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SAGE RENEWABLES

Battery Energy Storage Market Overview

The Changing Face of ZNE and Responsible Grid Citizenship

October 17, 2018

The BESS Market Today

- BESS Technology Overview
  - Main Type, Cost Trends
- Energy Storage Services
  - Regional, Utility and Customer
- BESS Economic Value
  - Where does BESS value come from?
- BESS and ZNE Today
  - How BESS is implemented
- Policy and Tariff Support

Battery Energy Storage Systems (BESS)

An Overview

- Technology
- Cost Trends

BESS Overview

95% of the US grid BESS market is Lithium-Ion

+ Lithium-ion (Li-ion and LIB)

- Highly developed – more bankable
- High energy density, portable
- 30 min to 3-hour applications
- 75-85% round trip efficiency
- Degrade over time, require replacement/disposal strategy
- No moving parts, high reliability
- Discharge rate, duty cycle and climate impact efficiency

BESS Overview

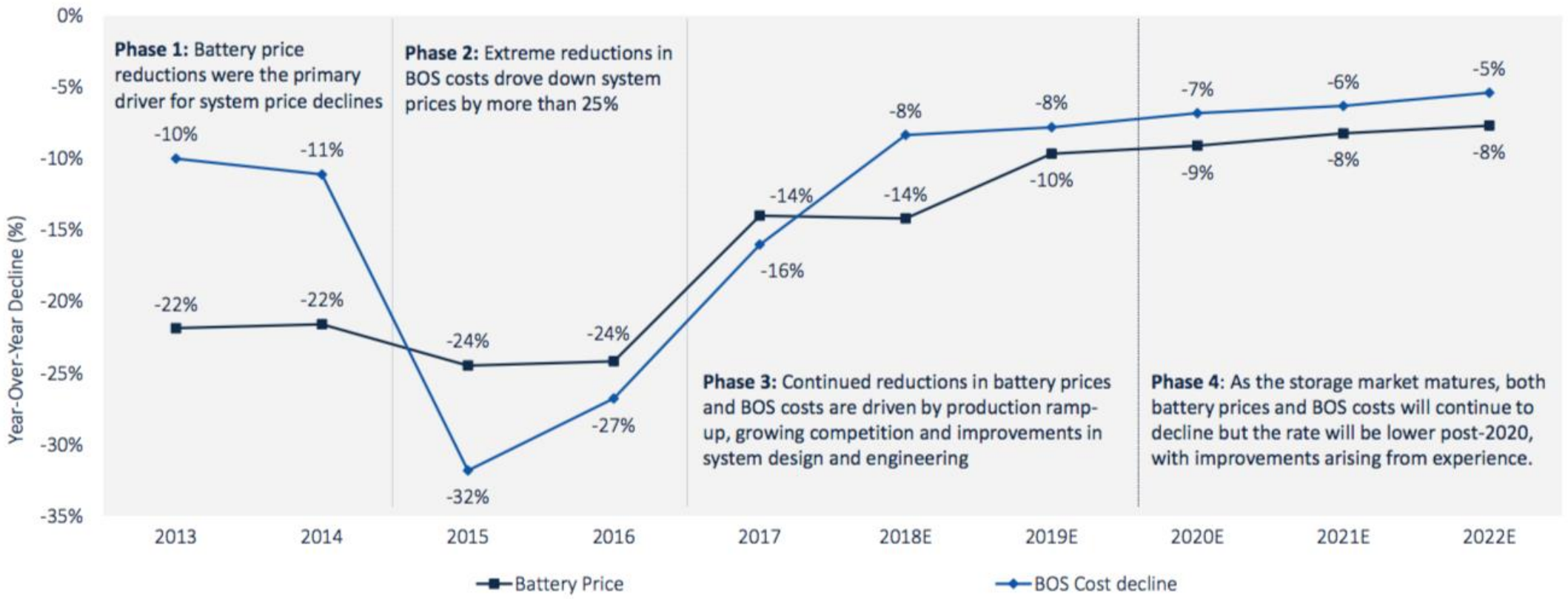
4% of the US grid BESS market are Flow Batteries

- **+ Flow (reduction-oxidation)**
  - Lower energy density
  - 4-hour+ applications
  - 65-75% round trip efficiency
  - Do not degrade significantly, long service and cycle life
  - Pumps reduce reliability

BESS Overview

BESS Cost Trends (LIB)

