Community Microgrids

Solar Energy
Battery Storage
EVs with V2G

Custom Power Solar Inc

Community Microgrids

- Community scale power systems
- Battery storage with inverters provides power 24/7 all year round
- Solar power fills energy storage during mornings
- EVs charged during afternoon excess solar power
- EVs may provide additional energy storage during long cloudy low solar events
- Can import/export to outside grid

What is a Community Microgrid?

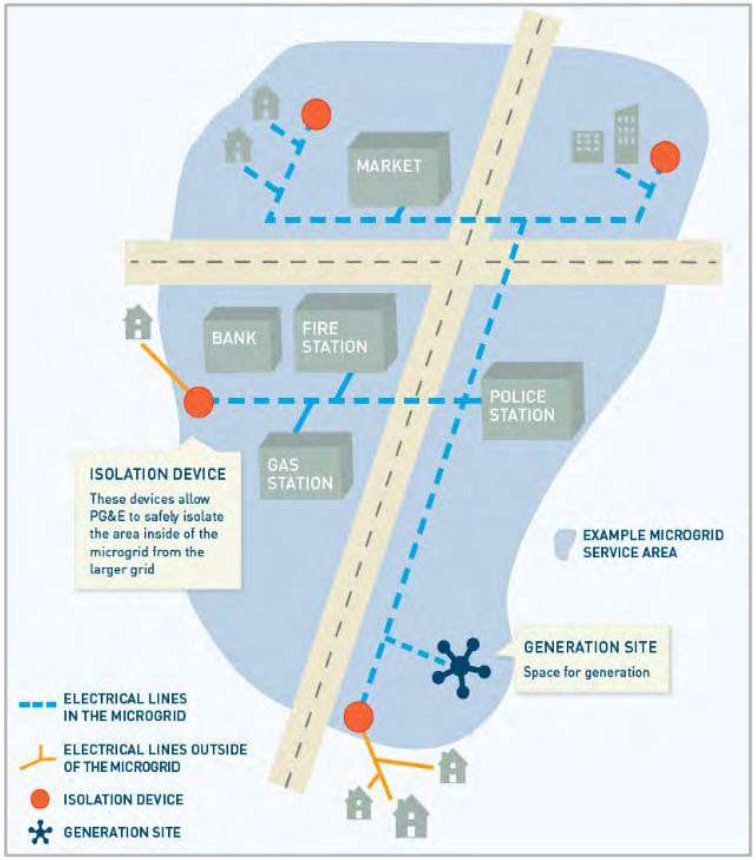
A **community microgrid** may allow PG&E to safely provide electricity using **generation** during an outage **(by disconnecting from the main grid).**

These microgrids would be designed to serve the portions of communities that include **community resources**, such as:

- Hospitals
- Police and fire stations
- Gas stations and markets

The community microgrid site selection process would likely consider **prior and expected future PSPS events**, along with other conditions that indicate an area is prone to outages.

Each community microgrid **would be unique and designed based on a number of different variables** that dictate the size of the microgrid, what community services are served and what elements are included in the design.



The diagram above represents an approximate layout of a community microgrid. The layout and dimensions are approximate and for illustrative purposes only.

Energy storage would occupy all isolated sections of microgrid and provide the voltage and frequency support. Generation could be anywhere, though preferably in the isolated area or nearby. If an isolated area has no generation, then a daily provision for recharging is needed if more than one day of outage is anticipated.

Ultimate Goals

- Completely self-reliant – no outside power needed
- Payback cost in 5-7 years – once payback reached, maintenance cost very low (2%/yr)
- Solar lasts essentially forever
- Energy storage 20 year lifetime, recycled
- Carbon free – zero carbon emissions
- Can disconnect from main grid during high fire threat events

Storage

- Primary storage – 2 MWh 40’ container energy storage with 1MW inverters (40’x8’)
  - Serves 200 residential customers (average 10kwh day)
  - 40 commercial customers (average 50kwh/day)
- Secondary storage – residential storage (10-30kwh)
- EV storage – typical 60kwh per EV

Residential Solar

- Standard roof installation and/or strapped ballasted roof mount on existing housing units. In the ballasted option, modules can be easily removed along with mounting hardware for replacement on new construction - Custom Power Solar unique solution
- Typical home 5-10kw

Commercial/Utility Scale Solar

- Roof, carport, or ground based mounting
- Average community needs 10kw PV per person, 30kwh of storage per person – includes both residential and commercial needs – this is 150% of annual load in generation
- Solar Area needed – 500 sqft/person

