122 West DUA

Benefit and Cost Comparisons of Energy Storage Technologies for Three Emerging Value Propositions

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ACKNOWLEDGMENTS

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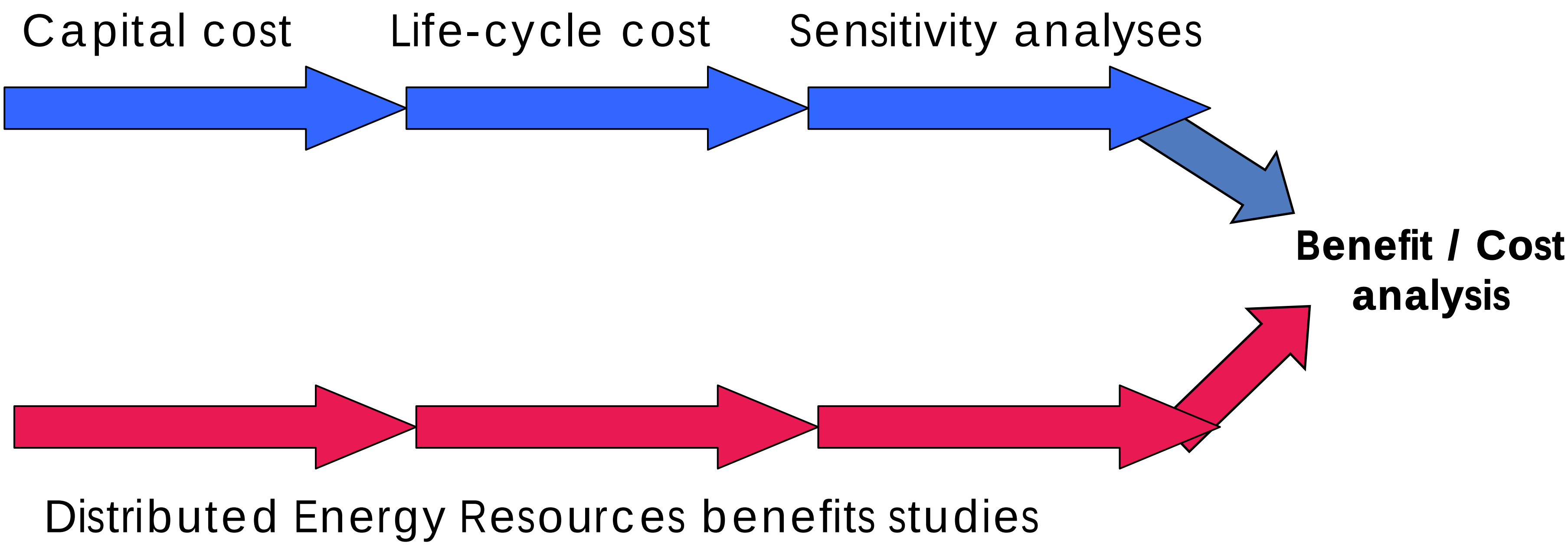
Objectives and Approach

- The objective of this task is to develop a process for merging the costs and benefits of energy storage systems, which have been generated separately, into a structure with consistent assumptions, so that valid benefit/cost factors can be calculated.
- This work is being carried out by Longitude 122 West, working in conjunction with Distributed Utility Associates (DUA).
- Longitude 122 West is responsible for the cost analysis and DUA is responsible for the benefits analysis. The parties are working together to establish consistent assumptions and analytical procedures.
- Cost and benefit data are derived primarily from previous work on distributed energy resources.

Energy Storage Analysis



Benefit / Cost analysis merges previous separate work

Storage "Value Propositions" or Scenarios

1. Utility owned transportable storage, used in alternating years for: 1) distribution upgrade deferral and 2) to improve localized power quality or for temporary power;
2. Utility-owned storage used for 1) T&D upgrade deferral for one year out of ten and 2) then wholesale electricity price arbitrage (buy low – sell high);
3. Utility customer owned storage used to 1) serve on-site power needs during periods when on-peak and critical peak pricing, 2) provide power quality and/or reliability benefits.

Parameters for Three Scenarios

	Scenario 1: Transportable T&D Deferral with PQ	Scenario 2: T&D Deferral with Arbitrage	Scenario 3: Customer Bill Optimization
Description	1st year deferral, 2nd yr PQ/reliability; move to new location; 3rd year deferral, 4th year PQetc.	1st year deferral, subsequent years arbitrage	Operate during peak and critical peak hours to avoid time-of-day charges and earn discount
Power range	300 kW – 1 MW	500 kW – 2 MW	20 kW – 1 MW
Hours of dispatchable storage	4 - 5 hrs	4 – 5 hrs	5 – 6 hrs
Energy stored, kWh	1.2 - 5 MWh	2 - 10 MWh	100 kWh - 6 MWh
Hours or days of operation per year	T&D: 200 hrs/yr PQ: 20 hrs/yr	T&D: 200 hrs/yr Arbitrage: 1000 hrs/yr	Peak: 1600 hr/yr Critical peak: 60 hrs/yr
Technology issues	Must be transportable, suitable for infrequent use, rapid availability	Routine use, high duty cycle	Seasonal use

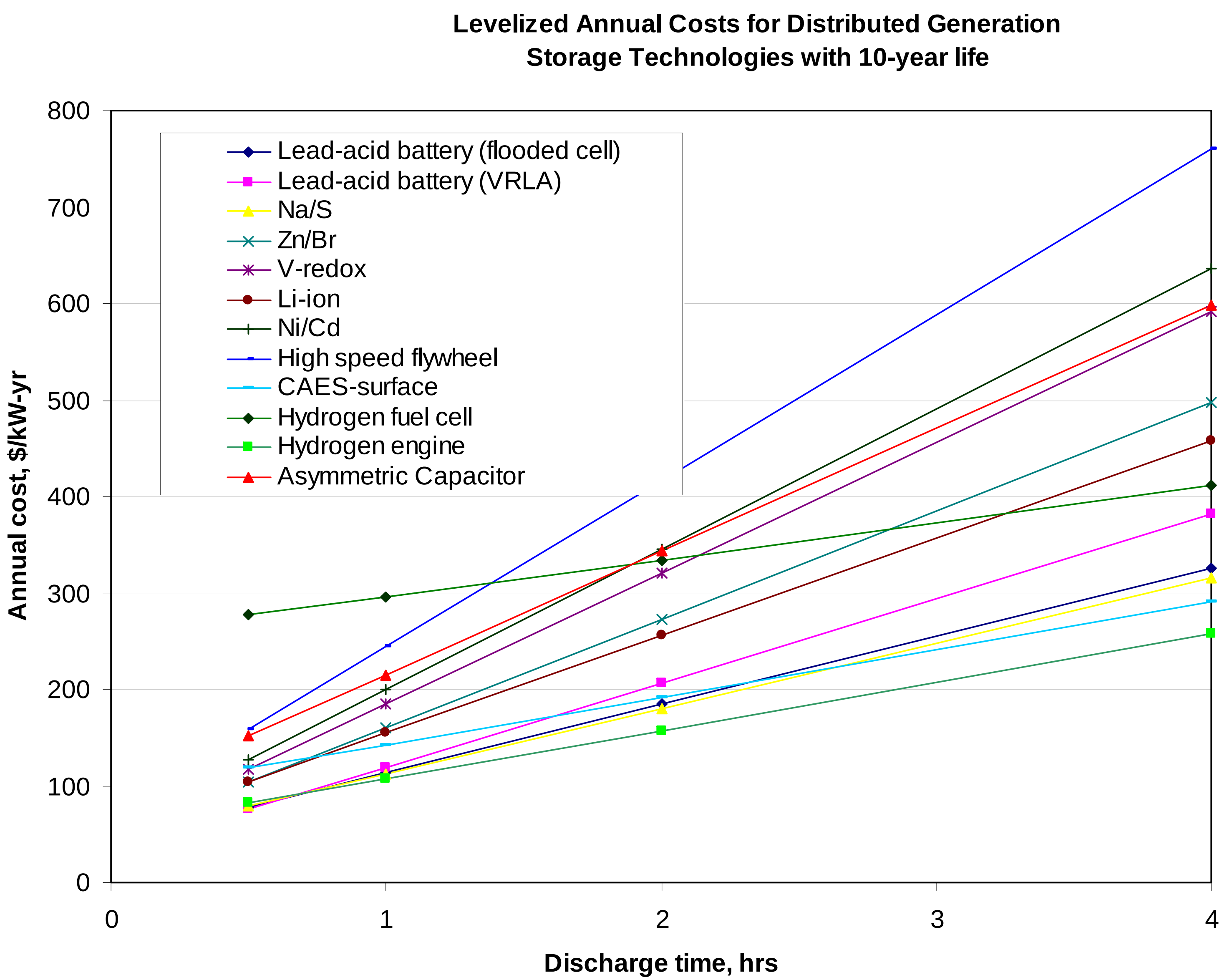
Economic Assumptions

Parameter	Value
General inflation rate	2%
Discount rate	10%
Service life	10 years
Utility fixed charge rate	11%
Customer fixed charge rate	15%
Fuel cost, natural gas (for CAS only)	5 $/MBTU
Electricity cost, charging	10 ¢/kWh

