CUSTOM POWER SOLAR

SOLAR + ENERGY STORAGE

Solar Plus Storage
Focus on Storage Benefits

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Getting to 100% renewables

- We cannot get to 100% renewables without energy storage
- Solar+Storage
- Wind+Storage

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Overview storage products

- Lead-acid
- Lithium ion
  - Nickel Cobalt Manganese (NCM)
  - Nickel Cobalt Aluminum (NCA)
- Lithium Iron Phosphate (LiFePo)
- Lithium Titanate (LTO)
- Flow Batteries

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Lithium Iron Phosphate Batteries

- Lithium Iron Phosphate (LiFePo)
- 96-98% efficiency
- 3000-10,000 cycle life
- High DOD (80%+)
- 3.2-3.6V/cell
- -20 to 60C operating temperature
- Much lighter weight than lead-acid
- Better fire resistance than Li-ion – they cannot burn
- Tend to allow inverters to operate more efficiently
- Typically can last 10+ years
- Limiting to 80% DOD extends life

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Value of Storage Batteries

- To evaluate batteries, calculate the actual lifetime dollars per kWh ($/kwh)
  - Typical lead-acid – $350/kwh / (1500 cycles * 50% DOD * 70% RTE[1]) = $0.67/kwh
  - Lithium - $500/kwh / (5000 cycles * 80% DOD * 85% RTE[1]) = $0.15/kwh
  - Lithium is 4X+ the value of lead-acid

[1] RTE – Round Trip Efficiency = one way efficiency squared

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Value of Storage Batteries in Cost Savings

- Arbitrage – moving energy from low rate periods to high rate periods
  - Highest value when high delta off-peak rate vs peak rate
- Demand Reduction – reducing the peaks of energy usage spikes = reducing demand charges
- Backup – prevent loss of assets when grid fails

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Storage Markets

- Residential – generally under 10kw
- Small commercial <30kw
- Commercial/Industrial >30kw
- Equity – Disadvantaged Communities & Resiliency
  - Residential
  - Non-residential

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CCA Impacts

- East Bay Community Energy
  - New NEM customers can receive up to $2500/year cash back for excess power
- Marin Clean Energy
  - No limit on cash back for excess power
- Peninsula Clean Energy
  - No limit on cash back for excess power
- Credits can roll over to succeeding years

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Some Residential Storage Systems

- BMZ
- Custom Power Solar
- LG Chem
- SimpliPhi
- Sonnen
- Sunrun
- Tesla Powerwall
- Darfon

Finance Options

- Cash - is king for contractors
- Home owner
- Equity Line Of Credit (HELOC)– 3 - 5% typical rate
- PACE funding – payments go on property taxes, 0% down, terms up to 25 years

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Residential Storage Only Systems

- Custom Power Solar
- Outback inverter includes automatic transfer switch (ATS)
- Energport LiFePo batteries
  - 4kw/10kwh - $19k
  - 8kw/20kwh - $26k
- $478/kwh after rebates and Federal Incentive Tax Credit of 30%

[1]Typical Installation costs - costs may vary and does not include permitting costs

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NEW SOLAR+STORAGE RATE 2019
EV is NOT required: Solar+storage is required

Schedule EV2 for Storage

Season	TOU Period	Rate ($/kWh)
Summer	Peak	0.469
	Part-Peak	0.358
	Off-Peak	0.156
Winter	Peak	0.342
	Part-Peak	0.325
	Off-Peak	0.156

Peak: 4PM – 9PM, All Days
Part-Peak: 3PM – 4PM & 9PM – 12AM, All Days
Off-Peak: 12AM – 3PM, All Days

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Residential EV-A vs new storage EV2 rate - Savings 8kw/20kwh

	Solar only	Solar+Storage	Difference
EVA	$3,825	$4,944	129%
EV2	$2,863	$4,241	148%
Difference	75%	86%	

All EVA customers will be moved to EV2 rate after grandfathering period

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Typical Residential Solar+Storage Savings - PG&E EV2 Rate

	Solar+Storage Savings	Raw Cost	Final Cost	Simple Payback Years	Payback with EV	kwh generated per year
4kw PV/10kwh	$2,120	$32,700	$20,400	9.6	5.6	6400
6kw PV/10kwh	$2,863	$34,500	$21,600	7.5	4.9	9600
7kw PV/20kwh	$3,757	$41,925	$24,847	6.6	4.7	11200
8kw PV/20kwh	$4,241	$45,800	$27,600	6.5	4.8	12800
12kw PV/20kwh	$5,725	$49,200	$29,900	5.2	4.1	19200

[1]Typical Installation costs – systems using Outback Radian or Skybox with LFP batteries & 20%+ efficiency modules at $0.60/watt. Savings assumes full arbitrage storage mode. Payback with EV assumes gas savings average 31 miles/day $4/gal compared to 30mpg. Final cost includes ITC (Investment Tax credit of 30%) and SGIP rebate (Self-Generation Incentive Program) at current rate $0.25/watt-hour

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Storage Benefit - Residential Solar+Storage EV2 rate

Savings	Solar Only	Solar+Storage	Storage Benefit
4kw PV/10kwh	$1,430	$2,120	48%
6kw PV/10kwh	$2,147	$2,863	33%
7kw PV/20kwh	$2,410	$3,758	56%
8kw PV/20kwh	$2,863	$4,241	48%
12kw PV/20kwh	$4,295	$5,725	33%

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Commercial Storage Systems

- Typical in USA 240V/480V 3 phase:
- Range of costs: $250-$1000/kwh
- After SGIP rebate and ITC - $0- $500/kwh

