Energy+Environmental Economics

Statewide Joint IOU Study of Permanent Load Shifting Workshop #2:

"Expanding the Availability of Permanent Load Shifting in California"

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About E3

- E3 is an electricity consulting firm founded in 1989 in San Francisco
- Clients span local, state and federal government, small and large public and investor-owned electric utilities, and energy technology companies
- Experienced in marrying engineering-economic analysis with public stakeholder process
- Approximately 25 staff in energy economics, policy, and resource planning

Energy and Environmental Economics (E3) Overview

- E3 Recent Projects
  - Energy Efficiency Policy and Cost-effectiveness
    - *E3 Calculator* used to evaluate all energy efficiency Programs by all utilities
    - Developed and maintain database of avoided costs
  - Demand Response: Development of the cost-effectiveness protocols for Demand Response in California for the CPUC
  - Distributed Generation, California Solar Initiative, Self-Generation Incentive Program
  - PEV Analysis, Large Utility and EPRI
  - Energy Storage Market Analysis for US EPRI
  - Developed GHG Calculator for CPUC, CEC, ARB

PLS Regulatory Background: CPUC order D.09-08-027

+ PLS Study mandated in CPUC Order D.09-08-027

- Each of the utilities shall provide its report to the Director of Energy Division no later than December 1, 2010 and provide copies to service list in this proceeding

+ D.09-08-027 ordering paragraph for PLS study

- IOUs will examine ways of expanding PLS
- IOUs will work with parties to explore standard offer for PLS, including, but not limited to thermal energy storage
- Study should consider ways to encourage PLS, such as TOU rates or another RFP process
- Study should summarize PLS offerings in US and evaluation of appropriate incentive payment for future standard offer
- Report will inform proposals to expand PLS in 2012-2014 applications

CPUC Filing 08-27-10

+ CPUC Filing 08-27-10

- Provides guidance for the 2012-2014 demand response applications

+ Section 3.6.2: Permanent Load Shifting

- Permanent load shifting (PLS) involves shifting energy use from one time period to another on a recurring basis
- PLS often involves storing electricity produced during off-peak hours and using stored energy to support load during peak periods
- Examples: battery storage, thermal energy storage, altering processes to shift the time of use or order of production activities
- Utilities 2012-2014 applications will be informed by PLS report
- Should discuss ways to increase cost-effective PLS through dynamic rates, future RFP's or standard offer

Overall CPUC goals

- **Provide a solid foundation for utility filings for a PLS program in the 2012-2014 DR proceeding**
  - Specifically, the proposed cost-effectiveness protocols in this study could be used by the Utilities in their filings
- **Effective stakeholder process to consider multiple perspectives, including**
  - Scope and definition of PLS
  - Cost-effectiveness
  - Technologies to consider
  - Program types
- **Document process and results in the PLS report due on December 1st, 2010**

Related PLS Policy & Regulatory Areas

Energy storage (and load shifting) are emerging components of other energy policy efforts underway in CA

+ AB2514 – requires CPUC to launch a new storage focused rulemaking to determine cost effective and technologically feasible 2015 and 2020 energy storage procurement targets by October 2013
+ SGIP Staff Proposal – implementation of SB 412 may create expanded incentives for energy storage coupled with renewable energy and eligible SGIP technologies on the customer's side of the meter (new funding available through 2012 only)
+ LTPP (CAISO Phase II Modeling) – PLS can be used to facilitate renewable integration, particularly cases of over generation. Workshops are underway at the CPUC to determine modeling requirements.
+ SB 17 Smart Grid Deployment Plans – requires utilities to develop smart grid deployment plans by July 2011. Energy storage is an enabling technology of the smart grid.
+ Federal (Storage ITC) – new federal legislation has been proposed to establish federal tax credits for grid storage – such incentives will have a beneficial impact to CA PLS project economics, potentially reducing the need for state incentives.

PLS definition – goals & principles

Overarching Goal of PLS

- Routine shifting of load from one period of time to another during the course of a day to help meet peak loads during periods when energy use is typically high and improve grid operation in doing so (economics, efficiency, and/or reliability).

Guiding Principles of PLS

- Technology neutral
- Business/ownership model neutral
- Provides measurable shifting at the program level for evaluation, measurement and verification (EM&V).

PLS definition – elements

- **Permanent.** Provides a sustained capacity of load shifting in normal operation a large number of days per year and for many years.
- **Load Shifting.** Decreases electricity usage during peak hours and shifts load to other hours to provide operational and resource planning benefits for the utility or ISO systems (such as increasing load to reduce ramp requirements).
- **Location.** Technology is located behind an electricity customer's meter. All customer classes are eligible to participate.
- **Additional Value Streams.** PLS services must be provided by the technology, but the technology can capture additional value streams if they are also provided.

Outside of scope of PLS

- **Not Solely Event-based DR**. PLS provides for shifting in normal operations, not in response to electrical grid emergencies or constraints.
- **Not Behavior-based EE.** PLS is provided and quantified by discrete equipment or controls, not solely by general customer behavior modification (e.g., home energy monitors). PLS does not reduce the level of customer service.
- **Not Commissioning or EMCS tuning**. The shifting that can be achieved by best practices commissioning, retro-commissioning or adjustment of controls (e.g., broadening set point temperature ranges or precooling a building) will not be considered PLS.
- **Not Fuel Switching**. Does not provide PLS through switching load to a different fuel.