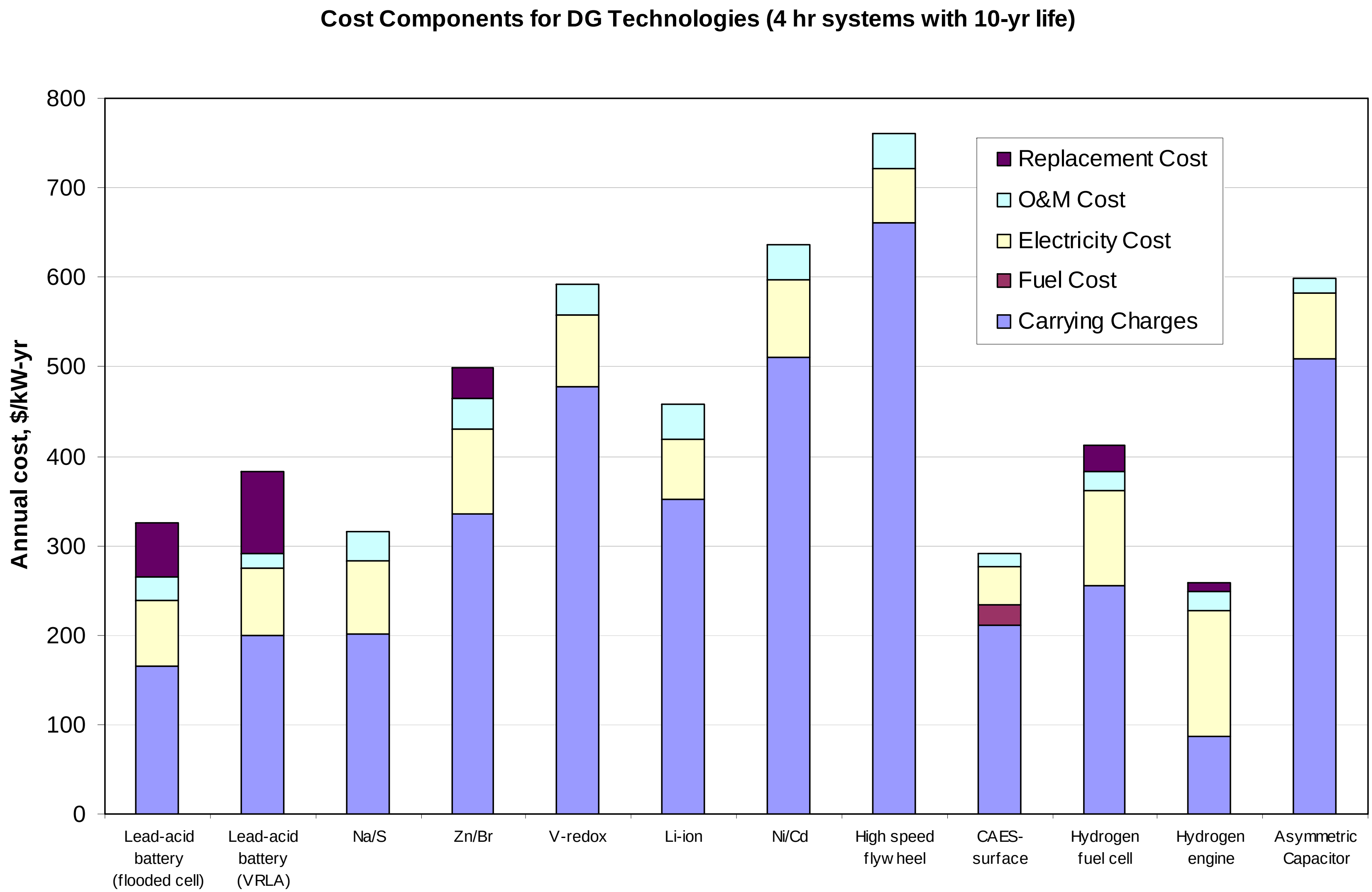
Storage Technologies

Scenario 1: Transportable T&D Deferral with PQ	Scenario 2: T&D Deferral with Arbitrage	Scenario 3: Customer Bill Optimization
Lead-acid batteries, conventional and VRLA 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 High-speed and low-speed flywheels Surface CAES Lead-carbon asymmetric caps Hydrogen fuel cell	Lead-acid batteries, conventional and VRLA Ni/Cd Li-ion batteries Zn/Br batteries V-redox batteries High-speed and low-speed flywheels Surface CAES Lead-carbon asymmetric caps Hydrogen fuel cell

