SMART GRID ACTIVITIES AT THE SACRAMENTO MUNICIPAL UTILITY DISTRICT (SMUD)

Harvard Electricity Policy Group

Cambridge, MA

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SMUD
SACRAMENTO MUNICIPAL UTILITY DISTRICT
The Power To Be More.℠

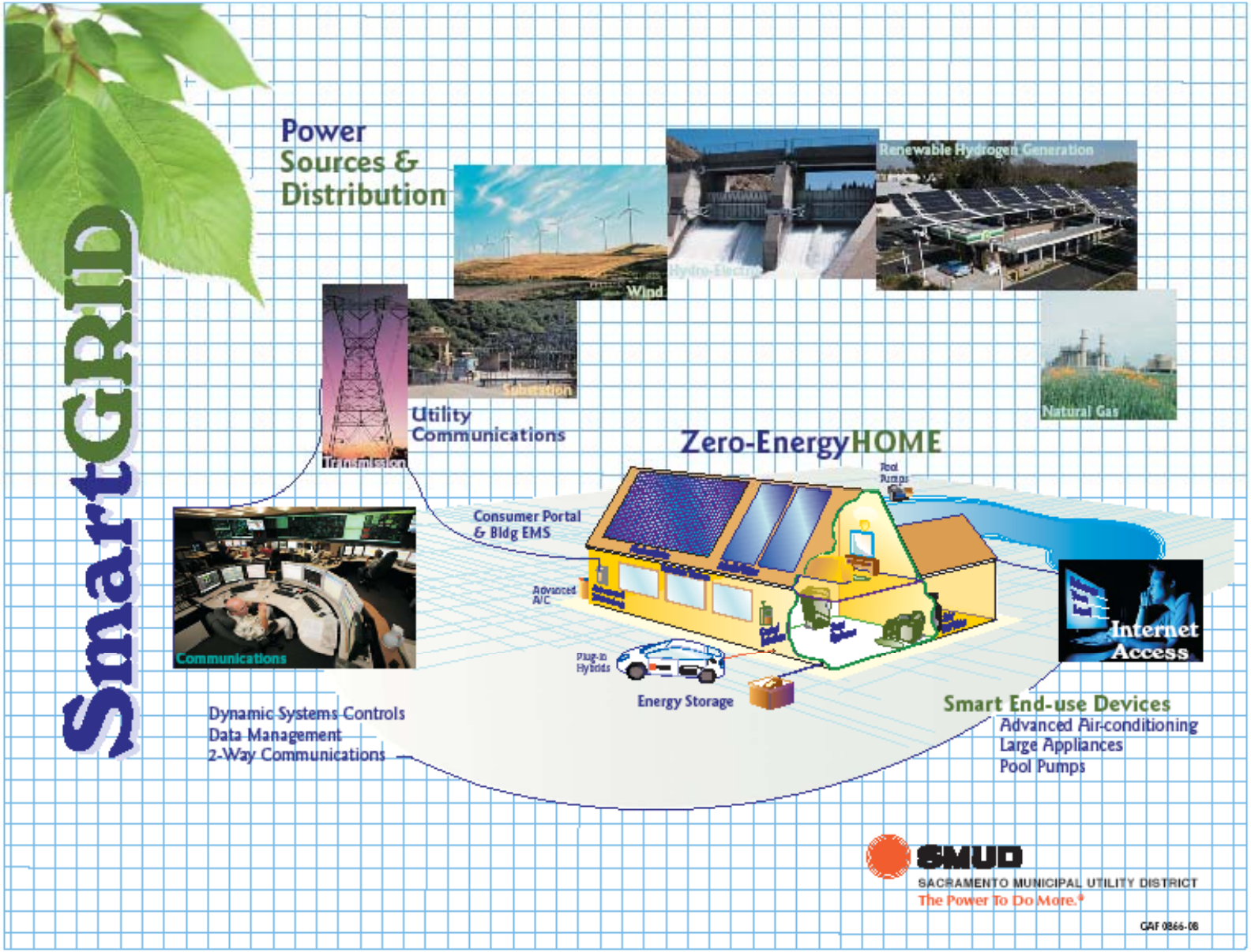





SMUD Profile

- Service territory area: 900 sq mi (2331 sq km)
- Population: 1.4 million
- Board Members: 7 members elected by voters
- Revenues: $1.3 Billion
- Employees: 2,100+
- Summer Peak: 3299 MW in July 2006
- 2nd largest muni in California, 6th in nation

Smart Grid Vision








Project Elements

1. Energy Efficiency
2. Renewables/Distributed Generation
3. Energy Storage
4. Demand Response
5. Advanced Metering Infrastructure
6. Dynamic Pricing
7. Distribution System Improvements
8. Generation Efficiency






Demand Response

- Test the functionality of various control devices (PCTs, in-home displays, home automation controls)
- Test the functionality and operability of controllable appliances
- Implement various TOU and CPP rate structures
- Install auto DR for both customer and utility load management
- Determine what information, and in what form, best facilitates customers making decisions about energy use (appliance purchases, envelope enhancements, and behavioral changes)






Historical SMUD DR Research

- 1993 Peak Corps (ACLM) Load Impact Study (residential AC load control program using controllers)
- 1994 Peak Corps Market Study
- 1995 RASS/Peak Corps Survey
- 1997 Customer Segmentation Study
- 2000 Peak Corps Market Study (conjoint analyis)
- 2001 RASS/Peak Corps Survey
- 2003 CEC/SMUD PowerStat Pilot (residential AC load control using thermostats)
- 2004 CEC/SMUD Power Choice Pilot (residential TOU/CPP using thermostats)
- 2006 Statewide CEUS Itron Study
- 2007 Compact with the Customer focus groups (30+)






2003 PowerStat Findings (Peak Corps with T-Stat)

Average kW Savings per Customer

Outdoor Temperature	Peak Corps Savings			PowerStat Savings		
	50%	67%	100%	50%	67%	100%
<=90ºF				0.9	1.2	1.8
91ºF -95ºF	0.5	0.7	1.0	1.0	1.3	2.0
96ºF -100ºF	0.6	0.8	1.2	1.1	1.4	2.2
101ºF -105ºF	0.7	0.8	1.4	1.2	1.6	2.4
106ºF -110ºF	0.8	1.0	1.7			