System Financials

- Commercial PV –$1.5/watt
- Residential PV - $2/watt
- Container 1 MW/2 MWh Storage – $150/kwh
- Residential storage $200/kwh

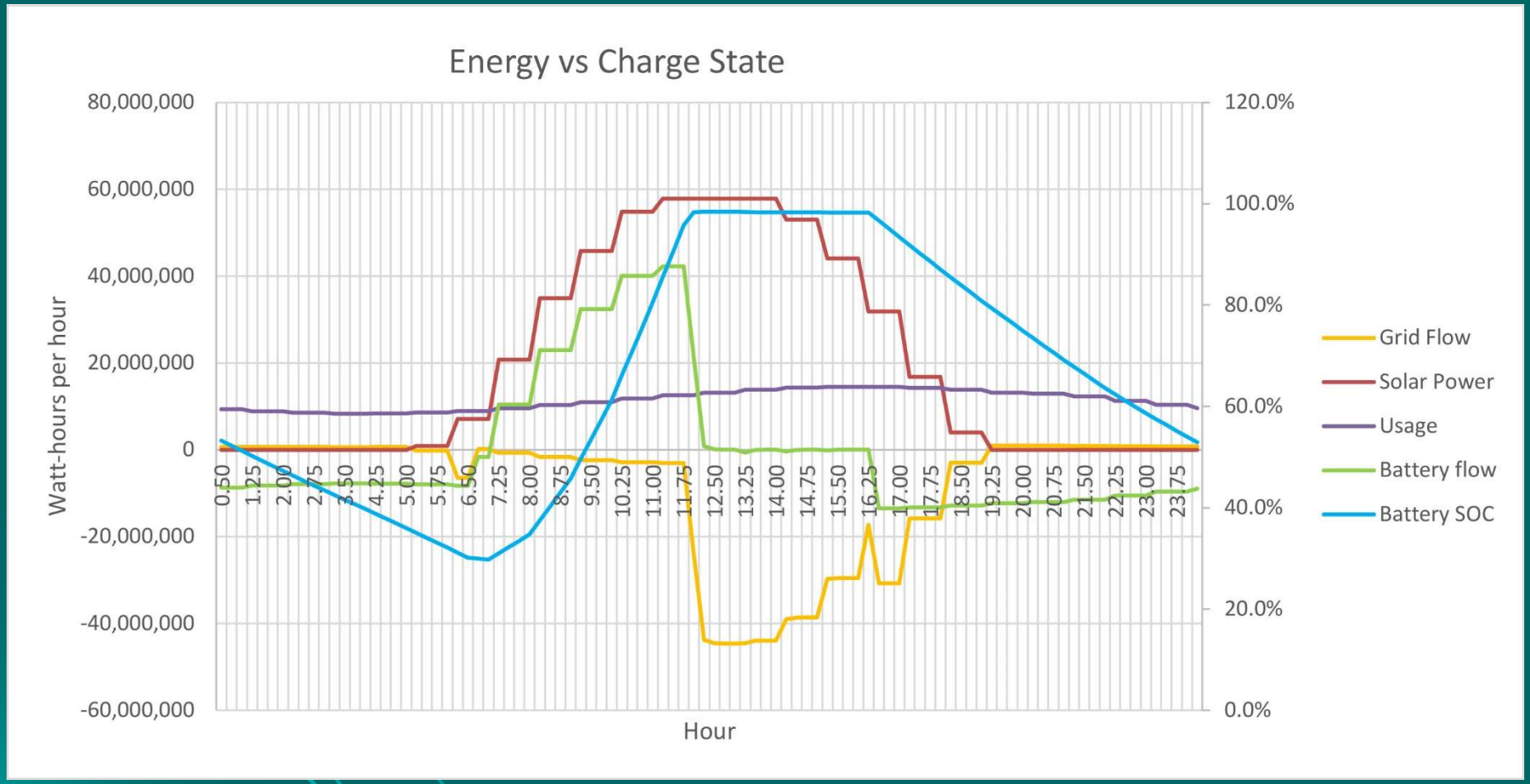
Storage Modes

- Charge from outside grid
- Charge from solar
- Charge from EVs

Example – Fort Bragg

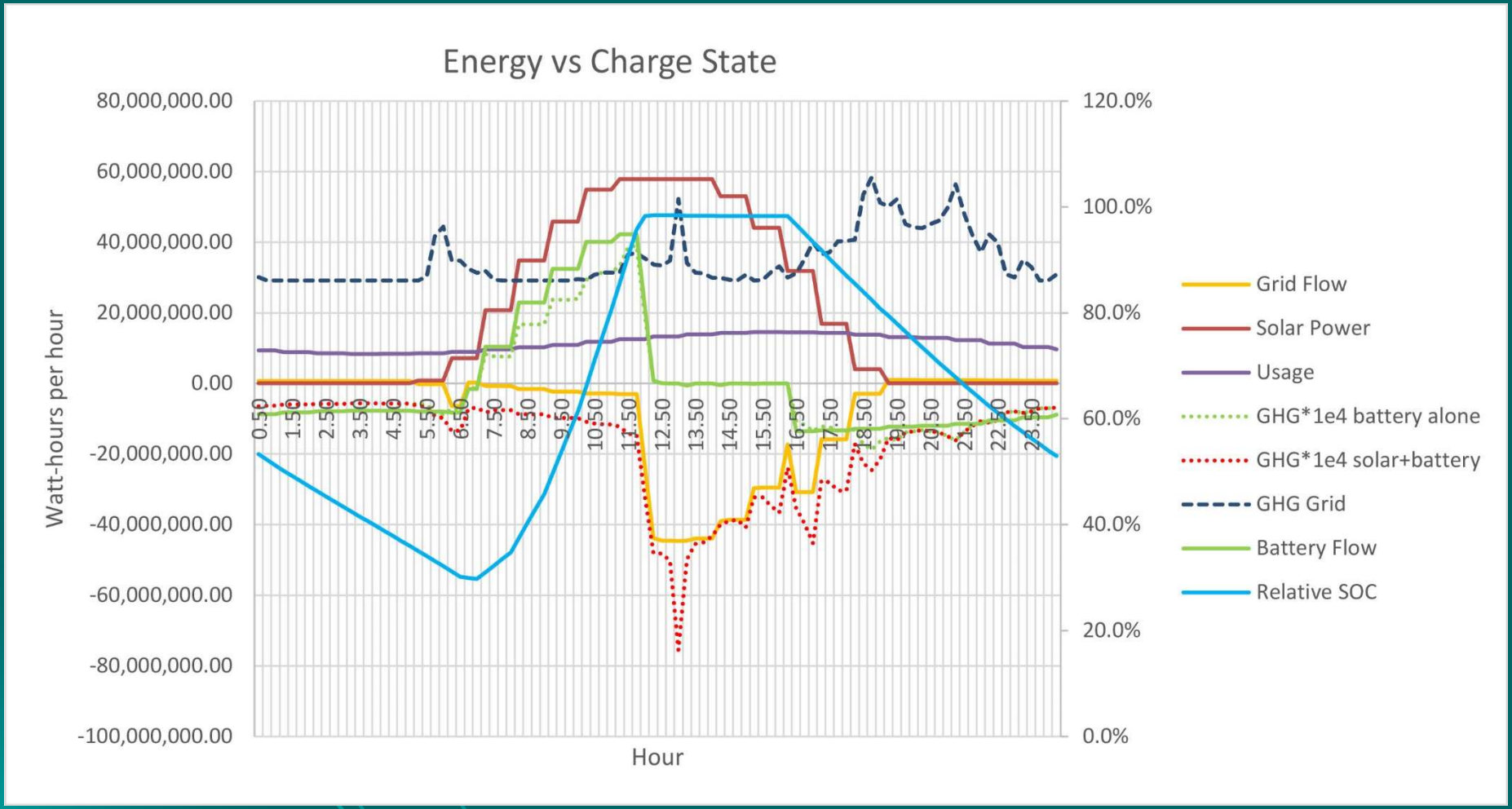
- Population 7359
- Northern California coastal city
- Peak Demand 17MW
- Solar 150% of load = 69MW peak
- Storage 3X = 208MWh
- Solar cost – 50% mix resi/commercial = $1.75/watt * 69MW = $121M
- Storage cost – 50% mix - $175/kwh * 208MWh = $36.4M
- Does not include tax credits or rebates

Self Supply Mode



Solar power charges battery during morning hours
Excess power exported to outside grid in afternoon
Battery supplies loads all other times
This example is max peak demand day

Self Supply Mode



GHG savings 24/7 with solar+storage – note GHG values negative (dashed red lines)

33,236 metric tons saved per year

System Analysis Rate & GHG Savings – 150% Solar

- Total $27M annual energy savings based on NEM EV2, $17M based on B19R behind the meter rates
- 108 Giga-wh generated annually
- 33,236 Tons of GHG savings per year
- With 26% tax credit total cost = $116M
- Simple payback based on 50% mix rates = 5.2 years