'Back of the Envelope' Calculation

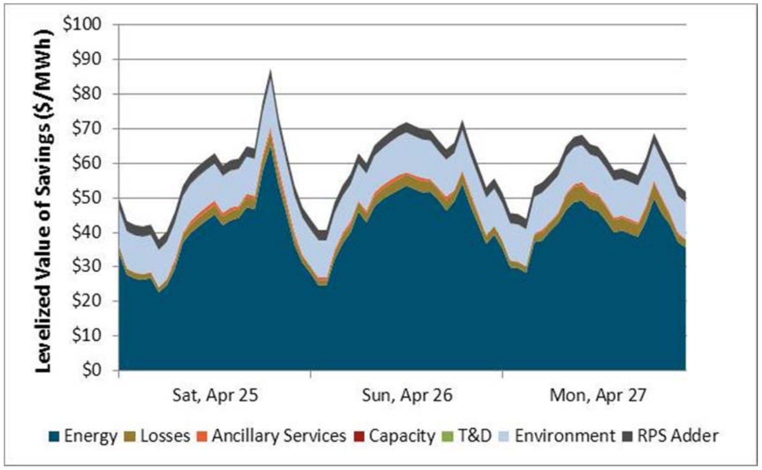
+ High Level Estimate of Value

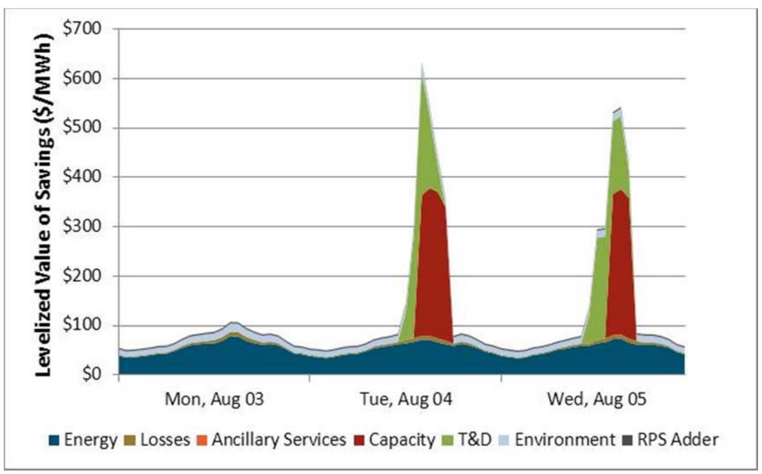
- Assumptions
  - 15 year life
  - Utility WACC (8%)
  - Capacity value $100/kW-year
  - Energy differential $40/MWh
  - Energy profile
    - 30% of time charging
    - 30% of time discharging
    - 40% idle
    - 2628 kWh / kW

Input Assumptions	
15	Life
8%	WACC
100	$/kW-year
40	Change (Buy - Sell) $/MWh
30%	Energy Charging Time
2628	Annual Energy (kWh)
Net Present Value Benefits	
$856	Capacity ($/kW)
$900	Energy ($/kW)
$1,756	Total Value ($/kW)

Components of the Avoided Cost

Three-Day Avoided Cost Snapshots





- Energy
- Losses
- Ancillary Services
- Capacity
- Transmission & Distribution
- Environment
- Avoided Renewable Purchases

Avoided Cost Model and Relationships

Benefits Included

Proposed in the DR C/E Proceeding

- Energy purchases or generation cost
- Generation Capacity
- T&D Capacity
- GHG Emissions
- Losses
- Ancillary Services Procurement Reduction
- Reduced RPS procurement
- Renewable Integration
  - Reducing overgen, Ramp

PLS Only – Under Development

CPUC proceedings with similar approach

- Energy Efficiency
- DG Cost-effectiveness
- Demand Response

CEC proceedings with similar model

- Title 24 Time-Dependent Valuation for evaluation of building standards

Characteristics of the Avoided Costs Used in the DG Cost-Effectiveness Framework

+ **Hourly:** the hourly time scale used in the avoided costs allows them to capture the relative value of retail load reductions at different periods throughout the day and across different seasons

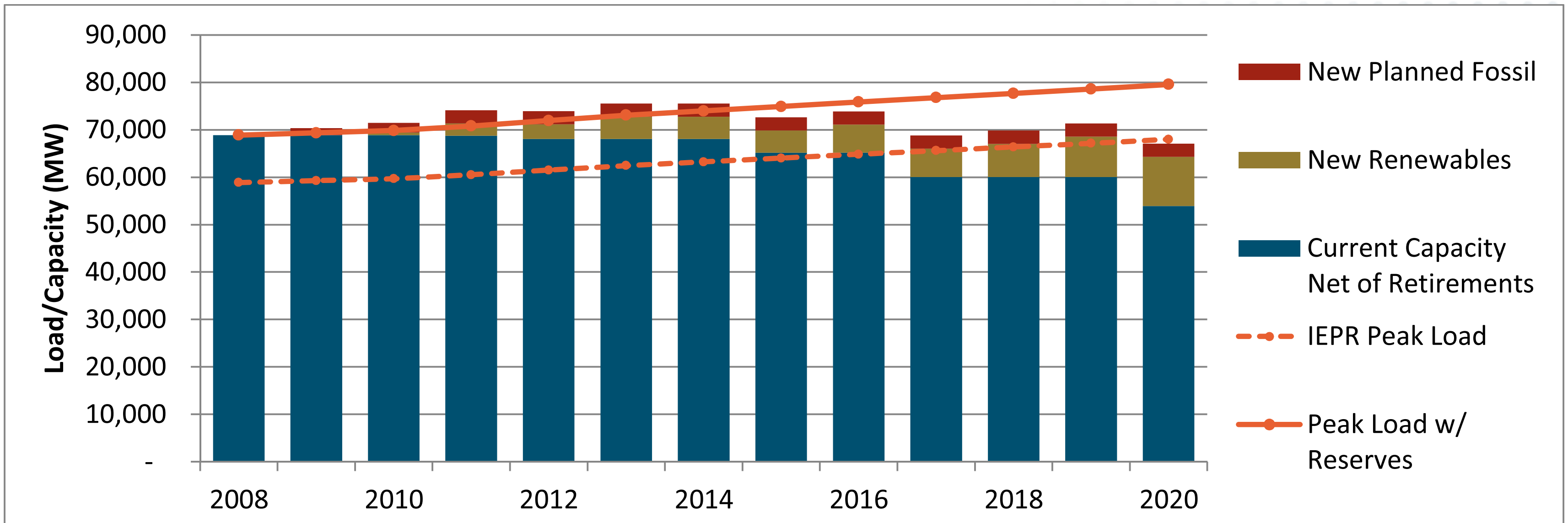
+ **Location-specific:** the avoided costs are calculated for each of the Title 24 climate zones, incorporating differences between northern and southern electricity markets and between the timing of local load constraints

+ **Historically correlated:** the avoided costs are based on historical hourly market data so that they are correlated directly with actual historical performance of DER technologies

+ **Public and transparent:** the avoided costs are calculated using publicly available data

Resource Balance Year

- **The avoided costs include short- and long-run components**
  - Short-run components based on current market activity
  - Long-run components based on cost and performance of new generation
- **The transition point between the short- and long-run costs in the DER Avoided Costs is 2015, the first year in which peak loads will exceed currently resource plans**



Broad Scenario Modeling

Broad Scenario Modeling

- Evaluate avoided costs and bill savings of PLS over a range of hypothetical conditions
- Allows us to explore idealized value of shifting over a range of conditions independent of the specific PLS technology performance

Assumptions, Variables, Metrics

Key Assumptions

- 100% round trip efficiency
- Shift is sized to 15% of maximum end use kW
- Shift is constant, year round, every day