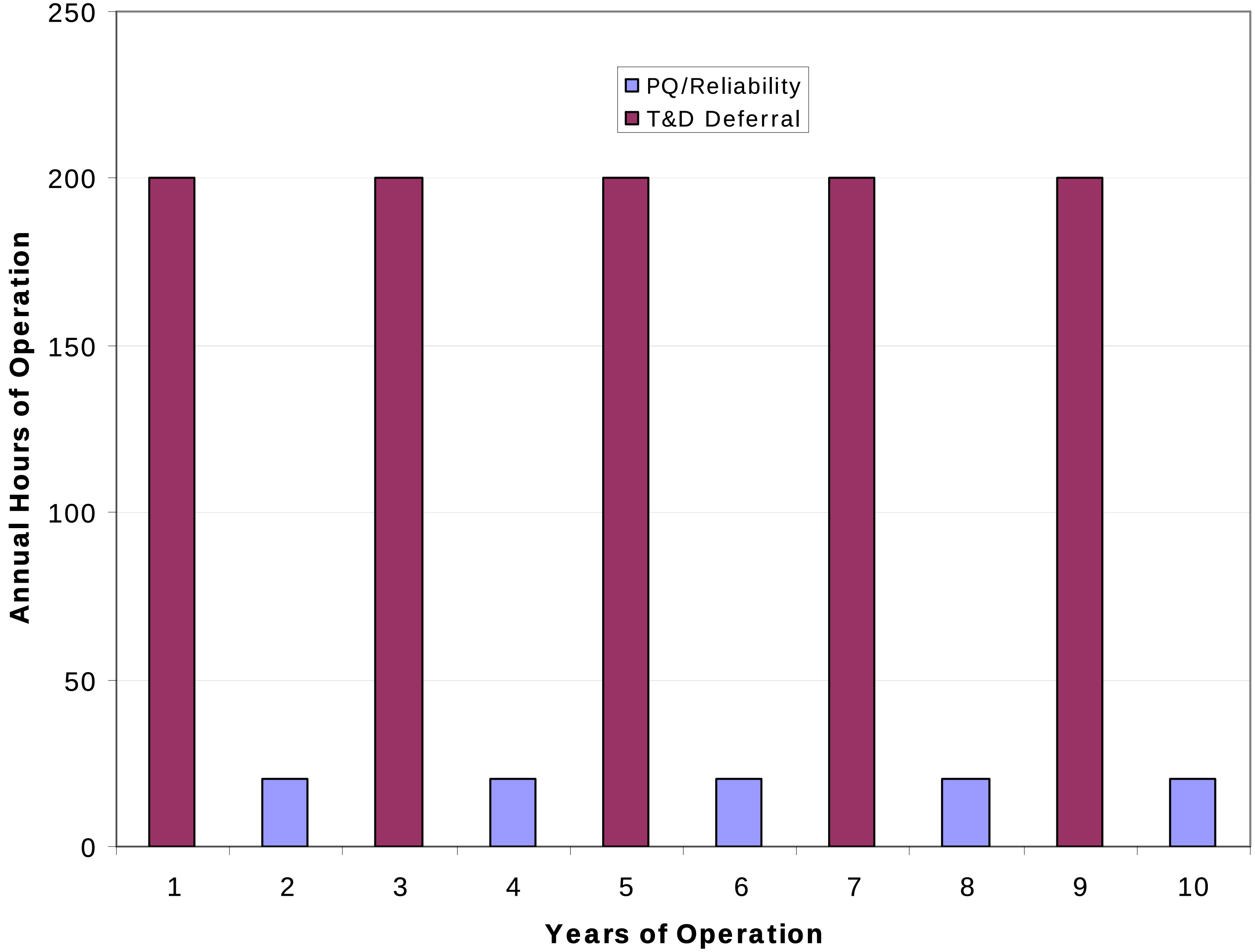
Earlier Results - Daily Operation



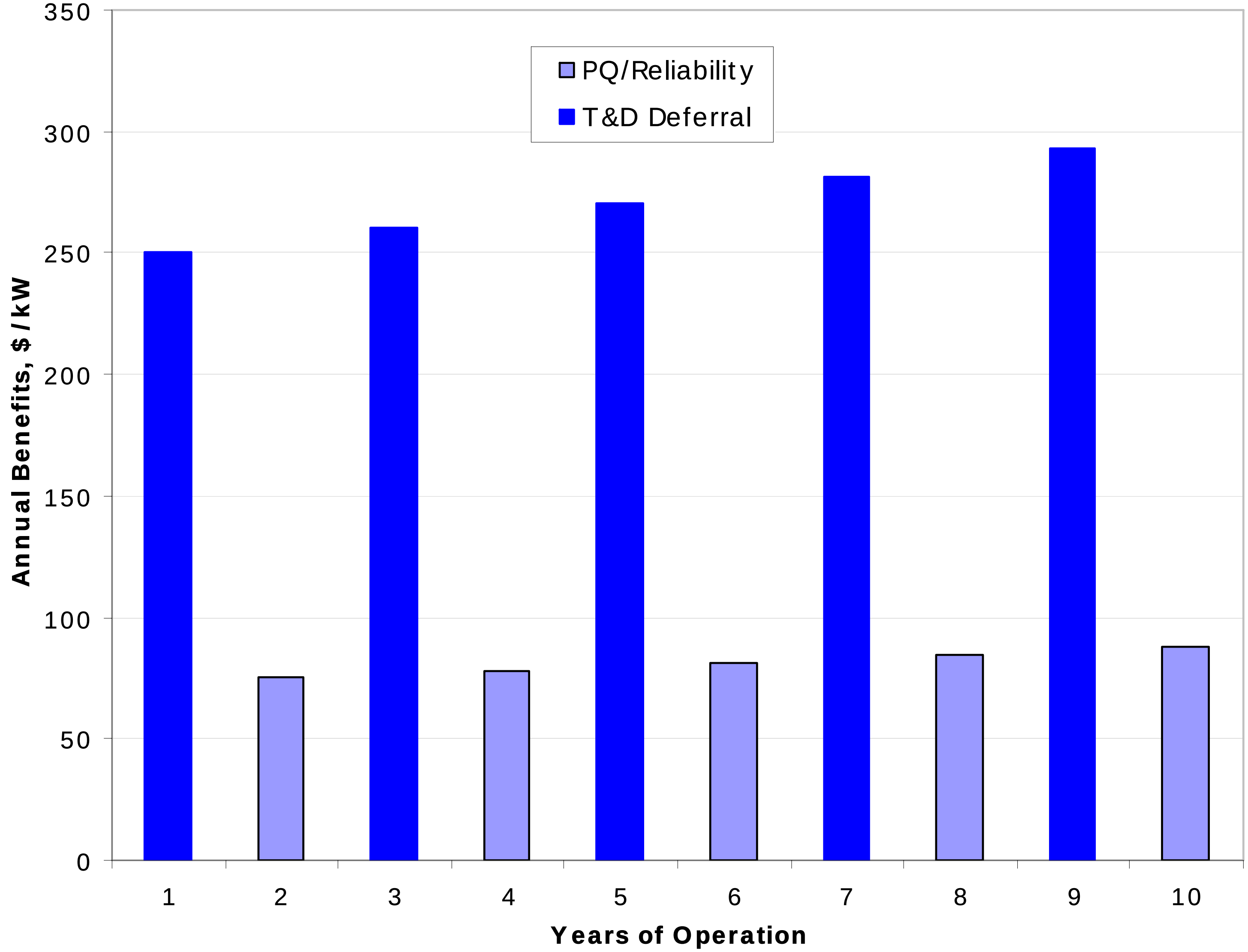
Earlier Results - Daily Operation



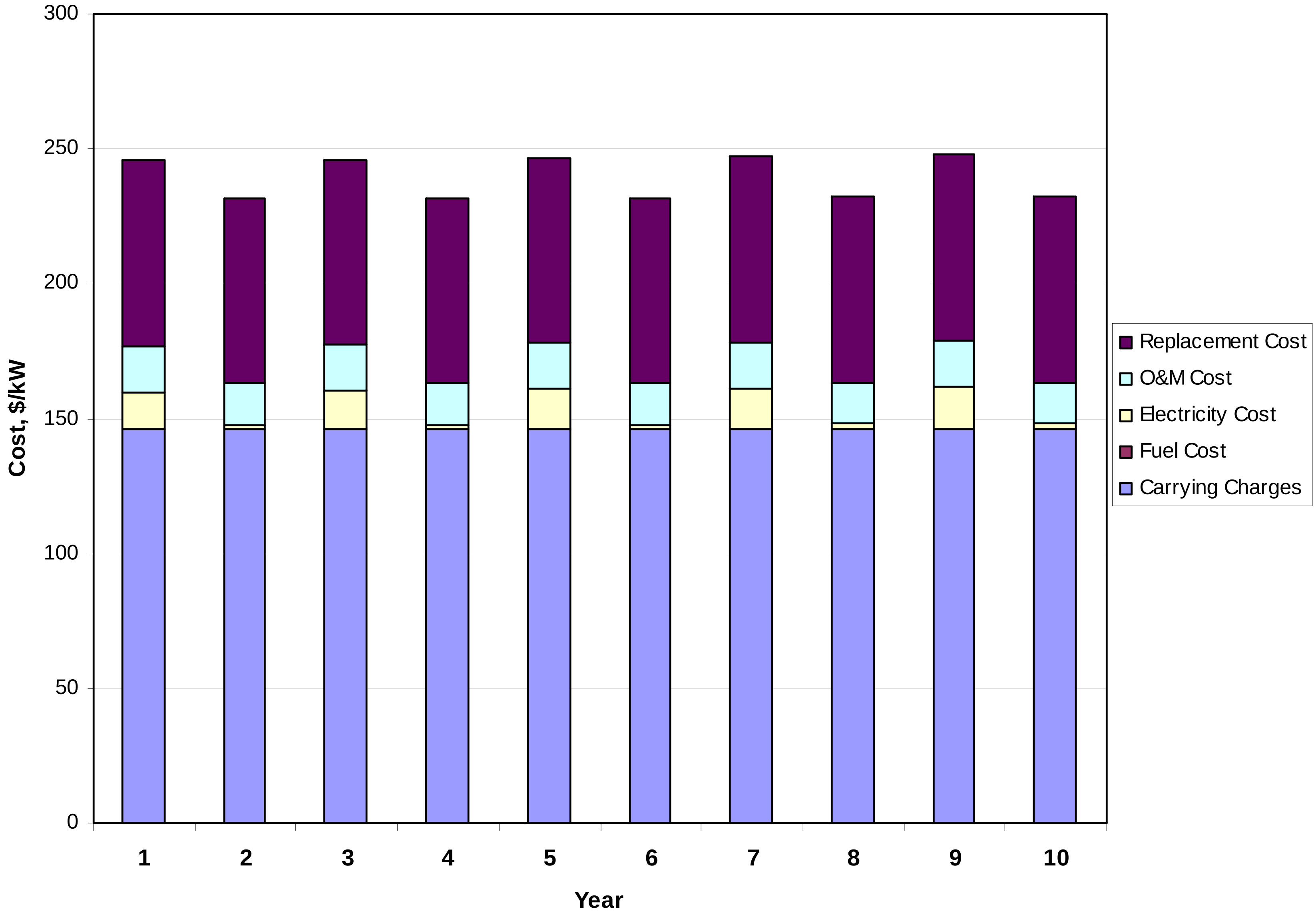
Scenario 1 Operation: Transportable T&D Deferral with PQ