- Unit kW savings almost double for PowerStat vs. Peak Corps (ACLM)
  - Difference in technologies – Two way communication allows for identification of non-operational controllers and AC units
  - Difference in populations – PowerStat more engaged in program






2004 Power Choice Findings (TOU/CPP with T-Stat)

- Energy use:
  - in the low price period *increased* by 1%
  - in the medium price period *declined* by 8%
  - in the high price period *declined* by 11%
  - during critical price period *declined* by 16%
  - across the summer season *declined* by 4%

Actions Taken	Percent
Checked thermostat display for critical period	83%
Routinely adjusted AC with override buttons	57%
Shifting became a habit in both summer and winter	55%
Had disagreements about using energy at particular times	47%
Changed the default setting of 78ºF for cooling	42%
Shifting became a habit in summer only	40%
Reprogrammed critical peak offsets	10%

Appliances Used

	Time-of-Use Period			
Appliance	Low	Med	High	Crt
Ran AC	**55%**	**60%**	**56%**	**23%**
Washed/dryed clothes	**85%**	**21%**	**13%**	**0%**
Used dishwasher	**72%**	**17%**	**11%**	**0%**
Used computer/printer	**64%**	**66%**	**55%**	**45%**
Watched TV	**60%**	**80%**	**70%**	**57%**
Showered or bathed	**71%**	**29%**	**24%**	**15%**
Cooked or baked	**38%**	**45%**	**34%**	**18%**
Barbequed outdoors	**19%**	**40%**	**47%**	**41%**

- Customers tended to be older, better educated and in the higher income brackets
- $50 Home Depot card to participants
- 4% savings across the summer






Current SMUD DR Research

- 2007-8 Power Choice Home Energy Display Pilot (TOU, no CPP)
  - Measures effects of concerns, capacity and conditions on response to TOU rate
  - Offers education plus usage feedback devices to existing residential TOU customers
  - Collaboration with Research Into Action, Dethman Associates, Washington State University, Mithra Moezzi and Blue Line Innovations, funded by PIER
- 2008 Small Business Summer Solutions Pilot (TOU/CPP & Direct Load Control)
  - Measures effects of pricing and control incentives on load response on small (<20 kW) com
  - Offers education plus PCTs with new critical peak rate or direct load control program to small commercial customers. 2/3 pre-set T-stat, 1/3 utility control, 4 degree temp reset
  - Collaboration with Heshong Mahone Group, Roger Levy Associates, Mithra Moezzi, Residential Control Systems and E-Radio, funded by PIER and SMUD
- 2008-9 Near Zero Energy Home Display Pilot (Standard Tiered Rate)
  - Measures effects of consumption/production feedback on load and consumption
  - Offers education plus usage/production feedback devices to existing energy efficient/solar homeowners
  - Collaboration with ConSol, General Electric, Florida Solar Energy Center, California State University Chico, and NREL, funded by the Building Industry Research Alliance (BIRA) and Building America






2007-8 Power Choice Findings (TOU Only with Display)

Actions Taken	#	%
Air Conditioning (use less, avoid use, open windows, add fans)	48	27%
General Conservation (non-specific shifting or conserving)	35	20%
Laundry (shift, line-dry, new gas dryer, full loads)	33	19%
Lighting (turn off, change lights)	25	14%
Pool / Hot Tub / Shower (shift, turn off, low-flow)	11	6%
TV / Appliances / Computers (turn off, reduce use, shift)	9	5%
Dishwashing (shift, reduce dishwasher use, hand wash)	9	5%
Cooking (outdoors, shift, microwave, use gas stove)	6	3%
Total (multiple responses)	176	100%

- **AC and pools are understood as big ticket items**
- **Actions are not always well-targeted to energy or bill savings**
- **Hard for consumers to tell if saving energy or money**
- **Preliminary price effect analysis supports initial reduction in peak use**
- **Will give up everything except pool, TV/computer, cooking and dishwashing**
- **4:1 differential between off-peak and peak (~7cents to 28 cents)**

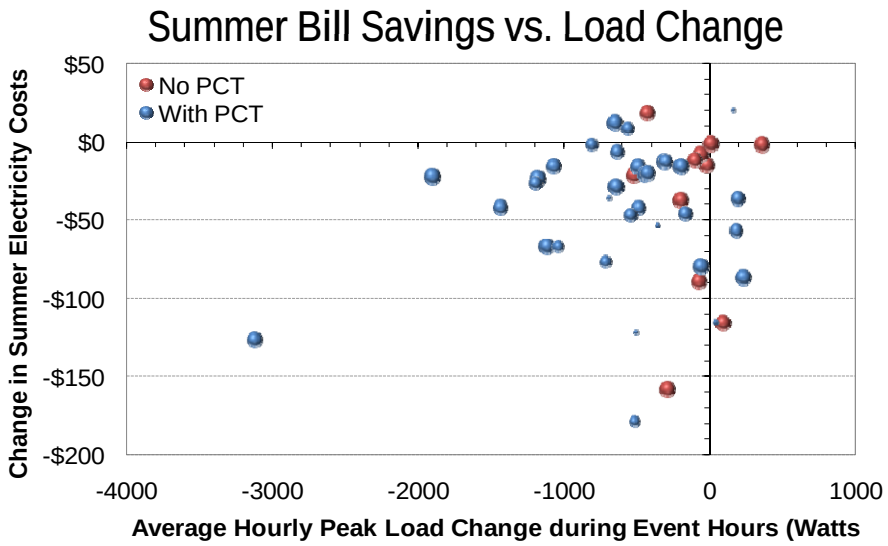





2008 Summer Solutions Findings – Load Savings

Average Load Drop During Events

Business Type	2-deg (kWh/h)	4-deg (kWh/h)	CPP (kWh/h)
Office	-0.48	-0.80	-0.57
Restaurant	-0.18	-0.10	-0.35
Retail	-0.45	-0.76	-0.81