BESS Overview



- $207/kWh 2017
- $144/kWh 2022
- 8-10%/year through 2022

Year-Over-Year Decline in Battery Price and BOS Cost, 2013 – 2022e

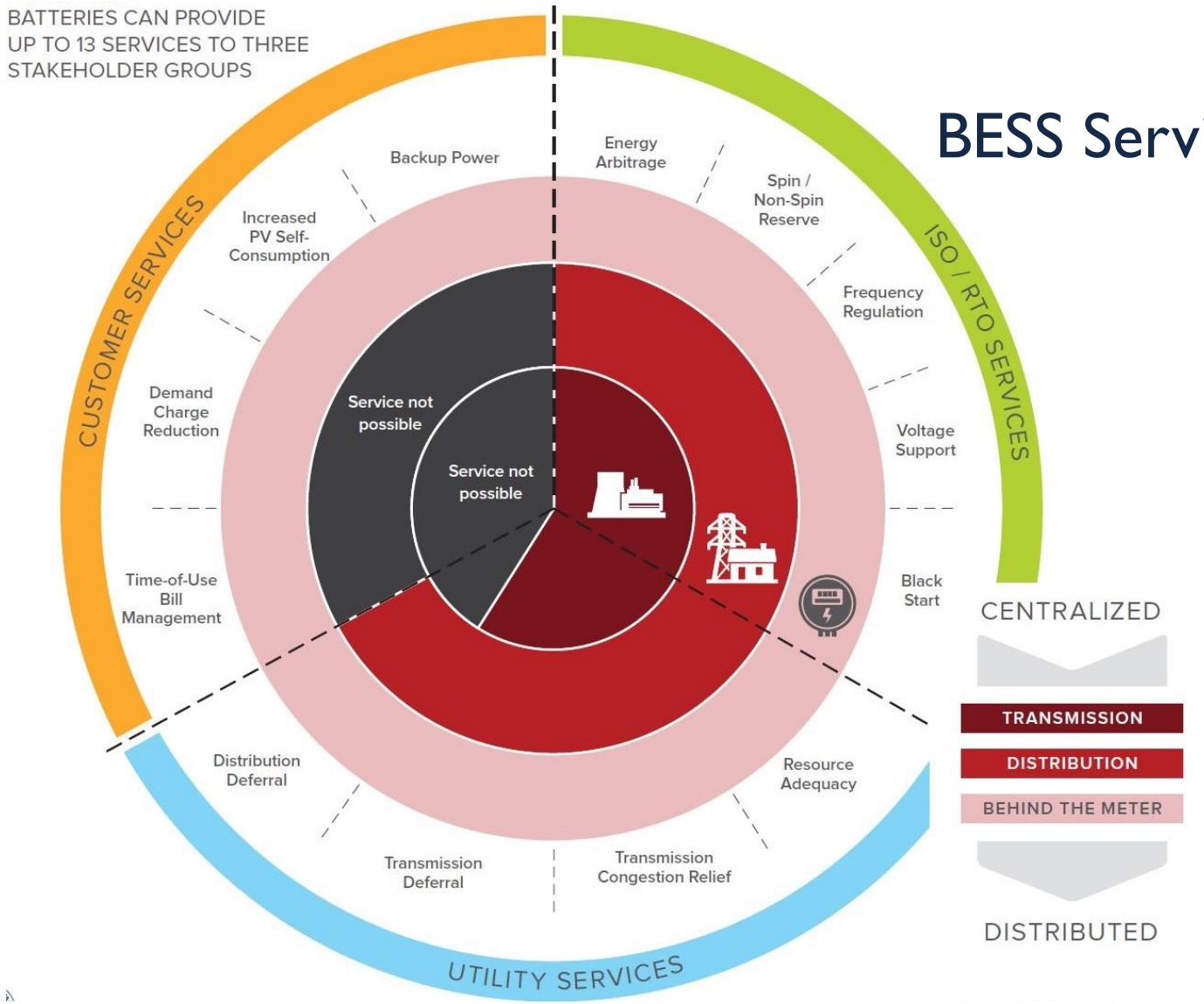
Source: GTM

BESS Services

by Market Sector

+ ISO/RTO
+ Utility (front of meter)
+ Customer (behind the meter)

