Energy Storage To Support SMUD's Sustainable Energy Goal

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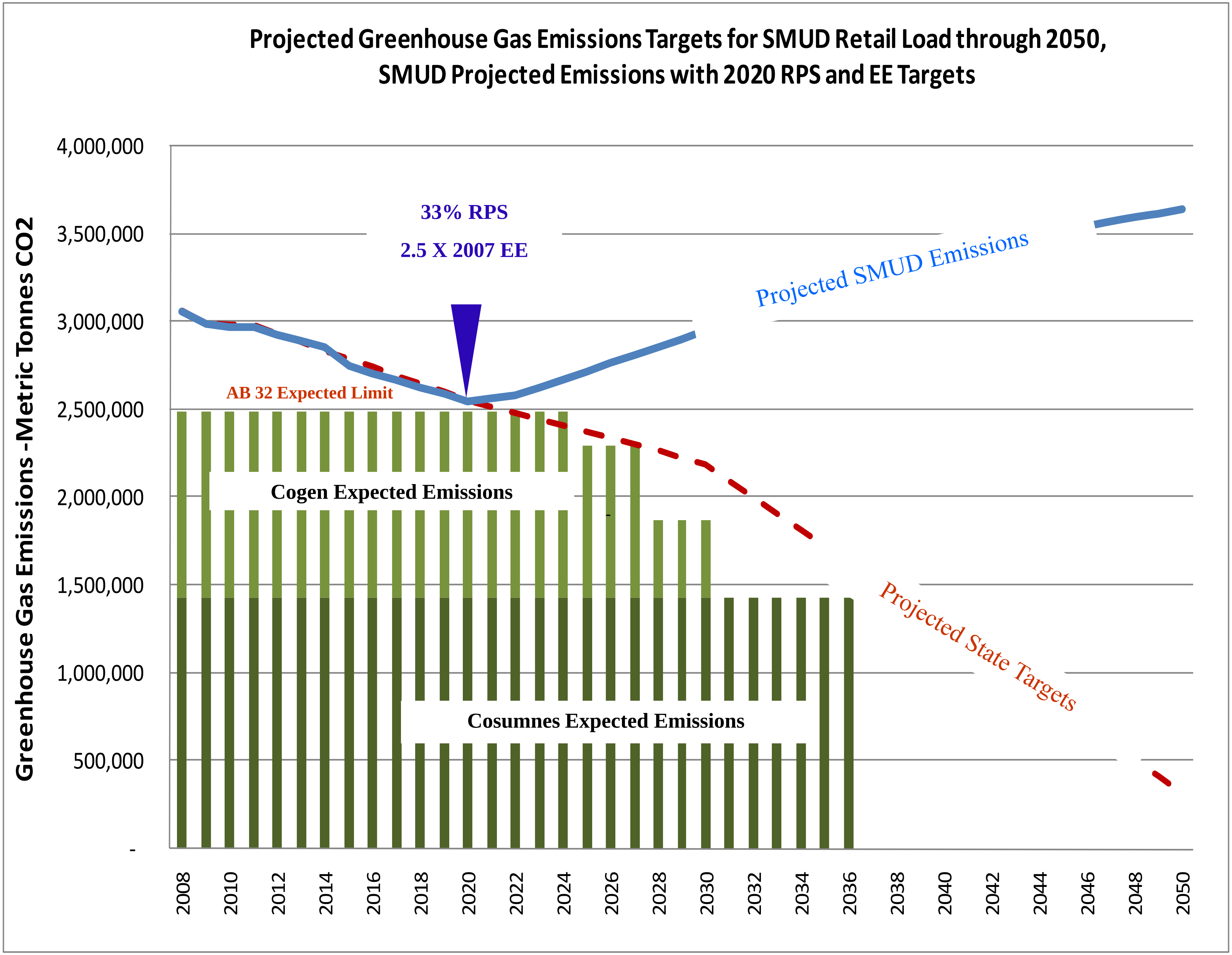
SMUD
SACRAMENTO MUNICIPAL UTILITY DISTRICT
The Power To Do More.[SM]

What Is Driving SMUD's Storage Interest?