Overall, restaurants saved least peak energy, retail most

Different program designs work best with different business types

Overall, customers reduced energy use by 20% and peak demand by 14%

$0.56 CPP rate






New SMUD DR Research

- Information and Controls for Successful Dynamic Pricing Programs in the Residential Sector
  - Phase 1: Technology Study
    - Determine most effective electricity usage information displays and user interface characteristics
    - Create short online game that collects player interaction data to reveal the information, controls and functionality that are most effective in modifying energy use – 500 participants completed the game in 3 days
  - Phase 2: Field Study
    - Implement results from the Phase 1 in the field to better understand what features residential customers find valuable, and how features are used to reduce home energy use
    - Deploy dynamic rates to about 200 residential customers in SMUD service territory and enabling technologies to about 100, 100 control
    - Collaboration with the Demand Response Research Center, Heshong Mahone Group and various technology vendors, funded by PIER and SMUD

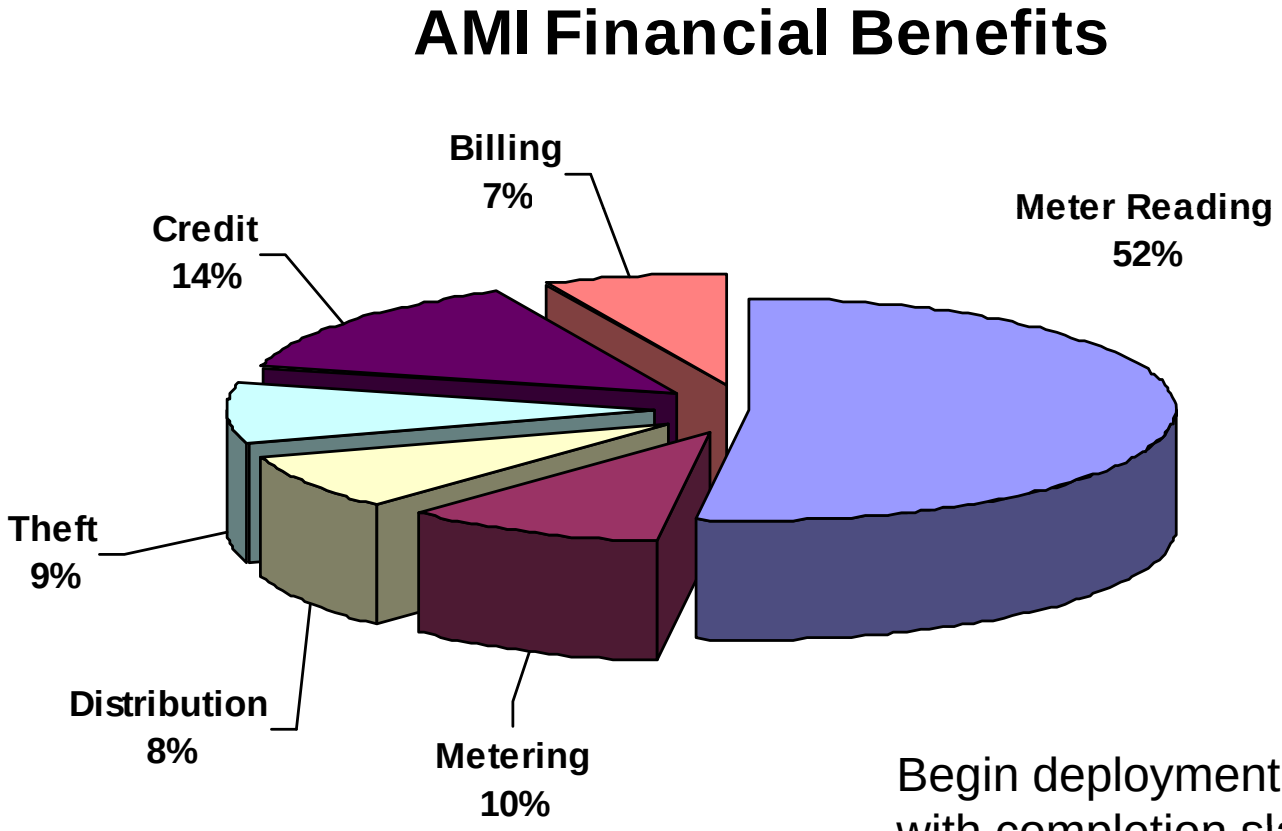





Advanced Metering Infrastructure/Rates

- Enables time differentiated rates and critical peak pricing opportunities
- Enables communication with appliances and equipment for demand response
- Enables loading information and automation all along the supply chain

AMI Business Case



Begin deployment 4th qtr 2009 with completion slated for 1st qtr 2011.