Variables

- Discharge start time and duration

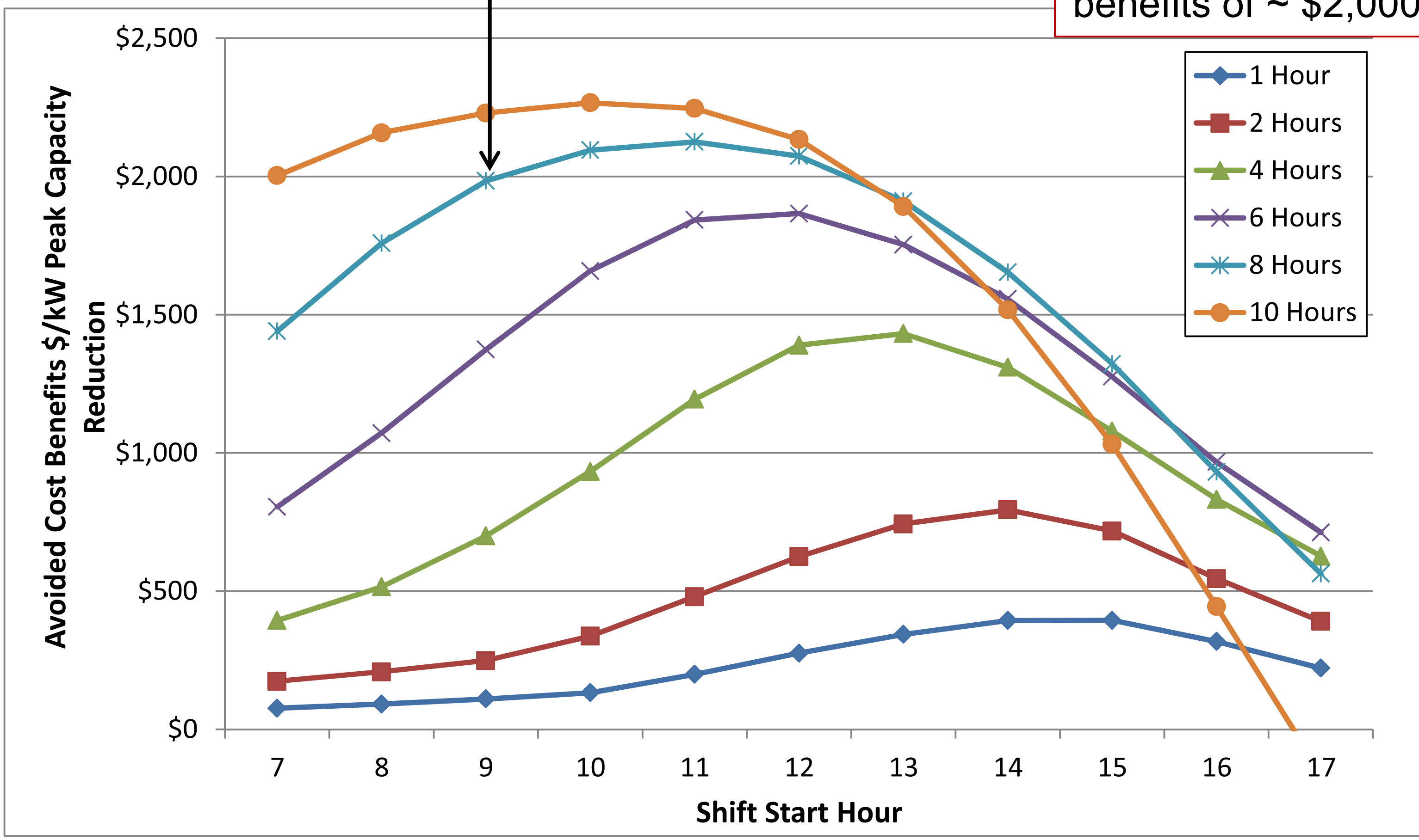
Metrics

- Present value of benefits/avoided costs in $/kW
- Present value of bill savings in $/kW
- Assumptions: 15 year measure life, 8.5% discount rate
- Normalized to maximum shifted kW

Broad Scenario Modeling Results

+ Avoided costs across all scenarios

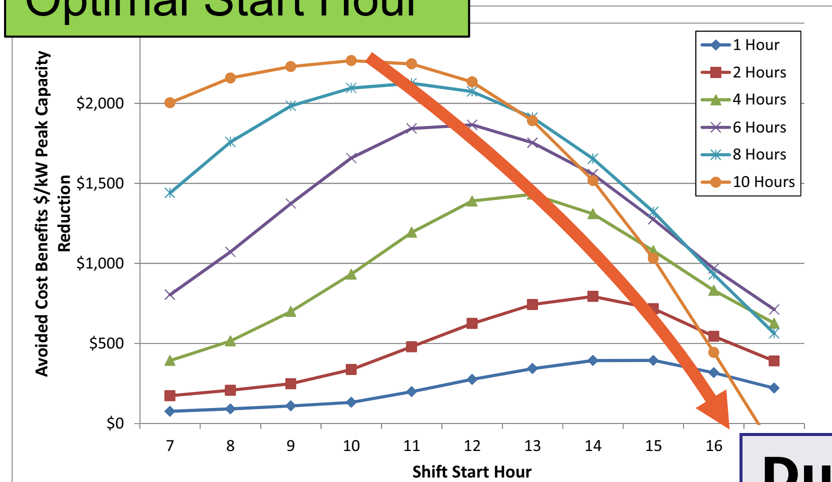
Ex: 8 hour shift starting at 9 am has present value benefits of ~ $2,000/kW



Climate Zone 12 (e.g., Sacramento)

