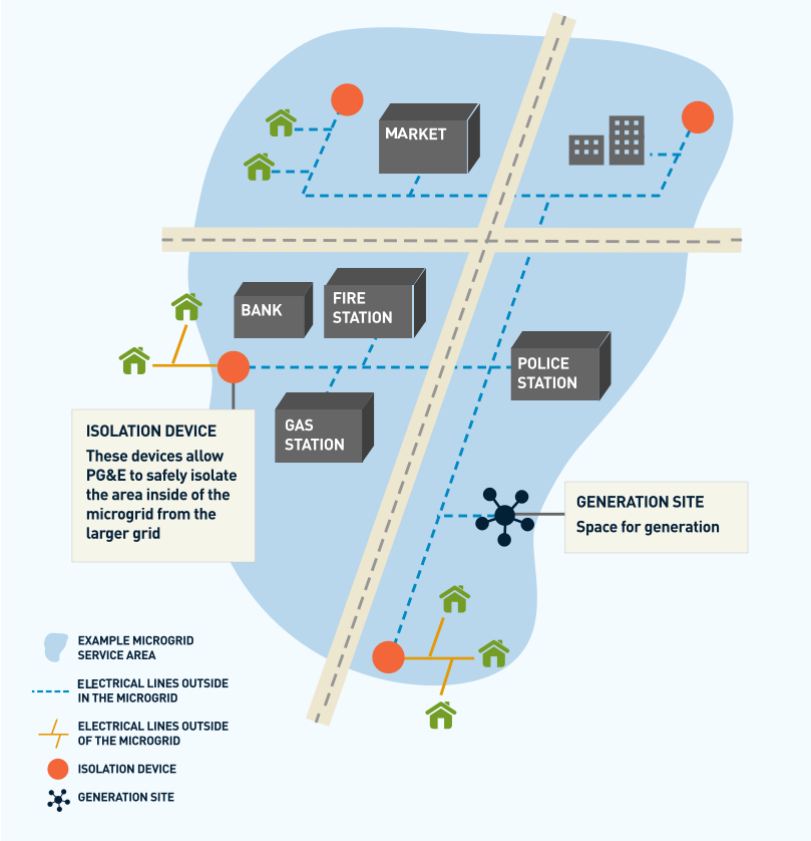


Image Source: PG&E

NUVATION ENERGY

Nuvation Energy

About Us

Who We Are

Since 1997, Nuvationhas completed over 1000 projects for high-reliability systems including energy storage, electric vehicles, industrial controls, defense & aerospace, and more!

1997
Founded
electronic design division

2008
Nuvation Energy
introduced BMS line

2022
Over 1000 projects
completed

OUR OFFICES

Headquarters
Silicon Valley, USA

Design Center
Waterloo, Canada

What We Do

Nuvation Energy provides **battery management systems**, **energy management systems** and **engineering services** to organizations that are developing or managing energy storage systems.

Battery Management Systems

UL 1973 Recognized battery management systems for small and large-scale energy storage applications.

Energy Management Systems

Energy assets control behind the meter for demand charge reduction and emergency backup.

Engineering Services

Energy storage design services and solutions for demand charge management and asset prioritization.

Energy Storage Solutions

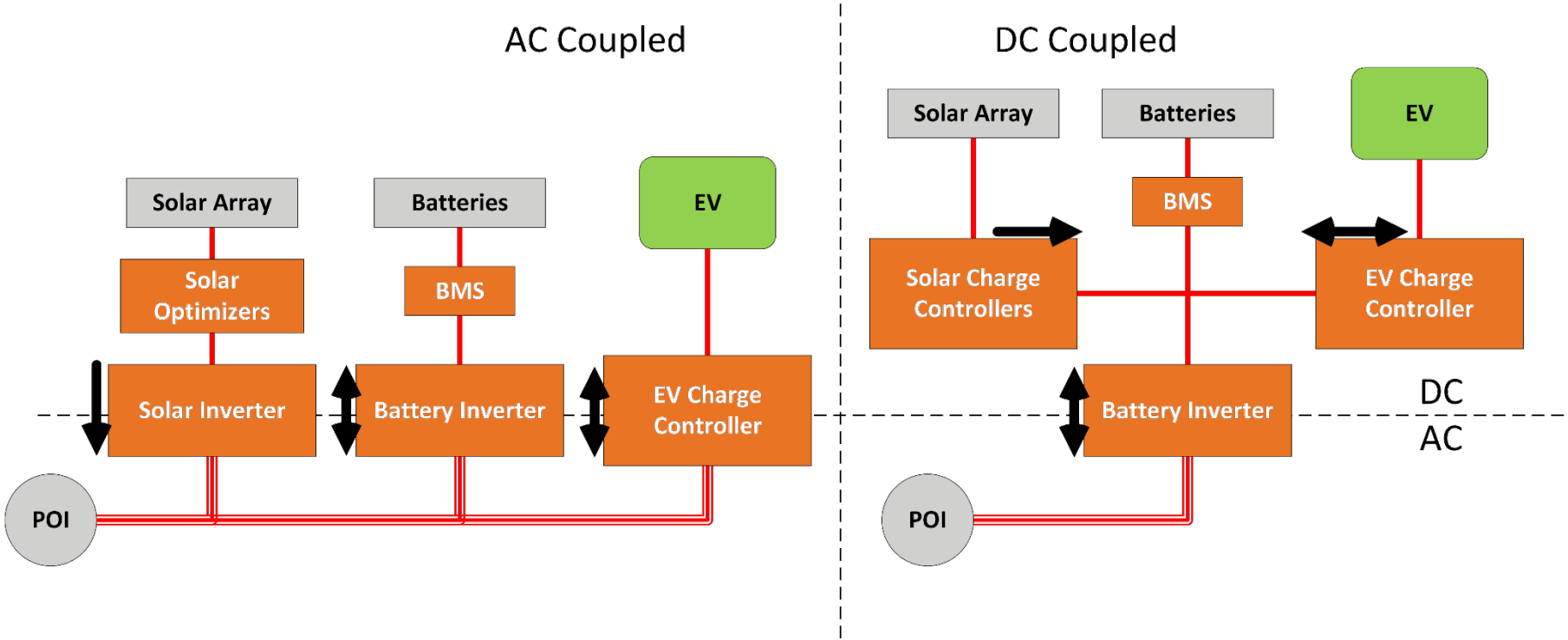
Engineering Consultation & System Design