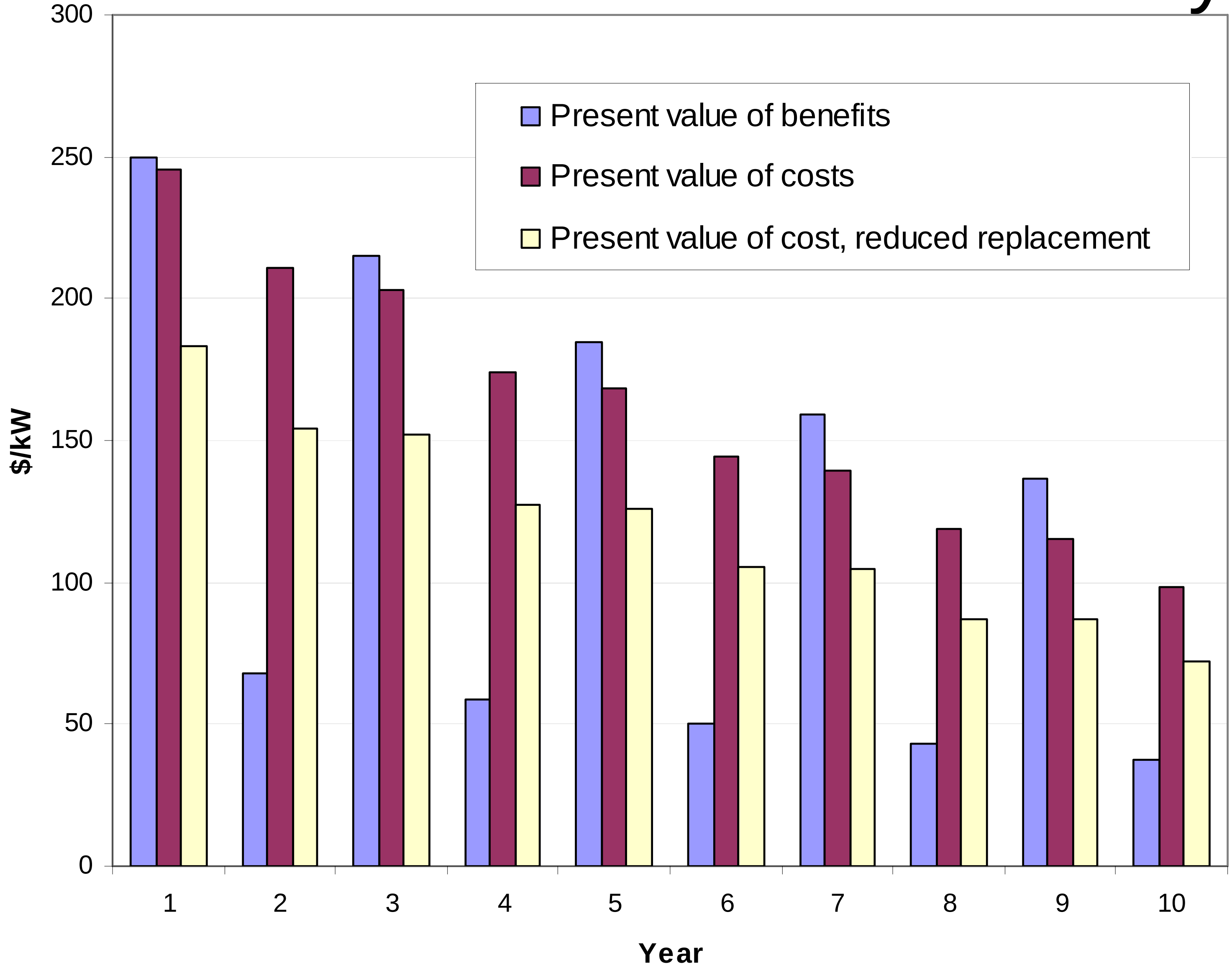
Scenario 1 Yearly Benefits



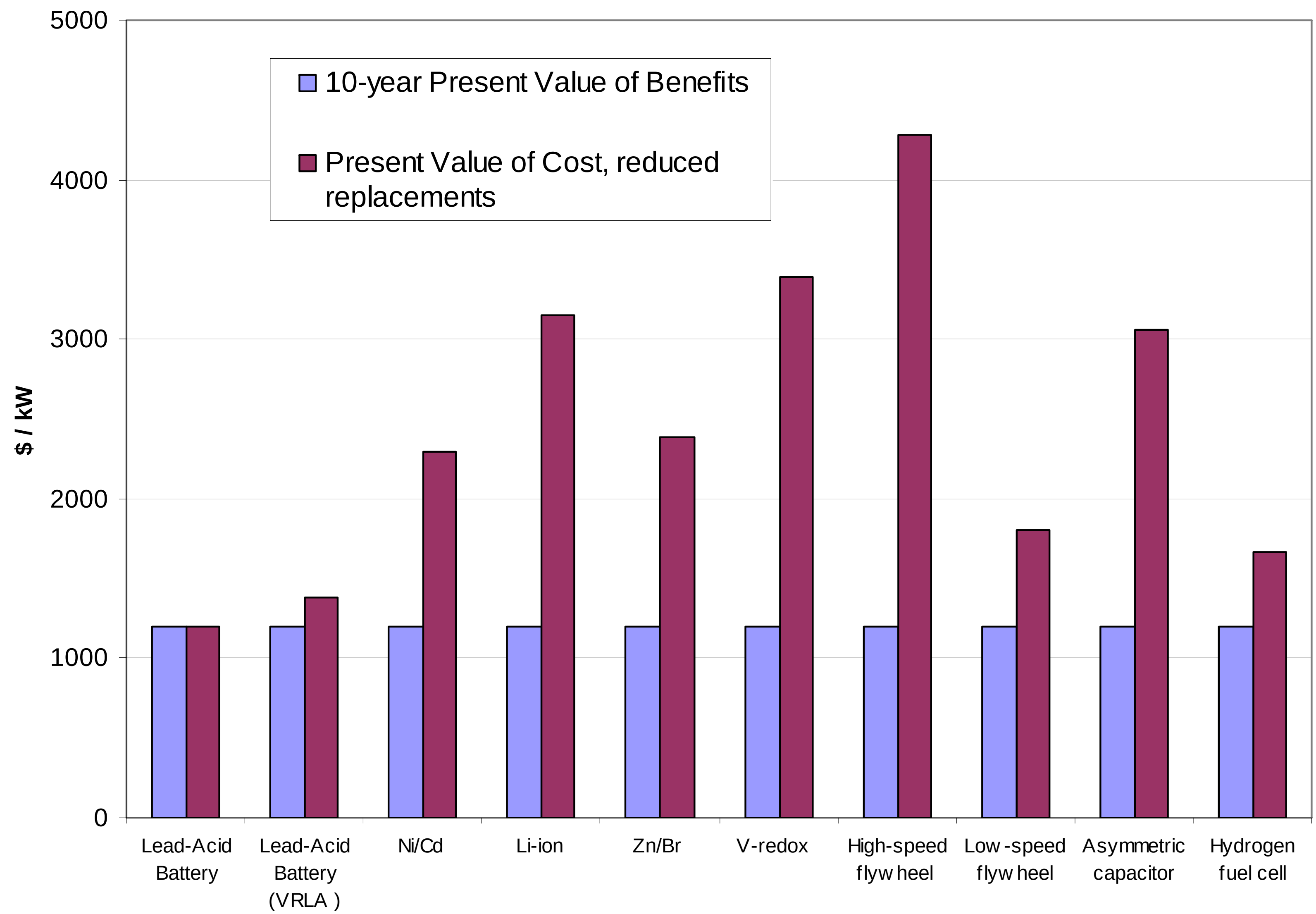
Scenario 1 Yearly Costs for Lead-Acid Battery with 5-hr Capacity