Best Discharge Windows based on Avoided Costs

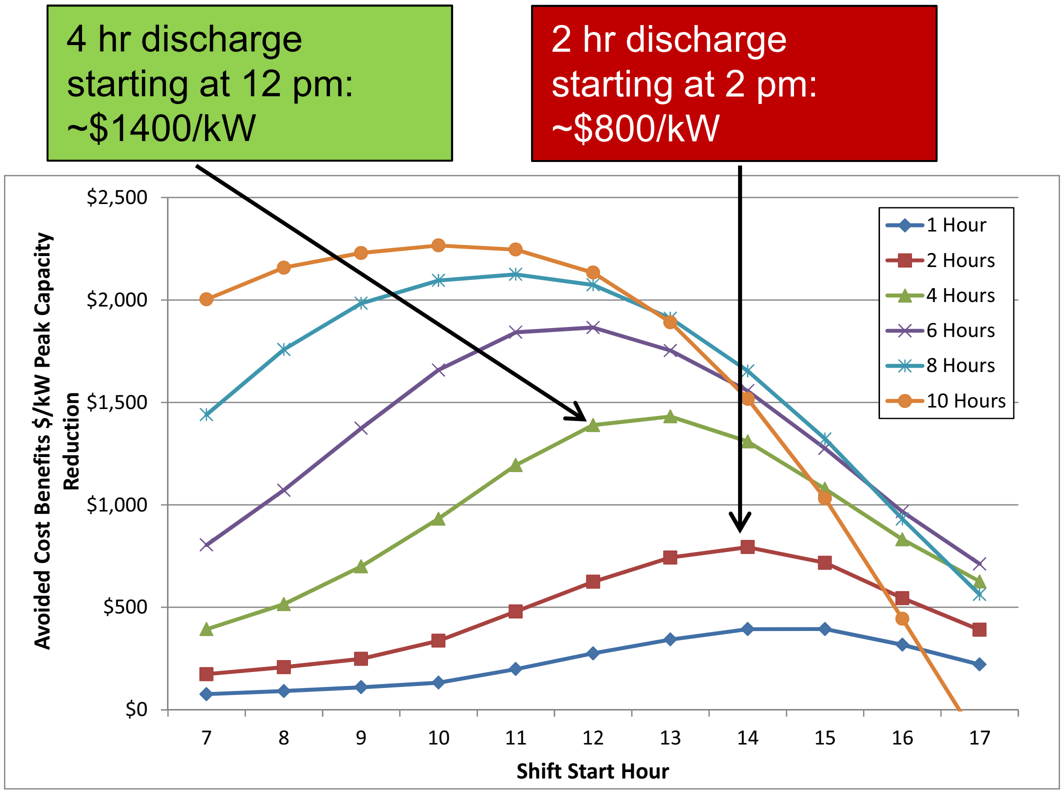
Optimal Start Hour



Duration (h)	Start- end time	$/kW
1	2-3 pm	~ 390
2	~1/2 – 3/4 pm	~ 790
4	12 – 4 pm	~ 1430
6	12 – 6 pm	~1860
8	11 – 7 pm	~2125
10	10 am – 8 pm	~2260

Comparing Two Scenarios with Equivalent Energy Shift

- **Comparing a 4 kWh shift:**
  2 hr (2 kW) discharge vs. 4 hr (1 kW) discharge



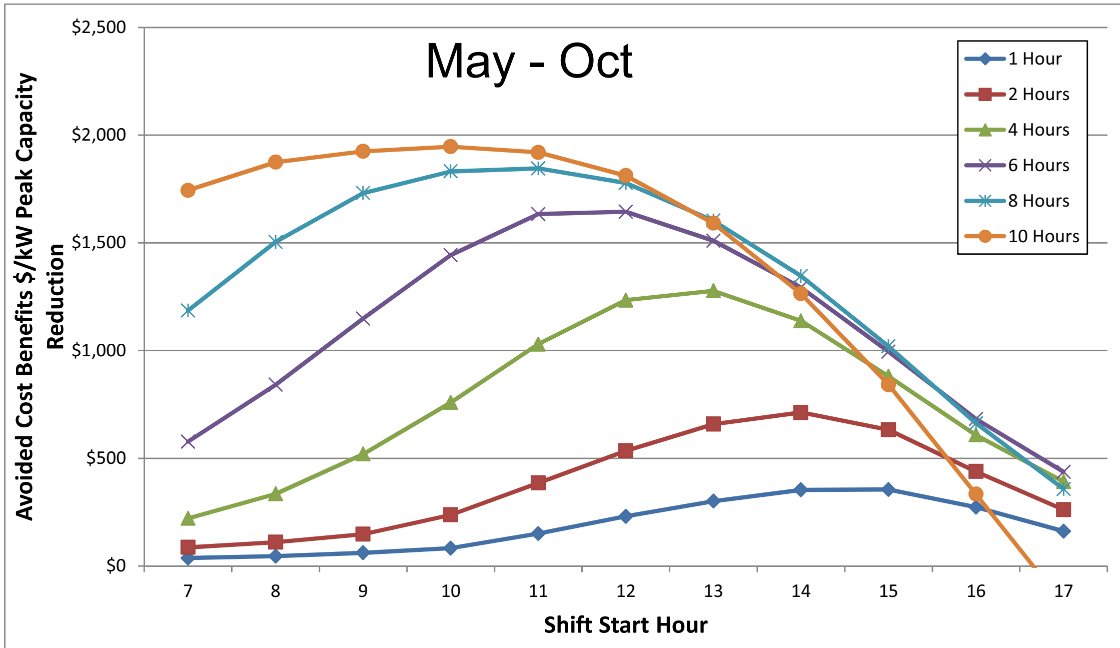
- **4 hr discharge: avoided costs = $1400 x 1 = $1400**
- **2 hr discharge: avoided costs = $800 x 2 = $1600**
- **Shorter duration discharge has more value on an equivalent energy basis**

Observations on Avoided Cost Results

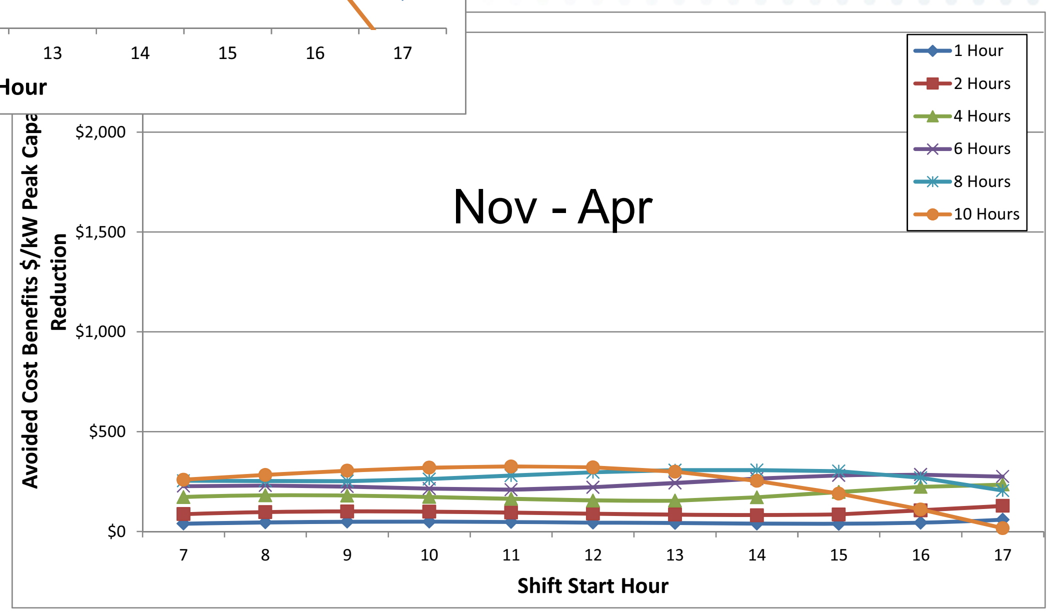
- **PLS technologies must cost on the order of $1500/kW to $2500/kW to pass TRC test**
  - Estimate is an upper bound based on idealized operation
- **Highest value: mid-afternoon, then early evening, then mid-morning**
- **Optimal 6 hour discharge period is 12-6 pm**
- **PLS technologies support entire map**
  - Batteries support 1-8 hour discharges
  - TES systems often designed to reduce load for at least 6 hours but can reduce load longer if capacity exists
  - Process shifting that begins at 11 am and concludes at 9 pm

