122 West

DUA

Modular Energy Storage Benefit and Cost for Three Emerging Value Propositions

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and

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Introduction

- Goal: high level evaluation of modular ESS benefit and cost using *consistent bases*
- Objectives
  1. update ESS cost data
  2. establish framework for “generic” financials
  3. concrete examples of B/C estimates for three emerging ESS value propositions
- Joint effort

  Longitude 122 West -- ESS costs

  Distributed Utility Associates -- ESS benefits

History

- ☞Update DOE's existing ESS *costs*
- ☞Evolution of DOE's ESS *benefits* work
- Start Date: April, 2005 (Life-cycle cost framework was developed in prior years.)
- Major Accomplishments prior to FY06
  - preliminary benefit / cost analysis, presented at EESAT 2005.
- Summary of FY06 Milestones:
  - completion of the analysis
  - completion of the report

Three Value Propositions

1. Utility-owned *transportable* storage
   - typical T&D upgrade deferral (alternating years)
   - localized PQ or reliability (alternating years)
2. Utility-owned *stationary* storage
   - single year, high value T&D upgrade deferral
   - nine years electricity price arbitrage
3. Electricity End-user-owned storage
   - avoid critical peak charges
   - avoid on-peak energy and demand charges
   - *could* improve on-site PQ and/or reliability (not included)

Economic Assumptions

Common Bases

Time Horizon*:	10 years
Price Escalation (inflation):	2.5%
Discount Rate:	10%
Utility Fixed Charge Rate**:	0.11
End-user Annualization Factor**:	0.15

Comments? Please provide them to John Boyes

* ESS salvage or remaining value, if any, is not included in *this* evaluation; though it could be accommodated by subtracting the present value from lifecycle cost.

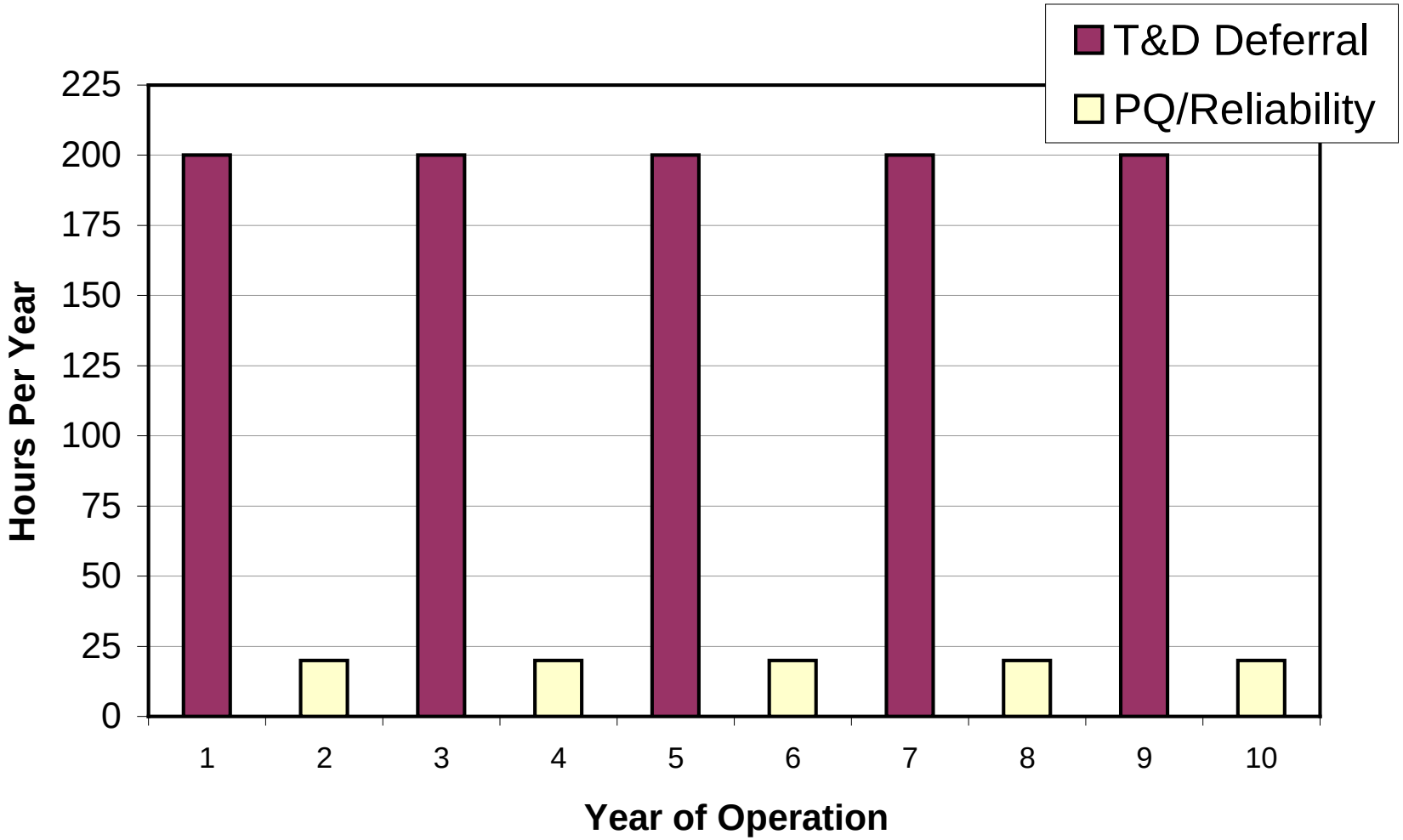
** Used to estimate annual "level" carrying charges for capital plant. 0.11 represents a fixed charge rate for typical utilities whereas 0.15 reflects higher opportunity cost associated with capital projects for commercial end-users.