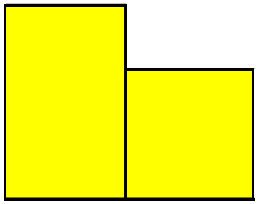




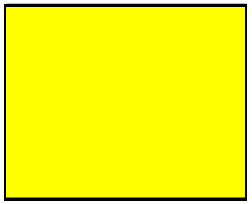

Rates Discussion

- Current rates range in how efficiently they signal underlying costs

Declining Block Rate
Medium Commercial
20 kW < < 300 kW

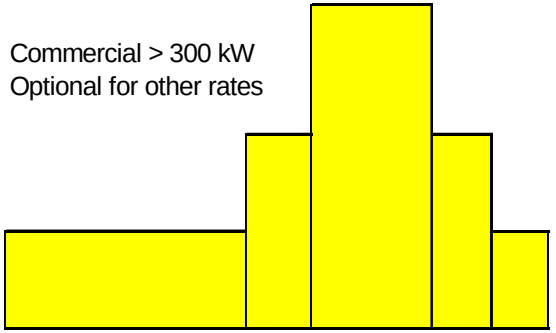


Flat Rate
Small Commercial
Residential 1st Tier Users



Inclining Block Rate
Residential

Time-Of-Use
Commercial > 300 kW
Optional for other rates



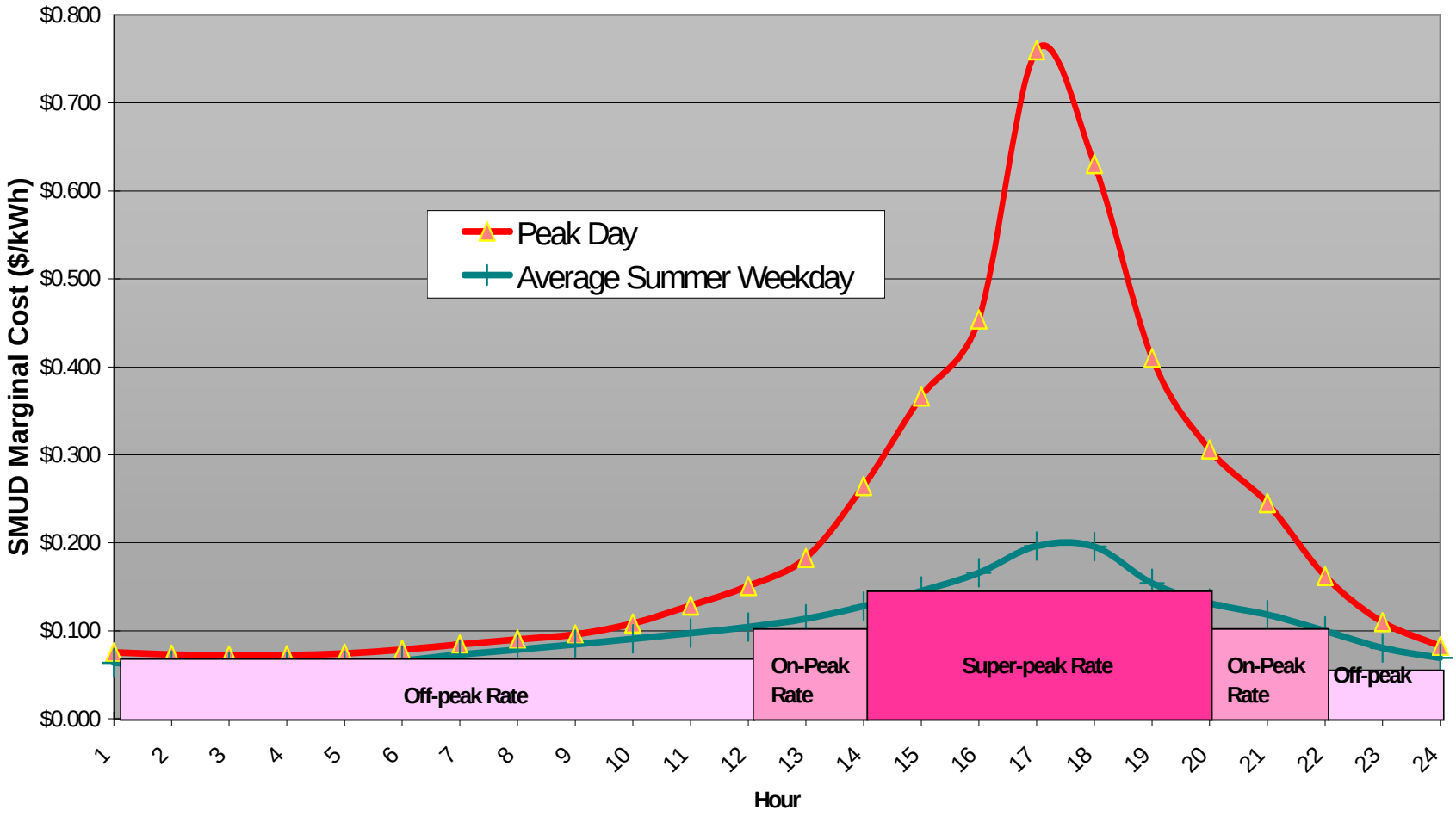
Worst ***Bad*** ***Fair*** ***Good***






TOU Rates Compared to Peak Profile

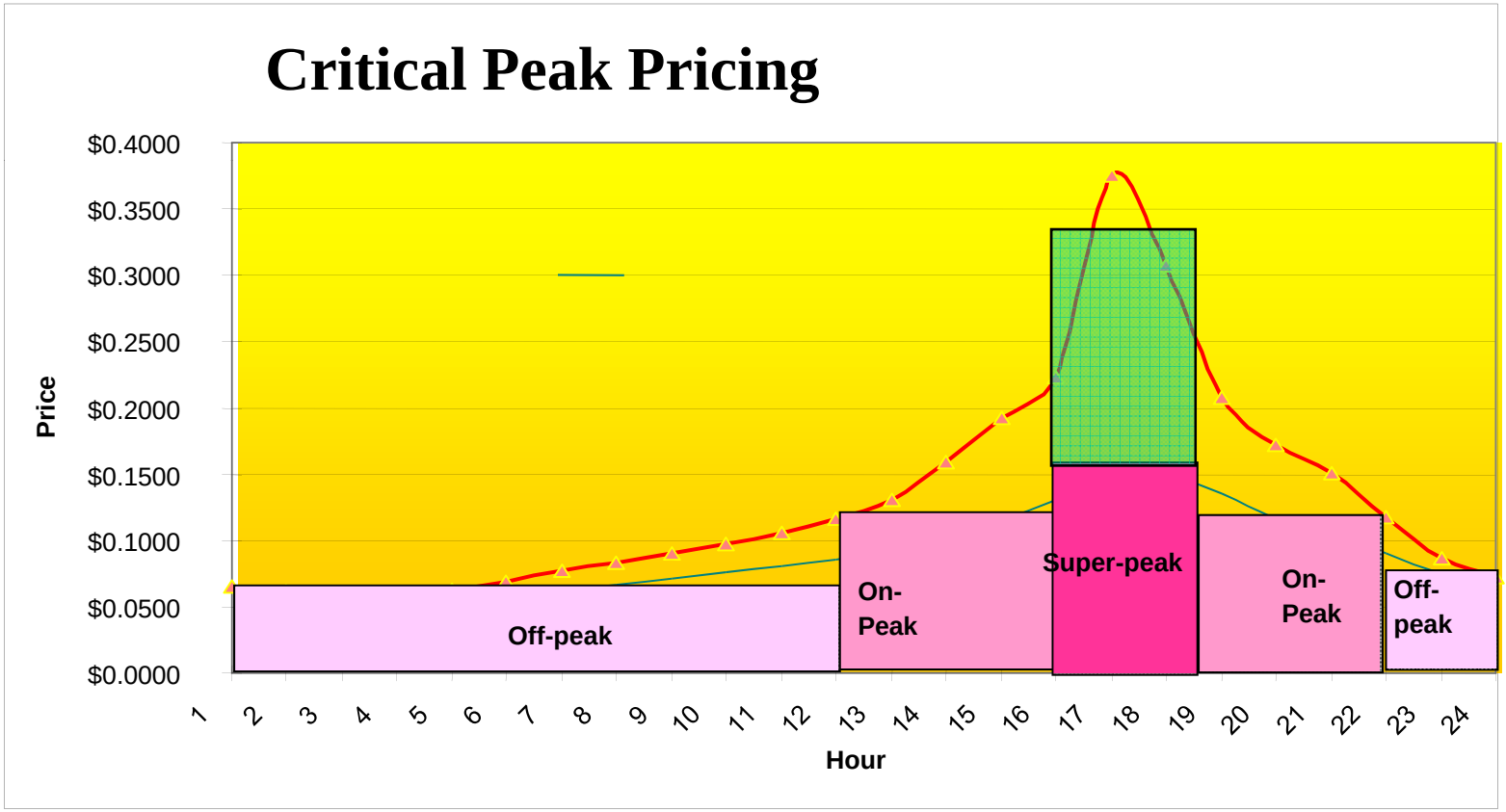
TOU Rates Approximate Average Summer Costs, But Not Critical Peak Days