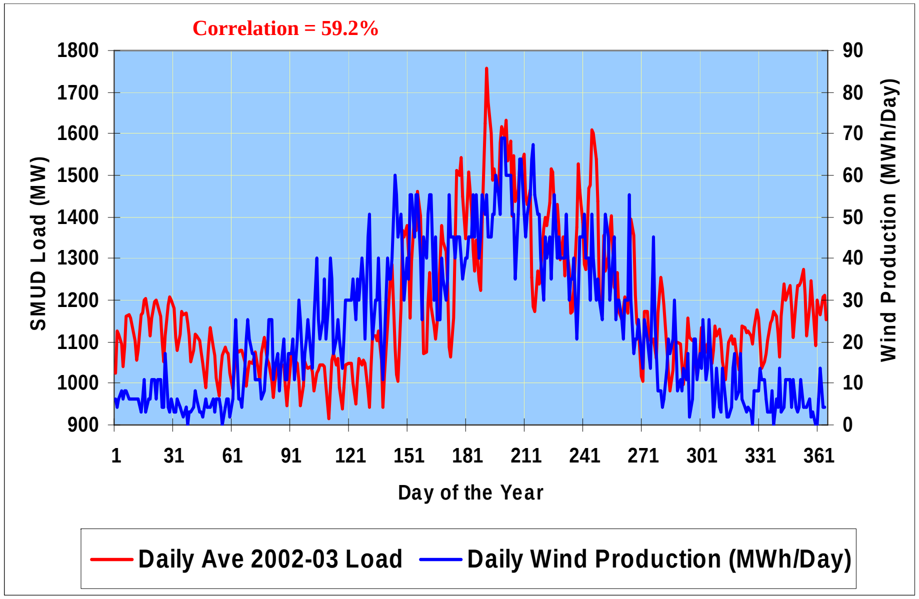
- GHG Regulations
  - Reshaping Energy Supply
  - Prompting PHEV Development
- RPS-driven Wind And Solar Energy Additions
  - Wind—weak Forecasting, Large Ramps, Unpredictable Production During Super Peaks
  - Solar—peaks 4-5 Hours Before Utility Peak

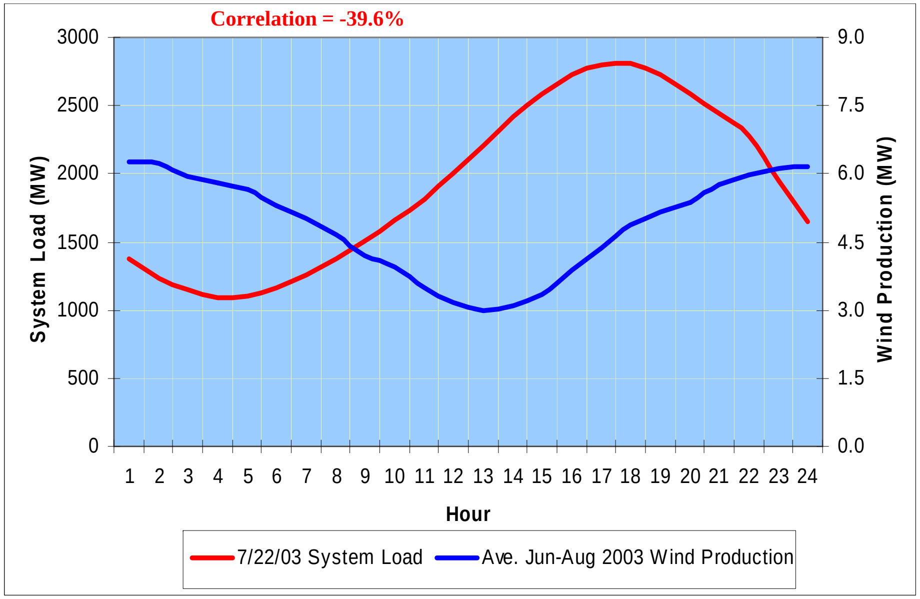
Sustainable Energy

A sustainable power supply is defined as one that reduces SMUD’s ***long-term greenhouse gas emissions from generation of electricity to 10% of its 1990 carbon dioxide emission levels by 2050*** (i.e. - <350,000 metric tonnes/year), while ***assuring reliability of the system***; ***minimizing environmental impacts*** on land, habitat, water quality, and air quality; and ***maintaining a competitive position*** relative to other California electricity providers.