- Full system engineering from cell to containerized ESS
- Research and selection of battery and PCS
- Rack and container design or selection
- Custom site controller development
- Design for regulatory certification
- UL 1973 certification management
- Thermal management
- Data logging and analytics solutions

Nuvation Energy

AC and DC Coupling

What is AC and DC Coupling



When AC Coupling Makes Sense

- When adding storage to existing solar installations, AC coupling storage is often the least disruptive
- If the site has high peak loads, AC coupling storage can enable aggregating solar AND storage to serve the load
- AC coupling is the more common installed option, so there is more equipment options for augmenting solar and storage capacity

When DC Coupling Makes Sense

- New solar plus storage with DC coupling can enable:
  - Higher efficiency when storing energy due to fewer energy conversions
  - Reduction in device count
  - Ability to enforce charging only from solar using solar inverters by configuration rather than EMS control loop with AC coupled
- Augmenting storage using DC coupling to existing solar sites can be done without changing grid interconnection
- To enable DC fast charging for battery electric vehicles without increasing grid interconnection

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Power Conversion

String Optimizers / Charge Controllers / DC/DC Converters

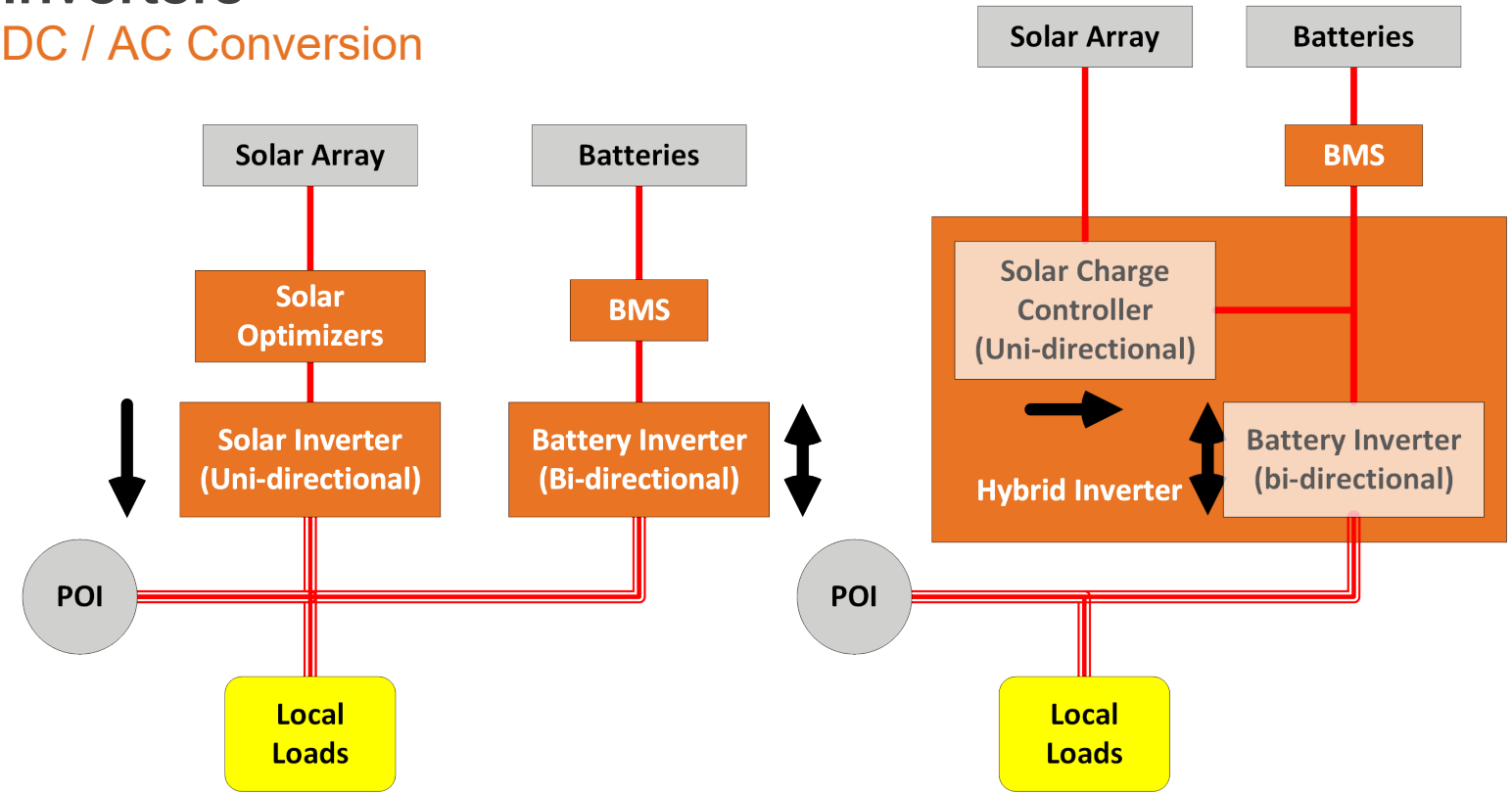
- Maximum power point tracking (MPPT) optimizes solar production
- MPPT can be implemented at each panel, each string, or centrally at the solar inverter

Alencon SPOT DC/DC String Optimizer (image courtesy of Alencon)

Dynapower DPS 500 DC-DC converters (image courtesy of Dynapower)

