UET ENERGY STORAGE

Microgrids & Long-duration Energy Storage

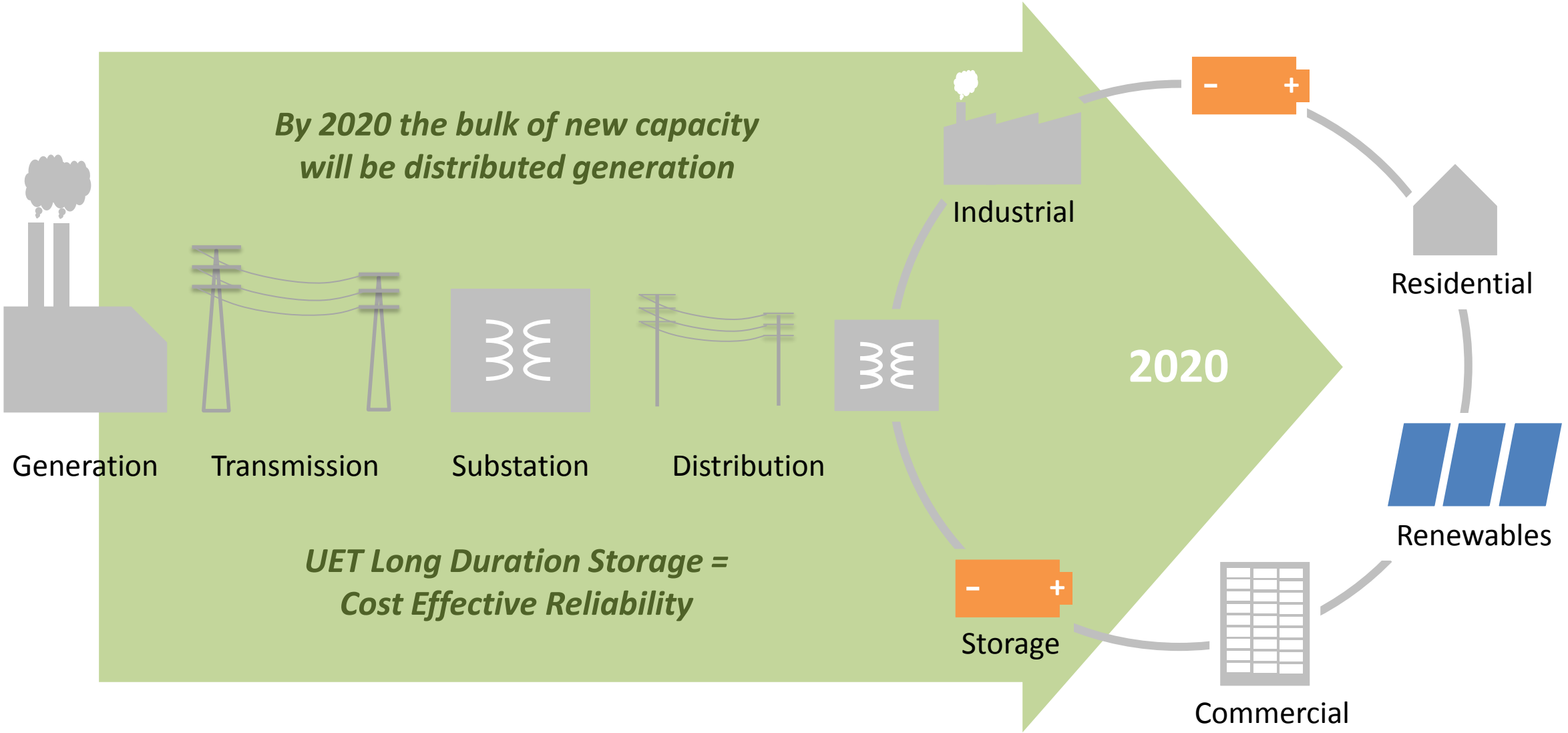
MAXIMIZING VALUE & RESILIENCY

MICHAEL CARR, VICE PRESIDENT OF STRATEGIC & WESTERN SALES, UNIENERGY TECHNOLOGIES

IDEA2017, June 2017, Scottsdale AZ

21st Century Energy

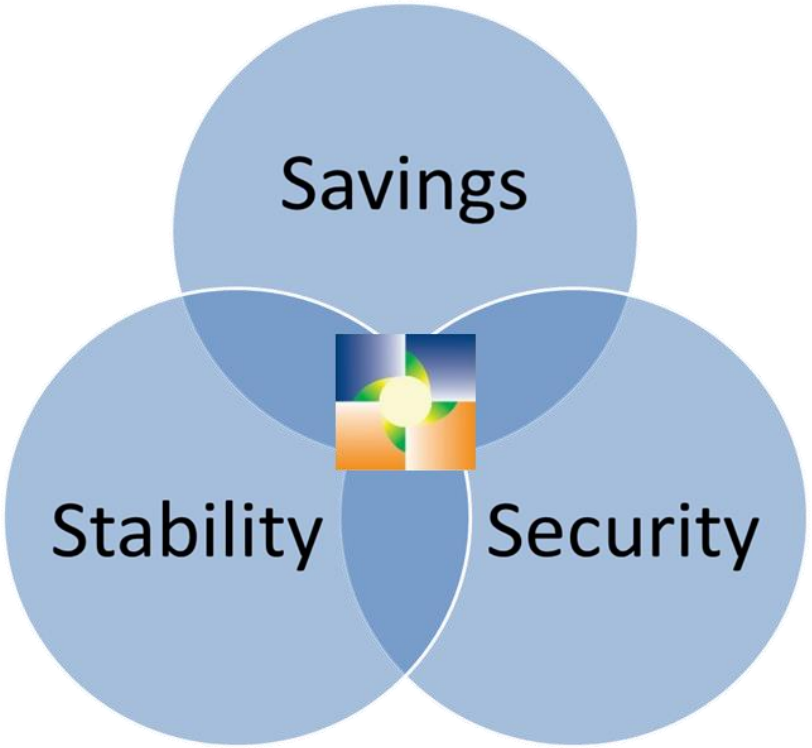
Global Shift to Distributed Energy Resources