Pricing Potential








Answers to Questions

1. What technology is actually being deployed and what have the results been to date?

   PCTs, energy displays, ld mgmt controls as discussed.

2. How have customers responded to the “smart grid” related offers?

   We get a response rate of around 2% when soliciting customers for participation in pilots.

3. To what kinds of technology are they receptive and to what types is more resistance being encountered?

   Depends on the technology and the customer. There’s no easy answer to this but further demonstrations will provide additional data.






Answers to Questions

4. Are customers more receptive where they have more control or are they willing to accept centralized demand response controls?

   When given a choice, customers prefer customer control 2:1.

   20-25% won't allow utility control under any conditions.

   Using an Opt-Out program, 20-25% will opt out and the rest will stay on.

5. What pricing and other incentives are being offered to customers?

   For demonstration projects/pilots, we offer sign-up incentives, e.g., Home Depot or Starbucks gift cards.

6. Which offers have proven successful in attracting positive responses, and which have proven to be less successful?

   For pilots, gift cards. For broad scale, we believe dynamic pricing mechanisms will need to be developed.






Answers to Questions

7. What types of consumer education are being carried out to encourage customers to avail themselves of the opportunities they are being offered?

   Save Today, Save Tomorrow campaign, bill stuffers and additional information for program participants including newsletters and technical instructions.

8. How is the pricing of “smart grid” related offerings being designed and implemented?

   Tiered rates subsidize low users, we will move to broad scale deployment of TOU/CPP over time. Large proposed pilot with ARRA funds.

9. What types of monitoring arrangements are being put in place to fully evaluate the effectiveness of the investments being offered?

   We develop an M&E plan prior to demonstrations to ensure our objectives are met. With AMI we can monitor usage more closely.

10. What criteria should we be using to determine whether smart grid investment has proven its worth and how much experience will we need to have to be able to fully learn the answer to that question?

    With strategic research, we will know enough to roll out successful, broadly-deployed programs.






Additional Comments

- Our focus is to provide price signals through TOU and CPP rate structures that will motivate customer participation
- Mandatory dynamic rates, couple with the ability to control appliances will provide the biggest benefits
- Software to orchestrate energy use can be invisible to customers, increasing the potential for participation
- Most smart grid applications are still in the demonstration phase so the number of broad-scale deployments are low. ARRA funds will change this.
- On demonstration projects, customers are targeted for participation by type, neighborhood, usage, etc.






Additional Comments

- The hope is to broadly deploy technologies, programs and rate structures that are cost effective and optimize benefits
- Criteria for success include:
  - Customer acceptance
  - Energy savings
  - Cost effectiveness
  - Reliability of equipment
  - Reliability improvements to the grid
  - Ease of implementation/installation
- Technology choices and functionality are varied making choices difficult