Inverters

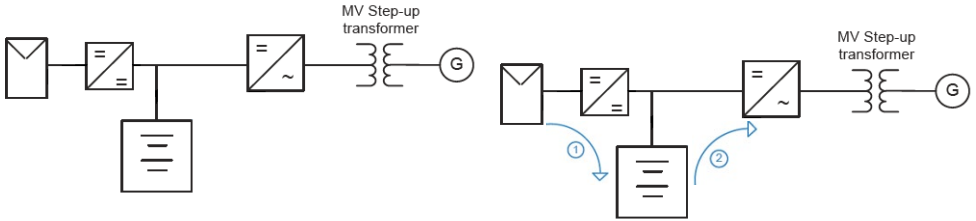
DC / AC Conversion



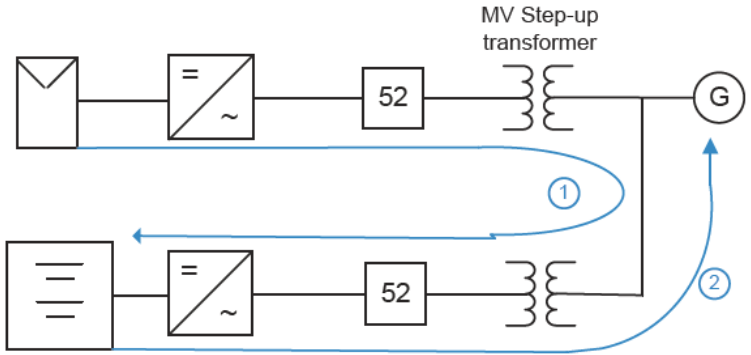
Round Trip Efficiency

- Comparison of AC and DC conversions shows that DC coupling can be more efficient
- Energy storage has additional round trip losses that depend on the technology
- Delivery of energy without storage will always be more efficient in terms of energy losses

DC Coupling



Traditional AC Coupled Approach



* Diagrams and computations curtesy of Alencon

Round Trip Efficiency (RTE) Comparison:

DC Coupling with SPOT:
1 x DC-DC Conversions (98.5%),
1 Inverter conversion (98.5%),
1 transformer conversion (99%)
RTE = 96.1%

Traditional AC Coupled Approach:
3 x Inverter Conversion (98.5%)
3 Transformer Conversion (99%)
RTE = 92.7%

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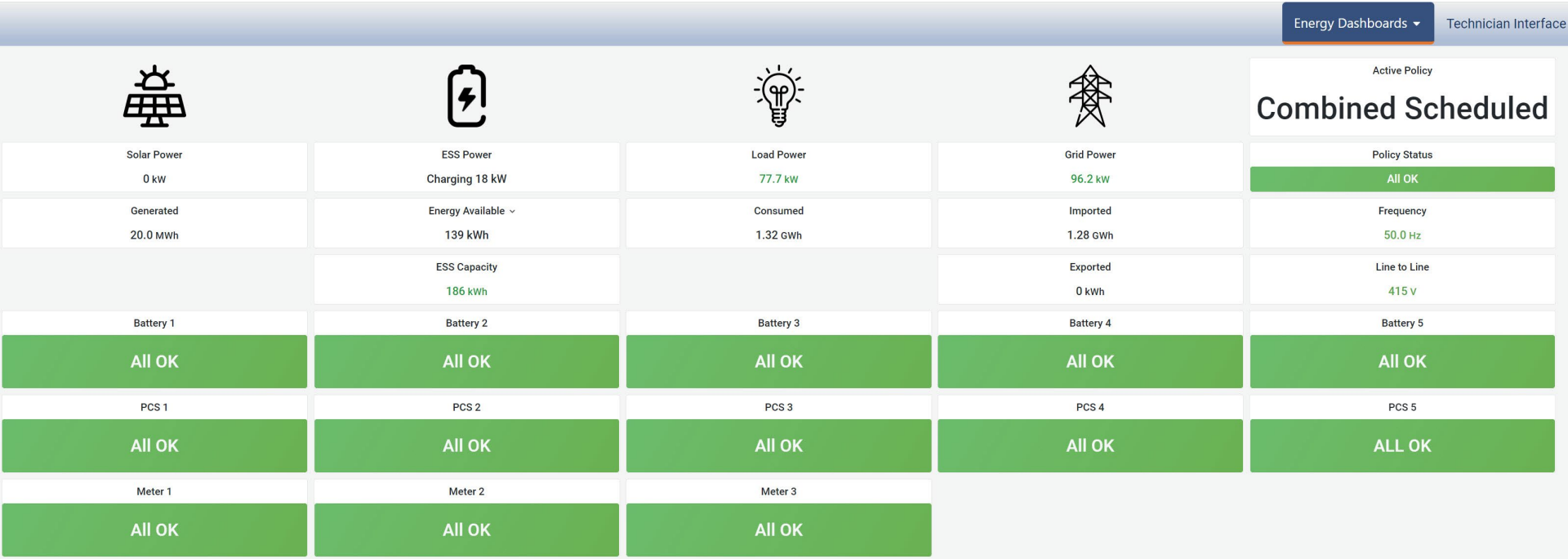
Nuvation Energy

Microgrid Architecture

Energy Management Requirements

EMS is required when storage is added

- EMS decides when to charge or discharge the batteries
- EMS may be local or external to the site