Key Drivers For Storage in Microgrid Contexts

EPB Chattanooga

Sandia National Lab



Las Positas College

Mission Produce

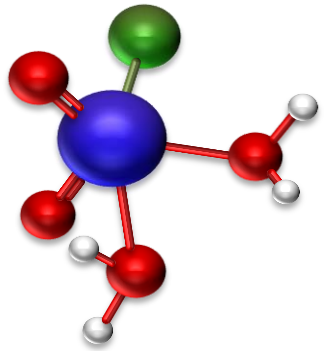
Naval Base Ventura County – Port Hueneme

Avista/Schweitzer

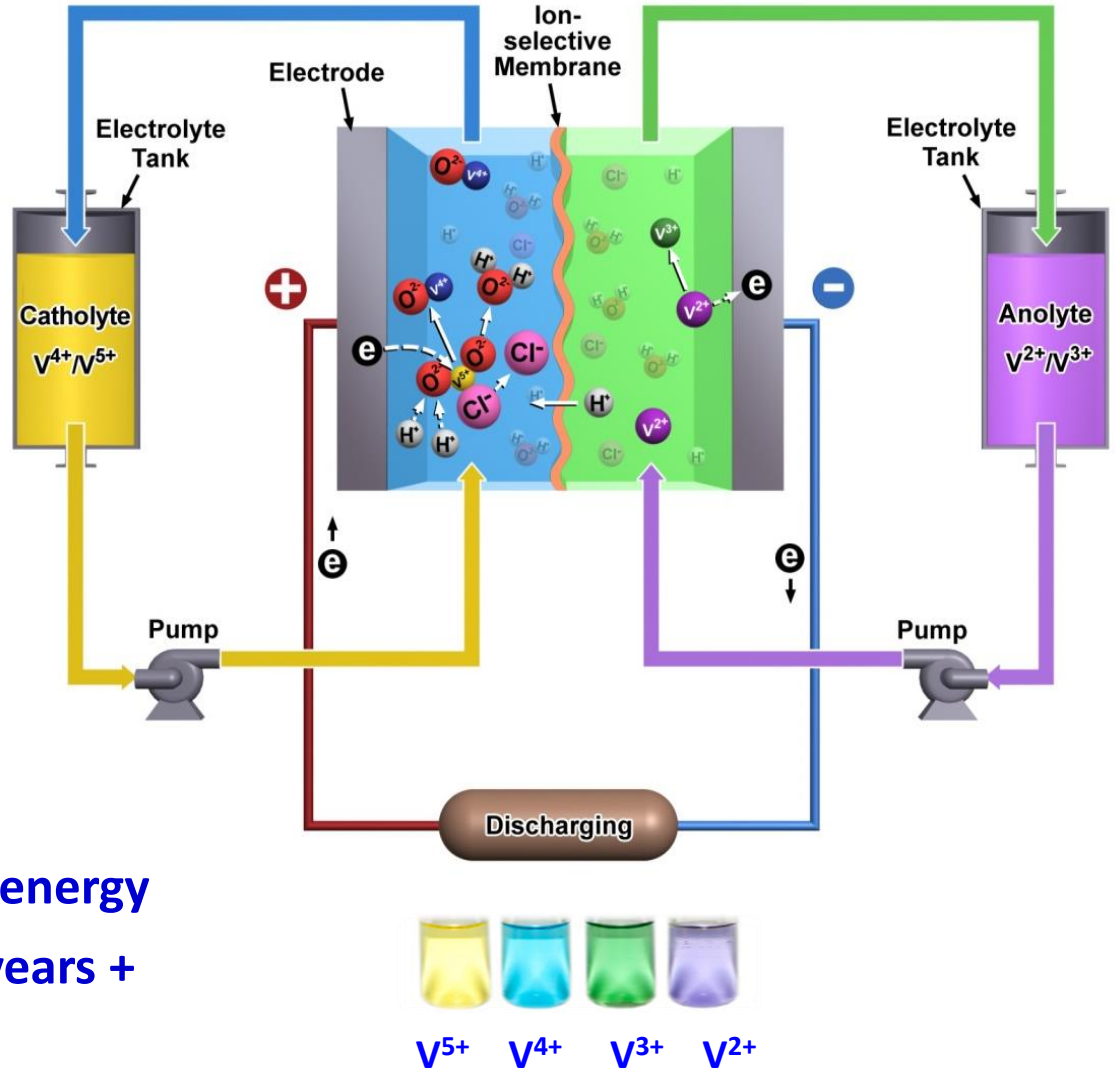
Advanced Vanadium Flow Battery

U.S. DEPARTMENT OF ENERGY
Office of Electricity

Pacific Northwest NATIONAL LABORATORY



$VO_2Cl(H_2O)_2$



- No limits on:
  - number of cycles
  - using 100% of stored energy
- No degradation for 20 years +
- Non-flammable

Product Flexibility for 4hr, 6hr, 8hr solutions

Decreasing Price/kWh

Uni.System (4hr)
20' container

Uni.System (6hr)
30' container

Uni.System (8hr)
40' container

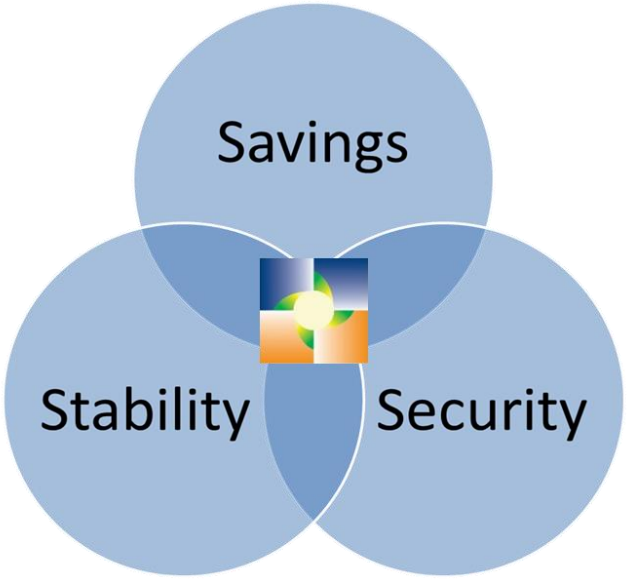
Increased storage duration requires no additional components beyond more e'lyte. Therefore, on a kWh basis:

- *System complexity is reduced*
- *Auxiliary power is reduced*
- *Reliability is increased*
- *Maintenance costs are reduced*
- *System footprint is reduced*

Key Advantages of Long-Duration Flow Batteries

- **Versatile – Change Happens**
  - Full range of fast-response & long-duration (power & energy) applications, same battery
  - "Stack" applications, e.g. concurrent ramping & frequency regulation
  - **No state-of-charge (SOC) or duty cycle limitations**
  - Operational from -40°C to +50°C
- **Durable**
  - **≥20-year system life** with unlimited cycles
  - 100% capacity access over lifetime – **NO DEGRADATION**
- **Intrinsically Safe**
  - Zero Flammability – no thermal runaway mechanisms
  - Aqueous electrolyte – zero reactivity

- **Cost Effective**
  - Low Total Cost of Ownership (CapEx, OpEx)
  - Capture multiple value streams



AVISTA UTILITIES – PULLMAN, WASHINGTON

SCHWEITZER ENGINEERING LABS

1MW/ 4MWh

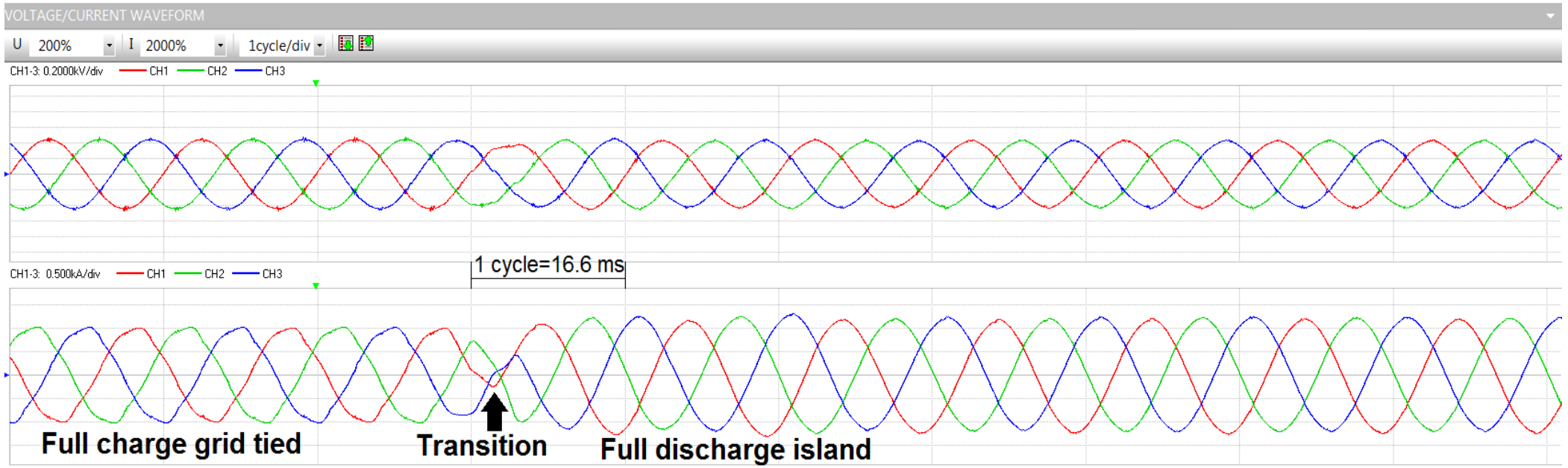
Grid-connected services
- Avista Distribution Circuit
- power: freq. & volt. reg.
- energy: peak shaving, ramp

Customer-side services
- Schweitzer Eng. Lab
- islanding, black start, seamless switching

DOE Global Energy Storage Database
http://www.energystorageexchange.org/projects/1406

Example of Sub-second Islanding

- The graphic illustrates a successful UET seamless islanding demonstration
- Transition from grid connected operations to islanded operations with minimal disturbance in approximately one cycle.
- At the beginning we are grid-tied and charging the battery with full power, and after the transition we are discharging at full power into an islanded load.



Naval Base Ventura County – Port Hueneme

U.S. Navy's Resilient Energy Program Office

Customer-side services
- Base Critical and Super Critical Loads
- Islanding, black start, resilience (hours – months)