Smart Grid Stimulus Funds

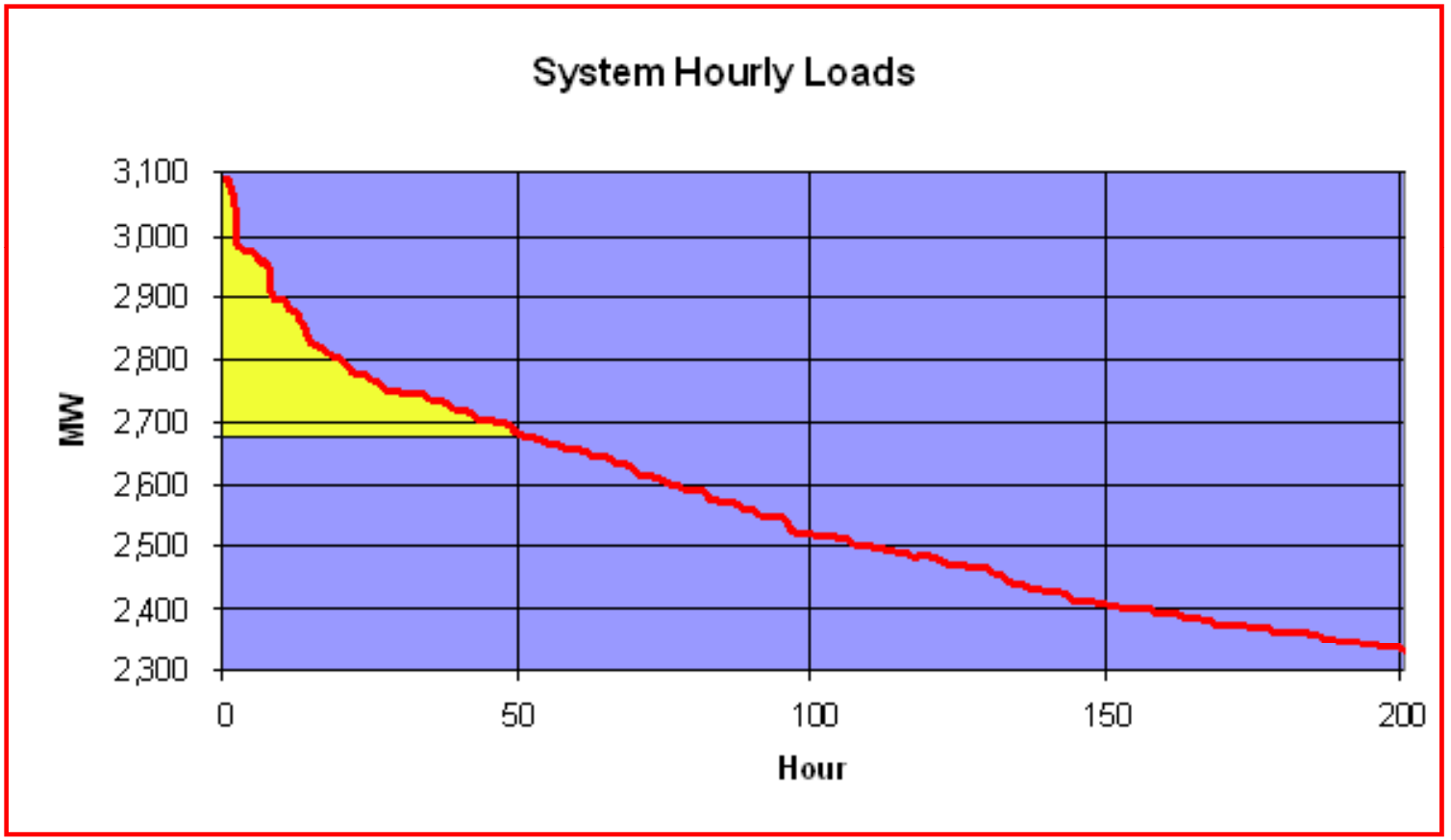
- Requested $128 million on $300 million worth of projects from FOA 58, Smart Grid Investment
  - FOA 58 requires mandatory dynamic pricing in order to maximize chances of an award
  - SMUD plans to do this in at least one zip code
- Requested $12.8M request for $33.2 M project under FOA 36, Smart Grid Demonstration
- Partnership with SMUD, California State University, Sacramento, Los Rios Community College District and State of California Department of General Services
- Stimulus funds will have a significant impact on implementation of Smart Grid technologies



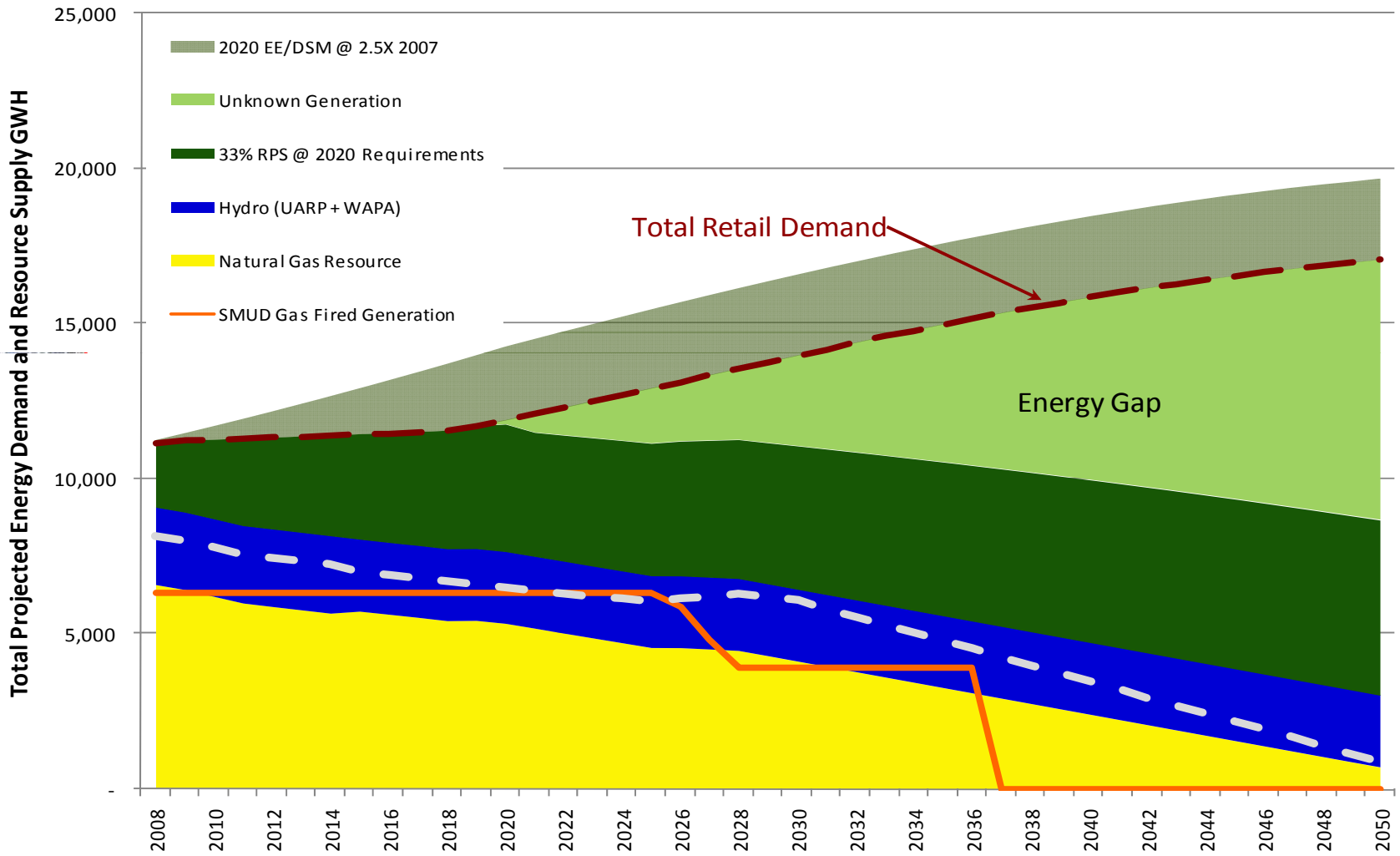



Smart Grid Project Drivers

Load Duration Curve – Another View of Peak Load



SMUD Projected Resource Mix Through 2050








Other Drivers

- NIMBY – TANC transmission line/new generation
- BANANA – Build Absolutely Nothing Anywhere Near Anything