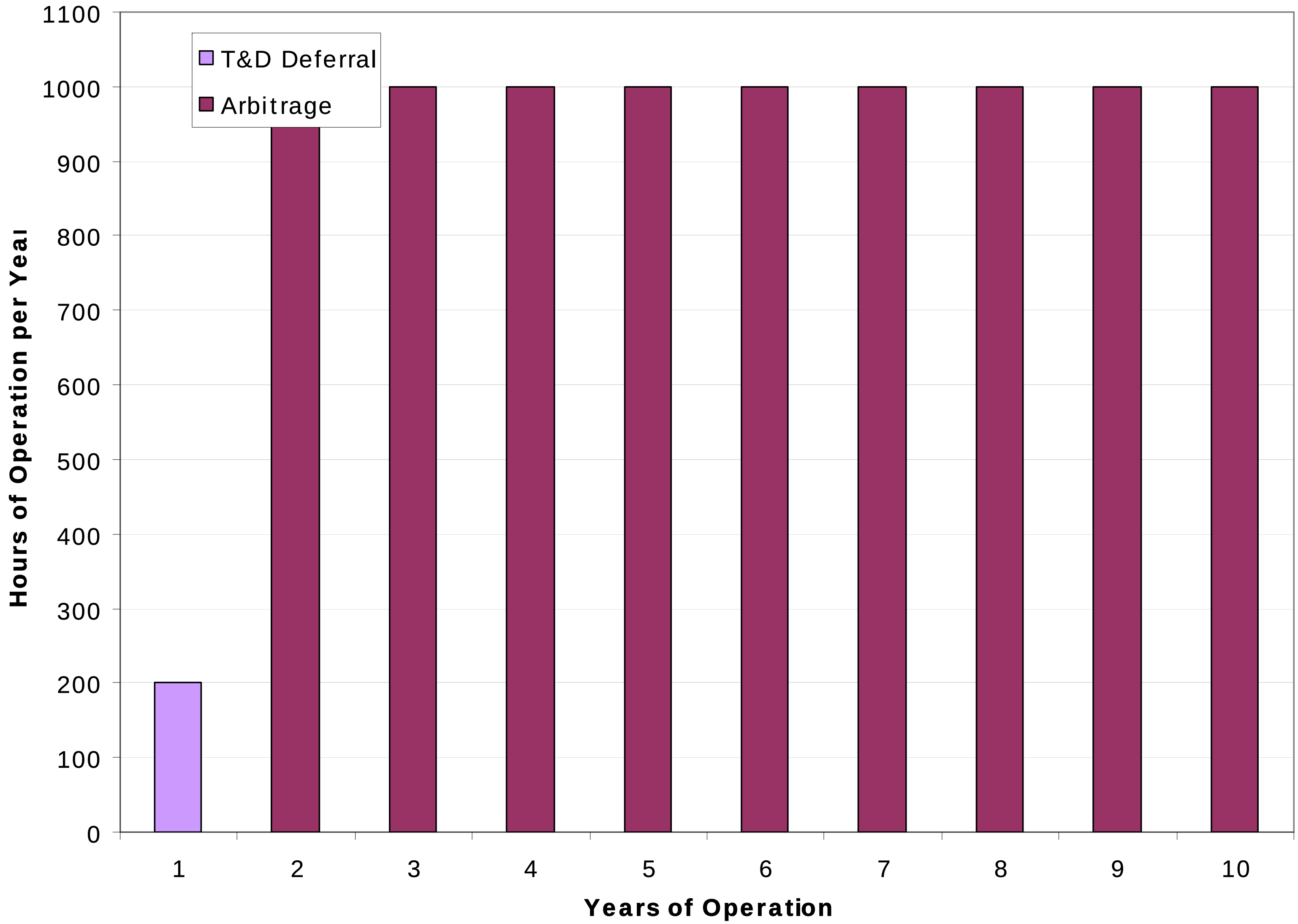
Present Value of Yearly Benefits and Costs for 5-hr Lead-Acid Battery



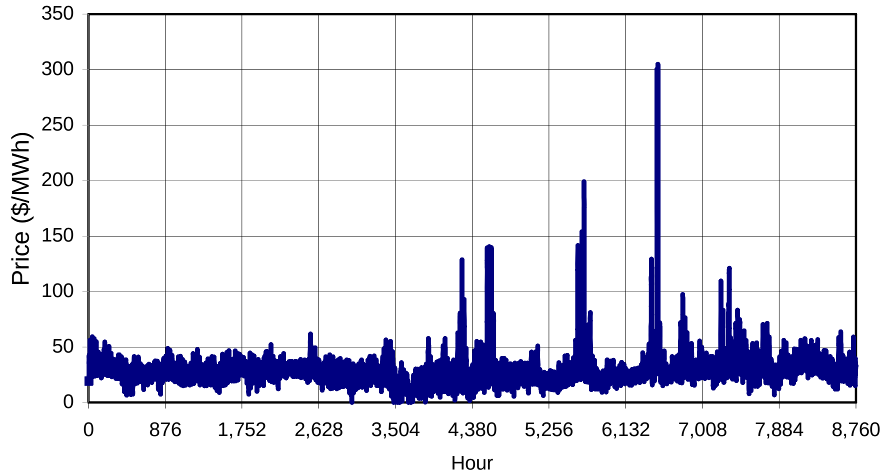
Present Value of Benefits and Costs for 5-hr Distributed Resources in Scenario 1