System Analysis & GHG Savings

Models by: **Custom Power Solar** Analysis

Load year 2018

	Annual					
	EV2	B-19R			CCA	PG&E
Cost	$18,974,989.75	$14,386,620.29	$0.00	$0.00	$18,974,989.75	$18,974,989.75
Cost Est. with Solar	-$4,020,221.50	-$87,772.85	$0.00	$0.00	-$2,255,811.38	-$1,098,107.17
Cost Est. with Solar+Storage	-$8,474,988.87	-$2,594,846.10	$0.00	$0.00	-$6,119,078.65	-$1,071,526.90
Improvement over solar only	19.37%	17.32%	0.00%	0.00%	18.20%	-0.13%
Cost Advantage batteries	$4,454,767.38	$2,507,073.25	$0.00	$0.00	$3,863,267.27	-$26,580.27
Solar only value	$22,995,211.25	$14,474,393.14	$0.00	$0.00	$21,230,801.13	$20,073,096.93
Total Value Solar+Storage	$27,449,978.62	$16,981,466.39	$0.00	$0.00	$25,094,068.40	$20,046,516.65
$/kw solar+storage	$395.30	$244.55	$0.00	$0.00	$361.38	$288.69
$/kwh storage only	$21.38	$12.03	$0.00	$0.00	$18.54	-$0.13

Total usage	73,207,145 kwh	69,440.02 kw Battery		
Total solar	109,810,717 kwh	69,440.02 kw AC Solar		
Surplus	36,603,572 kwh	208,330.00 kwh Battery		
Percent solar vs usage	150.0%	86.7% RTE		
GHG savings	33,448,733 kgs/CO2	np15	GHG Data	
GHG savings battery alone	3,779,662 kgs/CO2	39,454,621 kwh Battery use		
GHG savings battery per kwh	18.1 kg/kwh	5.19% % of Life used		

	Annual Demand Charges				Max Demand
	EV2	B-19R			
Cost	$0.00	$3,140,865.58	$0.00	$0.00	17035.53
Cost Est. with Solar	$0.00	$3,034,851.05	$0.00	$0.00	15877.43
Cost Est. with Solar+Storage	$0.00	$2,544,574.59	$0.00	$0.00	14465.91

	Annual Energy Charges			
	EV2	B-19R		
Cost	$18,974,989.75	$11,245,754.71	$0.00	$0.00
Cost Est. with Solar	-$4,020,221.50	-$3,122,623.91	$0.00	$0.00
Cost Est. with Solar+Storage	-$8,474,988.87	-$5,139,420.69	$0.00	$0.00
Grid Charge	1,203,912 kwh		1.64% of load	
Grid charge days needed	17 days			
Battery Mode	Self-supply			

Max daily load	309,087 kwh	Average load	200,568 kwh			
Max daily solar	506,869 kwh	Averga solar	300,851 kwh			
Population	7,359		9.44 solar kw/person		28.3	bat kwh/person
Vehicles per person	0.755		5,556 Vehicles		35	Average miles/day

EV Use	194,462 mi/day	GHG Value Adder	
EV Charge	48,615 kwh	$65	$/mT
EV Gas Savings	$9,463,796.65	$245,678.00	GHG Savings Battery alone
EV GHG savings	21,056,948 kg	$14,386,620.29	Baseline rate cost
Total GHG Savings	54,505,680 kg	($8,474,988.87)	Optimized rate final cost
Net GHG savings	30,706,291 kg	$23,107,287.16	Total Savings
GHG Load Only	-23,799,389 kg		