SMUD Strategic Directive 9

- Reduce Greenhouse Gas Emissions 90% below 1990 levels by 2050
- <350,000 metric tonnes/year
- Assure reliable power supply

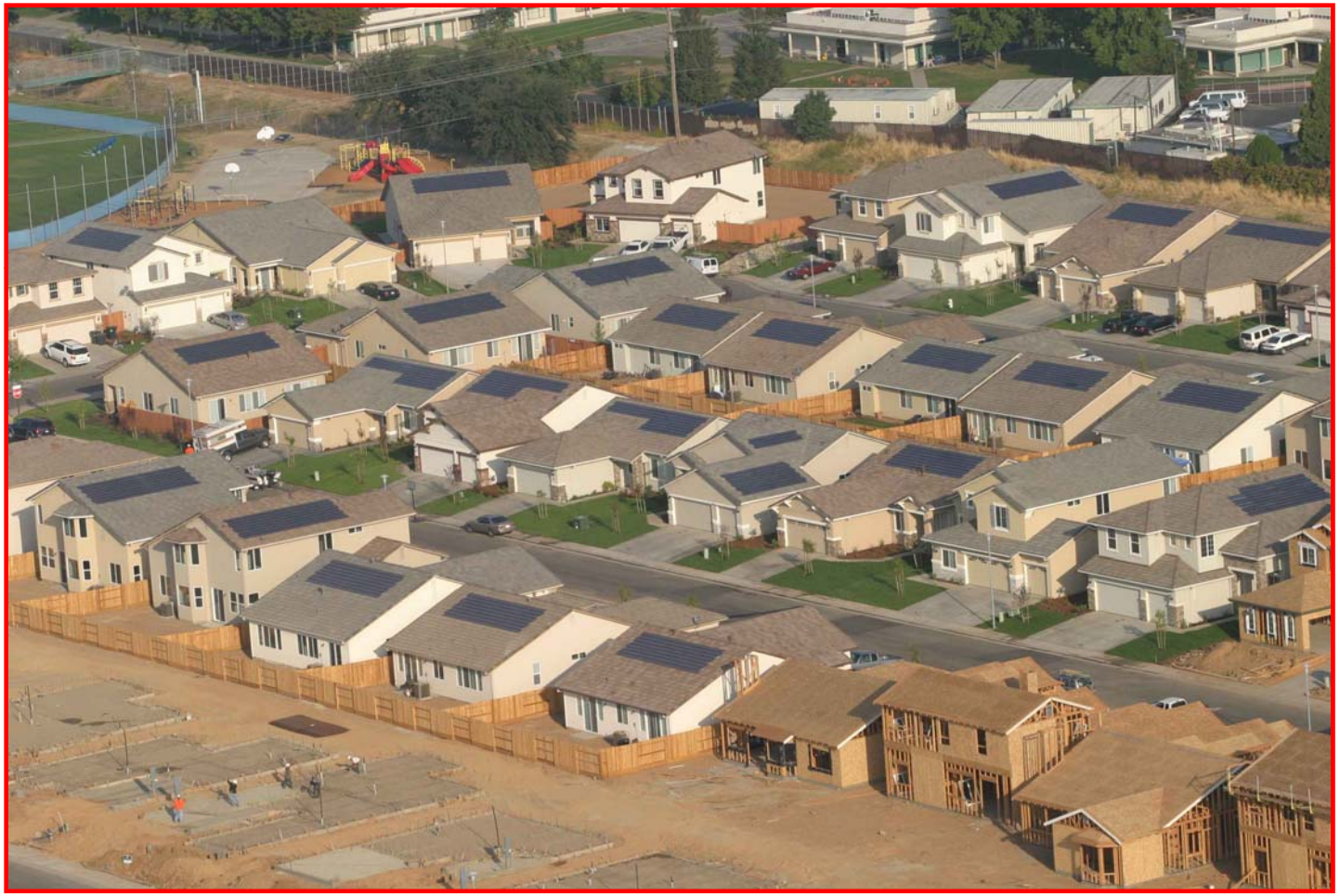





Next Steps

- Expand projects with Stimulus funds if awarded
- Continue developing net zero energy homes and commercial buildings on two fronts—
  - Net zero energy existing homes and commercial buildings (EE & DG)
  - Net zero new construction
- Continue testing demand responsive technologies and pricing mechanisms through demonstration projects
- Complete AMI deployment
- Develop energy storage projects to simulate plug in hybrid vehicle charging and generating
- Continue automating distribution system