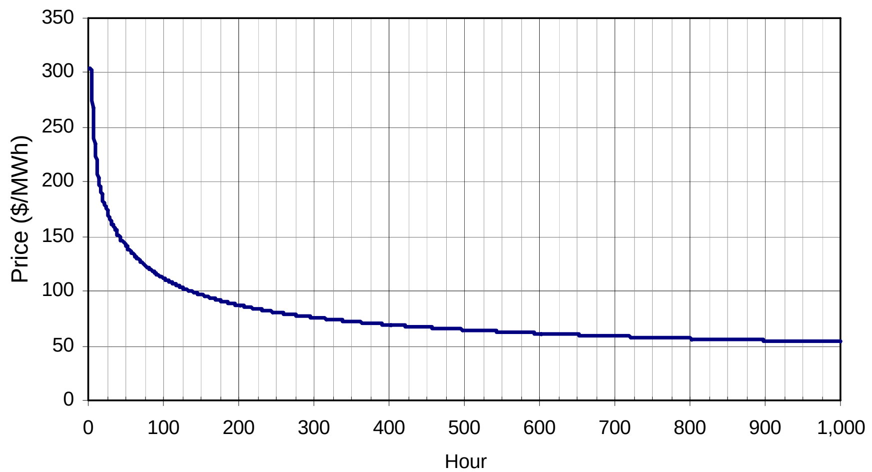


Scenario 2 Operation: T&D Deferral with Arbitrage



Price Variability presents an opportunity for arbitrage

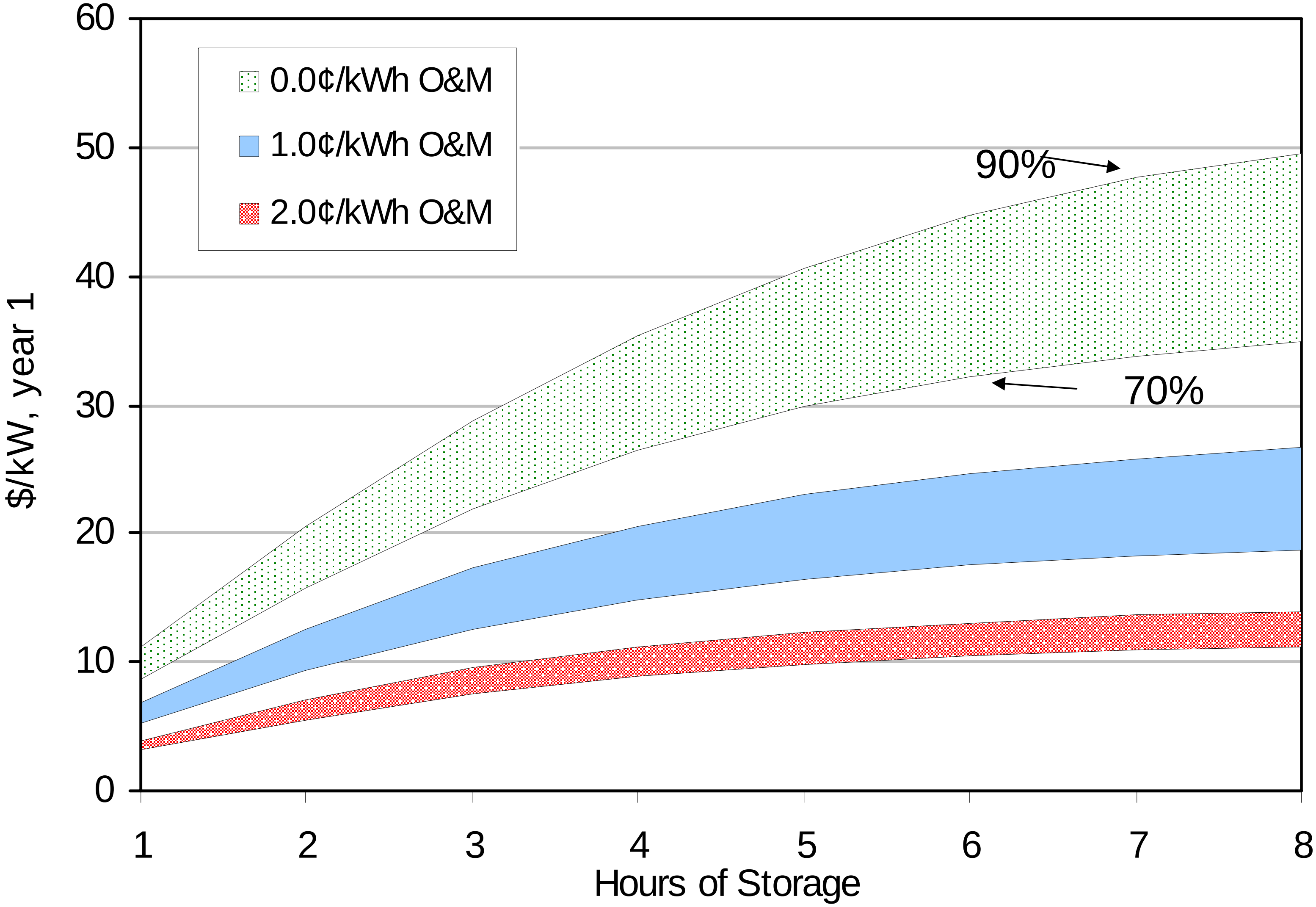




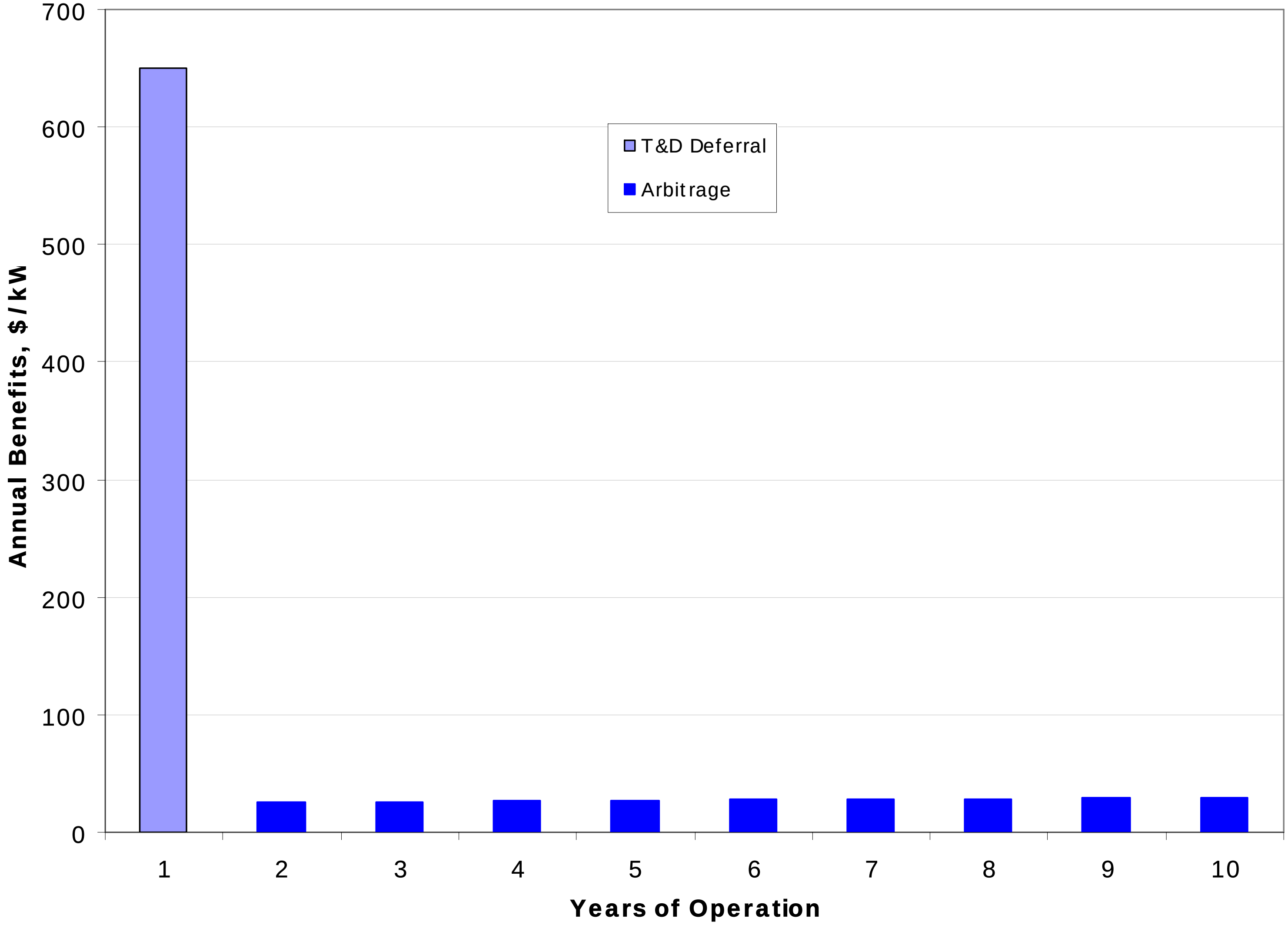
Computation of Arbitrage Benefits for Scenario 2 (Buy Low - Sell High)

- California 8,760 Chronological Prices
  - from CEC, using production simulation model
- DUA simple arbitrage model has "perfect knowledge"
- Sensitivities
  - efficiency 70%, 80%, 90%
  - "maintenance" 0¢/kWh, 1¢/kWh, 2¢/kWh
  - one to eight hours of storage

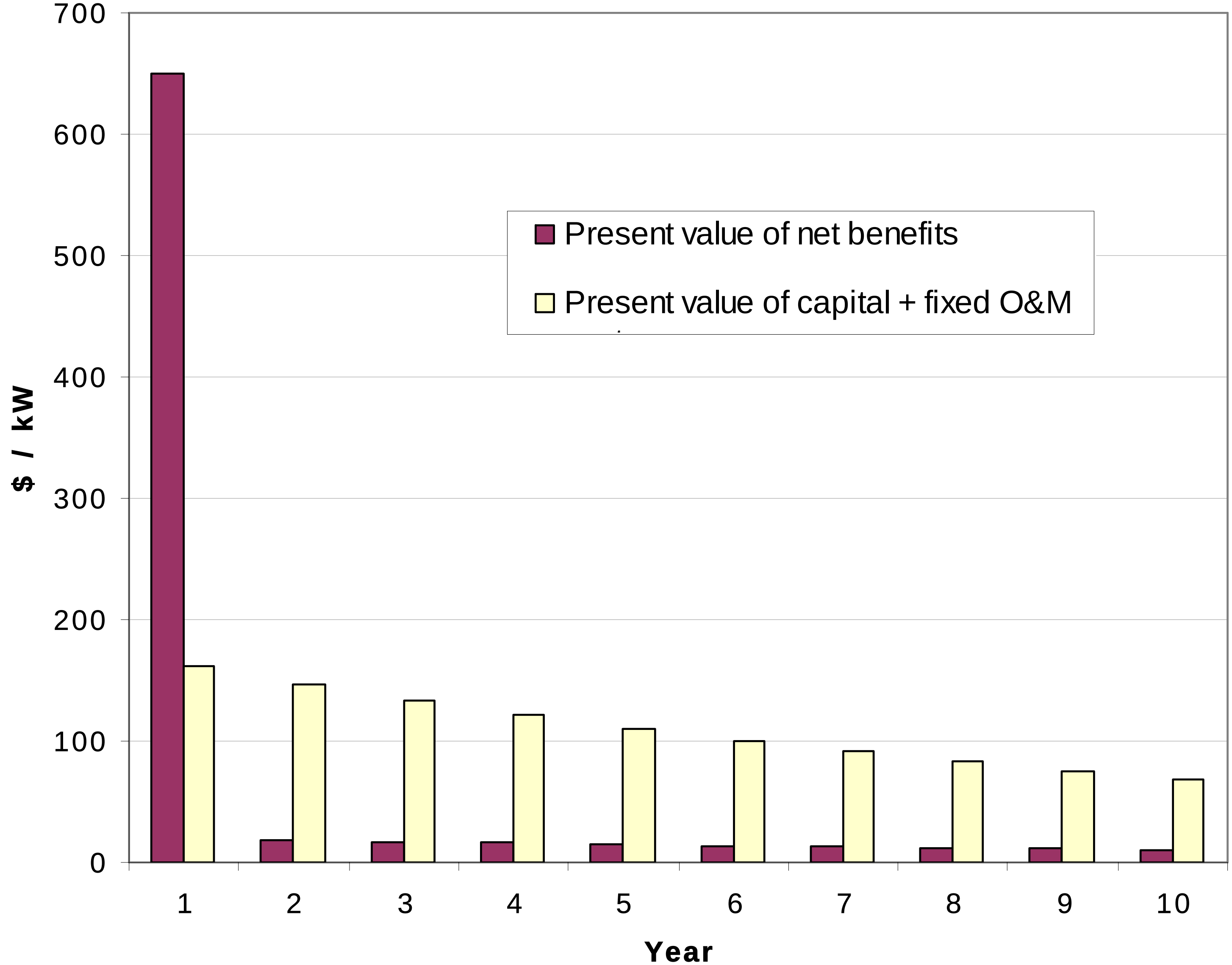
Net Arbitrage Benefits for Scenario 2 (California - one year)