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Some Commercial Storage Systems Providers

- Advanced Microgrid Solutions
- BYD
- Custom Power Solar
- LG Chem
- Sonnen
- STEM
- Tesla Powerpack
- Avalon (Flow batteries)

Battery Size vs Savings Solar+Storage

PV size kw	Storage Multiplier	Storage size kwh	Storage savings per kwh	Solar+Storage Savings/yr	Raw Cost	Final Cost	Simple Payback Years	10 year Total Income
240	0	0	$0	$40,080	$360,000	$252,000	6.3	$204,929
240	0.5	120	$71	$48,600	$402,000	$246,600	5.1	$307,461
240	1	240	$59	$54,240	$444,000	$241,200	4.4	$377,159
240	2	480	$46	$62,160	$528,000	$230,400	3.7	$478,250
240	4	960	$35	$73,680	$696,000	$208,800	2.8	$631,183
PV Rate $/watt	$1.50							
Storage rate $/kwh	$350							
Savings rate PV $/kw	$167							
SGIP rebate rate $/wh	$0.29							
ITC	30%							

PG&E E-19R 2019 rate. 10 year income includes 3%/yr utility increases, -0.5% solar degradation. Does not include depreciation

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Cost Modeling Tools

- Why do cost modeling?
- Determine cost savings using customer load profile and projected solar size
- Compare rates
  - Energy Toolbase
  - Geli
- Developer runs analysis for you
  - Custom Power Solar
- Public model
  - Enel.com (formerly EnerNOC)

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Cost Modeling Tools and Financial Modeling

- Model financial returns over time
- Property Assessed Clean Energy
  - HERO
  - Ygrene
  - Renew Financial PACE funding –
- CleanFund
- For Non-Profits – Collective Sun

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Cost Modeling Tool Tips

- Get the load profile
  - UtilityAPI – helps with format you need
  - PG&E Green Button
- Calculate solar size
- Best size - at least 100% of the annual energy usage in kwh of customer
- Quick calc – Usage/1500 = PV size in kw
- Make sure size fits available space
  - roof
  - ground
  - carport

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Cost Modeling Tool Tips Cont'd

- Storage size – best SGIP rebate value
- = 2X the solar size
- Example:
  - 5kw solar needed,
  - 5*2=10kwh battery best value
- Best customer long term value –
  - >2X, 4X the solar size
- 4X – rebate is not as large proportionally, but cost savings double that of 2X battery size (4X savings). Changing in 2020 to same value

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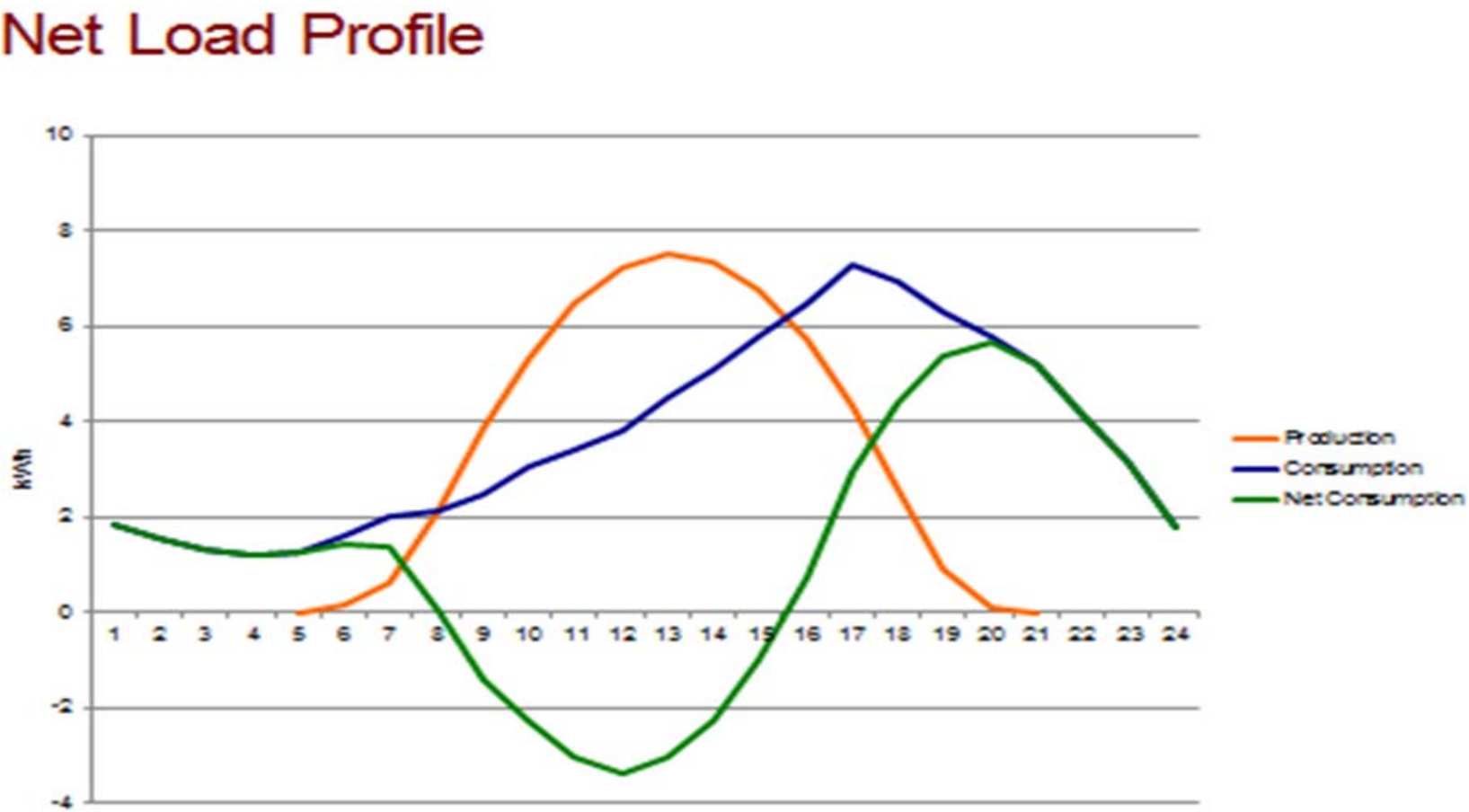
Typical Solar Production and Consumption