Sensitivity Analysis

Seasonal Sensitivity: Avoided Costs



- Avoided costs in summer dominate (winter avoided costs ~ 80% less than summer)
- Winter avoided costs insensitive to discharge time



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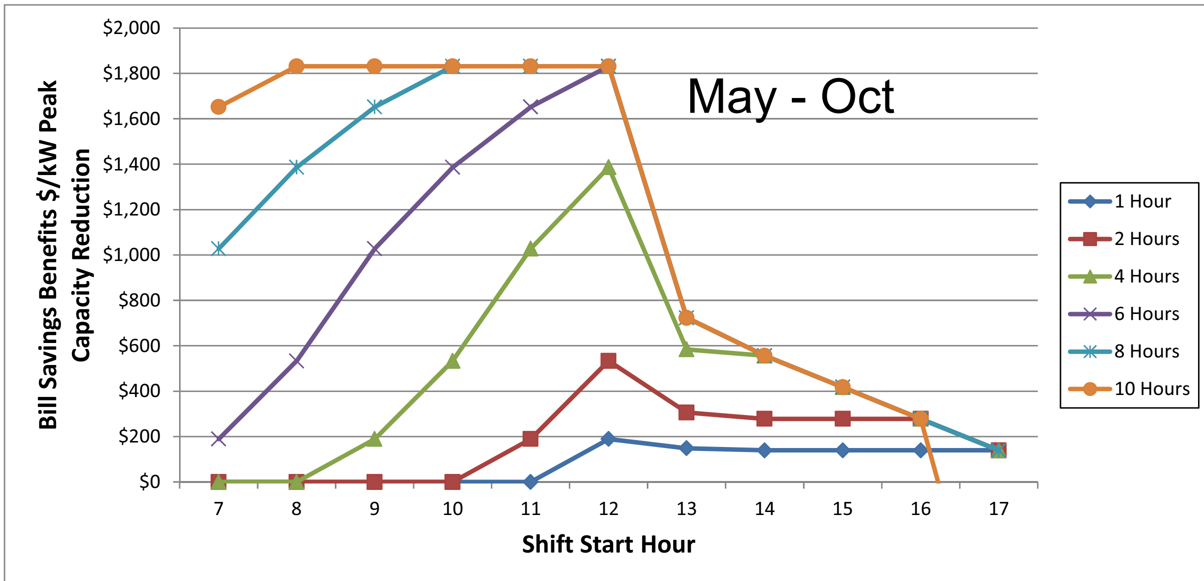
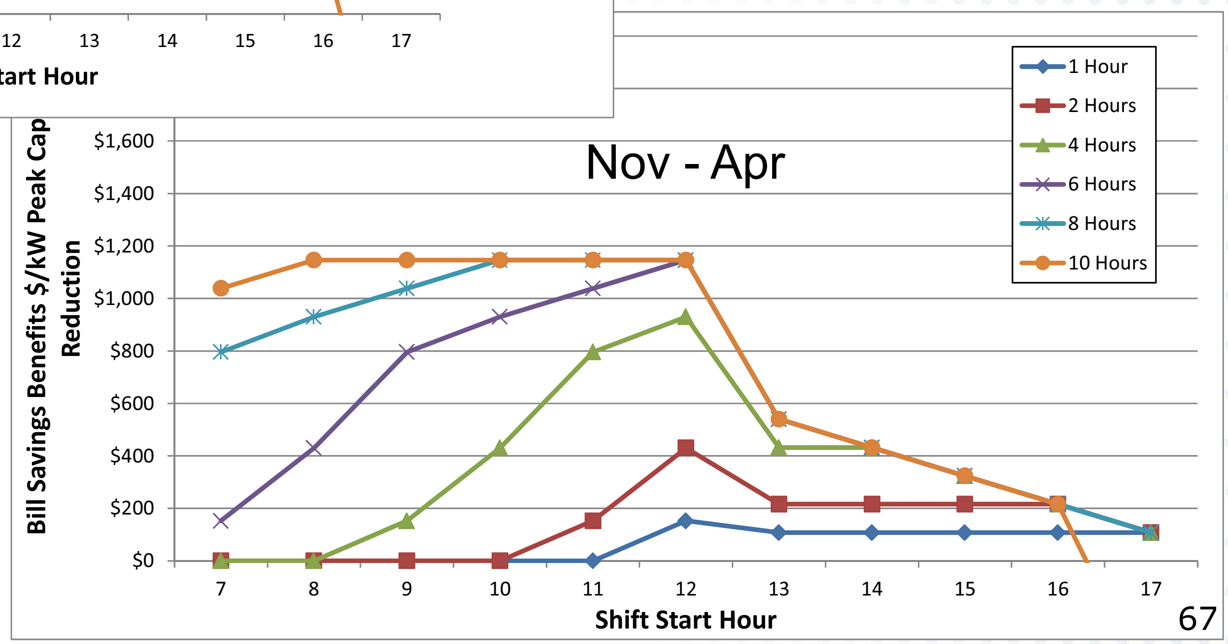
Seasonal Sensitivity: Bill Savings