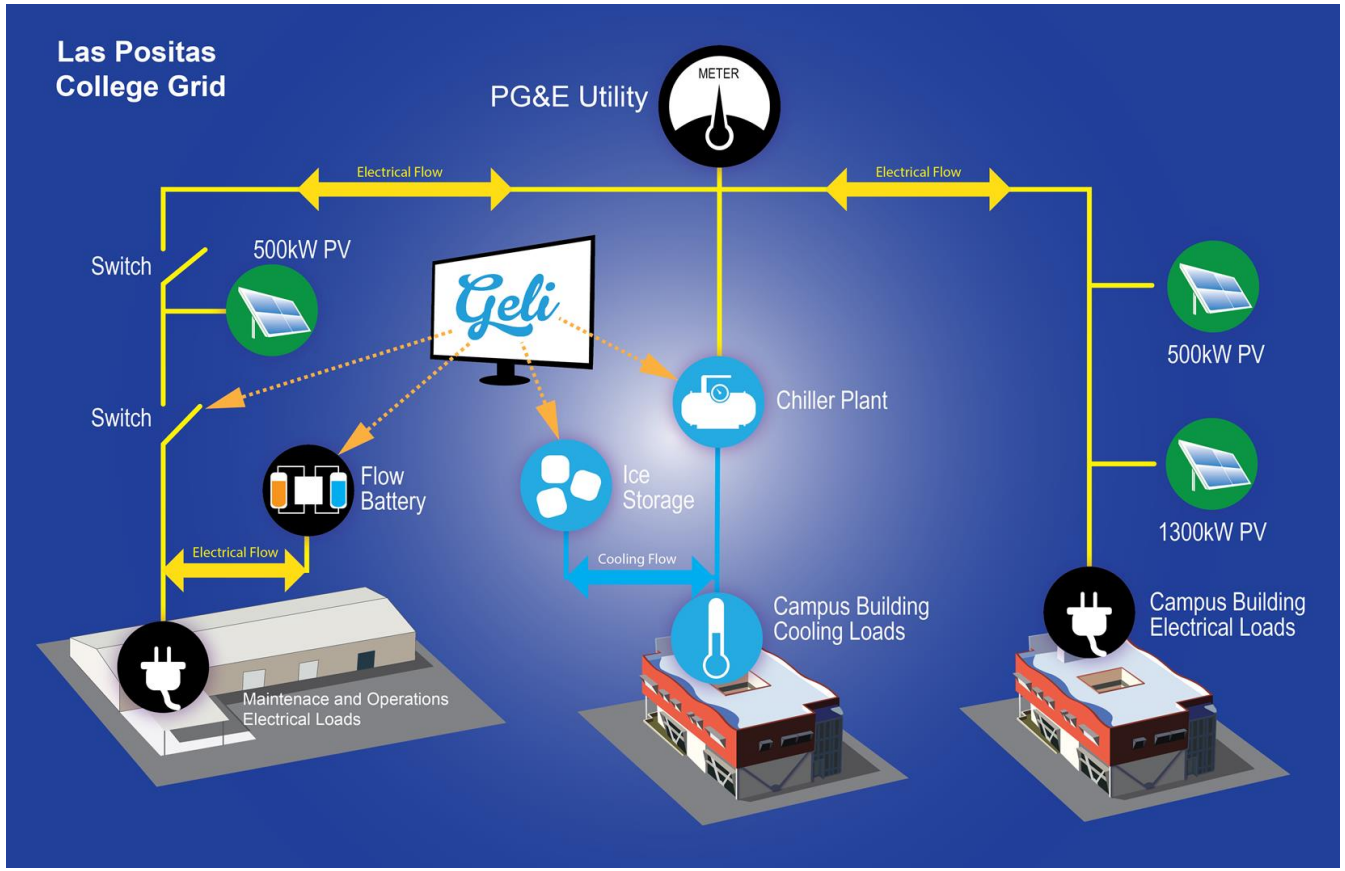
Grid-connected services
- Oxnard Distribution Circuit
- Power: freq. & volt. reg.
- Energy: RA, peak shaving