All Benefits for Scenario 2



Present Value of Benefits and Costs for Lead-Acid Battery in Scenario 2



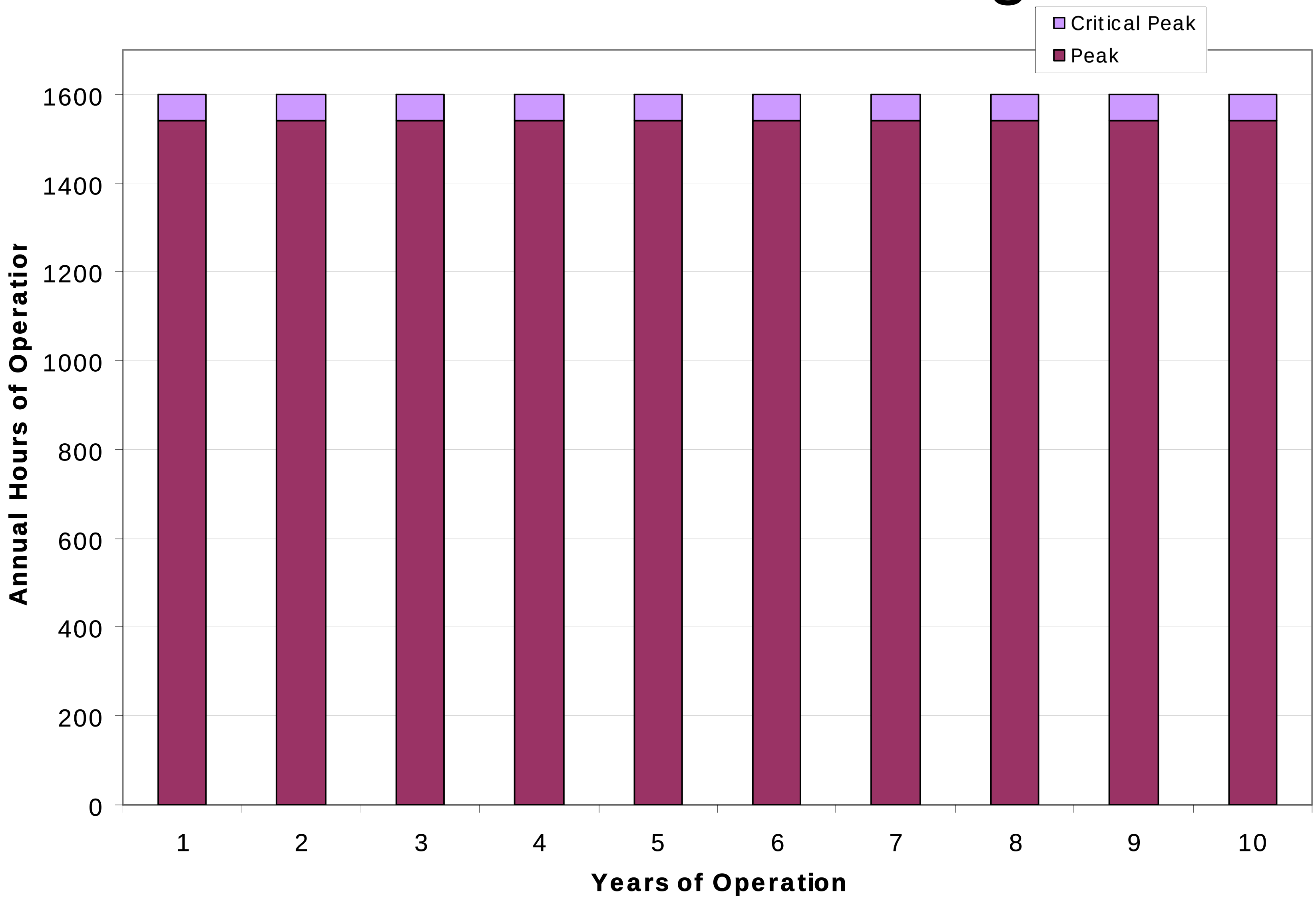
Scenario 3: Critical Peak Pricing

- For discount during non-critical peak and mid peak times customer agrees
  - to pay “very high” price for energy
    - Up to 5 times normal peak energy charge
  - “several times” per year
    - PG&E Target 12 days/year
  - for periods lasting from 3 to 6 hours per event

Benefits for Scenario 3: Customer Billing Optimization

- Install storage to operate during critical peak (5 hr), reducing energy bill
- Use storage to also load shift during peak, avoid time-of-day and demand charges

Scenario 3 Operation: T&D Peak and Critical Peak Pricing



PG&E CPP Tariff Sheet

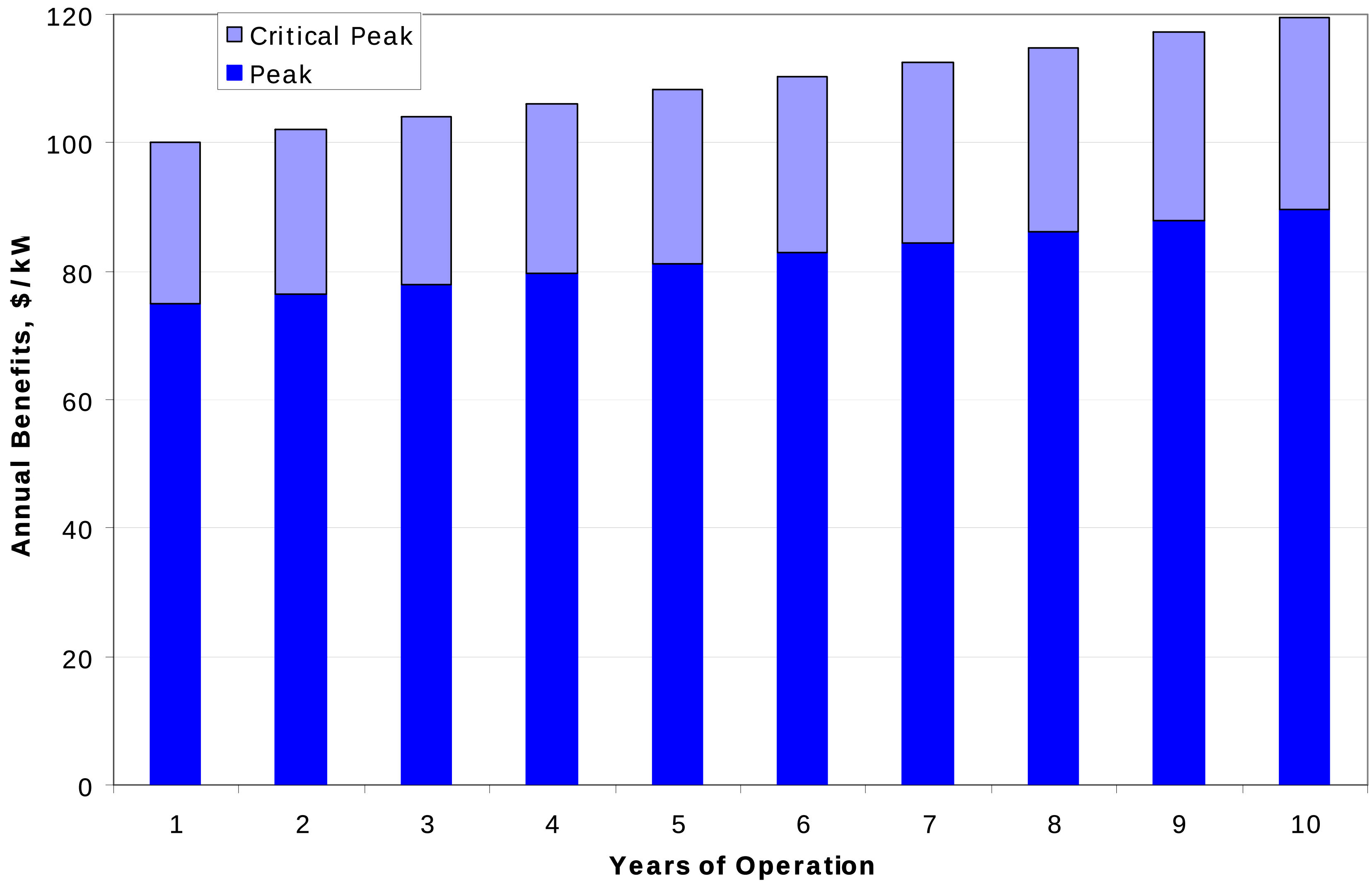
Pacific Gas and Electric Company		Revised	*Cal. P.U.C. Sheet No.* 23450-E
San Francisco, California	*Cancelling*	Original	*Cal. P.U.C. Sheet No.* 21686, 22861-E