Rates based on behind the meter tariffs

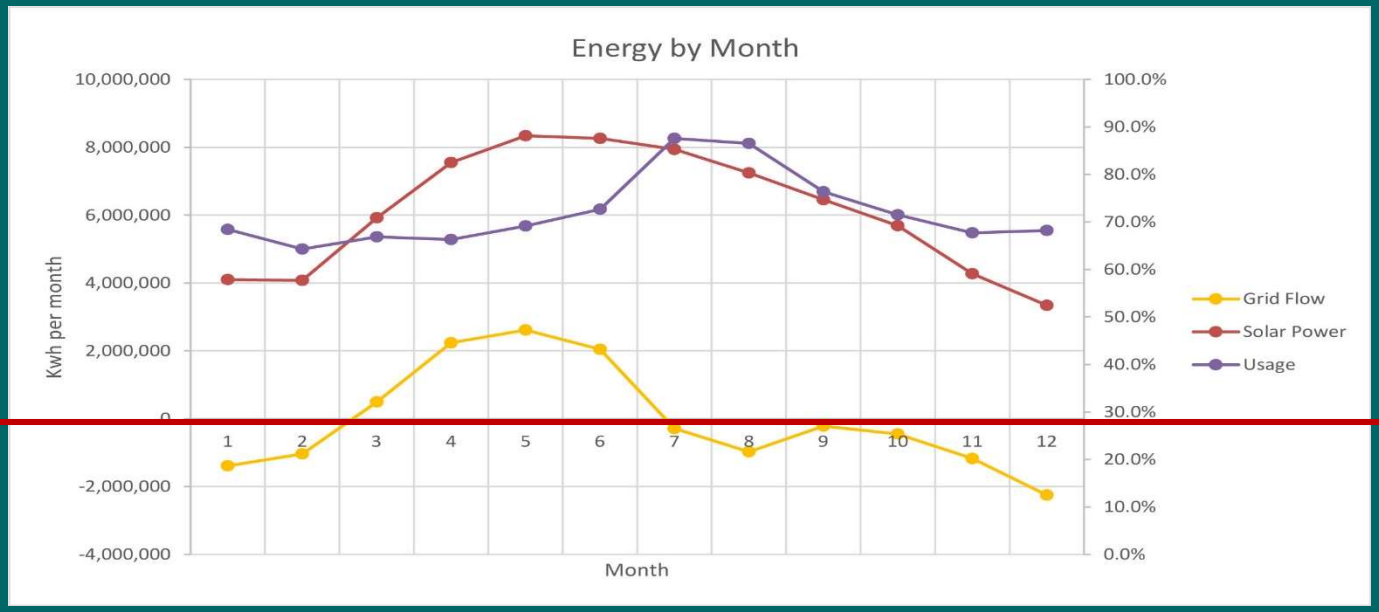
EV2 – best residential rate

B19R – best commercial rate

How It Works

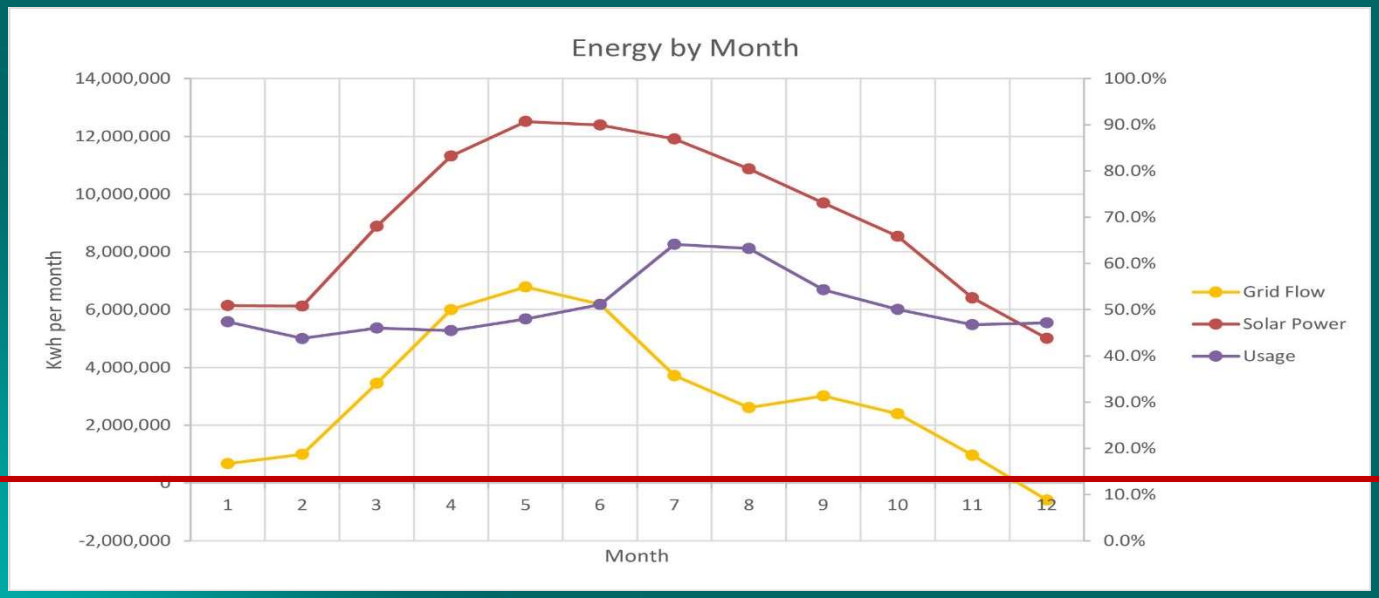
- Solar power generates energy stored in Lithium Iron Phosphate batteries during morning hours
- Energy storage reduces peak demand charges all year
- Energy storage offsets power from grid during peak rate periods & maximizes value
- Energy storage provides power in the event of grid failure, renewable by PV charging from the sun daily