U.S. DEPARTMENT OF THE NAVY
REPO
RENEWABLE ENERGY PROGRAM OFFICE

4.5MW/18MWh + 6MW Solar PV

Las Positas College – Livermore, California

200kW/1MWh

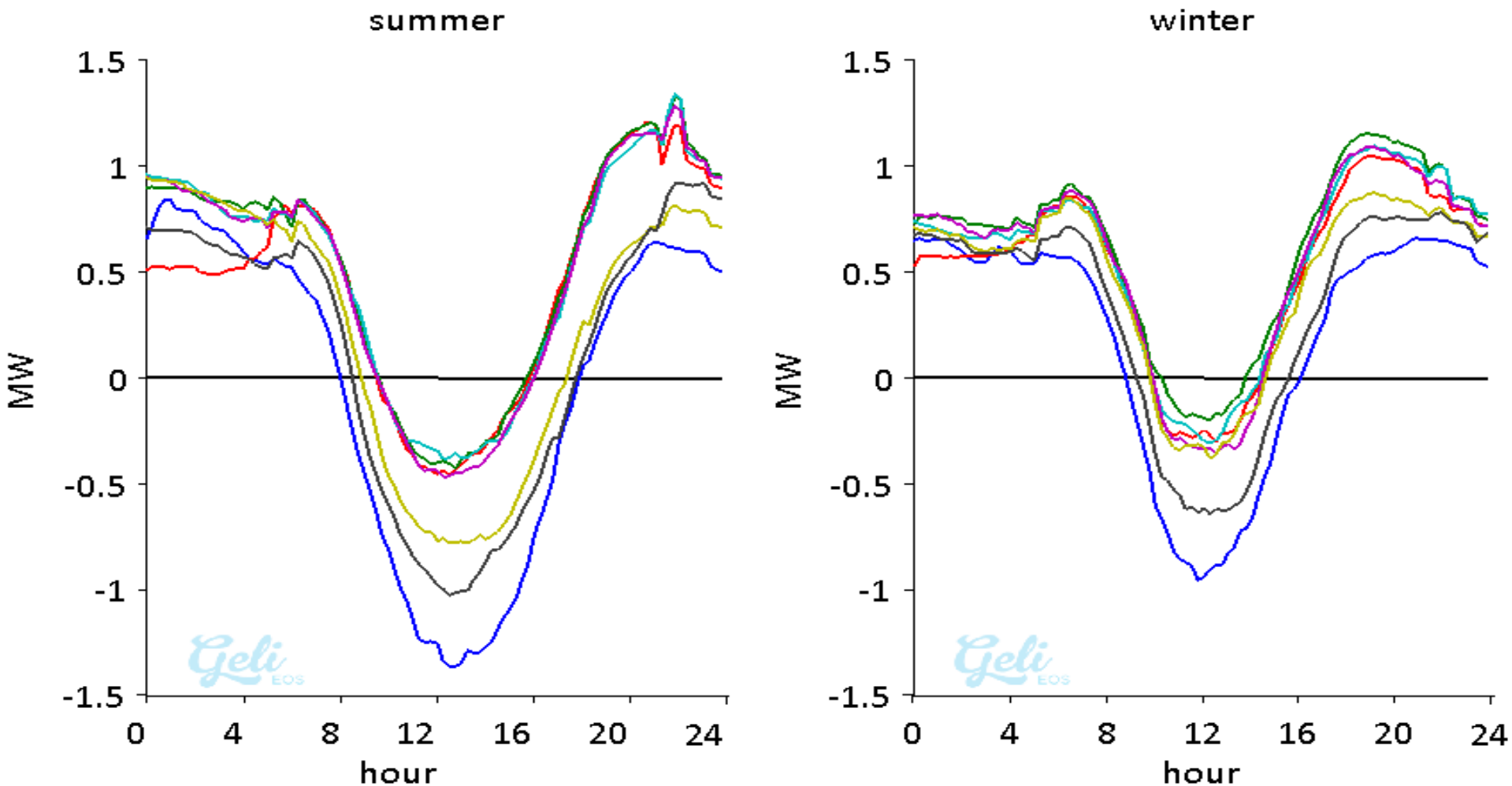


Grid-connected services
- Demand Response
- Ancillary Services

Customer-side services
- Demand Charge Reduction
- Energy Arbitrage
- Integrating PV
- Operations Bldg. Resilience