BESS Services



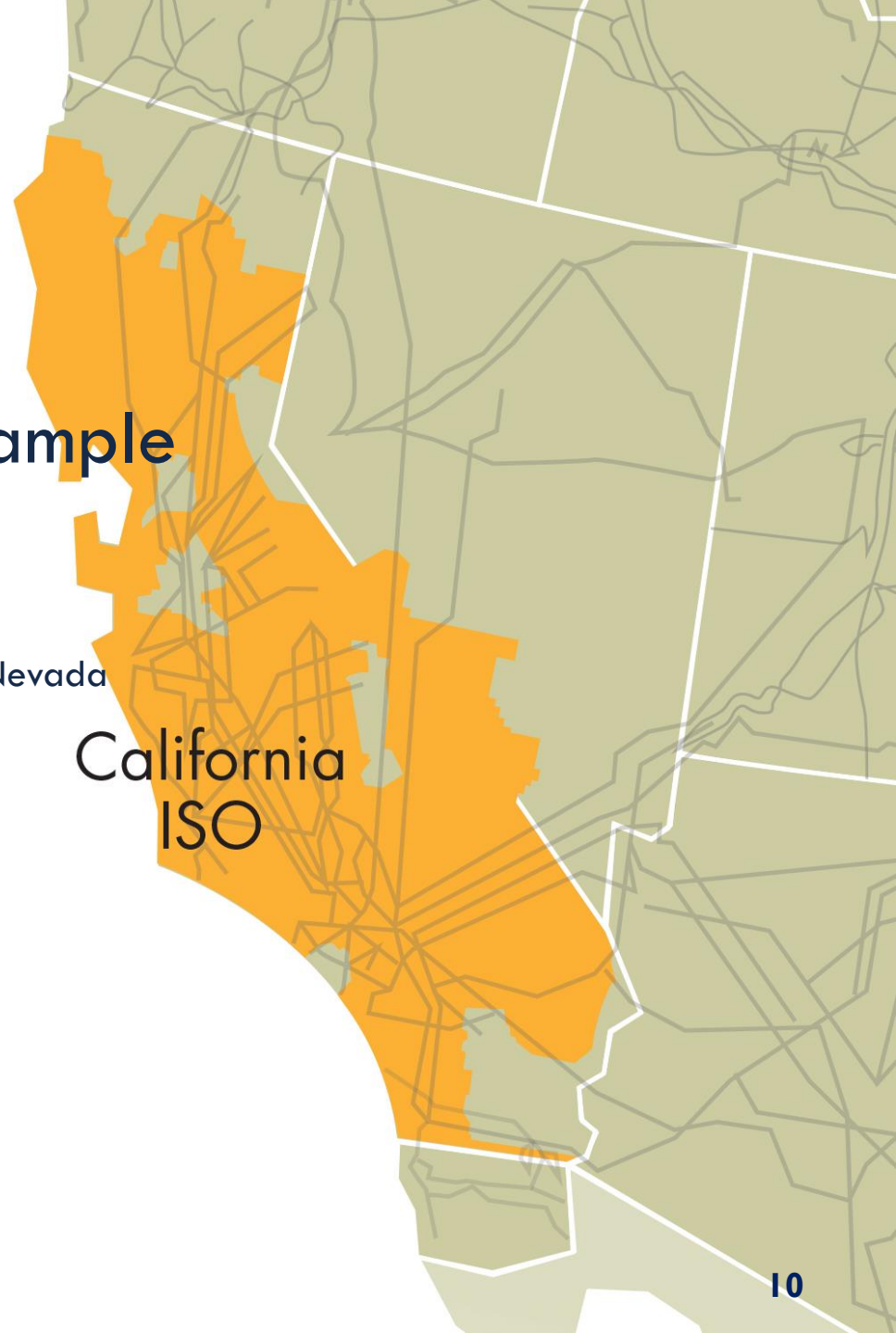
BESS Services by Market Sector

Source: NREL

BESS Services

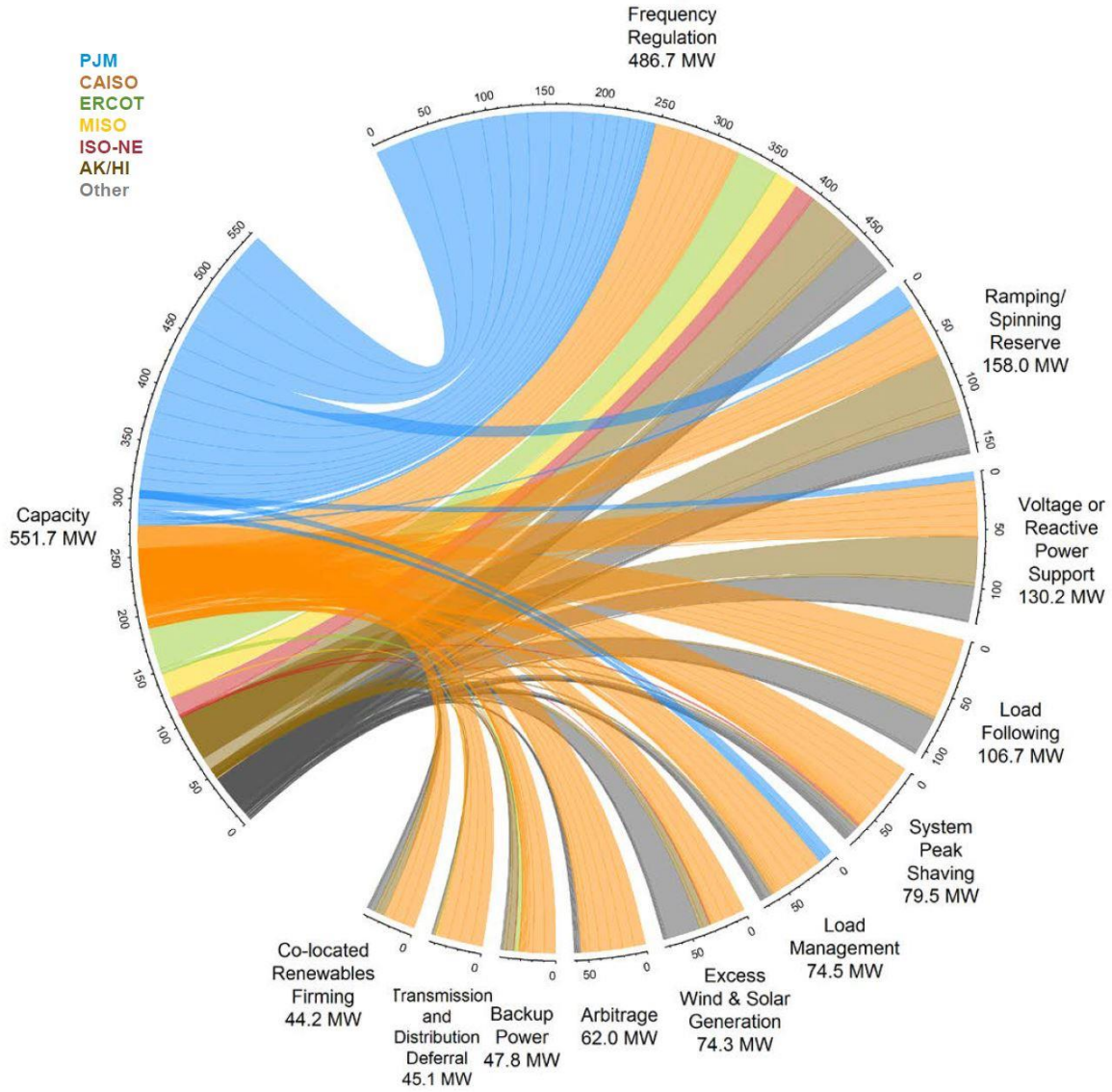
How are grid connected batteries used?