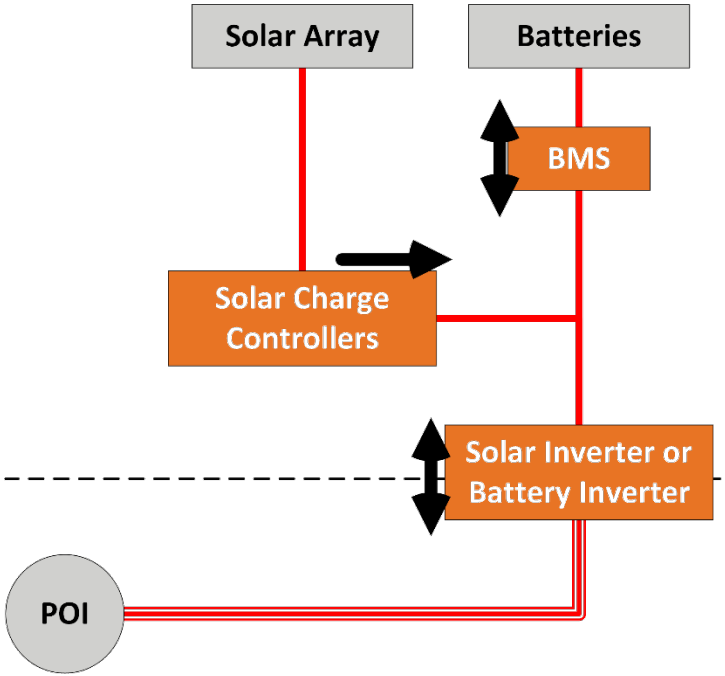


Energy Management Requirements

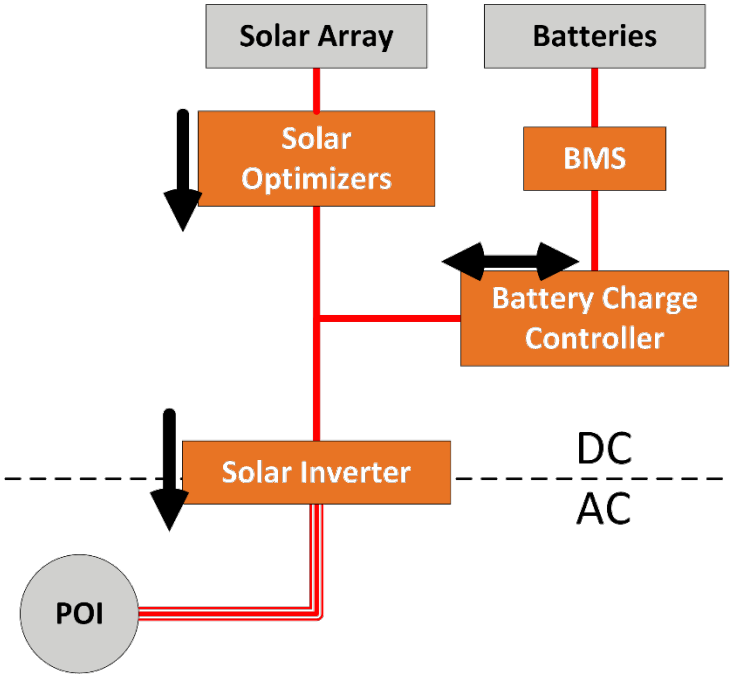
EMS is required when storage is added

- Decisions depend on application requirements
- Inputs to decision may include:
  - BMS telemetry
    - SOC/SOE/SOH
    - Current limits (essential for Lithium-ion technology)
  - Solar production telemetry
  - Site power meter telemetry
  - Schedule
  - Grid Voltage/Frequency
  - Pricing signals
  - Prediction algorithms