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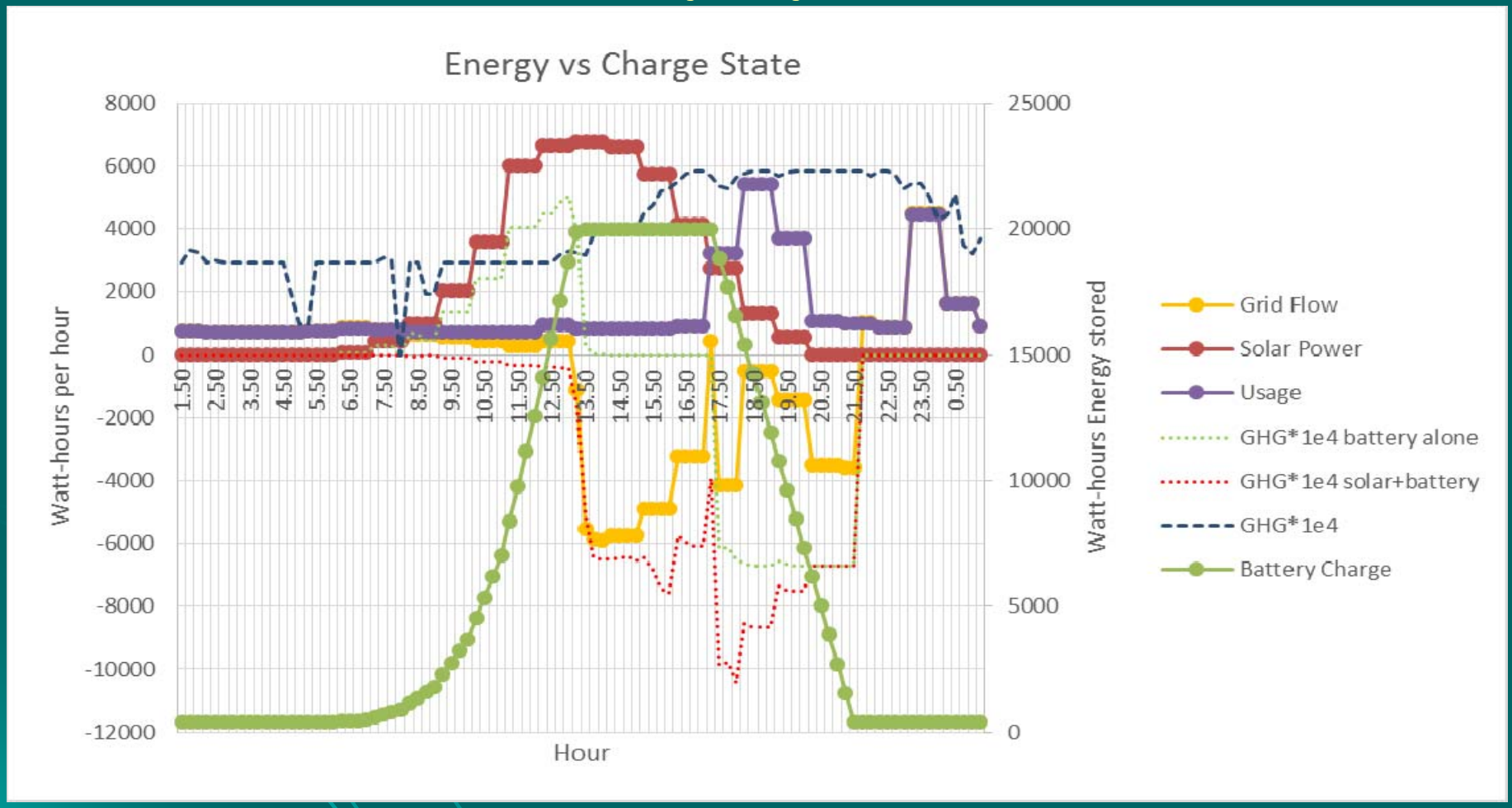
Residential Solar+Storage+EV – Arbitrage Daily Cycle



6/21 – cost savings through arbitrage – store solar power in am, discharge during peak