Projected Greenhouse Gas Emissions Targets for SMUD Retail Load through 2050,
SMUD Projected Emissions with 2020 RPS and EE Targets
Greenhouse Gas Emissions -Metric Tonnes CO2
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
-
33% RPS
2.5 X 2007 EE
Projected SMUD Emissions
AB 32 Expected Limit
Cogen Expected Emissions
Cosumnes Expected Emissions
Projected State Targets
2008
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
2042
2044
2046
2048
2050

SMUD Wind Generation





- SMUD's peak load driven by hot summer temperatures
- Wind resource weakest on hottest days
- Comparing daily and hourly system load with Solano Wind Plant production illustrates mismatch
- Must rely on firming resources to address mismatch and ensure system stability

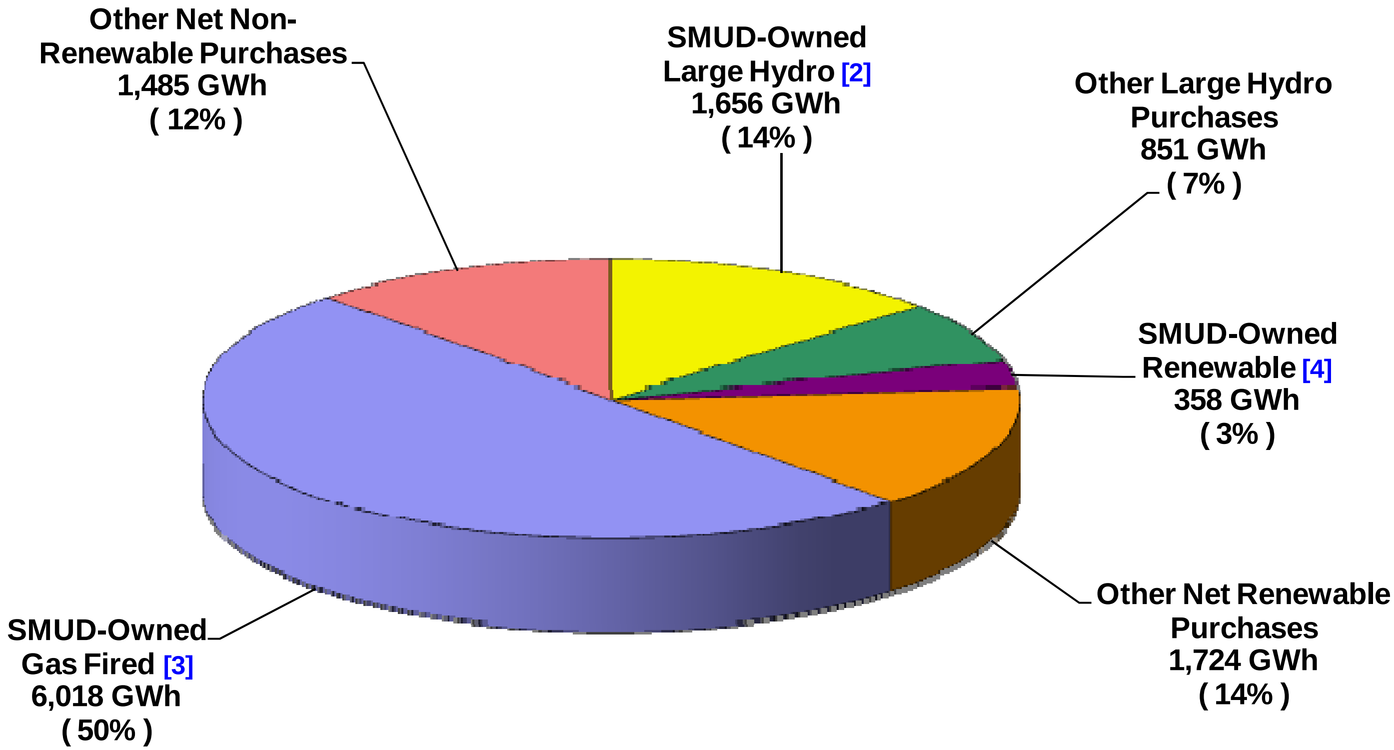