Why 150% solar



Solar generation = 100% of load

Only 4 months solar>load



Solar generation = 150% of load

11 months solar>load

150% Solar

- Solar modules are inexpensive compared to battery storage
- 150% Solar allows storage to cover loads using storage all year with only 17 days needing external power sources

Worse Case Scenario Multiple Days Solar < Load

- Option 1 – Charge from grid – prefer during daylight hours, capture solar generated from other parts of grid. Charge difference of projected local solar vs projected load
  - Mitigation – reduce load during low solar multiple day events
  - These only occur during winter months – low fire threat periods as they are rainy months, so ok to charge from grid – only 1.6% of total load needs to be drawn from grid with 150% solar 3x battery
- Option 2 – Charge from EVs

Charge from EV
Vehicle to Grid (V2G)

- 755 vehicles per 1000 persons in California
- If all vehicles were fully electric, 5556 BEVs in Fort Bragg * average 60kwh = 333 MWh of energy storage
- Even current 5% adoption of BEVs = 17MWh of currently existing energy storage
- Does not include trucks, bus and other large scale EVs
- V2G for homes provides up to 6 days of backup power (10kwh average home use)

Charge from EV
Vehicle to Home (V2H)

- Solutions now – Custom Power Solar & Outback Power inverters – V2H using 12V aux power – works on ANY EV or Plugin
- EV must remain powered on
- Main traction battery provides power to 12V system. 12V system provides power through 2kw inverter back to Outback Power generator input.
- Part of a complete solar+battery storage solution including EV charging

80% Solar

- 80% Solar allows storage to cover loads using storage all year with 67 days needing external power sources
- Lower up front cost than 150% solar
- Some grid charge events needed during summer months – fire season – not good

Example – Fort Bragg

- Solar 80% of load = 37MW peak
- Storage 6X = 222MWh
- Solar cost – 50% mix resi/commercial = $1.75/watt * 69MW = $65M
- Storage cost – 50% mix - $175/kwh * 222MWh = $39M
- Does not include tax credits or rebates

System Analysis Rate & GHG Savings – 80% Solar

- Total $17M annual energy savings based on NEM EV2, $10M based on B19R behind the meter rates
- 58 Giga-wh generated annually
- 19,162 Tons of GHG savings per year
- With 26% tax credit total cost = $77M
- Simple payback based on 50% mix rates = 5.7 years

System Analysis & GHG Savings

Models by: **Custom Power Solar** Analysis

Load year 2018

Annual

	EV2	B-19R			CCA	PG&E
Cost	$18,974,989.75	$14,386,620.29	$0.00	$0.00	$18,974,989.75	$18,974,989.75
Cost Est. with Solar	$6,710,877.09	$6,622,658.92	$0.00	$0.00	$5,329,386.00	$7,385,726.17
Cost Est. with Solar+Storage	$2,334,992.20	$4,399,731.30	$0.00	$0.00	$1,551,146.81	$3,034,736.82
Improvement over solar only	**35.68%**	**28.63%**	**0.00%**	**0.00%**	**27.69%**	**37.54%**
Cost Advantage batteries	**$4,375,884.89**	**$2,222,927.63**	**$0.00**	**$0.00**	**$3,778,239.19**	**$4,350,989.35**
Solar only value	$12,264,112.67	$7,763,961.37	$0.00	$0.00	$13,645,603.75	$11,589,263.58
Total Value Solar+Storage	**$16,639,997.55**	**$9,986,888.99**	**$0.00**	**$0.00**	**$17,423,842.94**	**$15,940,252.93**
$/kw solar+storage	$449.31	$269.66	$0.00	$0.00	$470.47	$430.41
$/kwh storage only	$19.69	$10.00	$0.00	$0.00	$17.00	$19.58

Total usage	**73,207,145** kwh	**37,034.68** kw Battery		
Total solar	**58,565,716** kwh	**37,034.68** kw AC Solar		
Surplus	**-14,641,429** kwh	**222,210.00** kwh Battery		
Percent solar vs usage	**80.0%**	**86.7%** RTE		
GHG savings	**19,162,340** kgs/CO2	np15	**GHG Data**	
GHG savings battery alone	**3,338,836** kgs/CO2	**37,975,778** kwh Battery use		
GHG savings battery per kwh	**15.0** kg/kwh	**4.68%** % of Life used		