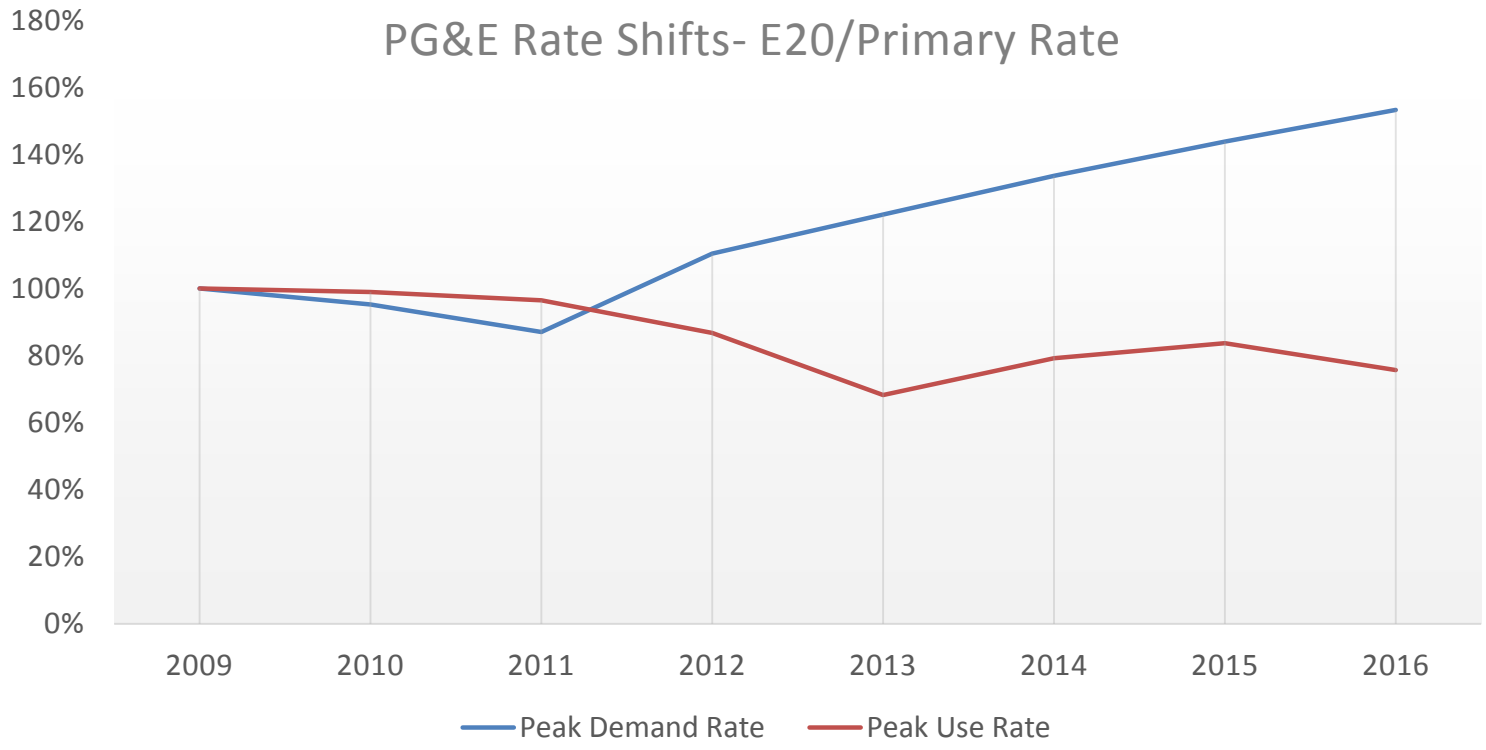
CHABOT LAS POSITAS COMMUNITY COLLEGE DISTRICT

Las Positas 7 Day PG&E Power Profiles



Las Positas College Microgrid

PG&E Rate Structure Trends, 2009-2016



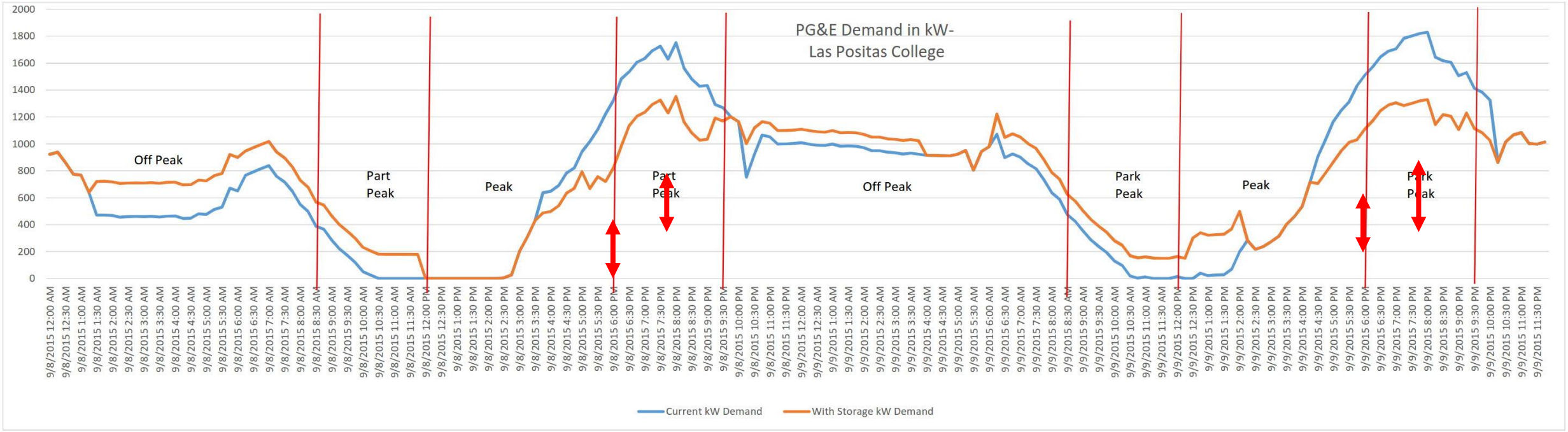
Blue- Peak Demand Charge/kW

Orange- Peak Usage Charge /kWH

CLPCCD- Billings 2009-2016, September rate structure

Las Positas College Microgrid

Projected Peak Demand Charge Management

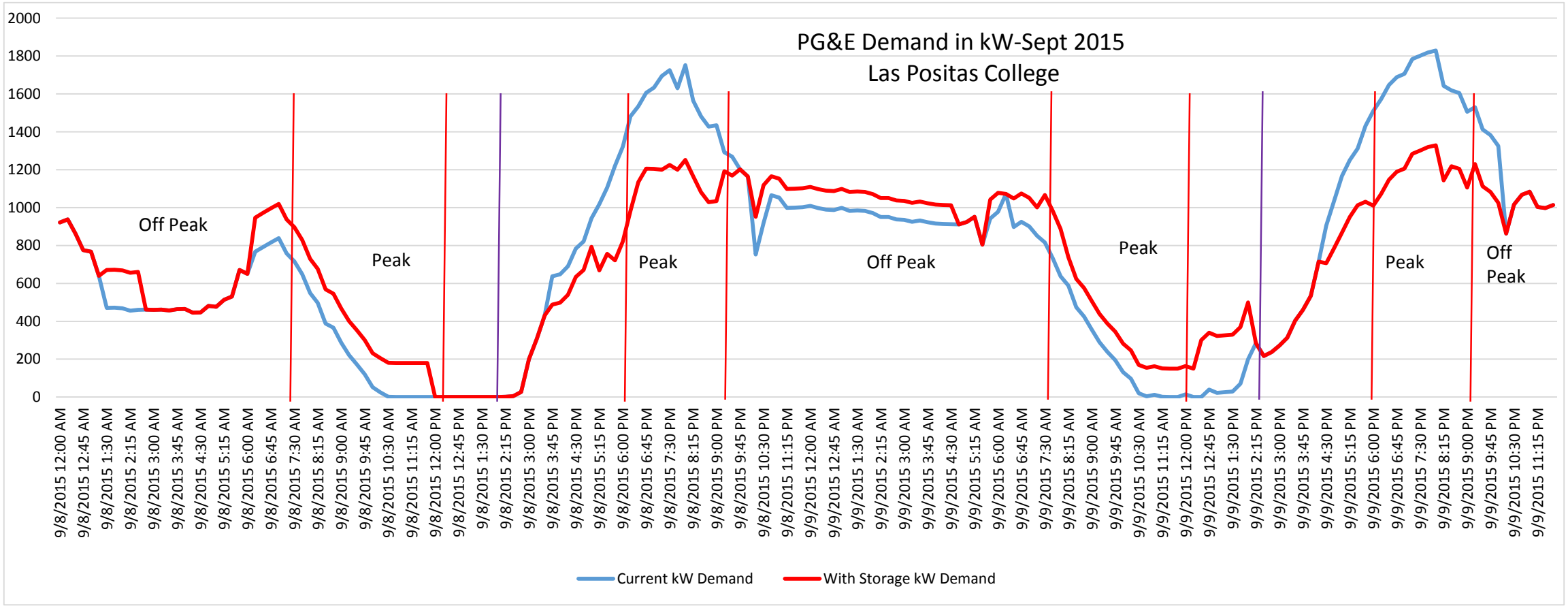


Blue- Current Purchased kW Power Red- Projected Purchased kW Power

*Combining 1MWH Electrical Storage with 3200 Ton-Hrs Thermal Storage

Las Positas College Microgrid

Impact of Suggested Changed Time of Use Periods



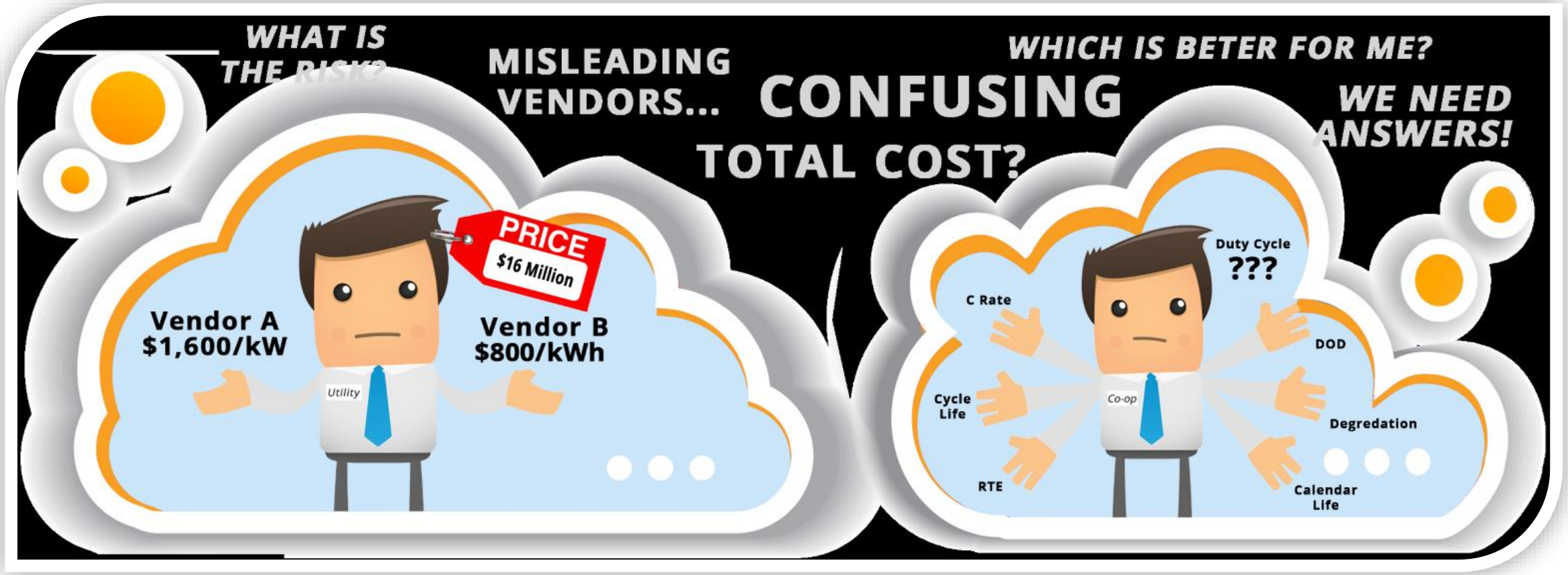
Blue- Current Purchased kW Power, Red- Projected Purchased kW Power

Las Positas Microgrid - Savings

Rate Schedule	Months	KW Reduction	Per kW Rate	Savings
Summer				
Monthly Max KW	6	400 KW	$14.44	$34,656
Peak Max KW	6	400 KW	$19.34	$46,416
Park Peak Max KW	6	400 KW	$ 5.17	$12,408