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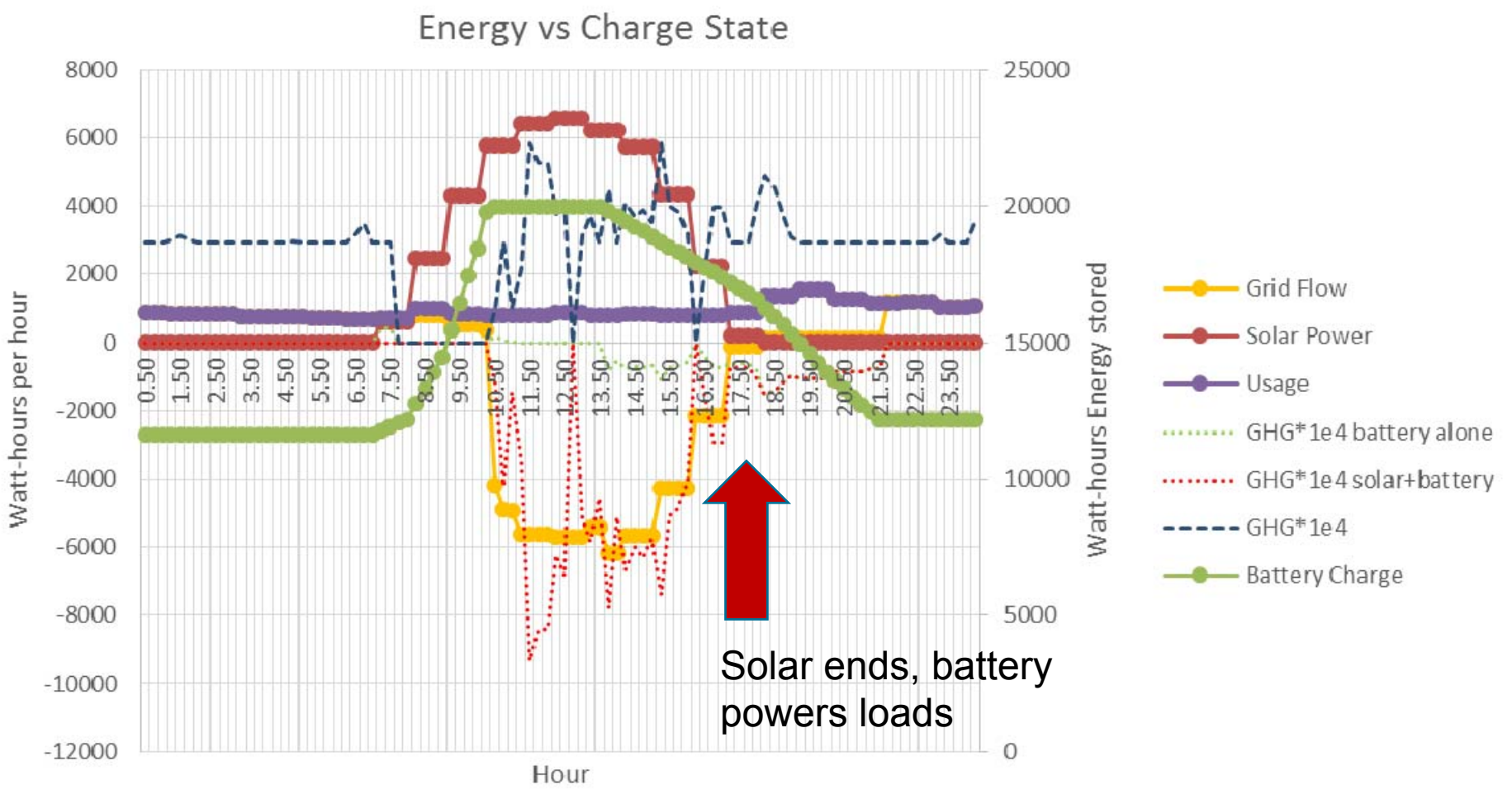
Resi Solar+Storage+EV Self Supply– Daily Cycle



2/4 – cost savings through self supply – store solar power in am, discharge during peak but only power loads

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Commercial Rate Analysis

Models by: **Custom Power Solar** Grocery_e19r_2019rates_10_18_19.xlsx

Load year 2017

Solar Data Lat, Lon: 37.89, -122.3

Annual

	E-19R 2019	E-19R	A-6	A-10	EBCE FIT
Cost	$60,641.85	$60,148.60	$90,395.58	$62,384.84	
Cost Est. with Solar	$21,195.30	-$4,417.59	-$23,409.90	$3,752.30	$39,074.74
Cost Est. with Solar+Storage	-$527.03	-$6,881.43	-$26,189.82	$2,871.97	**$67,534.67**
Improvement over solar only	**55.07%**	**3.82%**	**2.44%**	**1.50%**	
Cost Advantage batteries	**$21,722.33**	**$2,463.84**	**$2,779.92**	**$880.32**	
Cost savings solar only	$39,446.55	$64,566.19	$113,805.48	$58,632.55	
Total Value Solar+Storage	**$61,168.88**	**$67,030.03**	**$116,585.40**	**$59,512.87**	
Optimized Rate	$167.72	$274.53	$483.89	$249.30	solar only savings
	$45.25	$5.13	$5.79	$1.83	storage only savings