SMUD's Storage Approach

- Believe SMUD will need bulk **<u>and</u>** distributed storage in long run
- Questions of what kind, how much of it and when, and how much will it cost
- Pursuing a multi-pronged approach:
    1. Developing improved understanding of storage technologies
    2. Anticipate starting preliminary design on bulk storage project in 2010
    3. Determining the benefits of distributed storage to SMUD
        - Modeling and analytical work – assess the value of different storage technologies deployed at high value sites on the T&D system
    4. Conducting some distributed storage system demonstrations and monitoring performance
    5. Preparing SMUD for energy storage utilization

Additional Information

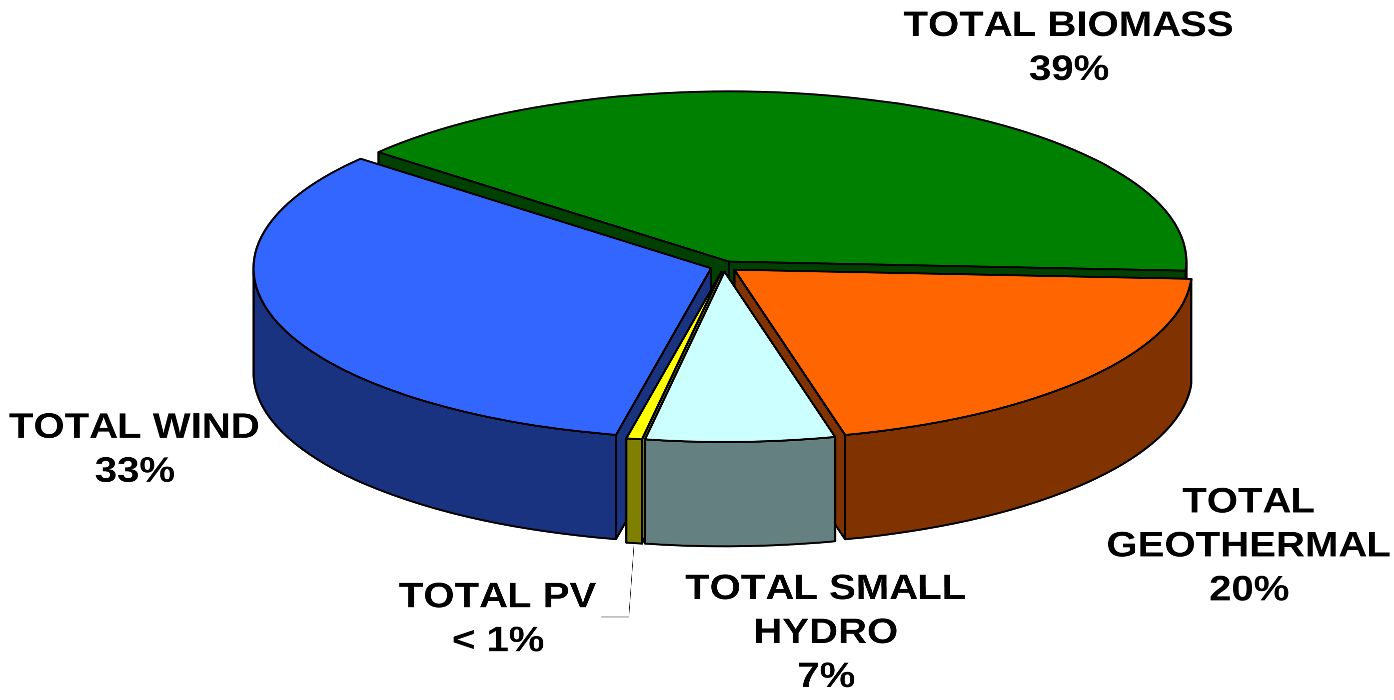
Expected Net Energy Requirements

(12,093 [1] GWh)