Winter		400 KW		
Monthly Max	6	400 KW	$14.44	$34,656
Park Peak Max	6	400 KW	$ 0.13	$ 312
ESTIMATED TOTAL	ANNUAL	SAVINGS		$128,448

*PG&E E-20 NEMMT- Primary Firm Rates, October 2016

Evaluating the Cost of Energy Storage



Upfront cost of system

Market Trend

Lifetime cost of energy

Evaluating the Cost of Energy Storage

Standard approaches for evaluating the cost of energy storage:

- Present Value Installed Cost ($/kWh Installed)
- Levelized Cost of Storage (LCOS), Energy (LCOE)
- Total Cost of Ownership (TCO)

A simple definition of $/kWh Installed:

$$\frac{CapEx + NPV\ of\ OpEx}{AC\ energy\ rating\ of\ the\ system} = \frac{\$}{kWh}$$

A simple definition of TCO/LCOS:

$$\frac{CapEx + NPV\ of\ OpEx}{Total\ energy\ deployed\ over\ system\ life} = \frac{\$}{kWh}$$

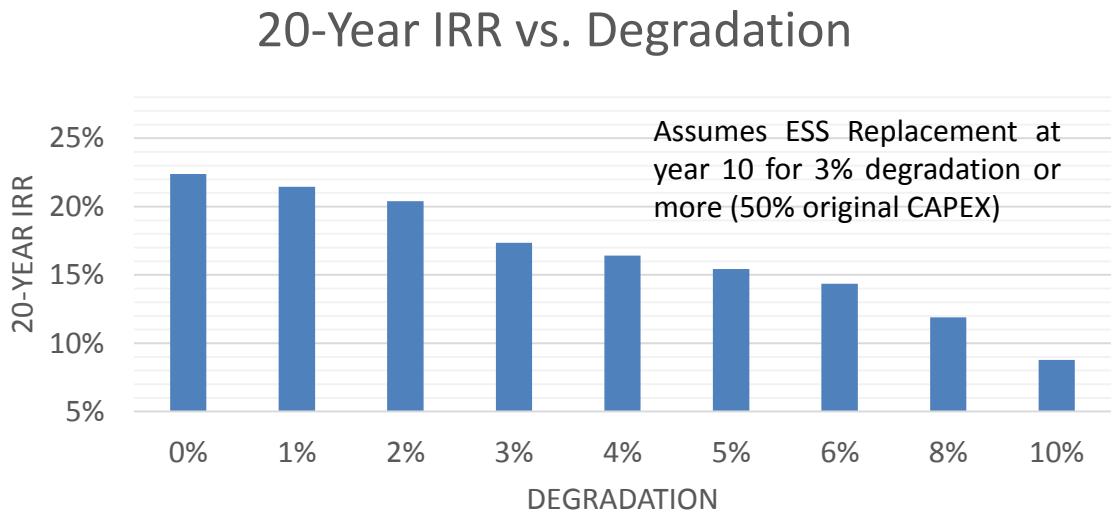
Financial Performance vs. Degradation

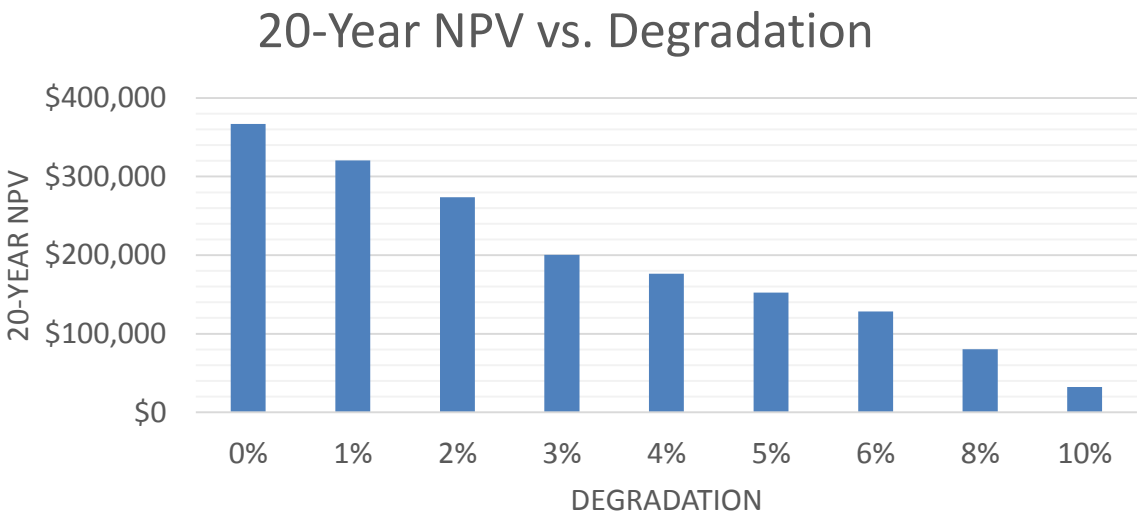
Case study compares the financial performance of the project vs. battery degradation