+ Regional ISO/RTO Services – CAISO Example
  - What is CAISO?
    - California Independent System Operator
    - Manages electricity flow across transmission lines in 80% of CA and part of Nevada
    - Coordinates energy resources and operates a wholesale power market
    - Forecasts electrical demand and dispatches lowest cost generation
  - ISO/RTO BESS Services
    - Frequency Regulation
    - Ramping/Spinning Reserves
    - Voltage/Reactive Power Support
    - Energy Arbitrage/Renewables Firming
    - Black Start



BESS Services

ISO/RTO
Capacity and Services



Source: EIA

BESS Services

+ Utility Services (in front of the meter)

- Resource Adequacy
- Renewables Firming
- Transmission Congestion Relief
- Transmission Deferral
- Distribution Deferral

PG&E Example

- Resource Adequacy/Peaker Plant Replacement
  - 567 MW Li-ion BESS project in Bay Area
  - Proposal to CPUC to replace 3 gas-fired peaker plants
  - CPUC has not approved yet, but likely to

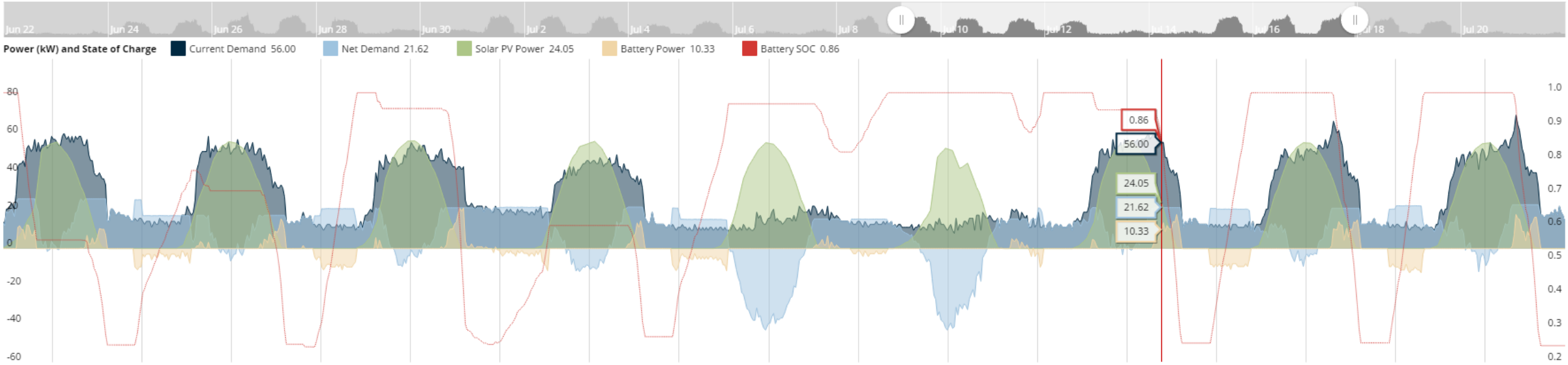
Counterparty (Project Name)	Storage Technology	Connection Point	Term (years)	Discharge Duration (Hours)	Size (MW)
Dynegy Marketing and Trade, LLC (Vistra Moss Landing Energy Storage)	Lithium Ion Batteries	Transmission	20	4	300
Hummingbird Energy Storage, LLC (Hummingbird Energy Storage)	Lithium Ion Batteries	Transmission	15	4	75
Micronoc Inc. (mNOC AERS Energy Storage)	Lithium Ion Batteries	Customer (Behind the Retail Meter)	10	4	10
Tesla, Inc. (Moss Landing Energy Storage)	Lithium Ion Batteries	Transmission	20	4	182.5
			Total Capacity (MWs)		567.5

BESS Services

+ Customer Services (behind the meter)

- TOU Bill Management
- Peak Shaving/Demand Charge Reduction
- Renewables Firming
- Backup Power/Resilience

This is where the vast majority of ZNE energy storage is deployed:
Customer sited, behind the meter



BESS Services

+ Customer Services Example: CA Public School District

- Peak Shaving/Demand Charge Reduction
  - Took almost a year to stabilize system function
  - Vendor connected one system to wrong meter, requiring major rework of interconnection
- TOU Bill Management (energy arbitrage)
  - Not available because system was installed with solar PV using Federal ITC
  - Batteries can only be charged from solar PV
- Backup Power/Resilience
  - Would like to augment portable backup generators
  - Can't be used for this because of SGIP requirements for discharge cycles, uneconomic to set aside significant portion of battery capacity as reserve

BESS Economic Value

Customer Sited Systems

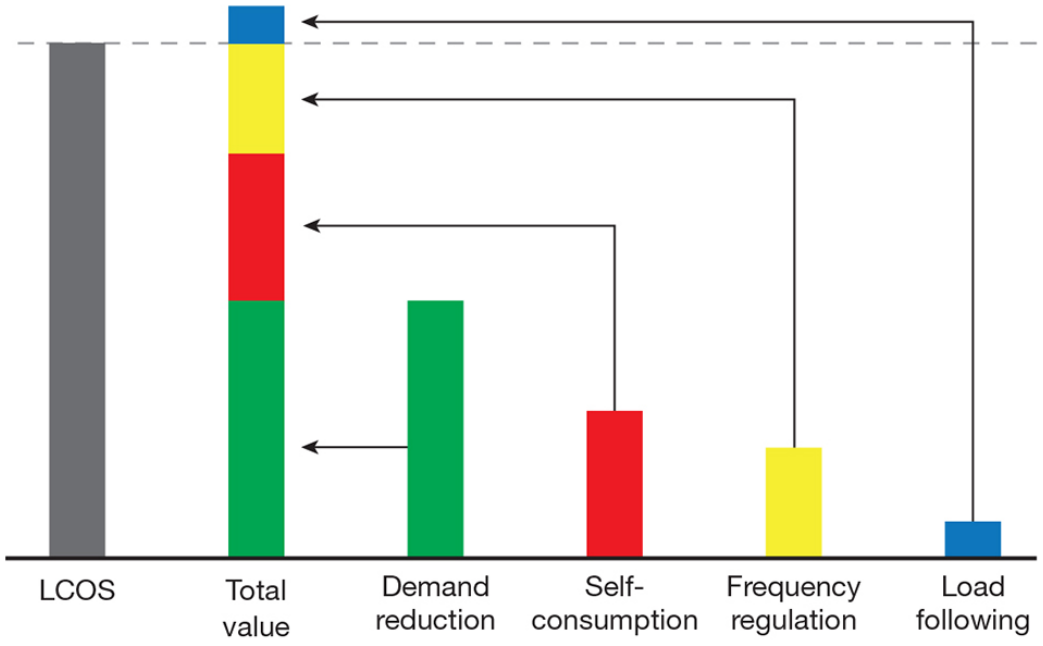
+ Value Streams and Stacking
+ Financing
+ Utility Tariffs