Storage Technologies

Value Proposition 1 **Transportable; T&D Deferral + PQ/Temp.**	**Value Proposition 2** **High Value T&D Deferral + Arbitrage**	**Value Proposition 3** **Critical Peak Pricing + PQ/Rel.**
Lead-acid batteries, conventional and VRLA Na/S batteries Ni/Cd Li-ion batteries Zn/Br batteries V-redox batteries High-speed and low-speed flywheels Lead-carbon asymmetric caps Hydrogen fuel cell	Lead-acid batteries, conventional and VRLA Na/S batteries Ni/Cd Li-ion batteries Zn/Br batteries V-redox batteries Surface CAES Lead-carbon asymmetric caps Hydrogen fuel cell	Lead-acid batteries, conventional and VRLA Na/S batteries Ni/Cd Li-ion batteries Zn/Br batteries V-redox batteries Surface CAES Lead-carbon asymmetric caps Hydrogen fuel cell

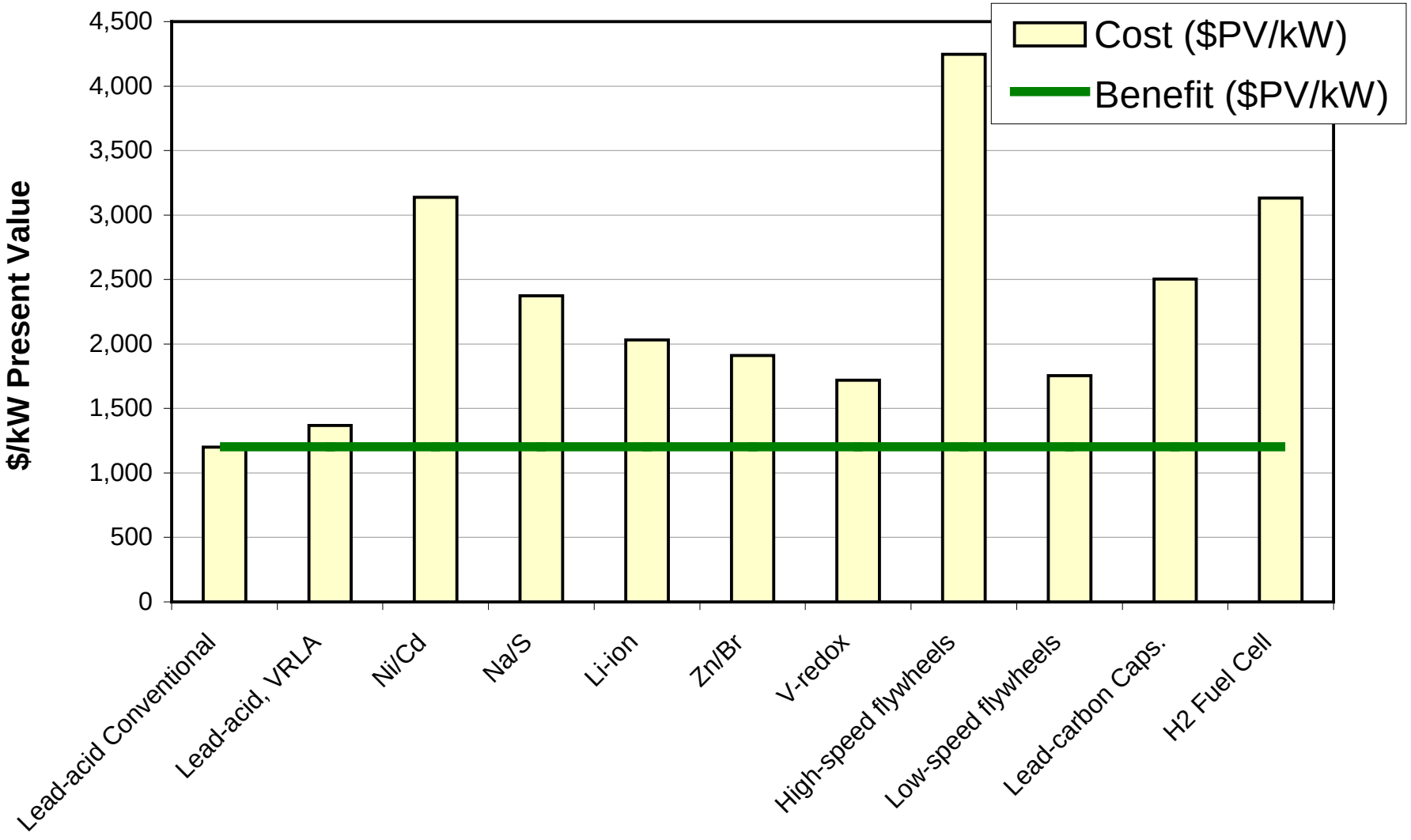
Operation for Value Proposition 1

Transportable ESS for T&D Deferral & PQ



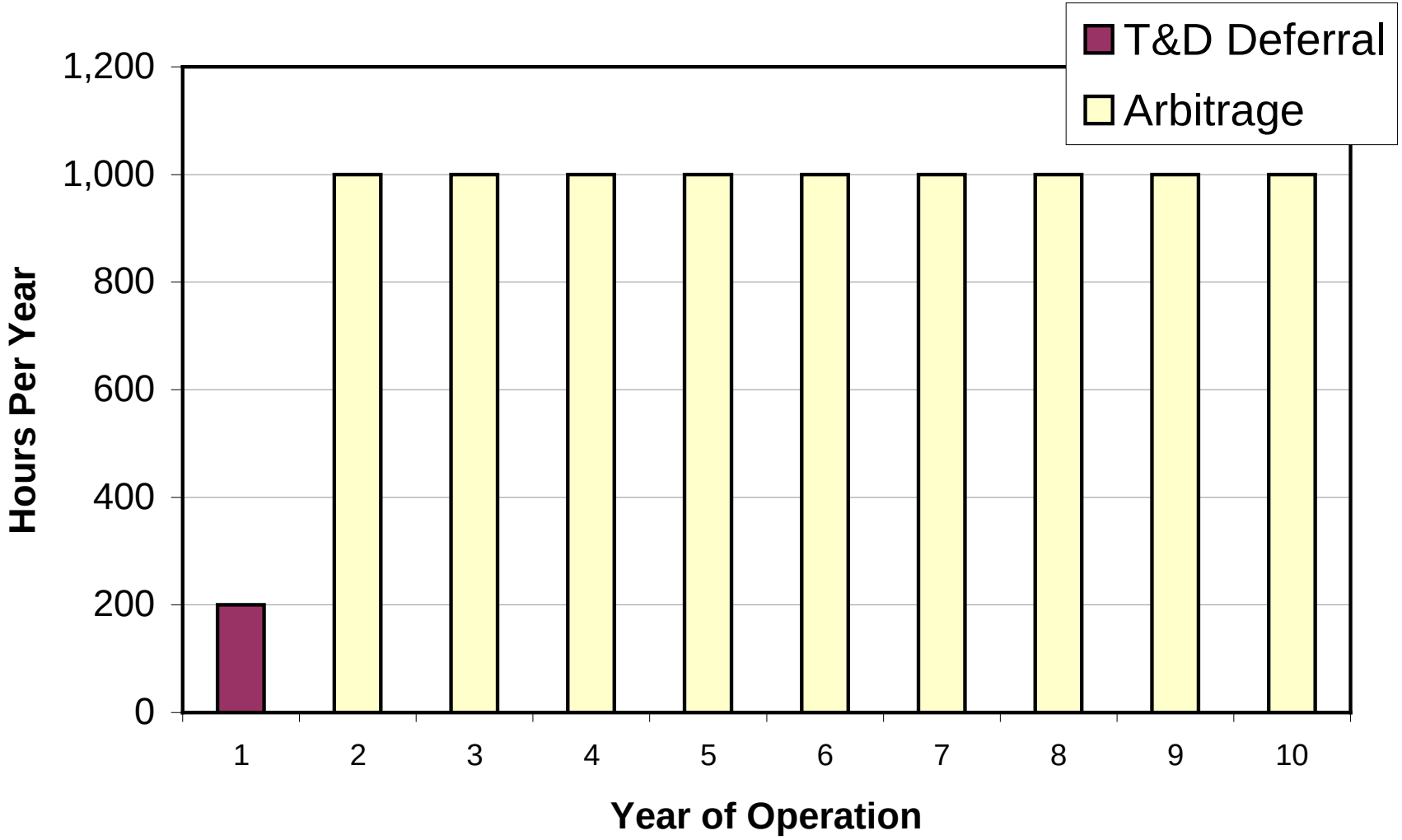
Benefit & Cost, Value Proposition 1

Transportable ESS for T&D Deferral & PQ



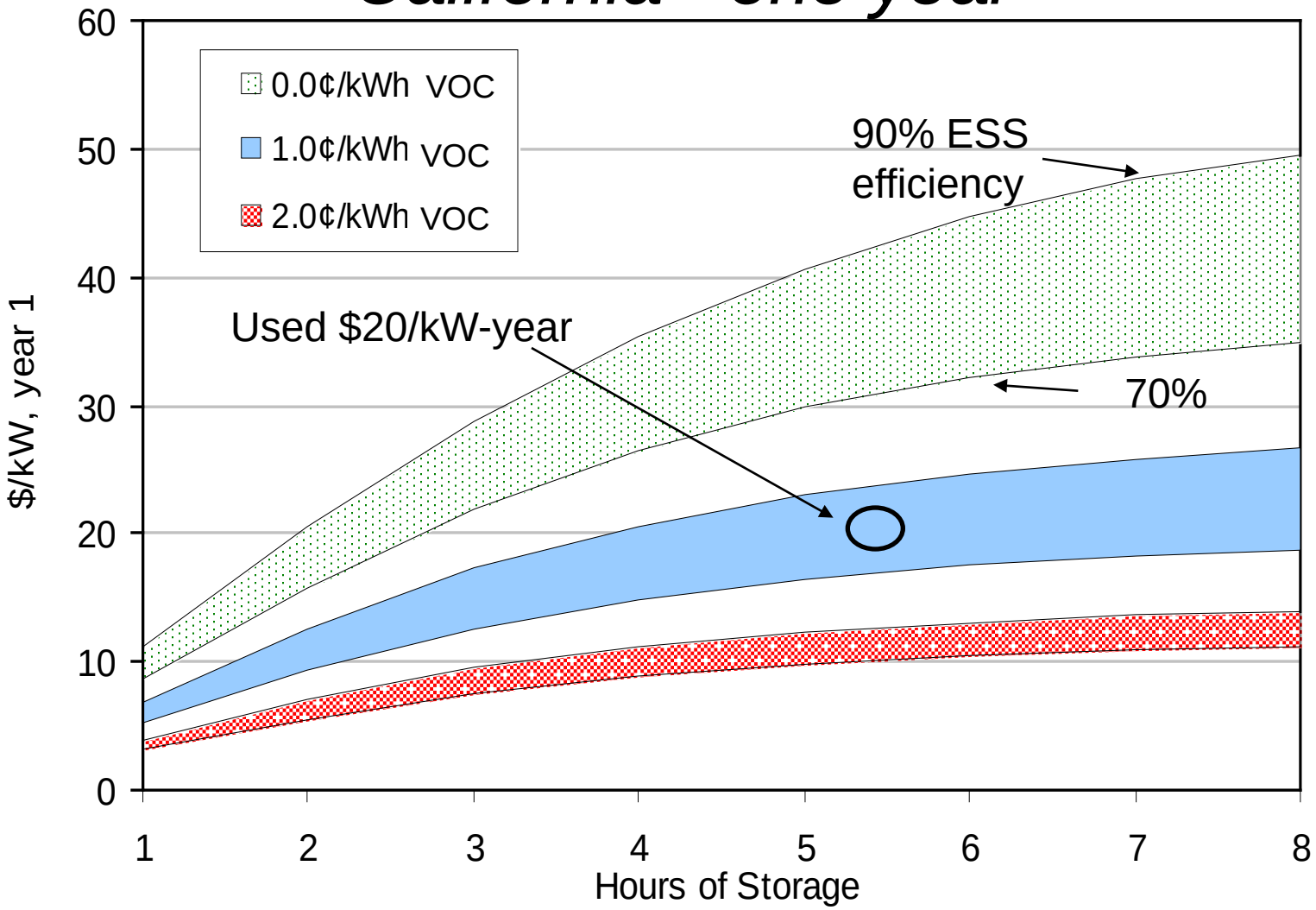
Operation for Value Proposition 2