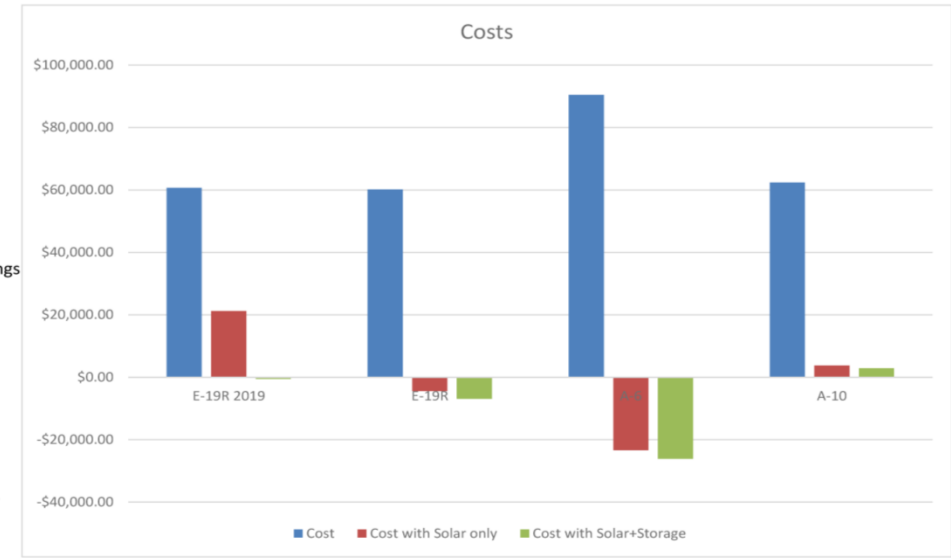
Total usage	**361,803**	**kwh**	**120.00**	**kw Battery**
Total solar	**361,803**	**kwh**	**235.19**	**kw AC Solar**
Surplus	**0**	**kwh**	**480.00**	**kwh Battery**
Percent solar vs usage	**100.0%**		**84.9%**	**RTE**
GHG savings	**117,208**	**kgs/CO2**	np15	**GHG Data**
GHG savings battery alone	**19,709**	**kgs/CO2**	**158,111**	**kwh Battery use**
Annual percent dispatchable	**43.7%**		**9.02%**	**% of Life used**

Annual Demand Charges **Max Demand**

	E-19R 2019	E-19R	A-6	A-10	
Cost	$14,304.38	$13,283.25	$0.00	$10,593.14	67.47
Cost Est. with Solar	$13,768.40	$12,531.79	$0.00	$10,200.49	64.69
Cost Est. with Solar+Storage	$13,038.70	$12,201.04	$0.00	$9,773.44	63.75

Annual Energy Charges

	E-19R 2019	E-19R	A-6	A-10
Cost	$46,337.47	$46,865.35	$90,395.58	$51,791.70
Cost Est. with Solar	$7,426.90	-$16,949.38	-$23,409.90	-$6,448.20
Cost Est. with Solar+Storage	-$13,565.73	-$19,082.47	-$26,189.82	-$6,901.46
Grid Charge	0 kwh			
Grid Charge	0 days			



EV Use	**0.0**	**mi/day**
EV Charge	**0.0**	**kwh**
EV Gas Savings	**$0.00**	
EV GHG savings	**0.0**	**kg**
Total GHG Savings	**117,208**	**kg**
Net GHG	**838**	**kg**
GHG Load Only	**-116,370**	**kg**

Solar rate	$1.50	**$/watt**
Storage rate	$350	**$/kwh**
Solar cost	$352,784.55	
Storage cost	$168,000.00	
Rebate rate	$0.29	$/wh
ITC	30%	
Final cost	$225,349.18	
Simple payback yrs	3.7	

GHG Value Adder

$65	**$/mT**
$1,281.07	**GHG Savings Battery alone**
$60,148.60	**Baseline rate cost**
($527.03)	**Optimized rate final cost**
$61,956.70	**Total Savings**

All rates run with same conditions, optimized to first column rate

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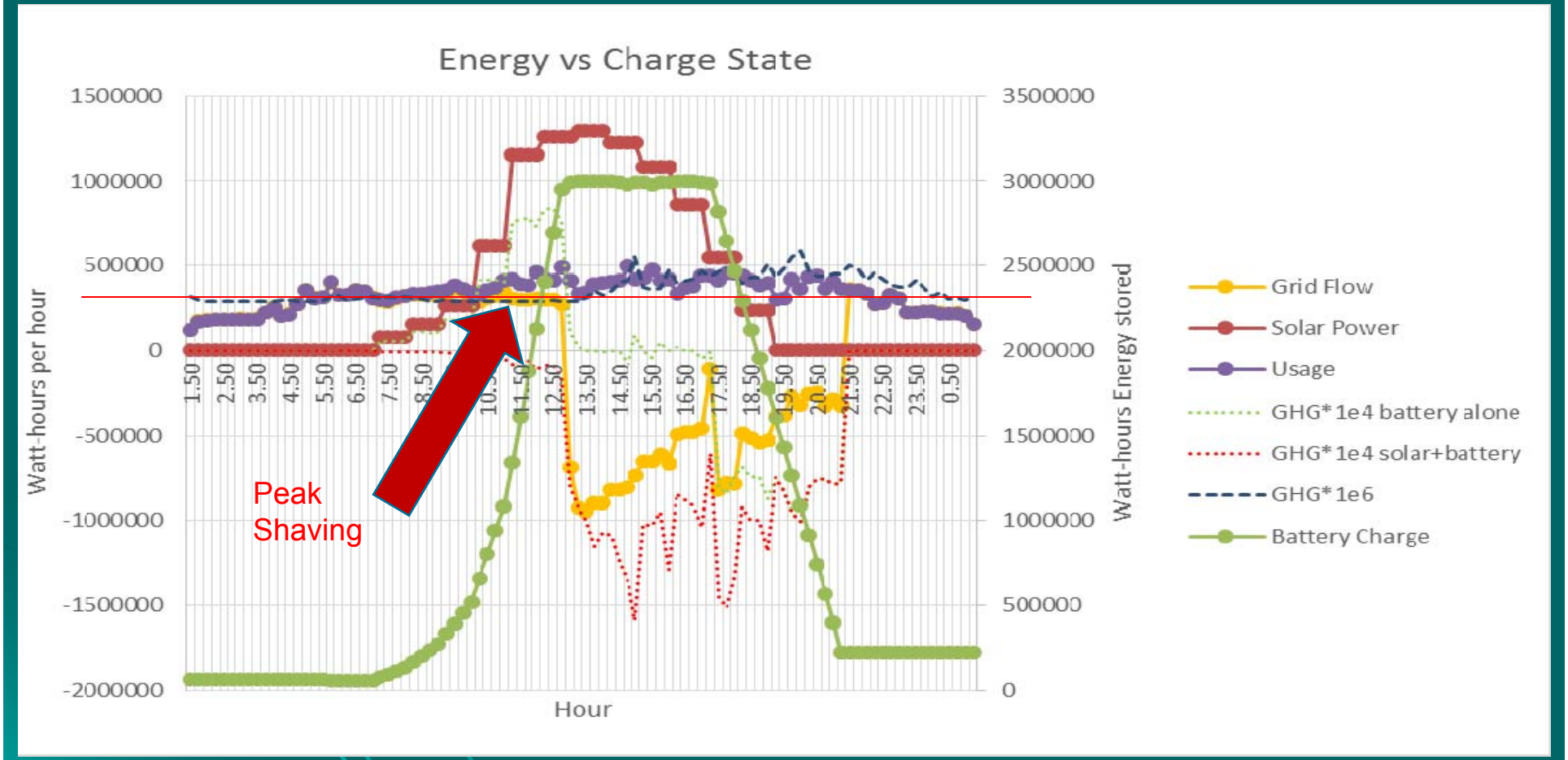
Commercial Solar+Storage – Arbitrage & Demand Reduction Daily Cycle