BESS Economic Value

For Customers (behind the meter), value stream stacking is limited

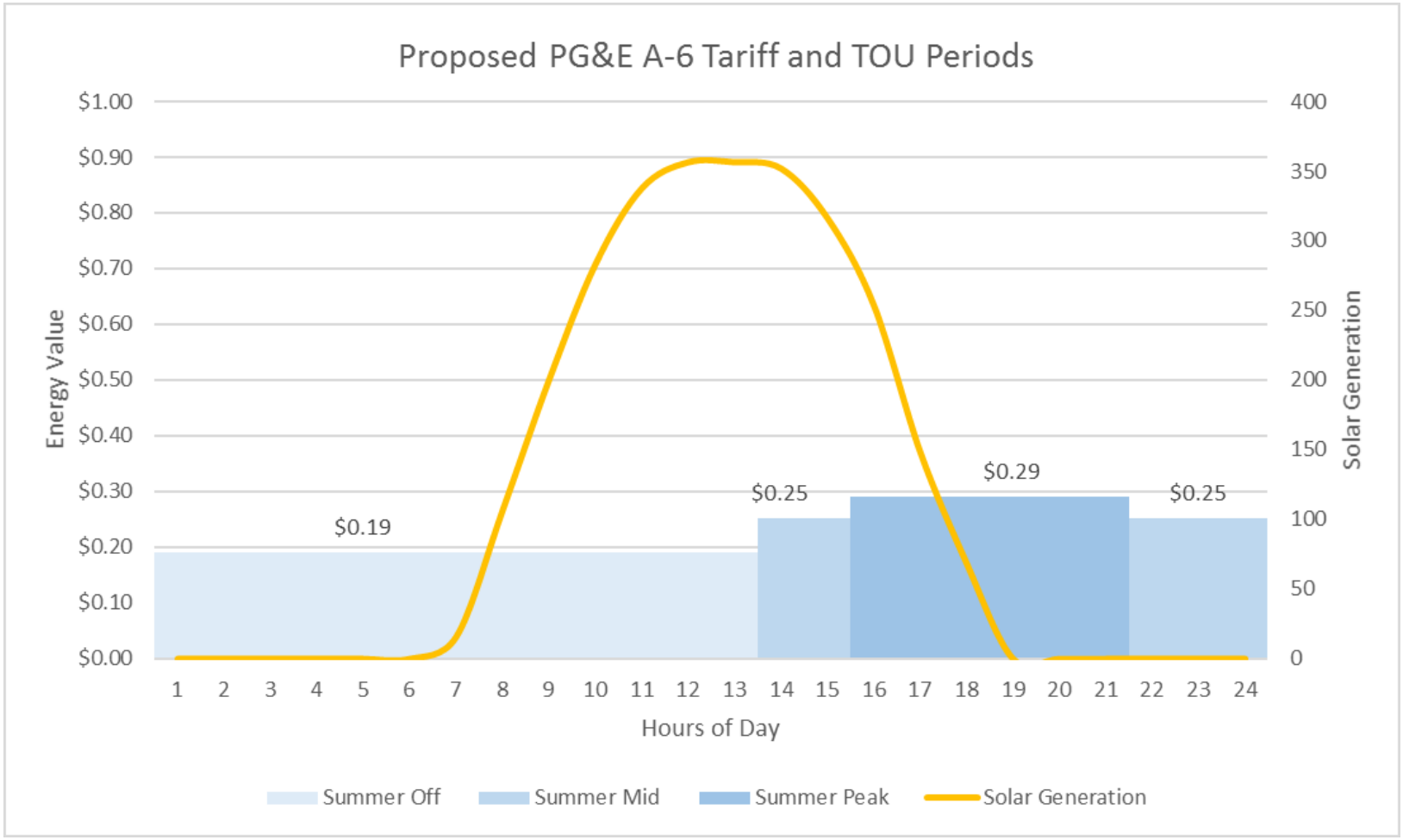
+ Value Streams and Stacking

- Regulatory, tariff, equipment, network barriers for Customers



- Primarily demand cost reduction
- Can sometimes utilize energy arbitrage
  - Limited by ITC financing with solar
- Other value streams limited
  - Regulation and tariffs years away and unpredictable

BESS Economic Value



BESS Economic Value

Tariff Change Example: PG&E Option S

- + New "Storage Friendly" tariff
- + Pilot program to address lack of tariff support for storage
  - Applies to E19 and E20 rate customers only (medium/large commercial)
  - Based on Option R solar friendly tariff
  - Hourly demand charges (instead of peak monthly)
  - No demand charges during middle of day
  - Capped at 150 MW of storage
- + Will have strong impact on energy management

The adopted Option S rate shall have the following characteristics, as modified from the original SEIA proposal:

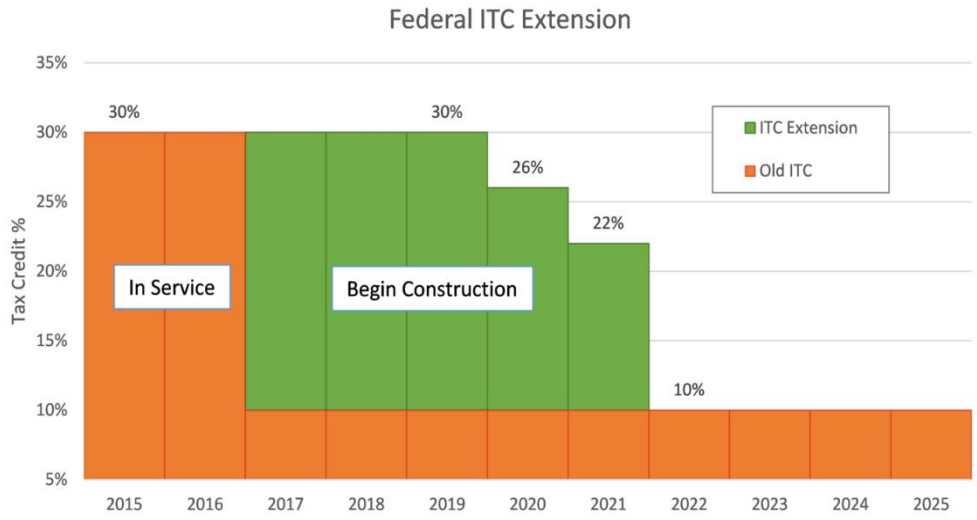
- We do not require SGIP-eligibility of an energy storage system in order to participate in Option S as requested by SEIA. We are concerned that doing so would mean that the rate would become tied to SGIP and its administration, when the program itself is due to sunset in 2020. This calls into question how PG&E would administer the Option S rate after 2020 if Option S eligibility was tied to SGIP and its rules. PG&E must use the same eligibility language as it uses for the A-1 STORE rate.
- The energy storage system must have a rated capacity in watts which is at least 10% of the customer's peak demand over the previous 12 months.[250] The Option S tariff sheet shall include a method for calculating rated capacity that mirrors the existing calculation from the SGIP Handbook.
- PG&E shall begin the design of the Option S rate by making it identical to the Option R rate available to the customer.
- After duplicating the Option R rate design, 80% of the revenue that would otherwise be collected from Option R E-19V, E-19, or E-20 customers by non-coincident distribution demand charges (referred to by PG&E as "maximum" demand charges) shall be collected instead through daily demand charges assessed during the peak period only (4 p.m. to 9 p.m. for MLLP customers) for customers on Option S.
- After duplicating the Option R rate design, 20% of the revenue that would otherwise be collected from an Option R E-19V, E-19, or E-20 customers by non-coincident distribution demand charges (referred to by PG&E as "maximum" demand charges) shall be collected through a non-coincident distribution demand charge for customers on Option S, except that no distribution demand charges may be assessed between 9 a.m. and 2 p.m. each day. An analysis of the data in CALSSA-2 indicates that the time period of 9 a.m. to 2 p.m. each day is when the marginal GHG emissions of the grid are generally at their lowest, and therefore this time period is appropriate for the "demand charge holiday" implicitly proposed by SEIA's proposal. This also corresponds to the "super off-peak" period adopted by PG&E and the MLLP settling parties for the months of March, April, and May, although under Option S this period of time free of demand charges will last all year.

BESS Economic Value

Solar and Storage Incentives phasing out over time

+ 30% ITC extended until the end of 2019
  - 3-year stepdown after 2019
+ SGIP Incentives for energy storage (PG&E)
  - Step 2 – Large Storage (Step 3, all others)
  - Step 4 – Small Residential

	CSE	SCE	SCG	PG&E
Large-Scale Storage	**Step 2**	**Step 3**	**Step 3**	**Step 2**
Energy Storage**	$0.40/Wh	$0.35/Wh	$0.35/Wh	$0.40/Wh
Energy Storage + ITC**	$0.29/Wh	$0.25/Wh	$0.25/Wh	$0.29/Wh
Small Residential Storage	**Step 5**	**Step 2**	**Step 2**	**Step 2**
Energy Storage**	$0.25/Wh	$0.40/Wh	$0.40/Wh	$0.40/Wh
Residential Storage Equity	**Step 3**	**Step 3**	**Step 3**	**Step 3**
Energy Storage <=10kW**	$0.35/Wh	$0.35/Wh	$0.35/Wh	$0.35/Wh
Energy Storage > 10kW + ITC**	$0.25/Wh	$0.25/Wh	$0.25/Wh	$0.25/Wh



+ Storage deployment barriers
  - SGIP Penalties (retroactive?)
  - Metering requirements ($15-25k)
  - No DC coupled systems
  - Lack of tariff support

BESS and ZNE Today

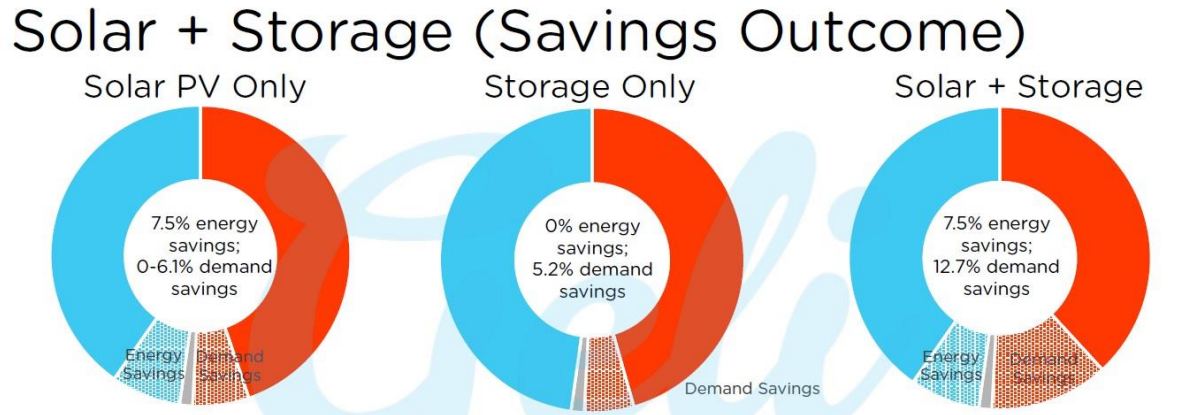
How BESS is Implemented

- An IT Energy Solution
- What does it look like?
- How do you know it works?