1 Year High Value T&D Deferral + Arbitrage



*Net** Arbitrage Benefits

California - one year

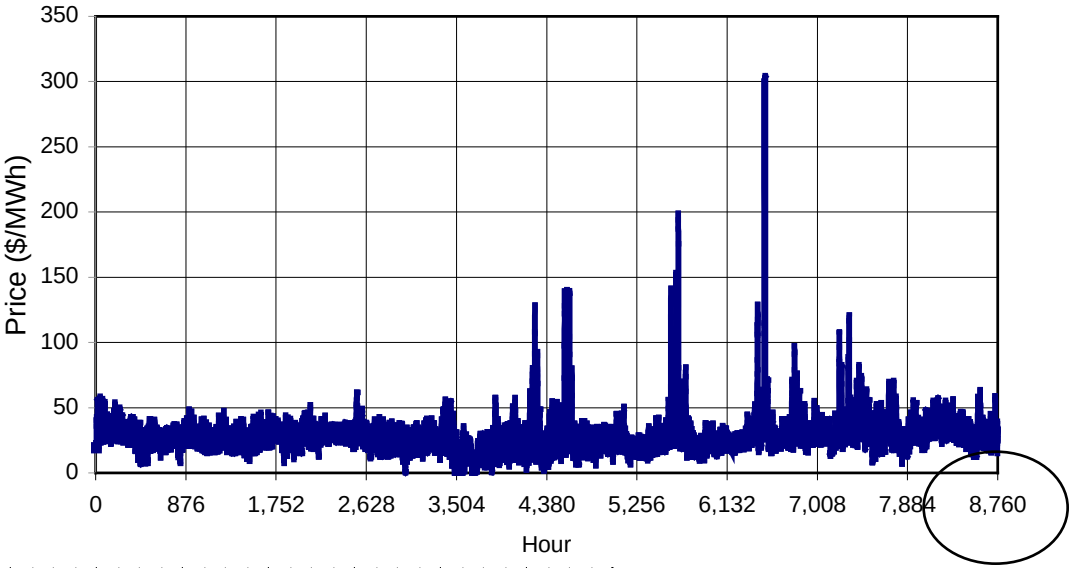


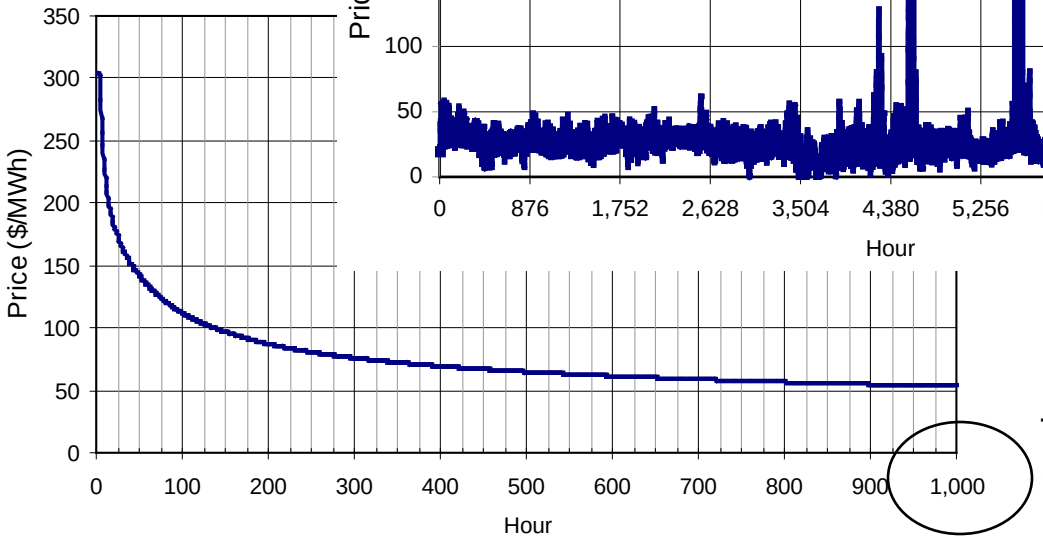
*Revenue - Charging Cost (with losses) - Variable Operating Cost (with replacement cost)

California Electric Energy Prices

- 8,760 hourly wholesale prices
  - from CEC, production simulation model results