6/21 – cost savings through demand response – peak shaving (red line) and arbitrage – store solar power in am, discharge during peak

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Rates with Highest Demand Charges

Utility	Rate	Applicable kW Range	Demand Charges
Southern California Edison	TOU-GS-2-B	20 – 200 kW	Demand Charge: $15.89 Summer OP: $19.89 Summer MP: $3.88
	TOU-GS-3-B	201 – 500 kW	Demand Charge: $18.29 Summer OP: $20.01 Summer MP: $3.94
	TOU-8-B	>500 kW	Demand Charge: $19.02 Summer OP: $21.73 Summer MP: $4.17
SDGE	AL-TOU	>=20 kW	Demand Charge: $22.55 Summer OP: $9.36 Summer MP: $6.86
PG&E	A-10 Secondary Voltage	200 – 499 kW	Summer: $19.52 Winter: $11.76
	E-19 Secondary Voltage	500 – 999 kW	Demand Summer: $17.74 Peak Demand Summer: $19.65 Part-Peak Demand Summer: $5.40 Demand Winter: $17.74
	E-20 Secondary Voltage	>=1000 kW	Demand Summer: $17.87 Peak Demand Summer: $19.02 Part-Peak Demand Summer: $5.23 Demand Winter: $17.87

Courtesy Energport

Best Rates for Solar+Storage Commercial

- PG&E
  - A1STORE – Nov 2019
  - E-19R
  - E-20R – very large systems over 1MW demand
- New TOU rates by Nov 2019

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Best Rates for Solar+Storage Commercial

- SCE
  - TOU8BR
- SDG&E
  - DG-R
  - New – DR-SES

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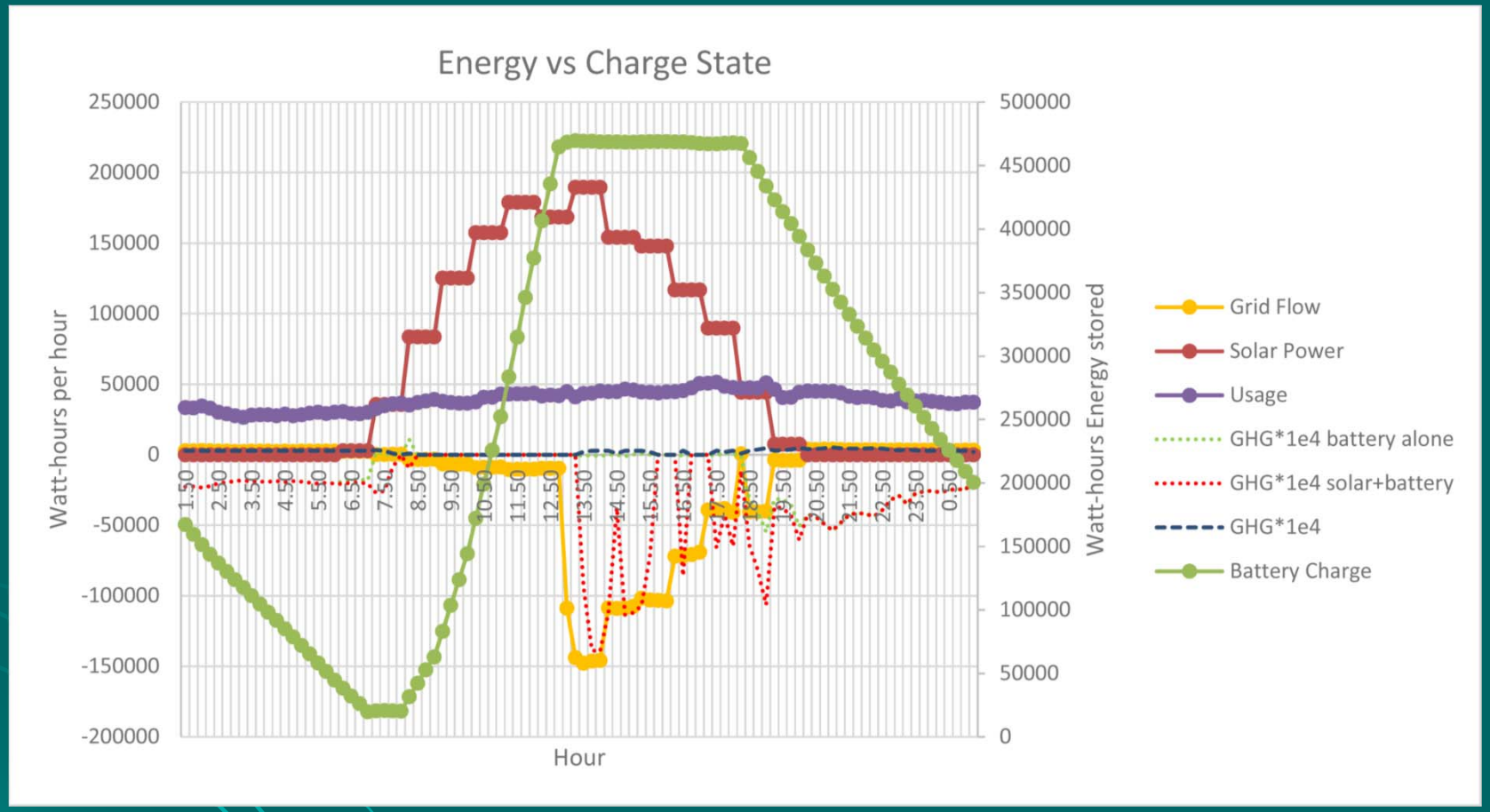
Backup