BESS and ZNE Today

What a real Storage project looks like

+ An IT Solution
  - It's all about the software
  - Data inputs:
    - Site usage
    - Generation (Solar PV, fuel cells)
    - Active tariff
    - Time of day
    - BESS parameters
      - Capacity, charge, temp,
      - Inport/export limits
    - Historical trends



Energy Charges	$210,367	Energy Charges	$249,579	Energy Charges	$210,367
Energy Savings	$39,207	Energy Savings	-	Energy Savings	$39,207
Demand Charges	$233,881	Demand Charges	$238,144	Demand Charges	$199,355
Demand Savings	$0-$31,668	Demand Savings	$27,405	Demand Savings	$66,194
Fixed Charges	$7,262	Fixed Charges	$7,262	Fixed Charges	$7,262
Total Charges	**$451,510**	**Total Charges**	**$494,980**	**Total Charges**	**$416,984**
Total Savings	**$39,207-$70,875**	**Total Savings**	**$27,405**	**Total Savings**	**$105,401**

Source: Geli

BESS and ZNE Today

What a real Storage project looks like

+ Vendor configurations
  - Software-only
    - STEM
    - Geli
  - Integrators (most BESS vendors)
    - Renewable Energy Systems Group
    - AES Energy Storage
    - NEC Energy Solutions
    - Engie/Green Charge Networks
  - Vertical (hardware + software in-house)
    - Tesla
    - Wartsila/Greensmith

BESS and ZNE Today

What a real Storage project looks like

+ Footprint
  - Residential
    - Wall Mounted

- Commercial
  - Up to 500kW/1000kWh = 1 parking space

BESS and ZNE Today

What a real Storage project looks like

BESS and ZNE Today

What a real Storage project looks like

+ Commercial BESS Project Financing

- Most ZNE BESS projects financed within overall project financing
  - Results in hard design by project contractors
  - Often not the most efficient PV/storage designs
- Can be financed separate through Design-Build competitive procurement
  - RFQ/P with performance specification
  - Contract doc set or term sheet
  - Performance guarantees must take into account PV contribution
- Financing Arrangements
  - Cash
  - Bonds (Muni tax-exempt or GO)
  - Lease/debt (typically a Capital lease)
    - Shared savings, No-loss
  - PPA (when paired with solar PV)

BESS and ZNE Today

What a real Storage project looks like

So, how do you know it works…?

+ The vendor/software tells you
  - How do you know the vendor/software is right?
  - Energy Storage is not like PV

+ Currently, there is no independent auditing function

BESS Policy and Tariff Support

Top Down and Bottom Up

+ Federal
+ State (CA)
+ CPUC/Utility

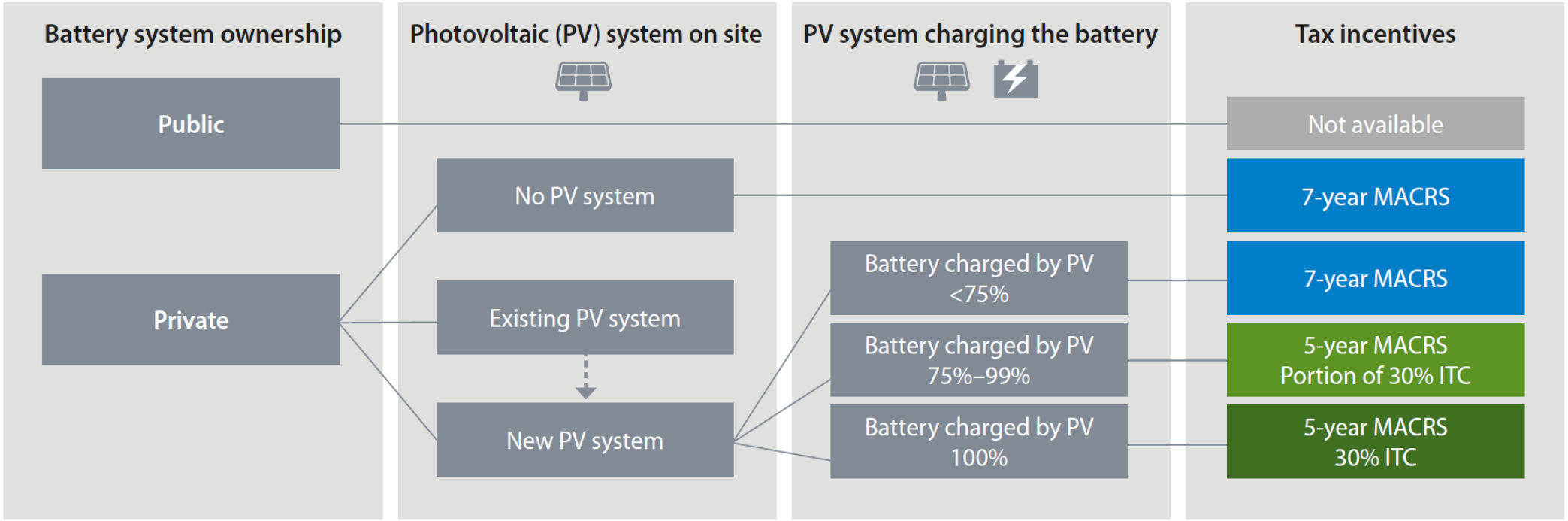
BESS Policy and Tariff Support

Current Affairs

+ Federal

- FERC – 2/2018 rule opening wholesale energy markets to storage
- IRS - Investment Tax Credit (ITC) for Solar
  - 30% through 2019
  - Can be used with battery storage