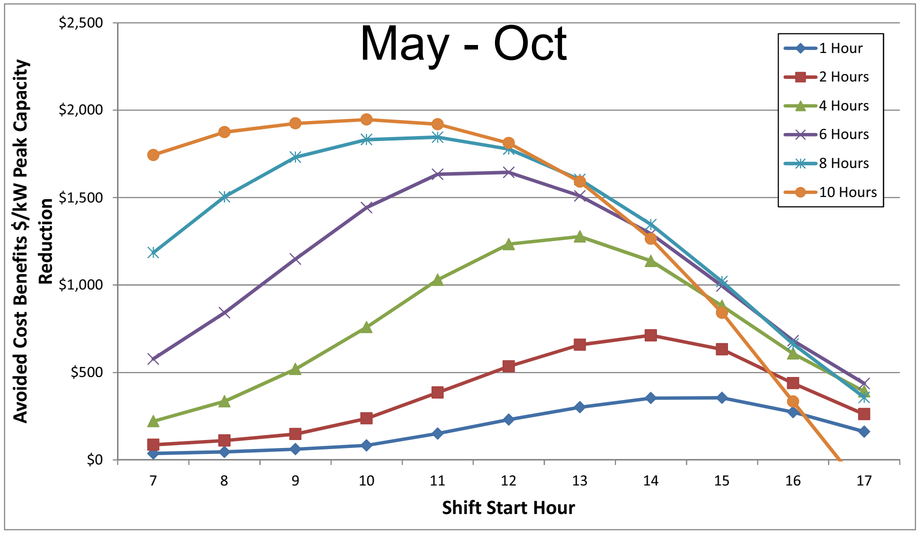


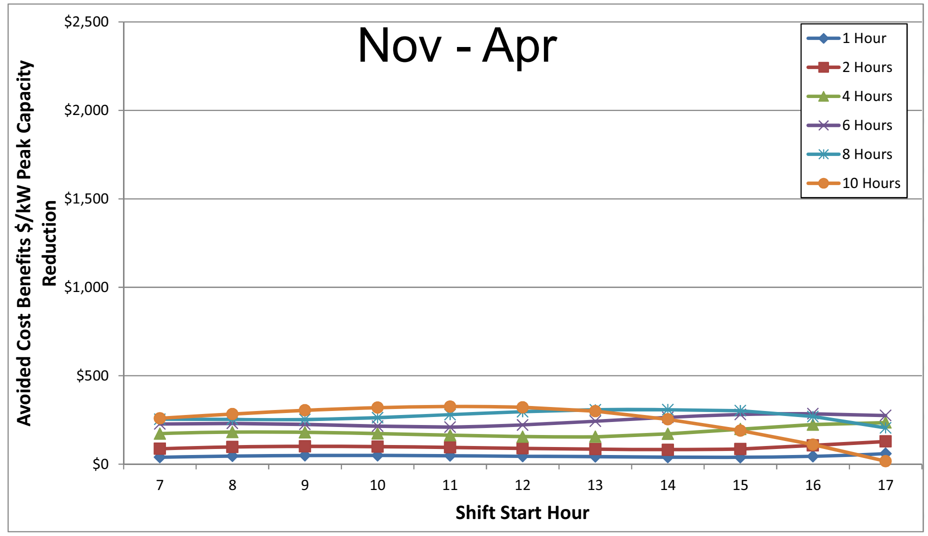


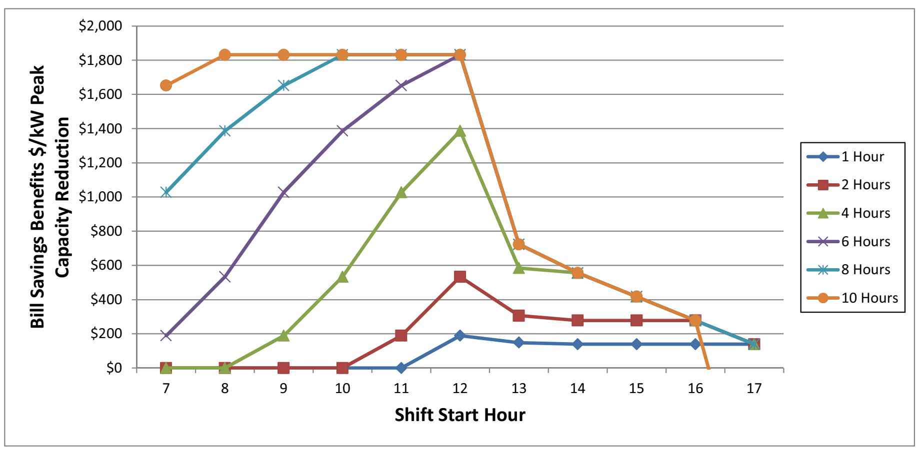
- **Bill savings ~ 60% less in winter but still significant**

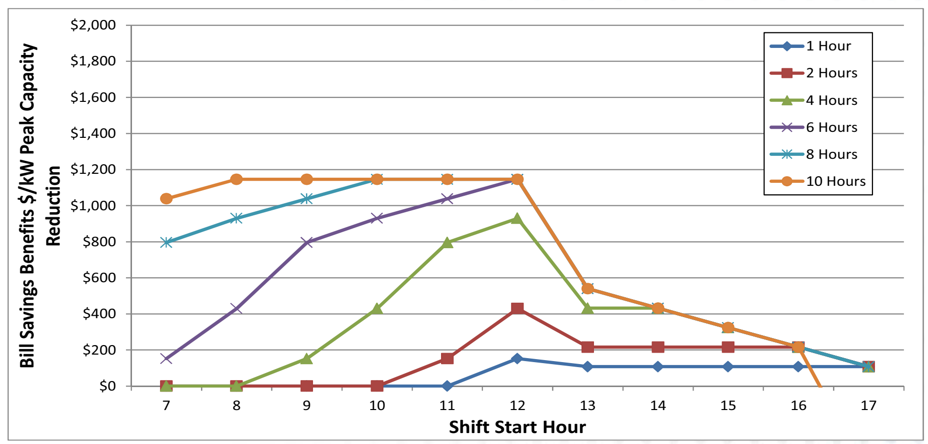
Seasonal Sensitivity: Avoided Costs and Bill Savings