Date: 4/30 Grid flow all negative – only exporting to grid. No export during power outage. Solar sized = 100% of load, 2X battery size

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How Realistic is Perfect Foresight in Real World Storage Operations?

- Many tools (Energy Toolbase, Geli) use a Perfect Foresight model to analyze load profiles+solar with given rate and determine “best case” cost savings –
- Not realistic in real life use
- More realistic – Forecasting

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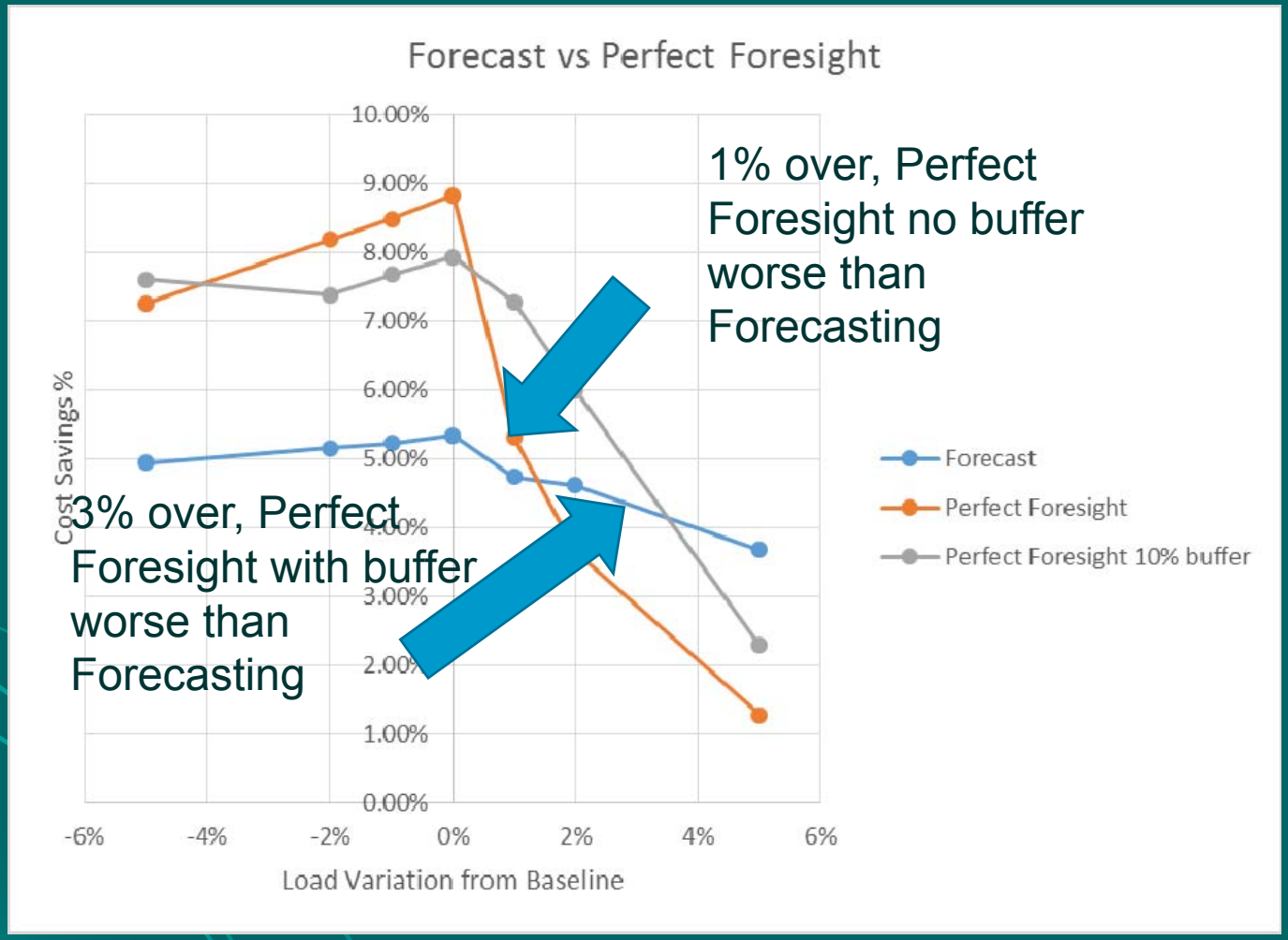
Forecasting Sensitivity Analysis – Cost Savings