Annual Demand Charges

	EV2	B-19R			Max Demand
Cost	$0.00	$3,140,865.58	$0.00	$0.00	17035.53
Cost Est. with Solar	$0.00	$3,040,039.47	$0.00	$0.00	16001.15
Cost Est. with Solar+Storage	$0.00	$2,882,382.78	$0.00	$0.00	16185.24

Annual Energy Charges

	EV2	B-19R		
Cost	$18,974,989.75	$11,245,754.71	$0.00	$0.00
Cost Est. with Solar	$6,710,877.09	$3,582,619.45	$0.00	$0.00
Cost Est. with Solar+Storage	$2,334,992.20	$1,517,348.52	$0.00	$0.00
Grid Charge	5,934,413 kwh		8.11% of load	
Grid charge days needed	67 days			
Battery Mode	**Self-supply**			

Max daily load	309,087 kwh	Average load	200,568 kwh			
Max daily solar	270,330 kwh	Averga solar	160,454 kwh			
Population	7,359		5.03 solar kw/person		30.2 bat kwh/person	
Vehicles per person	0.755		5,556 Vehicles		35 Average miles/day	

EV Use	**194,462** mi/day	**GHG Value Adder**	
EV Charge	**48,615** kwh	**$65**	**$/mT**
EV Gas Savings	**$9,463,796.65**	**$217,024.33**	**GHG Savings Battery alone**
EV GHG savings	**21,056,948** kg	**$14,386,620.29**	**Baseline rate cost**
Total GHG Savings	**40,219,288** kg	**$2,334,992.20**	**Optimized rate final cost**
Net GHG savings	**16,419,899** kg	**$12,268,652.42**	**Total Savings**
GHG Load Only	**-23,799,389** kg		

Rates based on behind the meter tariffs
EV2 – best residential rate
B19R – best commercial rate

Benefits

- Reduced energy costs
- Reliable Power – grid fails, storage power can operate island from one day to the next, provided solar power refills the battery
- Consider add chargers for electric vehicles for additional value
- Energy Security

Benefits to California

- Transmission lines can be disconnected for high fire threat events
- Vastly reduce green house gas emissions
- Big step forward to cleaner California with less global warming
- Reduce demand on grid loads

Custom Power Solar
Developer

- Specialists in Solar Power with Advanced Energy Storage
- Since 2012 solar-plus-storage solutions
- Solar power pioneers since 2004 – developers of thin silicon solar technology at Photon Energy Systems / Calisolar in Sunnyvale
- Solar Power Plants Installation, Operation, and Maintenance

Calwave Technologies, Inc
EPC

Calwave Background

2004

Gorun Energy, Calwave's affiliate, begins R & D and production of solar photovoltaic materials and battery components.

2008

Gorun completed its first solar photovoltaic power system integration and begins its first turnkey installation on Large Scale ground–mounted PV power plant.

2012

Gorun completed its first large-scale utility PV power plant.

2013-2016

Gorun developed over 1000MW of power with another 2GW being developed with 25 year contracts, including 20 rooftop projects.

2017

Gorun established Calwave Technologies in the US to develop, build, own, and operate renewable energy projects with a focus on Smart Energy Solutions.

2018

Calwave's access to Gorun's procurement, financing and development capability enables it to provide turn-key project development, implementation, and operation to maximize customer cash-flow.