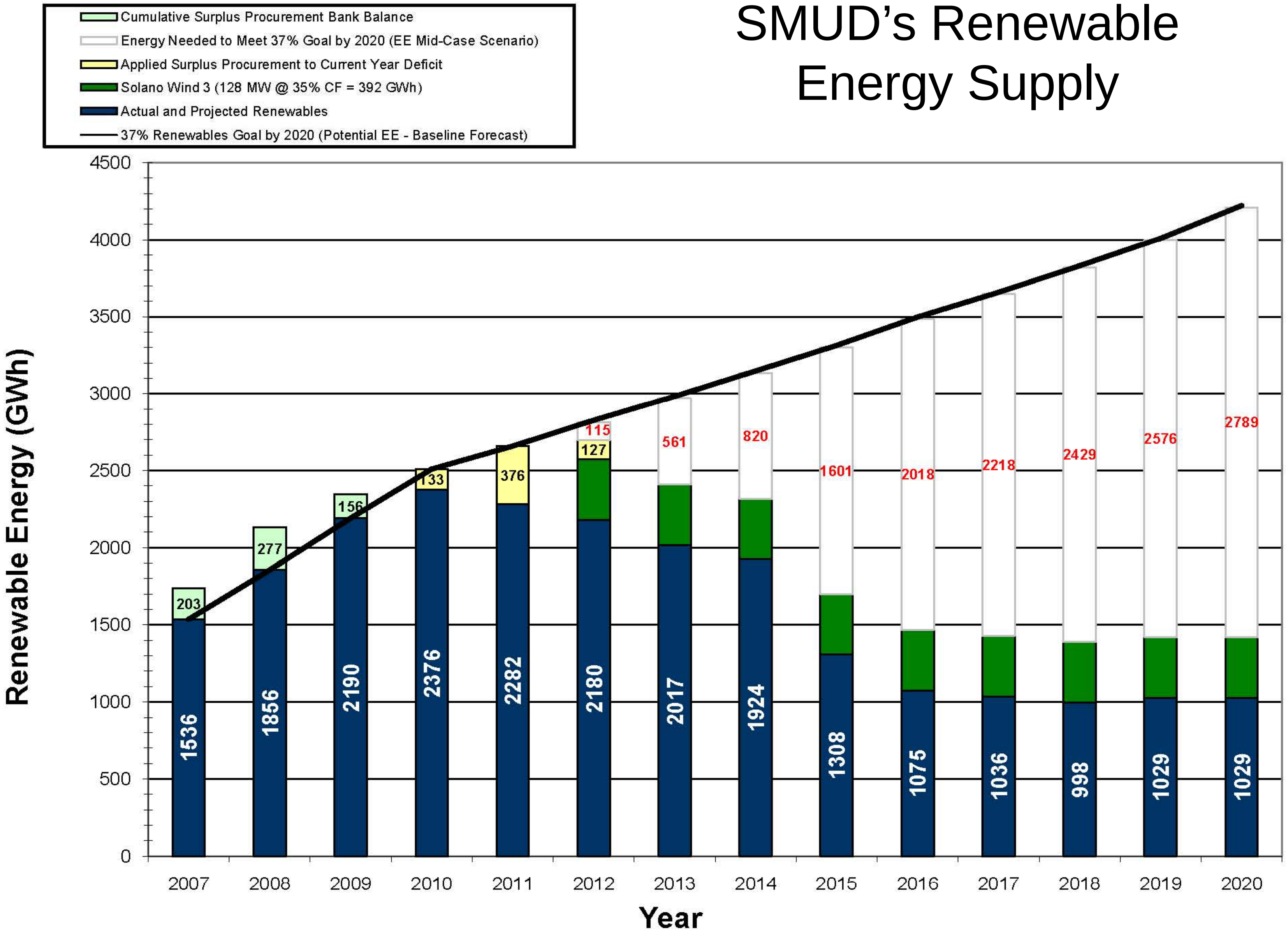


[1] *Expected Net Energy Requirement includes committed energy, exchanges, and wholesale sales*
[2] *This category excludes UARP's Jones Fork, Robbs & Slab Creek generation*
[3] *This category excludes Digester Gas generation from Carson Ice (CVFA) plant*
[4] *SMUD-owned renewable resources includes UARP's Jones Fork, Robbs & Slab Creek, Solano, PV and CVFA Digester Gas related generation*