Avoided Costs





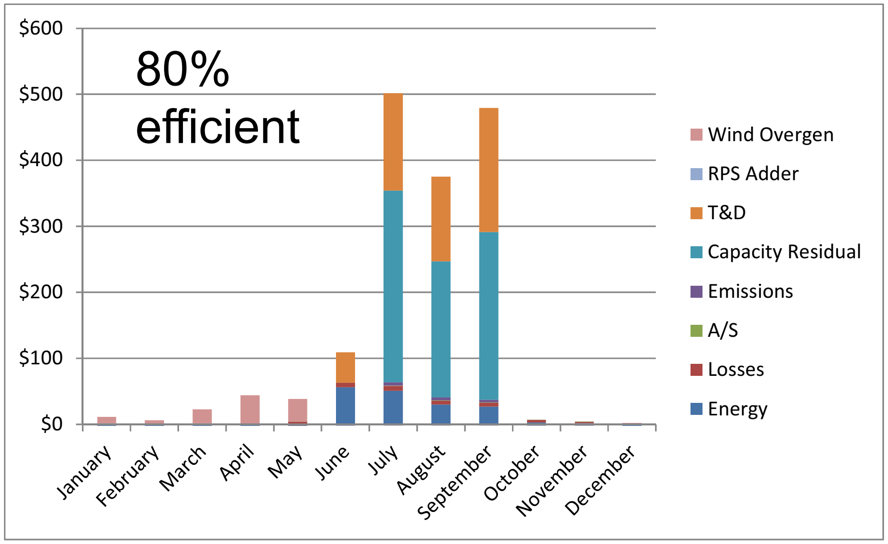


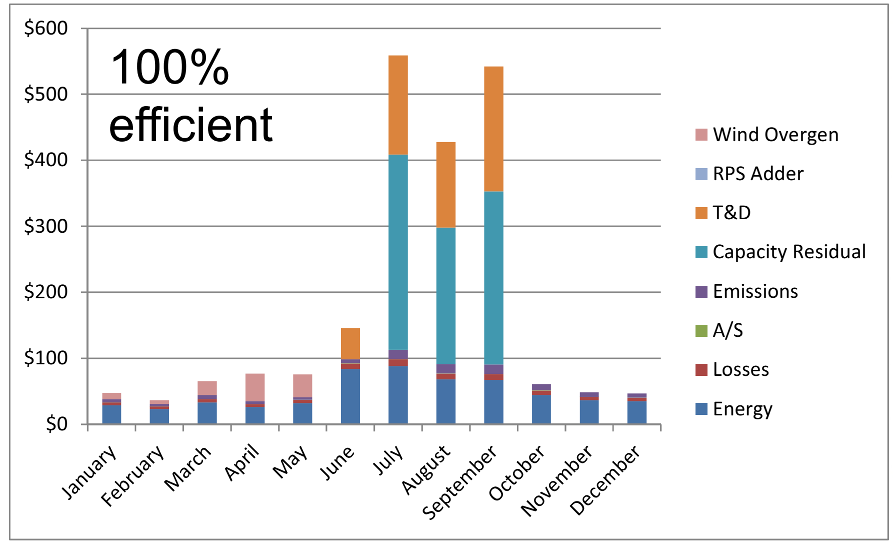


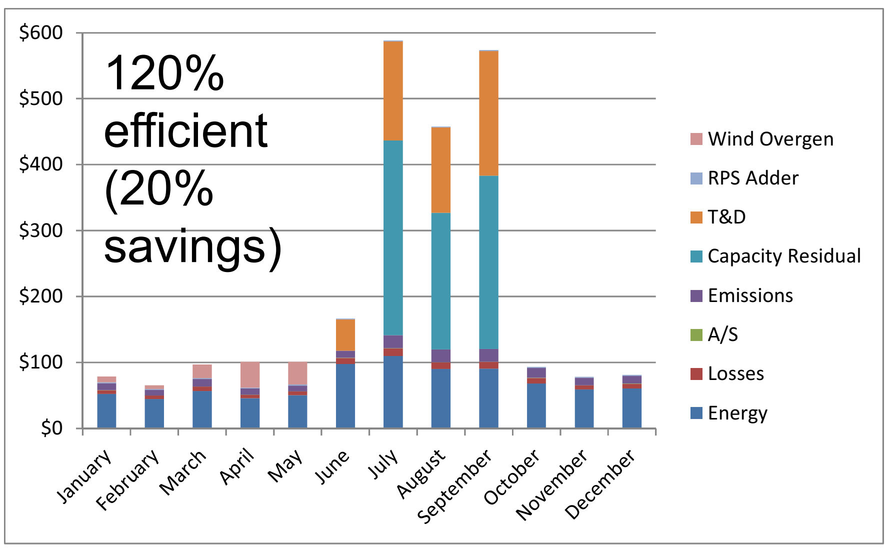
Bill Savings

Sensitivity to Energy Efficiency (round-trip): Avoided Costs

Avoided Cost Benefits PV $/kW
Peak Capacity Reduction



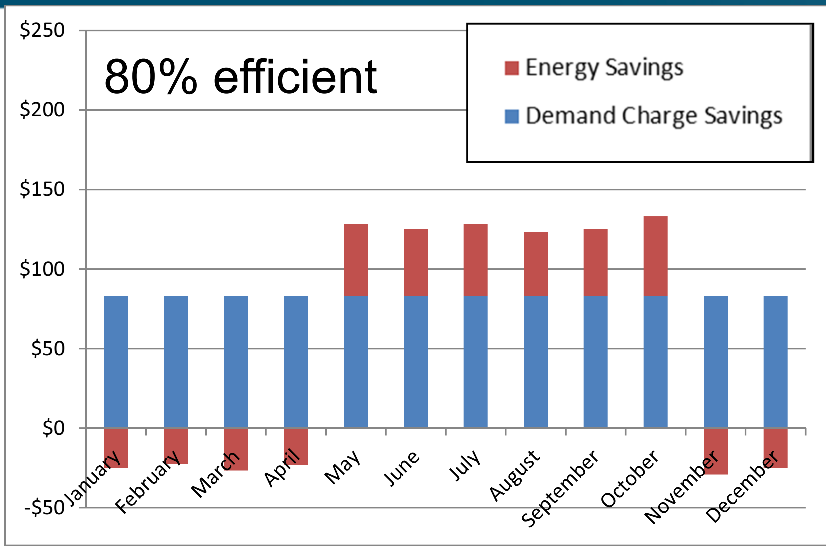


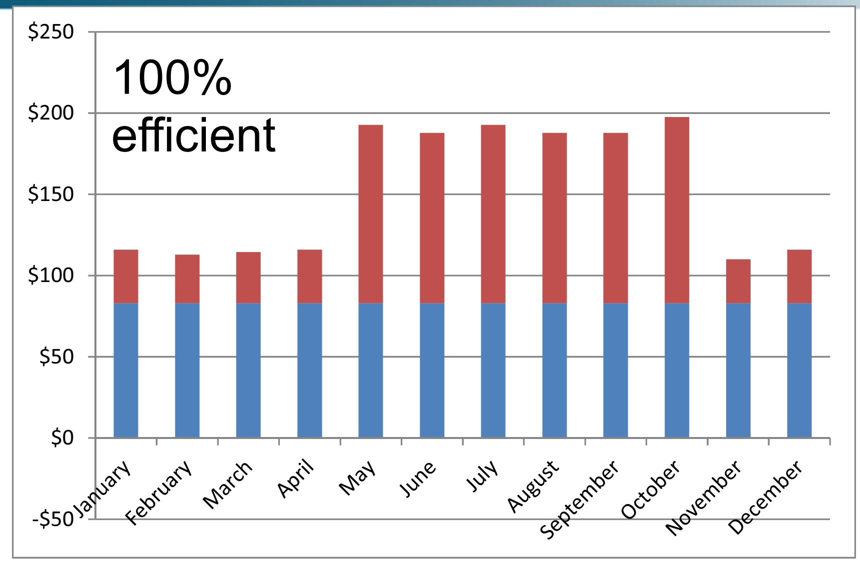


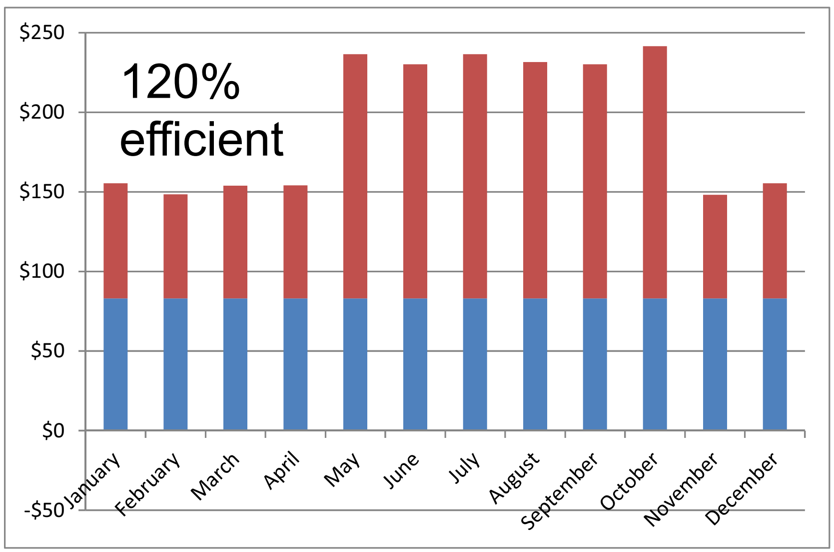
- **10 hour discharge: 10 am – 8 pm**
- **120% efficient system increases benefits by 16%**
- **80% efficient system reduces benefits by 29 %**
- **Greater impact in winter season, though benefits in winter are nominal**