Conditions – C9 load (500kw demand peak), storage only 370kw,870kwh

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Conclusions

- **Perfect Foresight is extremely sensitive to real life load conditions – if load exceeds baseline – even slightly, savings are lost**
  - **1% over load conditions eliminate all savings from Perfect Foresight vs Forecasting with no buffer**
  - **1% over condition virtually certain in real life conditions**
- **Forecasting method likely produces more consistent, reliable cost savings than perfect foresight**

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Conclusions

- **Be conservative with storage cost savings projections – nothing worse than customers getting less than they planned on**
- **Design at least a 20% buffer in the size of the battery system**
  - **Improves lifetime**
  - **Reduces impact of day-to-day variations in use**

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Thank You!

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SOLAR + ENERGY STORAGE

Lithium Iron Phosphate Batteries

- Lithium Iron Phosphate (LiFePo)
- 96-98% efficiency
- 3000-6000 cycle life
- High DOD (80%+)
- 3.2-3.6V/cell
- -20 to 60C operating temperature
- Much lighter weight than lead-acid
- Better fire resistance than Li-ion
- Tend to allow inverters to operate more efficiently
- Typically can last 10+ years
- Raw cost for cells now only $110-130/kwh

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Lead Acid Batteries

- 80-85% efficiency[1]
- 1000-1500 cycle life at best
- Limited Depth of Discharge (DOD) for best lifetime
- Typical DOD only 50%
- Some require maintenance
- Lifetime is typically 6-7 years
- Heavy – 4X as heavy as Lithium batteries
- Lead is a toxin
- Recycling an issue

[1] One way efficiency

Lithium Ion Batteries

- Nickel Cobalt Manganese (NCM)
- Nickel Cobalt Aluminum (NCA)
- 96-98% efficiency
- 3000-5000 cycle life
- High DOD (80%+)
- 3.6-4.2V/cell
- 0-45C operating temperature
- Much lighter weight than lead-acid
- Typically can last 10+ years

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Lithium Iron Phosphate Batteries

- Lithium Iron Phosphate (LiFePo)
- 96-98% efficiency
- 3000-6000 cycle life
- High DOD (80%+)
- 3.2-3.6V/cell
- -20 to 60C operating temperature
- Much lighter weight than lead-acid
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- Tend to allow inverters to operate more efficiently
- Typically can last 10+ years
- Raw cost for cells now only $110-130/kwh

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Lithium Titanate Batteries

- Titanate (LTO)
- 96-98% efficiency
- 3000-30,000 cycle life
- High DOD (80%+)
- 2-2.6V/cell
- -30C to 45C operating temperature
- Lower energy density than other lithium
- Generally very high charge/discharge rate
- Higher cost but longer cycle life
- Typically can last 10+ years

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Flow Batteries

- 80-85% efficiency
- 30,000+ cycle life
- Higher Capex
- Heavy
- Long cycles are typical

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Storage System Components

- Batteries
  - Cells in parallel
  - Cell groups in series
- Battery Management System (BMS)
  - Required for lithium batteries
  - Maintains cells within 0.02V of each other
- Inverter
  - Moves energy to/from battery
- Automatic Transfer Switch (option)
  - Disconnects solar+storage system from grid
  - Allows on grid or off-grid operation

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Storage System Components, cont'd

- Monitoring system - all system functions
  - Voltages
  - Temperatures
  - Current flows
- Typically data stored in cloud and locally
- Control –
  - Network interfaced system operations
- NGOM –
  - Separate Metering for monitoring solar vs battery
  - Not needed in residential systems

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Examples - SGIP approved battery systems

- Energport
- BYD
- LG
- SimpliPhi
- Tesla
- Contact your SGIP Program Administrator for specifics

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Energport

Features:

- Saves electricity cost by reducing demand charges and shifting load to off-peak period
- System payback in less than 4 years
- Simple modular design, scalable for any size and use
- LFP - Safest Lithium ion battery on the market
- Cloud-based optimization and reporting
- Small footprint
- Connects to existing circuits
- Emergency backup as bonus function
- $0 down lease available
- Low APR financing available
- California SGIP rebate available
- 30% federal tax credit with Solar PV
- 15-year design life; 10-year warranty
- Fully installed for less than $0.40/Wh
- CE, UL compliance

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BYD Energy Storage System

240 Kwh in outdoor container
Includes all operational and climate controls

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Residential Storage Systems Cont'd

- Tesla Powerwall
- 5kw/14kwh
- -20 to 60C operating temperature
- ~$7800

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Residential Storage Systems Cont'd

- LG Chem – high voltage 400V
  - 9.8kwh - ~ 2500 cycle life
  - 10 year warranty
  - ~ $6500
- Solaredge StorEdge inverter
  - 7.6kw
  - ~ $4000

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Residential Storage Systems Cont'd

- SimpliPhi (LiFePo)
- Various sizes from 2.5kwh
- Example:
- 15kwh with 8kw Outback 8048A inverter - $22.5k

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Residential Storage Systems Cont'd

- BMZ (Li-ion NMC/NCA)
- 6.8/8.5/10kwh 45-61.5V – 5000 cycle life
- After SGIP rebate and ITC
- ~$800/kwh

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