DC Coupling Options

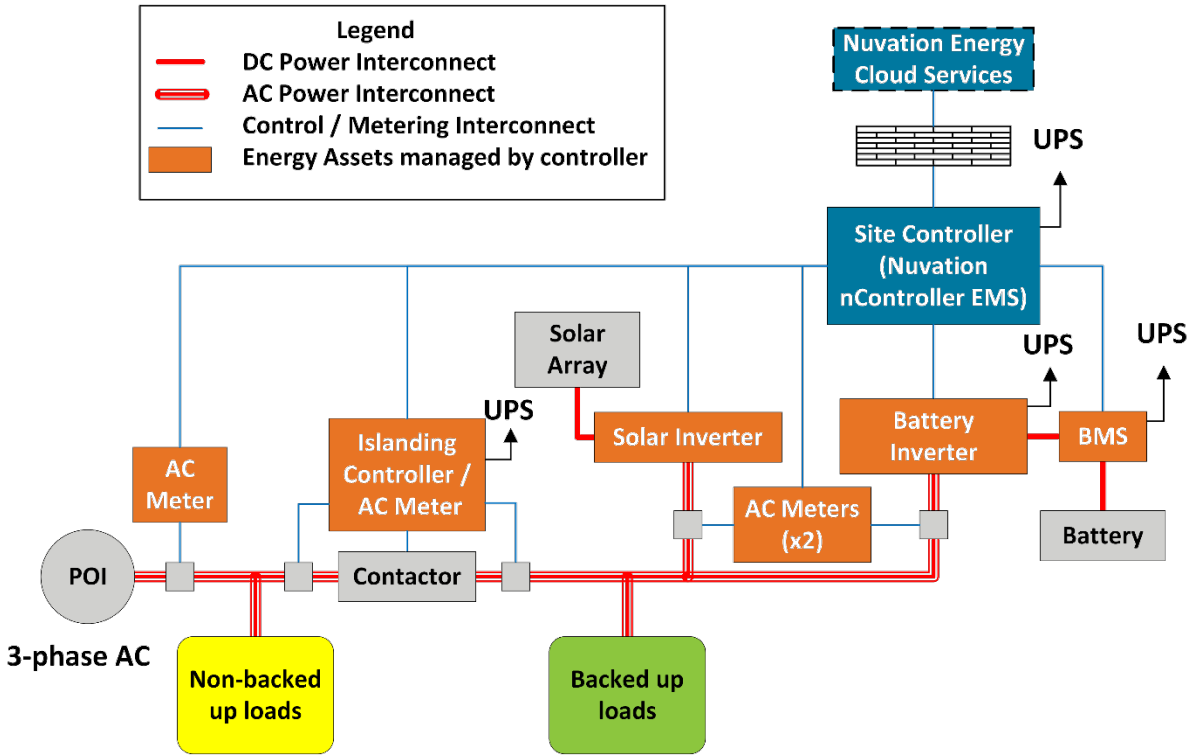


DC coupled solar and storage – option A



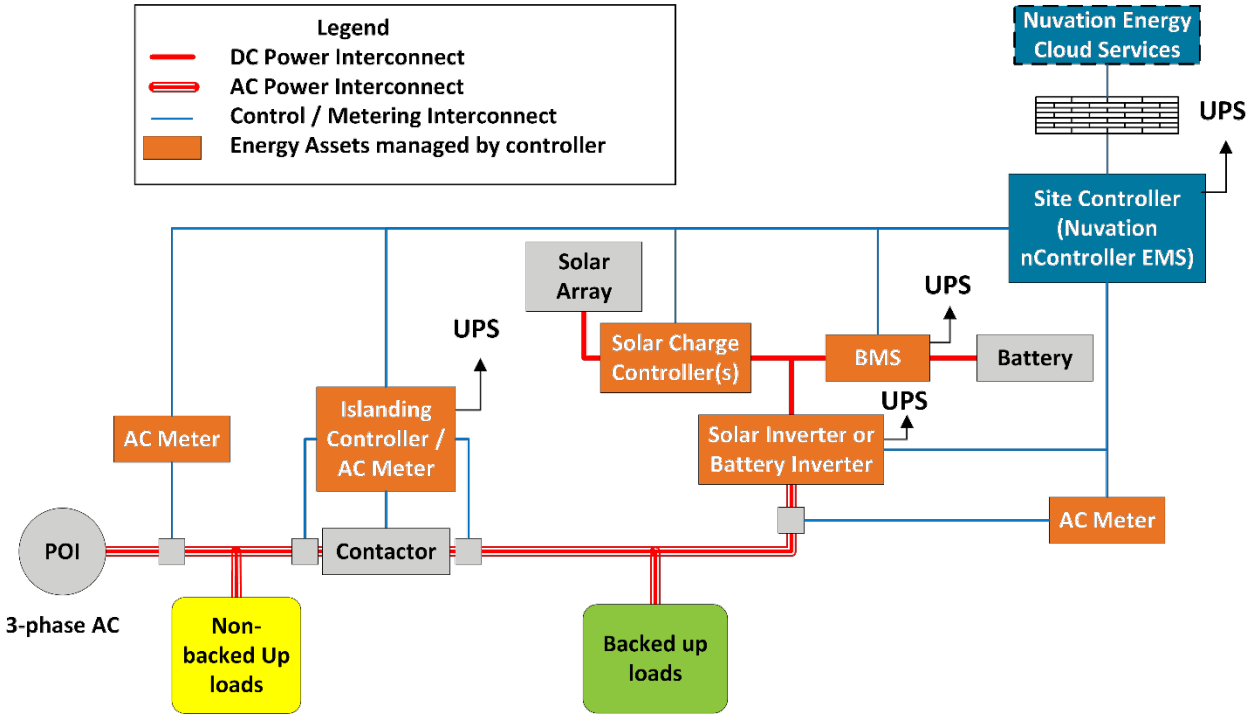
DC coupled solar and storage – option B

AC Coupled Solar Plus Storage with Backup Power



- Solar Array
- Solar Inverter
- Battery Inverter
- BMS / Battery
- AC Meters
- Islanding Controller
- Energy Manager

DC-Coupled Solar Plus Storage with Backup Power



- Solar Array
- DC-DC Charge Controllers
- Solar or Battery Inverter
- BMS / Battery
- AC Meters
- Islanding Controller
- Energy Manager

Components Comparison

Component	AC coupled	Qty	DC coupled Option A	Qty
Solar MPPT Optimization	Solar Optimizers	N	Charge Controllers	N
Solar DC to AC	Solar Inverter	1	Solar or Battery Inverter	1
Storage DC/AC	Battery Inverter	1	Not Required	0
AC Meters		4		3
Total		N + 6		N + 4

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Nuvation Energy and Maximo Solar

Project Example

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PV & Energy Storage
System Presentation

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Company profile

SOBRE NOSOTROS

Energía renovable a su alcance

•RENEWABLE ENERGY MARKET EXPERIENCE

- All integrated services from sales to service
- More than 10,000+ total installations in Puerto Rico and Florida
- More than 4,000 energy storage residential and commercial projects
- Founded in 2009
- Warehouse in Aguadilla and Carolina
- Offices: Aguadilla, Carolina, Ponce, Humacao,
- Twenty (32) vehicles and four delivery trucks

4,000

Over 4,000+ energy storage residential and commercial projects

10,000

Over 10,000+ installations in Puerto Rico and Florida

Thirty (32) vehicles and four trucks

Three Stores, two Warehouses and one manufacturing site totaling near 60,000 sq ft

PV racking and battery cabinets manufacturing facility in Humacao

www.maximosolar.com • 787.891.80.80

SUNBEAT

Li-ion Battery
Hybrid Inverters
All in One ESS

A line of products designed to meet the needs of the residential and small commercial markets of renewable energy

Project Objective

Install a 194 kW Solar PV Array and ESS to supply a minimum of 24 hours of backup UPS power for a freezer for critical power during catastrophic grid failures.

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Key Components

Solar & Storage

Modular expandable technologies

PV – Solar Installation (Mission Solar)

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EMS & BMS

Energy Storage System

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LS Energy Solutions
PIONEERING THE FUTURE OF ENERGY STORAGE

Bi-directional Inverter

DC/DC Converter
1500 Vdc MPPTs

ALENCON

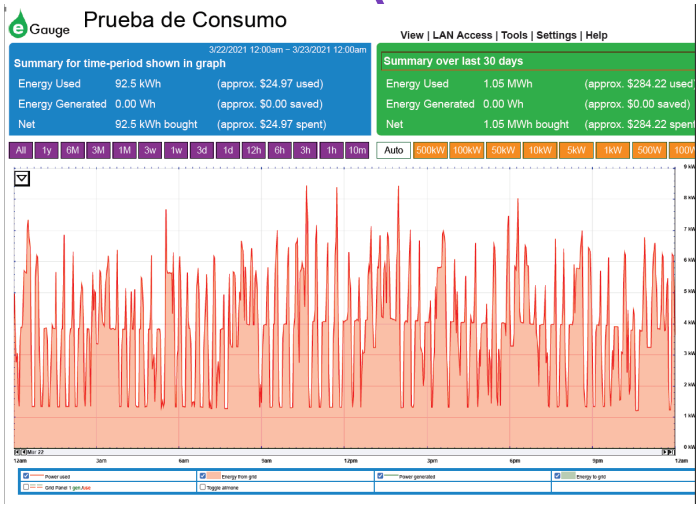
Freezer Daily Energy Utilization

Based upon the information provided on the freezer at the location, the average daily energy consumption of the freezer system is at around 92.5 KWh.