2008 Renewable Energy Mix



SMUD's Renewable Energy Supply



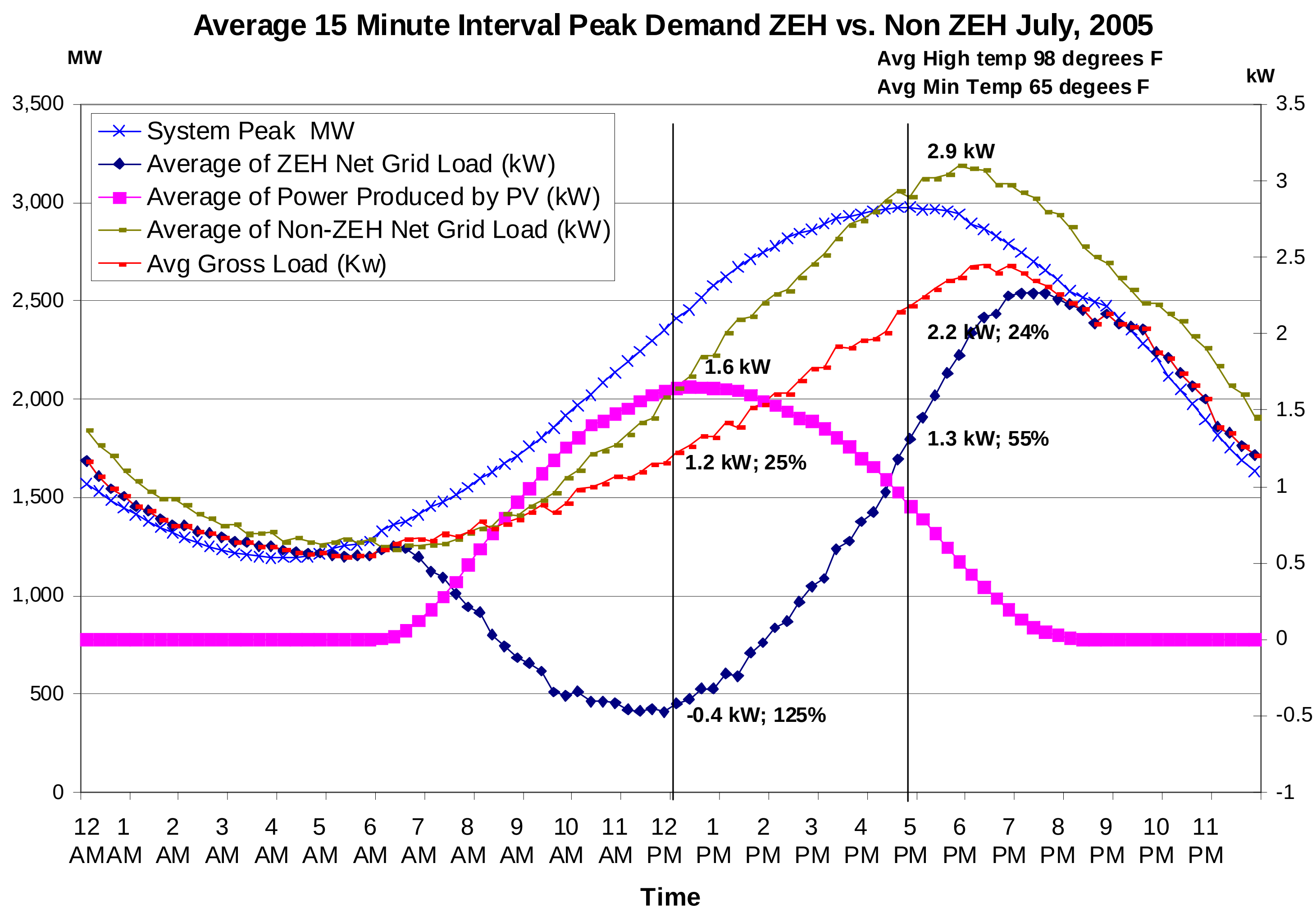
RENEWABLES TRACKING DATA.xls

Last Updated: 3/10/2009

2050 LOAD CHALLENGES

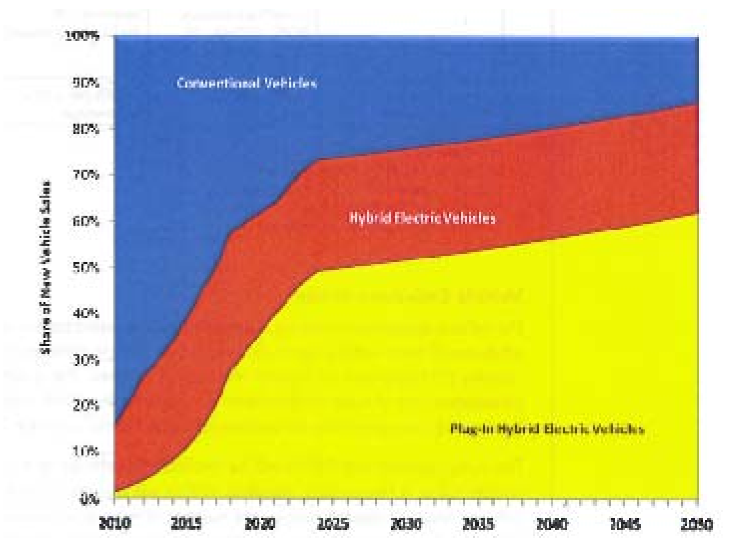
- Thermal/Carbon emitting - ~10%
- Large hydro - ~15-20%
- Other non-carbon resources - ~70-75%
  - Renewables (33%+?)
  - New demand-side/energy efficiency programs
  - Carbon sequestration
  - Other non-carbon generation
  - Purchasing carbon offsets

PV/ZEH Load Compared To System Peak



Projected PHEV Penetration Load Impacts

EPRI PHEV Market Penetration Projection



Assumed new car market share for the Medium PHEV scenario for conventional vehicles, hybrid electric vehicles, and plug-in hybrid electric vehicles for each vehicle category