Prices for all hours in the year, in chronological order

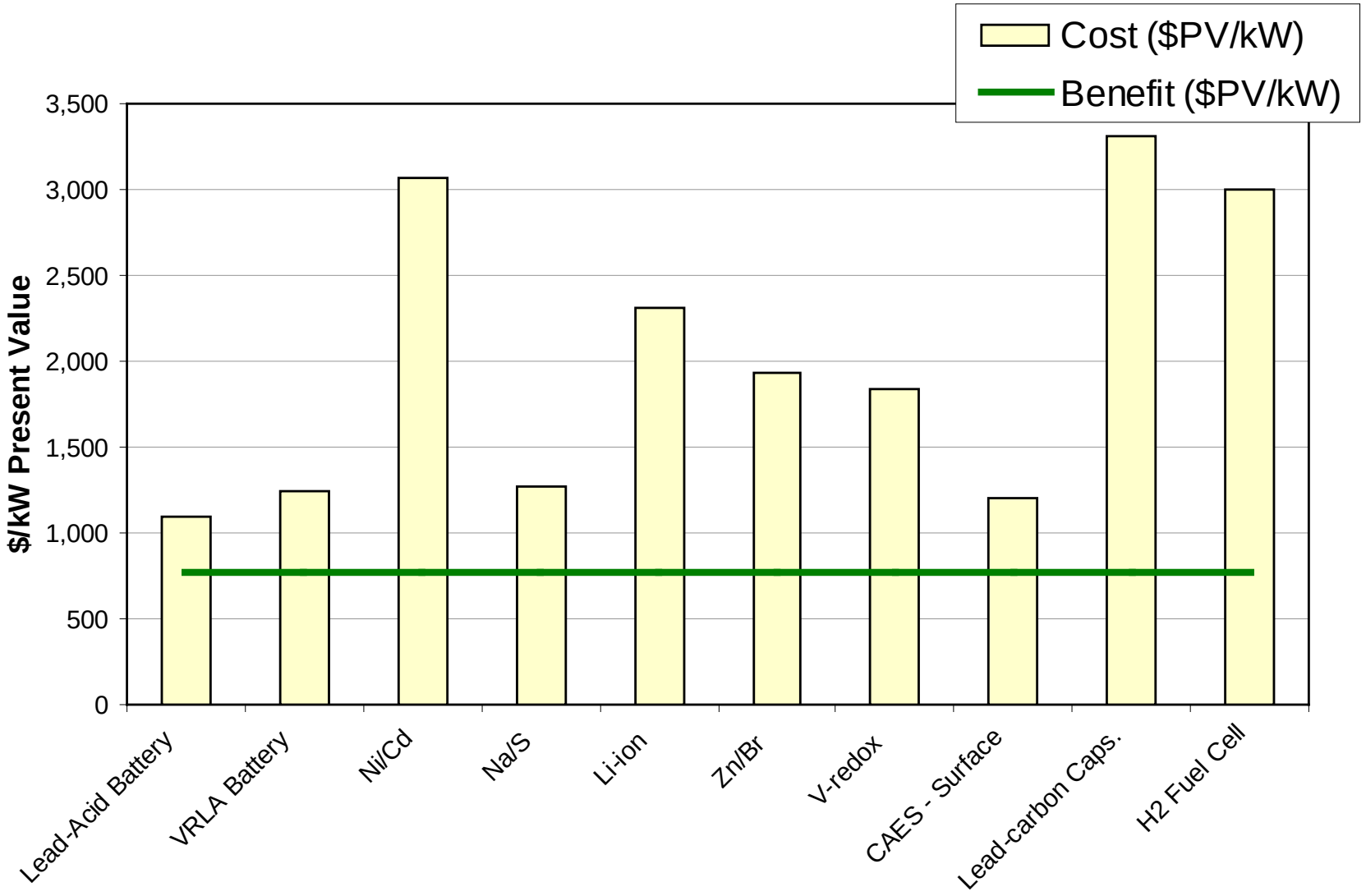




1,000 hours with the highest priced energy

Benefit & Cost, Value Proposition 2

1 Year High Value T&D Deferral + Arbitrage



Critical Peak Pricing

Pacific Gas and Electric Company
San Francisco, California

Cancelling Revised Original

Cal. P.U.C. Sheet No. 23450-E
Cal. P.U.C. Sheet No. 21686, 22861-E

SCHEDULE E-CPP—CRITICAL PEAK PRICING PROGRAM

APPLICABILITY: The critical peak pricing (CPP) program is a voluntary alternative to traditional time-of-use rates. Schedule E-CPP is available to PG&E bundled-service customers with billed maximum demands of 200 kW or greater during any one of the past 12 billing months, and served on PG&E Demand Time-Of-Use (TOU) electric rate schedules A-10 TOU, E-19 (including E-19 voluntary), E-20, AG-4 (rates C and F only), AG-5 (rates C and F only) or their successors. Each customer must continue to take service under the provisions of their otherwise-applicable schedule (OAS). The CPP program only operates during the summer months (May 1 through October 31). Customers on this tariff must agree to allow the California Energy Commission (CEC) or its contracting agent to conduct a site visit for measurement and evaluation, and agree to complete any surveys needed to enhance the CPP program. This program will remain in place until superseded by a mandatory CPP rate schedule, which is expected in the Advanced Metering OIR, Rulemaking (R.) 02-06-001 or subsequent filings. (T)

	Non-CPP Days (Credit) per kilowatt hour of usage		CPP Days (Charge) per kilowatt hour of usage	
	On-Peak	Part-Peak	Moderate-Price	High-Price
E-20T	$0.02682 (R)	$0.00146 (R)	$0.09116 (R)	$0.45124 (R)
E-20P	$0.03012 (R)	$0.00153 (R)	$0.10010 (R)	$0.48280 (R)
E-20S	$0.03424 (R)	$0.00349 (R)	$0.10415 (R)	$0.58900 (R)
E-19T	$0.03102 (R)	$0.00259 (R)	$0.14360 (R)	$0.54340 (R)
E-19P	$0.03104 (R)	$0.00230 (R)	$0.11879 (R)	$0.49672 (R)
E-19S	$0.03656 (R)	$0.00394 (R)	$0.12429 (R)	$0.59652 (R)
A-10T	$0.01392 (R)	$0.00627 (R)	$0.11735 (R)	$0.22991 (R)
A-10P	$0.04076 (R)	$0.00318 (R)	$0.21143 (R)	$0.67480 (R)
A-10S	$0.04686 (R)	$0.00322 (R)	$0.22008 (R)	$0.65292 (R)
AG-4C, F	$0.02305 (R)	$0.00583 (R)	$0.12857 (R)	$0.41080 (R)
AG-5C, F	$0.01874 (R)	$0.00504 (R)	$0.09670 (R)	$0.34808 (R)