Facility Type: Manufacturing Plant
Location: CA
Application: Demand Reduction
Tariff: PG&E E-20
System Size: 1 ReFlex
Incentives: SGIP + MACRS
System Installed Cost: $338,256
Results:

@ 0% Annual Degradation:
- 21.6% IRR
- $345,942 NPV

@ 3% Annual Degradation:
- 17.36% IRR
- $200,401





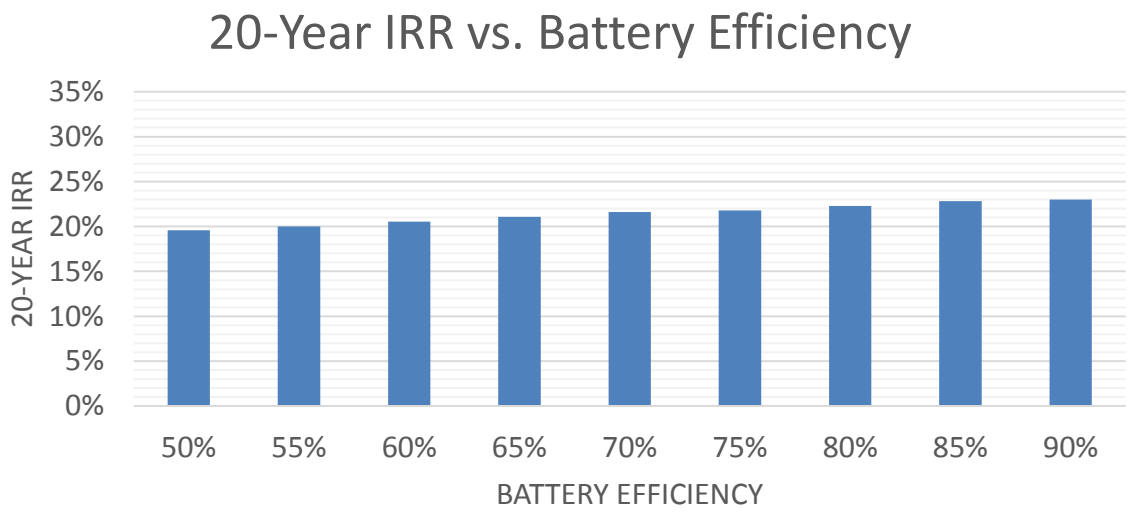
Financial Performance vs. Efficiency

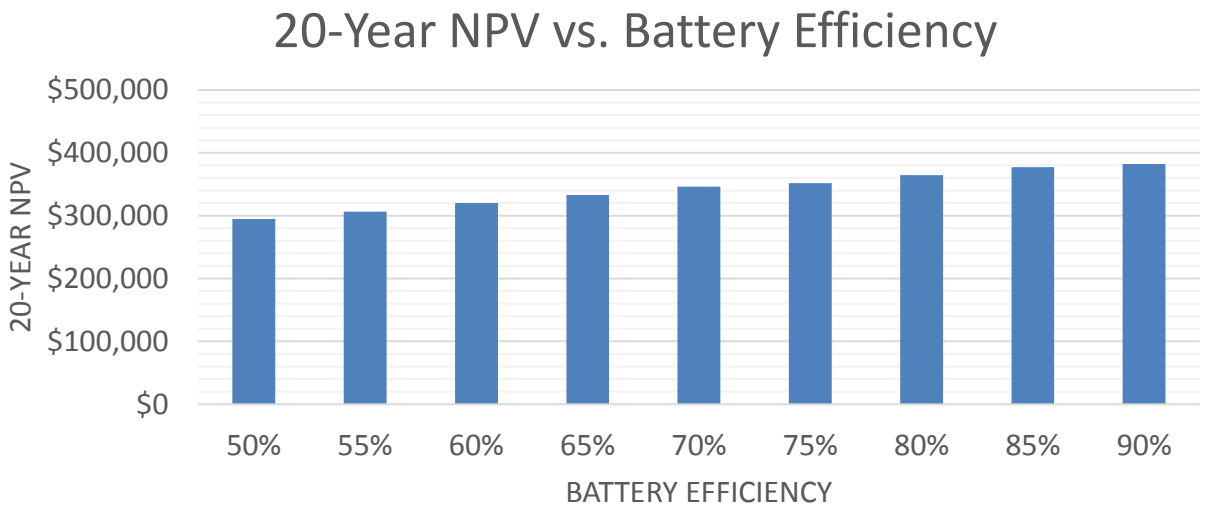
Case study compares the financial performance of the project vs. battery efficiency

Facility Type: Manufacturing Plant
Location: CA
Application: Demand Reduction
Tariff: PG&E E-20
System Size: 1 ReFlex
Incentives: SGIP + MACRS
System Installed Cost: $338,256
Results:

@ 70% eff:
- 21.6% IRR
- $345,942 NPV

@ 85% eff:
- 22.8% IRR
- $377,096 NPV





Questions?

Washington Governor Inslee @ SnoPUD Dedication Event, March 2017

Thank you
&
Go with the Flow!

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