Total Runtime at 6kW Load the battery :

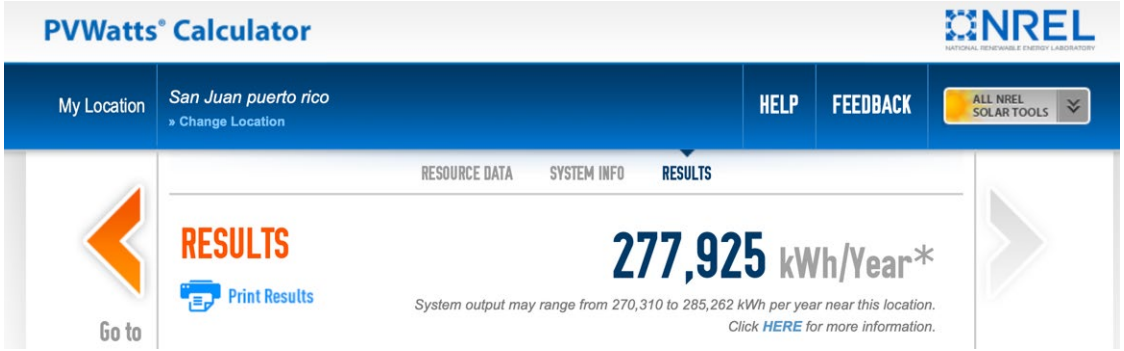
From Full at 348 kWh: 58 Hours

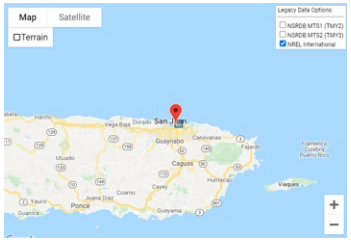
From 50% DOD 174 kWh: 29 Hours



Solar Energy Production

PV Production utilizing NREL solar data for your community.





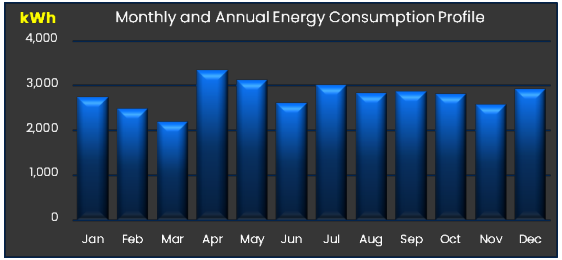
The amount above is based on a 194 KW PV Grid tie system for a daily average of 741 Kwh. Depending on final setup system (full off grid, self consumtion, load shaving or backup mode) is expected to save within 300 to 741 KWh per day.

Building Annual Energy Consumption

Step 1: Determine Annual Energy Utilization

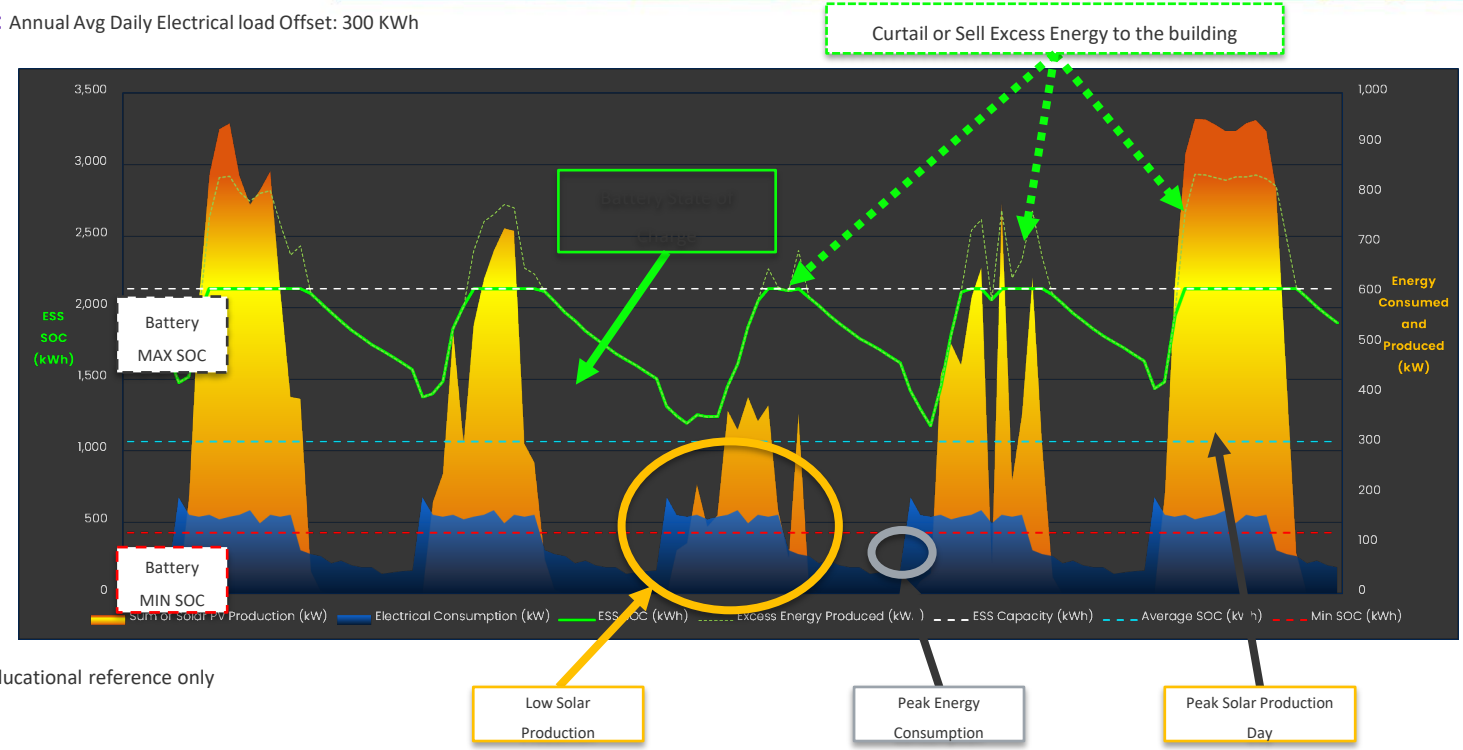
Energy utilization data within Powersync ESS System Sizing calculator