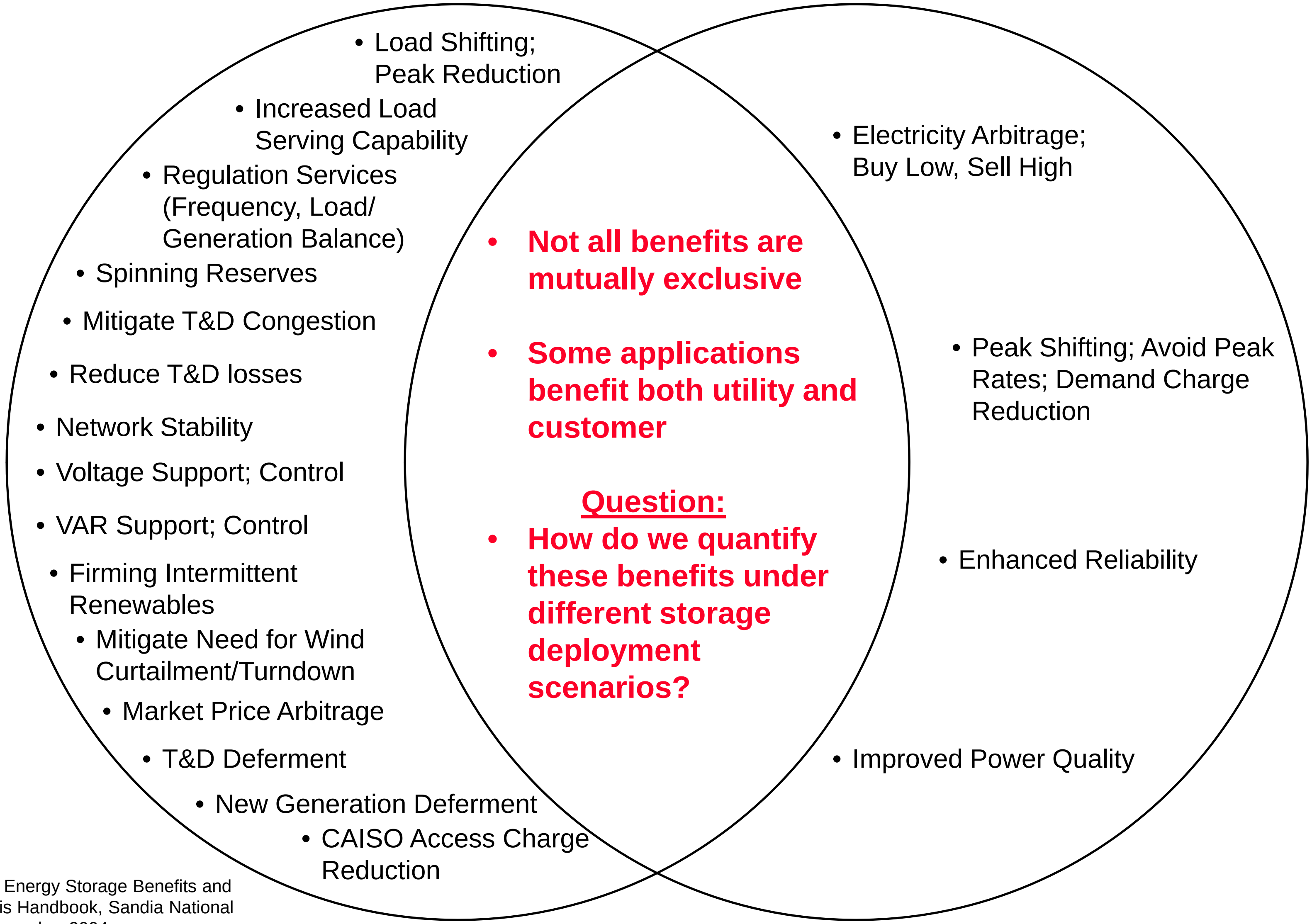
EPRI-NRDC 2007 Study

Year	EPRI* PHEV%	Sacto PHEV Qty.	Load**	Annual*** Energy
2015	**11%**	**24,053**	**36MW**	**53GWh**
2020	**35%**	**135,209**	**203MW**	**296GWh**
2025	**49%**	**330,330**	**495MW**	**723GWh**
2030	**52%**	**490,097**	**735MW**	**1,073GWh**

*New car sales percentage
**Assumes 1.5 kW charger per vehicle
***Assumes 6kWh charge per day for worst case scenario

Variety of Potential Applications and Benefits

Utility Grid Benefits | Customer-Side Benefits



Adapted from: Energy Storage Benefits and Market Analysis Handbook, Sandia National Laboratory, December 2004

Optimal Technologies - Past and Future

- Used Optimal to optimize SMUD load serving and import capability using DG and capacitor banks
- Compound objective: minimize real and reactive power losses and minimize voltage variation
- Results used in part by Transmission Planning for placing recent capacitor additions
- Work planned for 2009 to expand effort for DG and storage
  - Update transmission model
  - Integrate distribution system
  - Incorporate modeling “validation” functions for Transmission Planning
  - Determine optimal locations for storage and DG technologies
  - Compare storage costs to traditional solution costs

Vehicle to Grid - Home Energy Potential