SCHEDULE E-CPP—CRITICAL PEAK PRICING PROGRAM

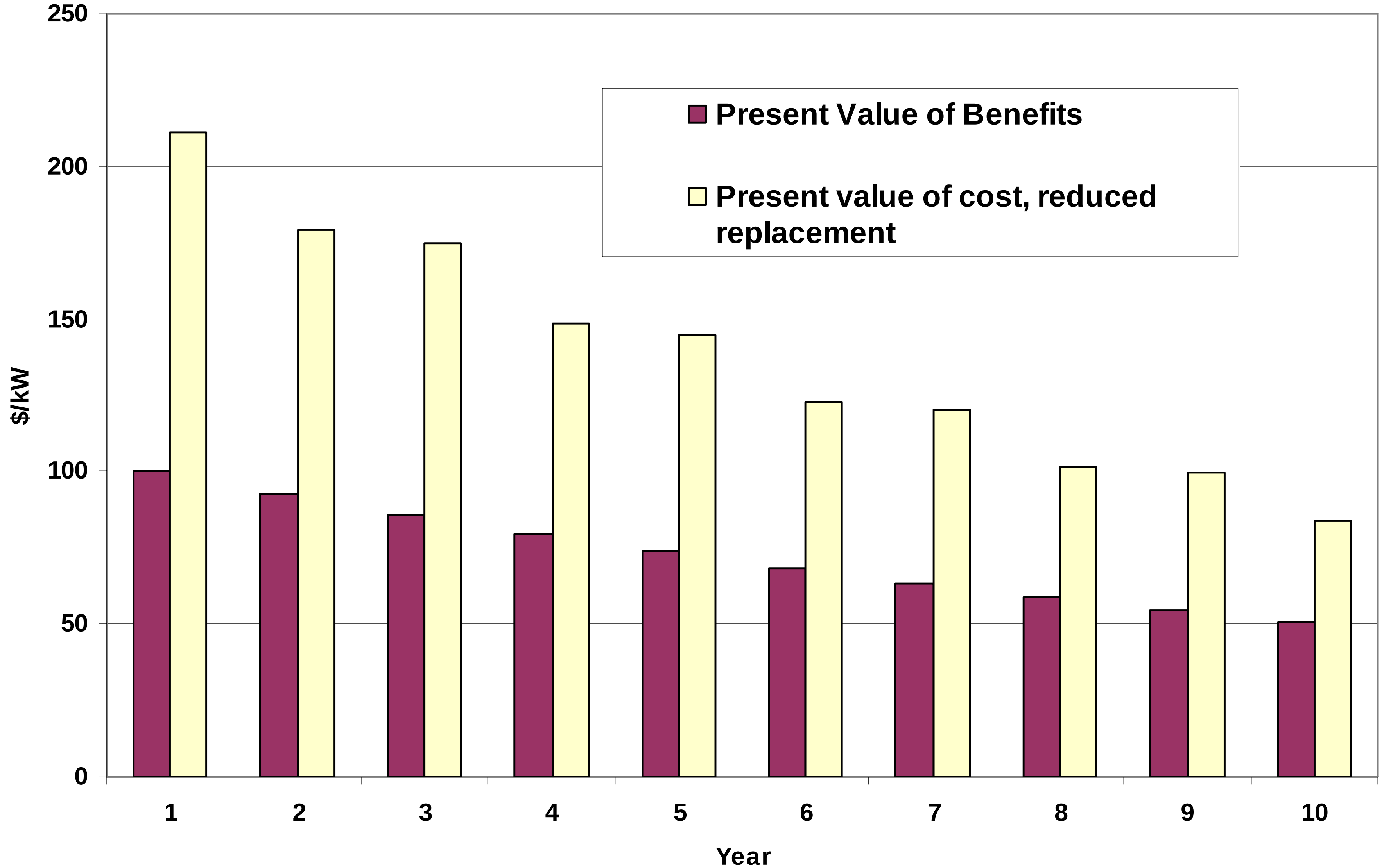
APPLICABILITY: The critical peak pricing (CPP) program is a voluntary alternative to traditional time-of-use rates. Schedule E-CPP is available to PG&E bundled-service customers with billed maximum demands of 200 kW or greater during any one of the past 12 billing months, and served on PG&E Demand Time-Of-Use (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)

Yearly Benefits for Scenario 3 (based on California)

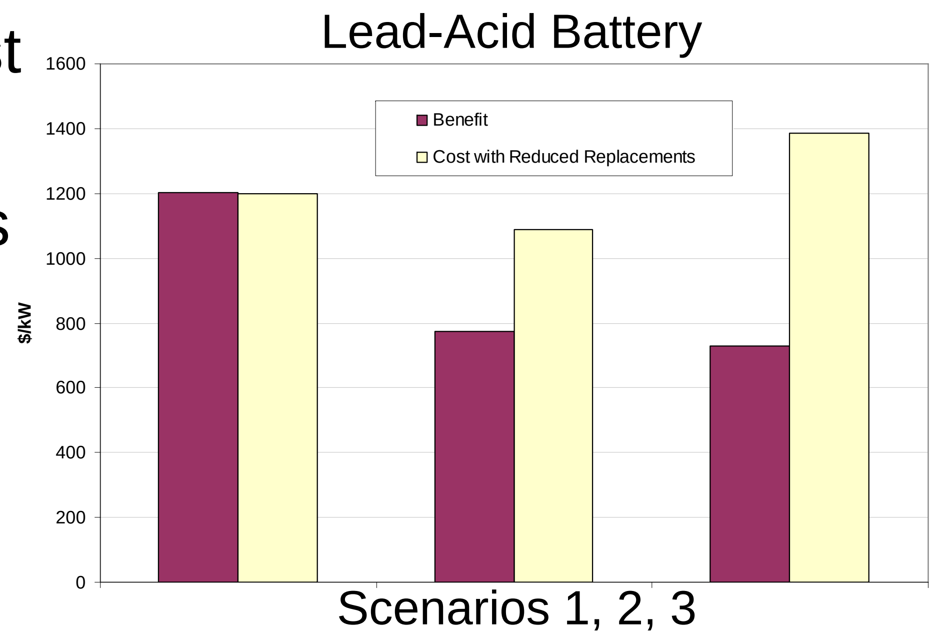


Present Value of Benefits and Costs for Lead-Acid Battery in Scenario 3



Preliminary Conclusions

- Based on preliminary analysis for benefits and costs, only scenario 1 gives a benefit / cost ratio approaching one.
- To improve these results, costs need to be reduced, especially capital and replacement costs. Ideally, systems would have adequate service life that no significant replacements are required.
- Multiple uses must be sought so that greater benefits will accrue.



Plans

- Check consistency of assumptions, refine methodology for Scenarios 2 & 3.
- Complete Scenario 2 & 3 cost analysis for full range of technologies.
- Consider additional combinations of benefits.
- Final report due in December.