Period: 12/03/19 to 01/03/20, Consumption: 186,120kWh, Peak: 330kW, Load Factor: 0.758065
Period: 01/03/20 to 02/03/20, Consumption: 174,900kWh, Peak: 383kW, Load Factor: 0.614122
Period: 02/03/20 to 03/05/20, Consumption: 175,560kWh, Peak: 310kW, Load Factor: 0.760675
Period: 03/05/20 to 04/03/20, Consumption: 139,920kWh, Peak: 310kW, Load Factor: 0.648063
Period: 04/03/20 to 05/05/20, Consumption: 219,780kWh, Peak: 370kW, Load Factor: 0.774309
Period: 05/05/20 to 06/03/20, Consumption: 199,175kWh, Peak: 370kW, Load Factor: 0.774306
Period: 06/03/20 to 07/03/20, Consumption: 171,745kWh, Peak: 403kW, Load Factor: 0.592511
Period: 07/03/20 to 08/04/20, Consumption: 192,060kWh, Peak: 403kW, Load Factor: 0.621184
Period: 08/04/20 to 09/03/20, Consumption: 180,055kWh, Peak: 403kW, Load Factor: 0.621178
Period: 09/03/20 to 10/05/20, Consumption: 188,740kWh, Peak: 378kW, Load Factor: 0.648717
Period: 10/05/20 to 11/04/20, Consumption: 179,381kWh, Peak: 393kW, Load Factor: 0.633342
Period: 11/05/20 to 12/04/20, Consumption: 168,999kWh, Peak: 352kW, Load Factor: 0.617262



Solar + ESS Charts Explained

Energy Usage: Annual Avg Daily Electrical load Offset: 300 KWh

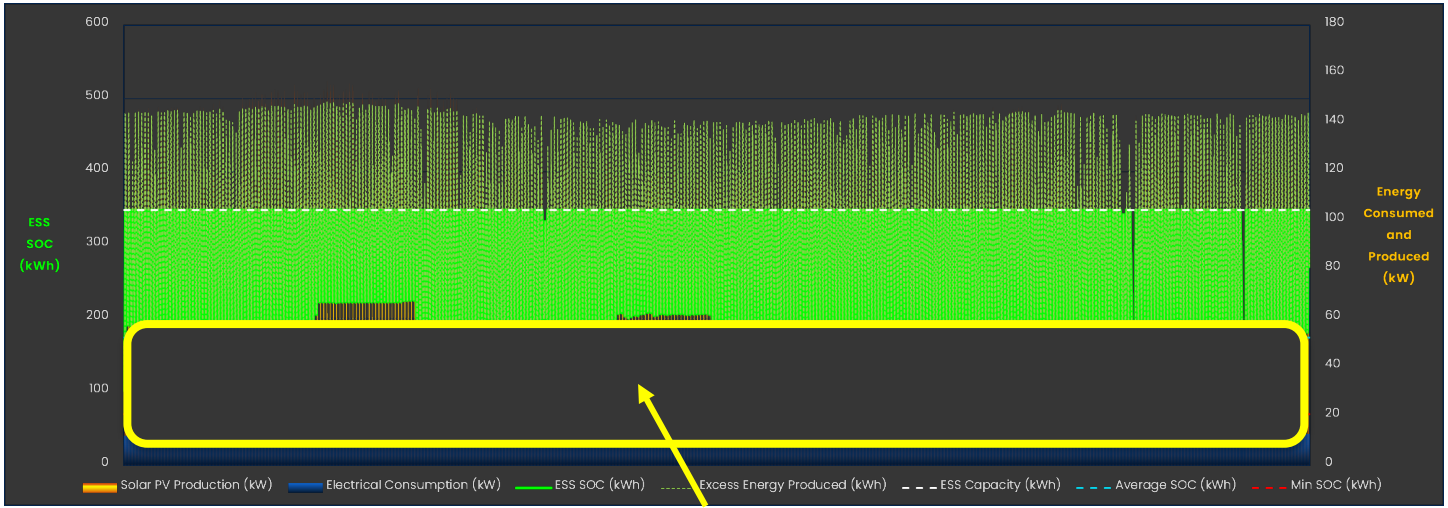


Graph above for educational reference only

The customer's primary need is to provide backup power for the refrigeration load for at least 24 hours. This can achieve this by making sure that the stored energy under normal operation never goes below a specified threshold of say 100 kWh. This can be setup in the scheduled energy policies as a parameter. Under backup power operation when the ESS is grid-forming for the local site, the BESS can provide up to 140 kW of site power, but the primary load is only about 10 kW.