- 50th percentile commute pattern is 13 miles round trip
  - SACOG commute database
- 13 Miles round trip estimated to need 3 kWh average for PHEV Energy
  - Based on 2006 SMUD PHEV Testing and historical BEV energy data
- Parametric Vehicle to Grid / Home Energy Storage Potential
  - Assume 3 kWh of usable energy storage on average day

Year	Sacramento Aggregate # PHEV's	Usable Energy
2015	24,053	72 MWh
2020	135,209	405 MWh
2025	330,330	991 MWh
2030	490,097	1,470 MWh*

***1470 MWh approaches 1600 MWh critical peak load need (400MW, 4 hrs/day, 10 days/yr)**

SMUD's Pumped Hydro Storage Project

Key Features of Iowa Hill

- New development added to existing Upper American River Project (UARP), near Placerville, CA
- 400-MW Pumped-storage facility
- New 6,400 ac-ft reservoir atop Iowa Hill
- Existing Slab Creek Reservoir as lower reservoir
- Underground water conveyance and powerhouse
- 2.5-mile transmission tie-in connects to existing UARP transmission line

Benefits

- Helps meet load growth by increasing dependable capacity 400 MW
- Promotes intermittent, non-dispatchable renewable resources by helping to manage their energy output
- Supports load following, improves system reliability, provides voltage control and spinning reserves
- Variable-speed reversible turbines essentially deliver 800 MW of regulation value