Value Proposition 3

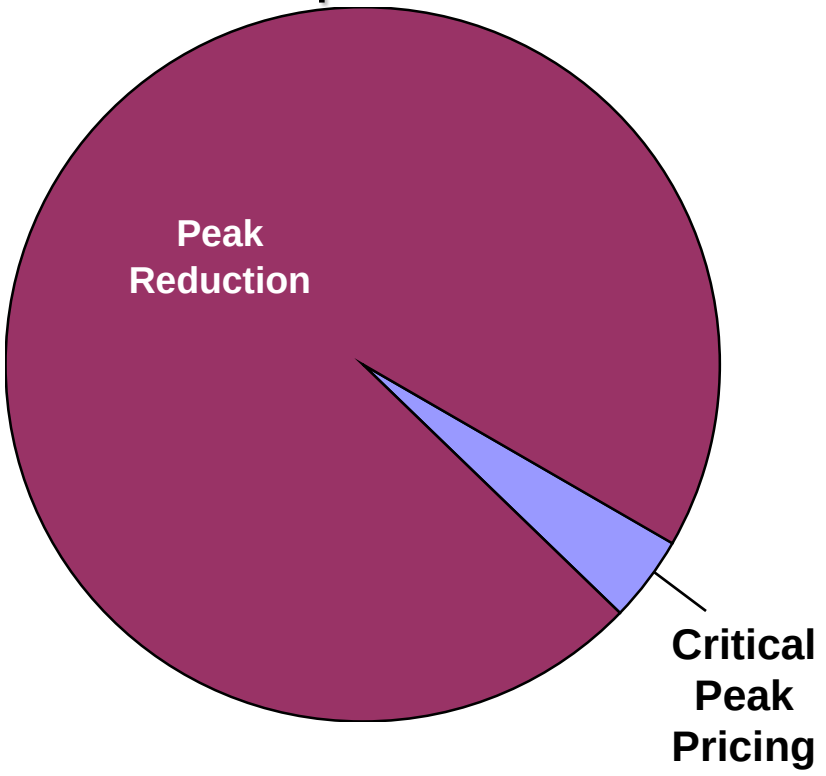
Critical Peak Pricing + Peak Reduction

- PG&E Critical Peak Pricing:
  For discount during most hours of the year, customer agrees
  - to pay "very high" price for energy
    - up to 5x normal peak energy charge
  - "several times" (events) per year
    - PG&E Target: 12
  - for a target of 3 to 6 hours per event
- Note: some end-users could benefit from better onsite PQ and/or reliability.