Sensitivity to Energy Efficiency (round-trip): Bill Savings

Bill Savings Benefits PV $/kW Peak Capacity Reduction



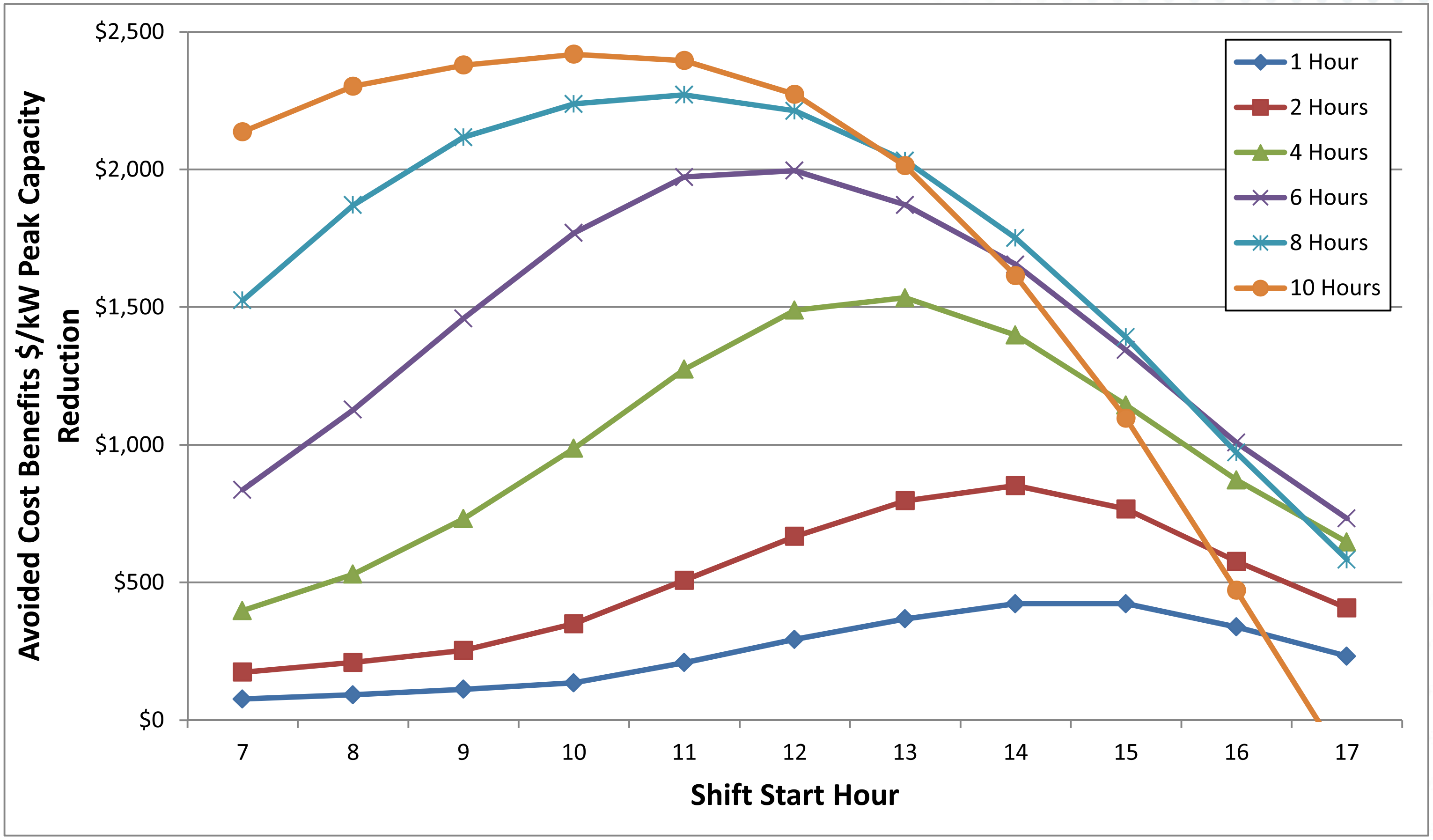




- **120% efficient system increases benefits by 27% (vs. 16% avoided costs)**
- **80% efficient system reduces benefits by 39 % (vs. 29% avoided cost)**
- **Efficiency matters more for bills!!**

Sensitivity to Resource Balance Year

- Assumed resource balance year: 2010
- Roughly 7% increase in total avoided cost savings



Sensitivity to Technology Lifetime

- With a technology lifetime of 20 years rather than 15 year, both present value avoided cost benefits and present value bill savings increase by approximately 13%