calwave

CSLB C-10 Lic#1028005

Calwave Installations

Solar Carport

Battery Storage

Solar Rooftop

Solar Suspension Racking

Solar Floating Panels

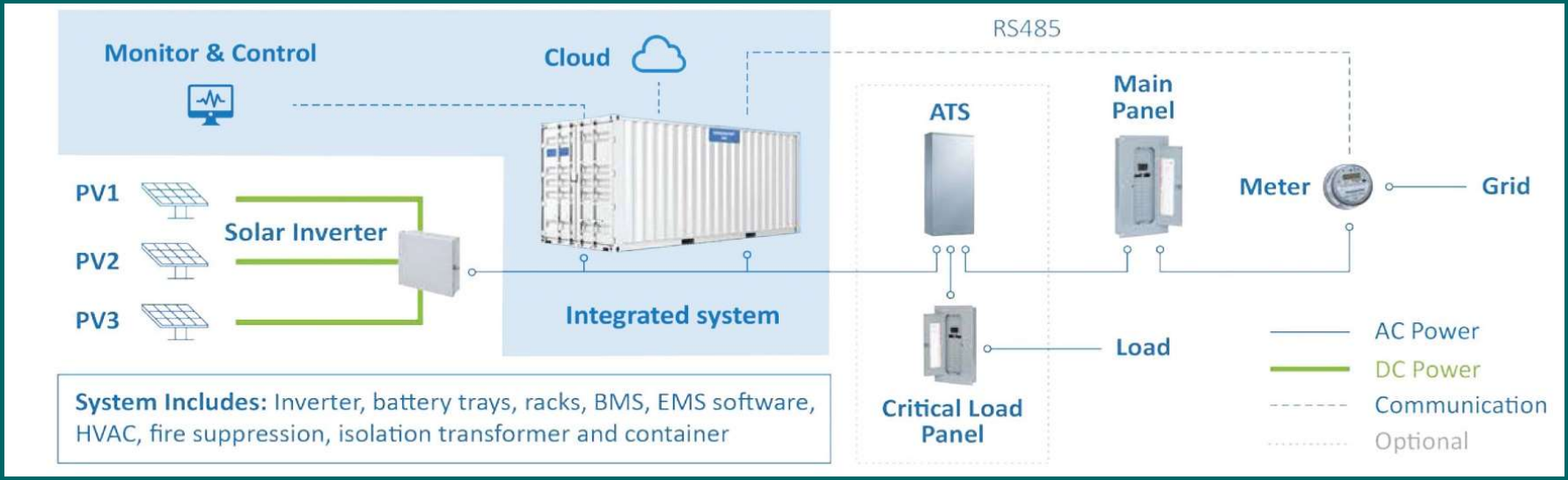
Equipment

- 375-400 watt Modules with embedded micro-inverters or equivalent
- LFP Battery Storage systems with integrated inverters
- CEC and Code Compliant

Warranties

- Energport storage system comes with a 10-year warranty - can be extended to 20 years
- PV system manufacturer's 25-year performance warranty - > 80% power level, typically greater than 90% at 25 years
- PV inverters – 10-year warranty, may be able to increase to 20-year warranty

Energport Energy Storage System



Three - 2MW 2MWH 40x8x9.5ft containers
Total 6MW with 6MWH storage
Includes all operational and climate controls
System will Include automatic transfer switch
Automatic Transfer Switch (ATS) automatically
Switches to battery power in the event of grid failure

Energport Energy Storage System

Resiliency. The system provides backup power during grid outages and prevents losses.

Solar Integration. The system stores excess solar energy produced during the day for use at another time.

Frequency Regulation. The system can provide frequency regulation in wholesale markets.

Demand Charge Management The system will intelligently charge and discharge to reduce peak loads.

SYSTEM DATA	L120240	L5001000	L20002000
Nominal AC Voltage – 3 Phase*	480V/60Hz	480V/60Hz	480V/60Hz
Nominal Continuous Power Rating (kW AC)*	120	500	2,000
Nominal Battery Capacity (kWh DC)	258	1,144	1,980
Duration of Discharge (Hours)*	2	2	1
Nominal Battery Voltage (Vdc)	358	666	768
DC Amp-hours (Ah)	720	1,728	3,456
System Round-Trip Efficiency (RTE%)	89%	89%	89%
Dimension (D x W x H, In.)	10' x 8' x 8.5'	20' x 8' x 8.5'	40' x 8' x 9.5'
Weight (tons)	5.5	15.7	42
Operating Temperature	32 °F - 131 °F		
Standard Warranty Length	10 years; designated for daily cycling		
Certification	UN38.3, UL 1973, UL 1741-SA, UL 1973 & UL 9540		
Enclosure Rating	IP54/NEMA 3R		
HVAC	Included		
Isolation Transformer	No	Yes	Yes
Fire Suppression	No	Yes	Yes
Operation Mode	On/Off Grid		
EMS Software & Control	Included; cloud-based web interface		

Three – L20002000
Total 6MW with 6MWH storage

Energport Energy Storage System

Example access panel
Includes all operational and climate controls

Advantages of Storage

- Utility peak periods have shifted to evening hours in 2019
- Energy Security – power during grid outage
- Buffers fluctuations – clouds, rainy days
- Save solar power in battery energy storage in the morning
- Provide power in the afternoon and during evening peak rate periods
- Adds value by offsetting power use at peak rate periods
- Potential to sell power at peak periods

Operations & Maintenance

- Custom Power Solar & Calwave Technologies provide operations, maintenance, and monitoring
  - Inverters may need replacement in 10-15 years
  - Batteries will probably need replacement in 10-15 years.
  - Batteries likely to be less than $100/kwh in 10-15 years
  - Solar PV panels typically warrantied for 25 years

Custom Power Solar, Inc
Calwave Technologies, Inc

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Thank you!