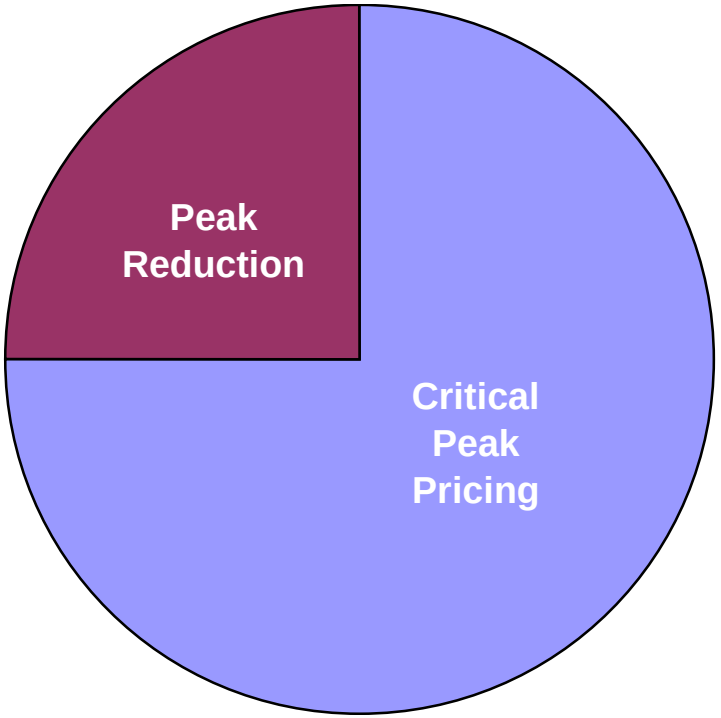
Value Proposition 3

Critical Peak Pricing + Peak Reduction

1,600 Annual Hours of Operation

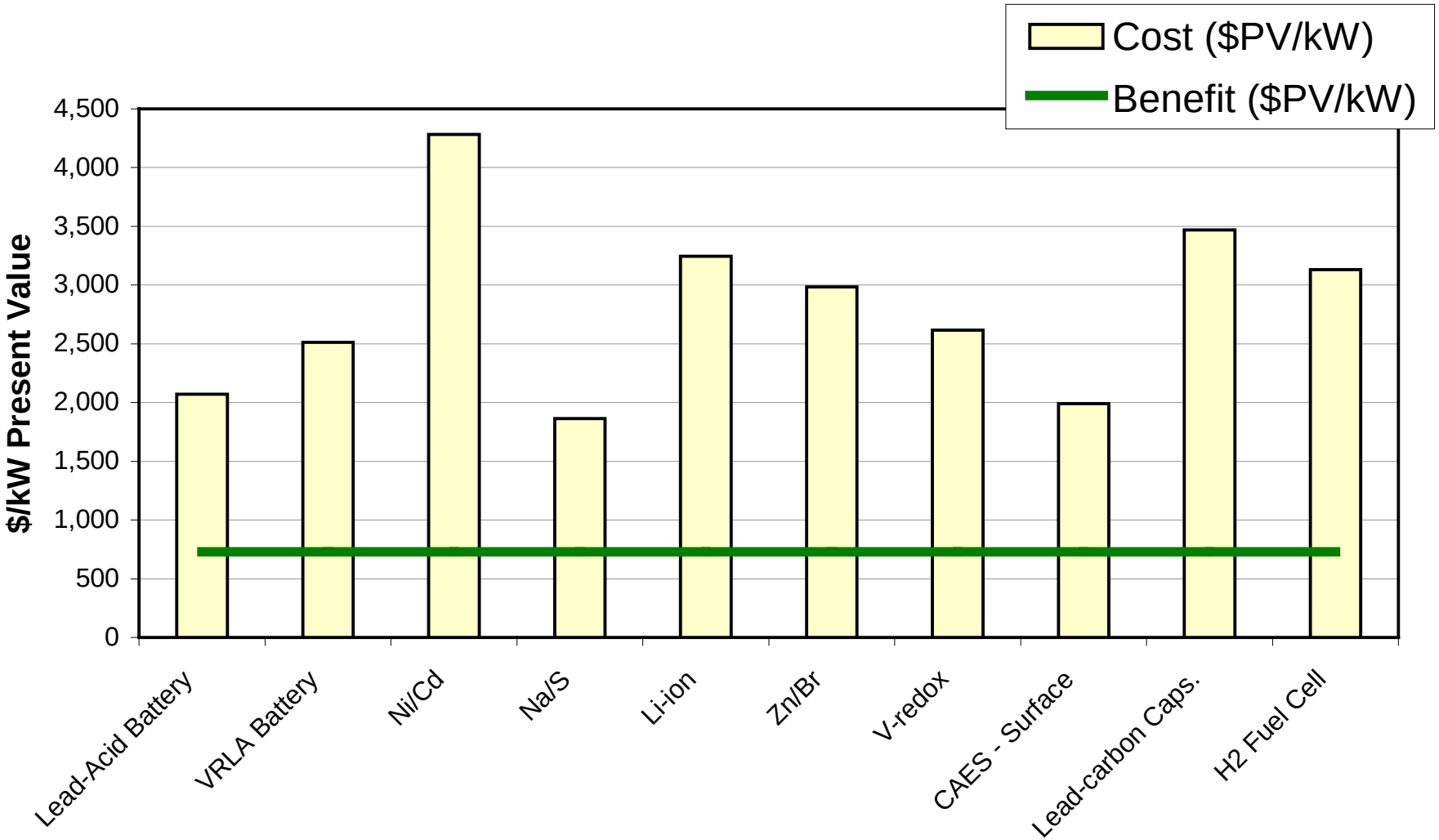


$100/kW-year Annual Benefits



Benefit & Cost, Value Proposition 3

Critical Peak Pricing + Peak Reduction



Conclusions

- ☞ California-centric results will be different for different regions & utilities.
- Benefit aggregation is an important way to improve storage value propositions!
- Transportable ESS for Deferral + PQ yields B/C approaching 1 for lead-acid
  - Transportable ESSs offer more opportunities to aggregate benefits.
- Deferral + Arbitrage may be attractive if generation *capacity* benefit is included.

Next Steps

- Consider additional financially attractive and realistic near and mid-term value propositions for ESSs that include
  - Additional use scenarios for transportable ESSs
  - Distributed PV capacity firming.
  - Peak Capacity and Energy for Small and Packaged Air Conditioning.
  - “Critical System Stability” during system/regional grid emergencies.
  - T&D equipment “life extension.”