Net Zero Energy Homes by 2020



Home of the Future in Folsom, CA

1950 sf



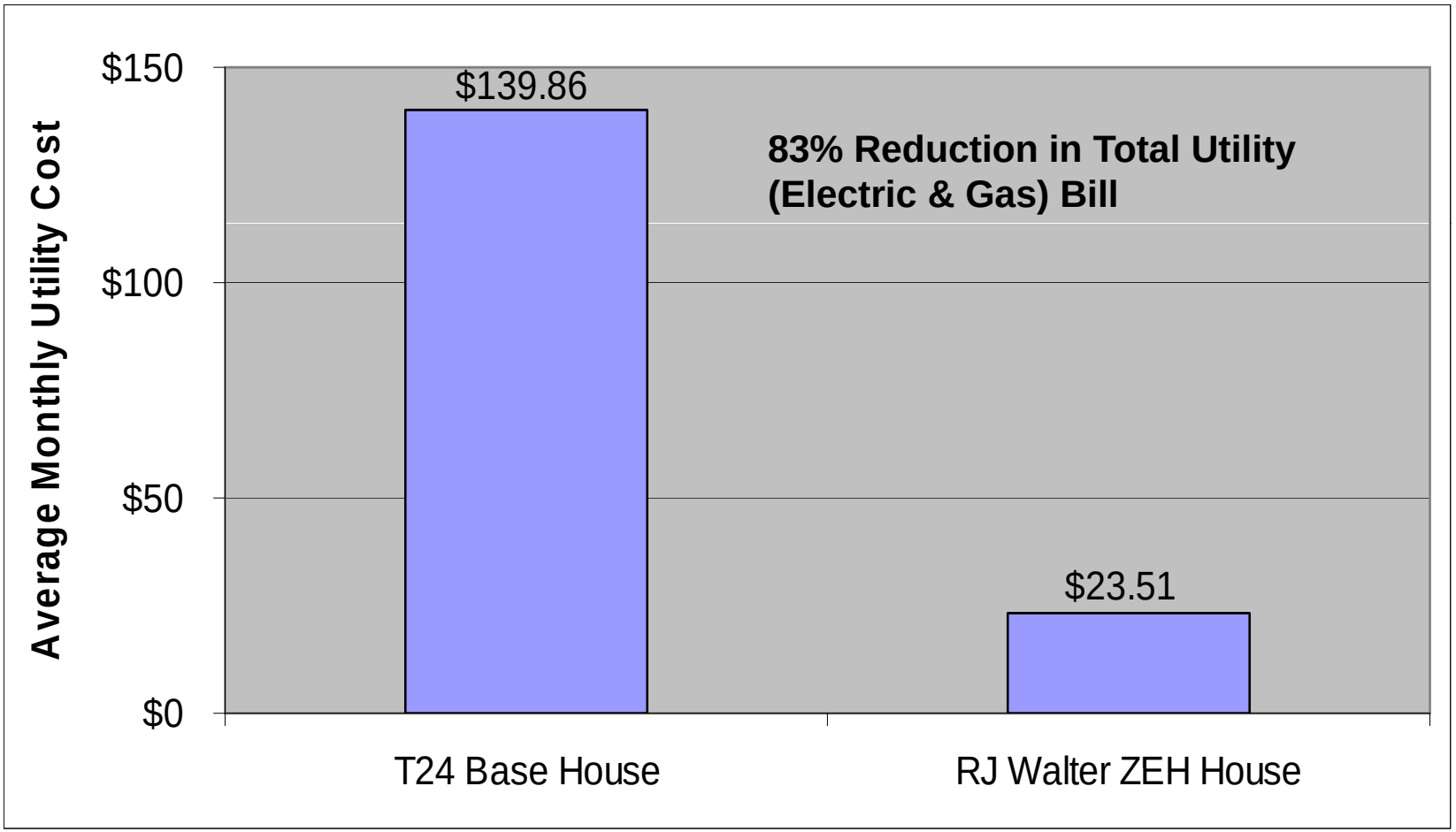



60% better than 2005 Title-24, LEED Platinum Home

- Attic R38 ceiling assembly (low density foam)
- Wall 2x6/R19-R21 cavity/R12 insulating sheathing-R30
- Envelope .0002 SLA (4 ACH50)
- Windows 0.29 U-value, 0.27 SHGC
- Ducts Tight ducts, inside conditioned space
- FURN Solar Assisted Hydronic space heating
- A/C Aqua Chill Water Cooled AC (Home)
- Ductless, HE, Mini-split Heat Pump (Casita)
- Water Solar with HE boiler hot water backup
- Lighting 100% CFL and LED Lighting
- Solar 3.9 kW AC Solar Electric PV
- Gas and/or Energy Star Appliances
- Home Automation
- Grid Tied Battery Back Up

Incremental Cost ~$50k

Total Estimated Energy Bill Savings



Save $116.35/month on a payment of $360-$370/month



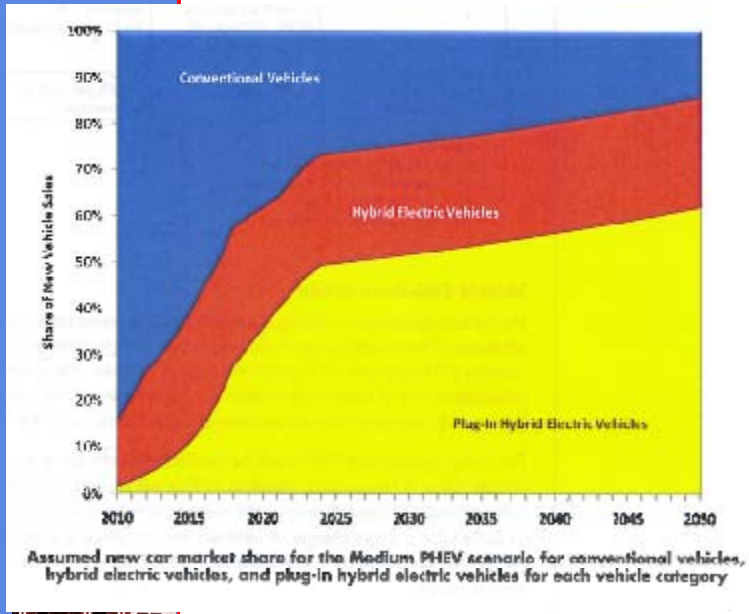



Electric Vehicles and Energy Storage

- Develop infrastructure standards for plug in hybrid vehicles that charge off-peak and generate during peak periods
- Test the effectiveness of battery storage and power management products
- Build 400 MW pumped storage facility
- Optimize non-dispatchable renewable resources through storage

Projected SMUD 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

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

EPRI-NRDC 2007 Study






Plug In Hybrids and Battery Electric Vehicles

- Automate the entire process – customer sets parameters
  - Charge the batteries based on a low price
  - Sell energy based on a high price or for grid reliability
  - Never let the charge fall below a pre-specified level
- Automakers not supportive of using batteries for grid stabilization – 10-year warranty on smog equipment
- One PEV is like adding a house to the grid/transformer






Conclusions

- Smart Grid has the potential to revolutionize the utility industry by maximizing control over the system through:
  - Better load management through demand response and energy storage
  - Improved customer participation through Home Area Networks and utility programs
  - Automation of the distribution system
  - Improved home and commercial building performance by moving towards net zero energy
  - Improved reliability through implementation of distributed generation and micro grids
- Smart Grid promotes the silver buckshot approach—working on multiple strategies simultaneously—energy efficiency, renewables and DG, distribution automation, energy storage, demand response, generation efficiency, AMI and rates to maximize benefits