Source: NREL



BESS Policy and Tariff Support

Current Affairs

+ CA Legislature and State:
  - SGIP Program
  - 50+ 2018 bills that affect solar and storage
  - Title 24 update ZNE
+ CAISO
  - Storage as a Transmission Asset
    - Straw proposal August, 2018
+ CPUC/Utility
  - PG&E Option S
  - DER and Storage Committees

BESS with Solar PV ZNE Case Study

CA Public School
PG&E Territory

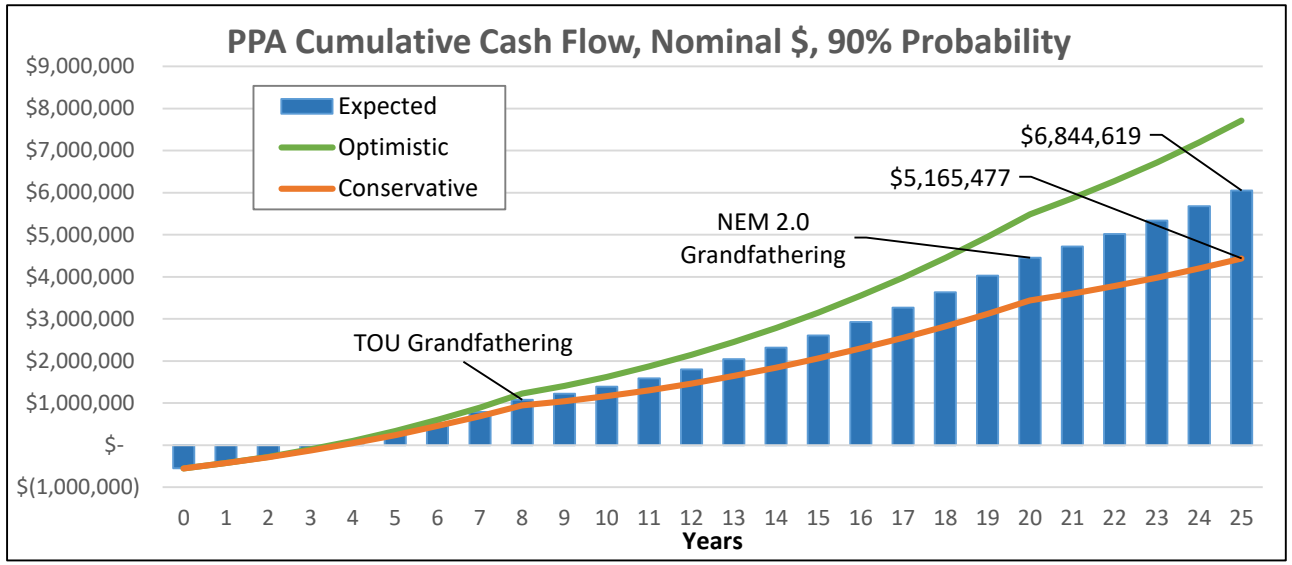
PG&E Case Study: 5-Site School

Metric	Site A	Site B	Site C	Site D	Site E	Cumulative Project Cash Flow (Loss)
Do Nothing - Business As Usual						
25-year Nominal Elect. Energy Cost	$ 11,147,000	$ 17,077,000	$ 47,589,000	$ 25,585,000	$ 7,263,000	$ 108,649,000
Solar PV						
25-year NPV, 3% Discount Rate	$ 647,000	$ 911,000	$ 793,000	$ 1,134,000	$ 386,000	$ 3,871,000
25-year Nominal Return	$ 1,025,000	$ 1,442,000	$ 1,256,000	$ 1,795,000	$ 611,000	$ 6,129,000
BESS						
25-year NPV, 3% Discount Rate			$ 201,000	$ 207,000		$ 408,000
25-year Nominal Return			$ 307,000	$ 314,000		$ 621,000
Project Total						
25-year NPV, 3% Discount Rate	$ 647,000	$ 911,000	$ 994,000	$ 1,341,000	$ 386,000	**$ 4,279,000**
25-year Nominal Return	$ 1,025,000	$ 1,442,000	$ 1,563,000	$ 2,109,000	$ 611,000	**$ 6,750,000**
Environmental						
CO2 Offset 25-year Total (Tonnes)	5,550	9,340	8,730	11,440	4,850	39,920
Equivalent Cars	40	70	60	80	30	280
Equivalent Trees Planted	44,420	74,730	69,820	91,530	38,810	319,340

PG&E Case Study: 5-Site School

Site	Energy Provider (kWh)	New PV System Size (kW DC)	New PV System Type	BESS System Size (kW/kWh)
Site A	PG&E	537.6	Carport	-
Site B	MCE (CCA)	947.2	Carport	-
Site C	Constellation (DA)	877.7	Carport	250/500
Site D	Constellation (DA)	1,154.4	Carport	250/500
Site E	Constellation (DA)	483.2	Carport	-
Totals		**4,000.1**	**Carport**	**500/1000**

PG&E Case Study: P-50, P-90 and Sensitivity



25-Year Nominal Returns

- P-50 = $6.8 MM
- P-90 = $5.2 MM