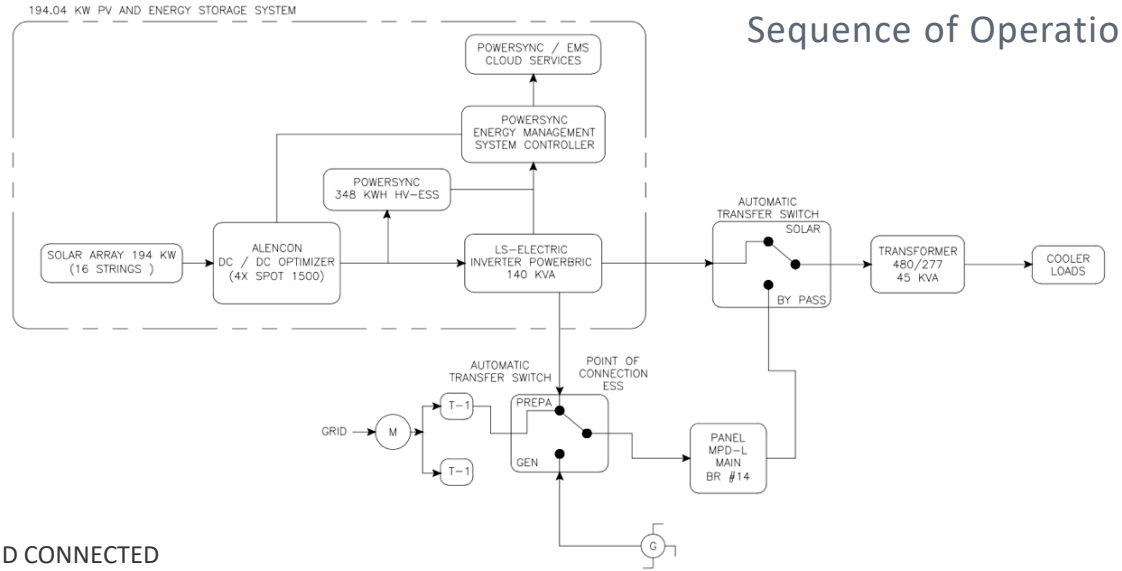
Annual Battery State of Charge

Below graph shows daily performance if battery is to be depleted daily while shedding excess energy to building loads. This is for reference only as to show the system can assure 24 hours of cooler backup energy in hurricane situations.



System Description

TYPICAL DAY, GRID CONNECTED



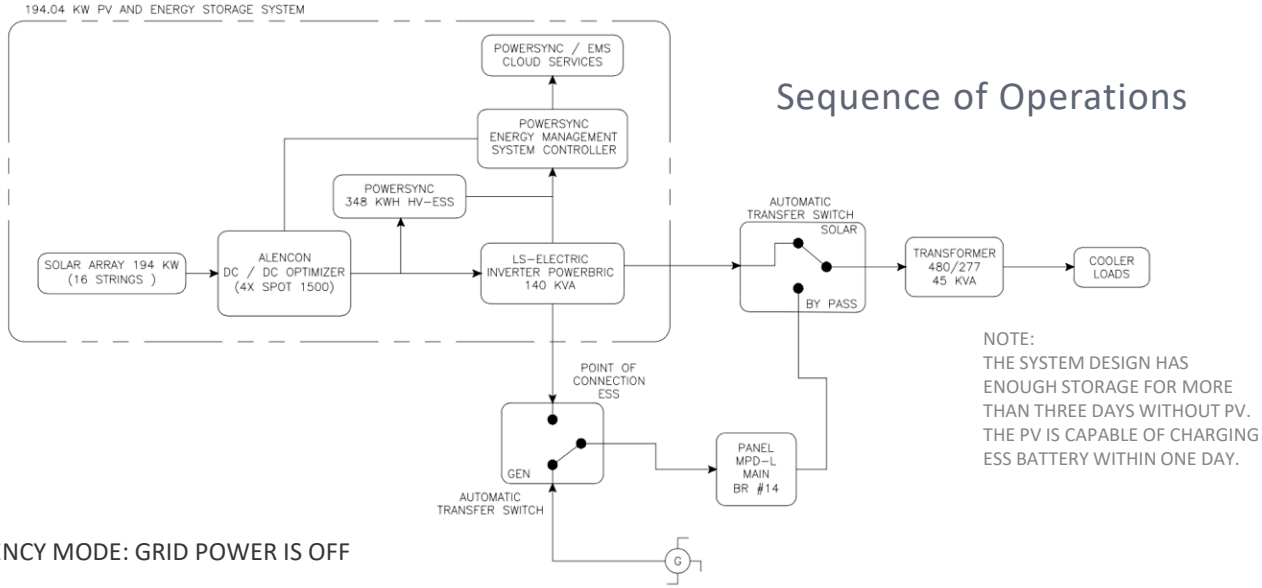
Sequence of Operations

SCENARIO 1: TYPICAL DAY, GRID CONNECTED

1. ESS is composed of: Ncontroller, LS-electric inverter, Alencon dc/dc optimizers and Powersync 348kwh hv- ESS batteries
2. Energy management system Ncontroller manages pv power thru Alencon dc/dc optimizer, manages charging and discharging of batteries, as well providing power to the loads from pv energy and/or energy from grid based on the load consumption.
3. If Powersync batteries are charged and excess PV power is available; energy flows to the ESS LS-electric inverter grid input, the building receives the excess power.
4. Energy flows from PV inverters to energy storage system (Powersync ESS).
5. System is capable to control export or no export to the utility based on system programming and CTs location.
6. If solar system inverter fails, an ATS transfer power to building panels to assure power continuance.

System Description

EMERGENCY MODE: GRID POWER IS OFF



Sequence of Operations

NOTE:
THE SYSTEM DESIGN HAS ENOUGH STORAGE FOR MORE THAN THREE DAYS WITHOUT PV. THE PV IS CAPABLE OF CHARGING ESS BATTERY WITHIN ONE DAY.

SCENARIO 2: EMERGENCY MODE: GRID POWER IS OFF

1. Energy flows from batteries to loads.
2. In daytime PV power charge the ESS battery and supplement loads.
3. If PV power is higher than load, ESS charges the battery, if fully charged, it controls energy flowing by reducing PV output. Below applies if batteries are discharged.
4. In the unlikely event battery is depleted or inverter fails, an automatic transfer switch is available to transfer loads to building in which utility or generator can charge the batteries. In daytime and on generator, the PV systems charges the battery.

THANK YOU

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Recap, Key Takeaways

- Always start with understanding the application requirements
- DC coupled solar plus storage
  - Can improve energy storage energy efficiency
  - Can improve DC fast charging energy efficiency
  - Enables DC fast charging power without increasing grid interconnect
  - Can make DC bus changes without impacting grid interconnect permit
  - Can reduce total number of components
- AC coupled solar plus storage
  - Has a larger ecosystem of products and technology
  - Easier to add to existing installed systems
  - Adding to AC coupled system adds to total AC bus power availability
  - Provides viable solutions for most applications
- Today AC coupled is more common.Over time DC coupled will become more common due to efficiency advantages.

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Thank You!

Questions?

AC AND DC COUPLED ENERGY STORAGE

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