



# SMART GRID ACTIVITIES AT SMUD

## California Commissioning Collaborative

March 18, 2009

Jim Parks,  
Energy Efficiency and Customer R&D



## SMUD Vision Statement

- ◆ SMUD's vision is to empower our customers with solutions and options that increase energy efficiency, protect the environment, reduce global warming, and lower the cost to serve our region
- ◆ In implementing this vision, the District will adhere to these principles:
  - ◆ Preserve our customers' quality of life by offering flexibility and options
  - ◆ Enable customers to use both active and passive means to achieve these goals
  - ◆ Enable all customers to participate
  - ◆ Collaborate, as appropriate, with partners who share SMUD's goals
  - ◆ Focus on investing in energy efficient infrastructure for both SMUD and customer facilities
  - ◆ Use a comprehensive communication strategy
  - ◆ Leverage SMUD's leadership role to achieve these goals



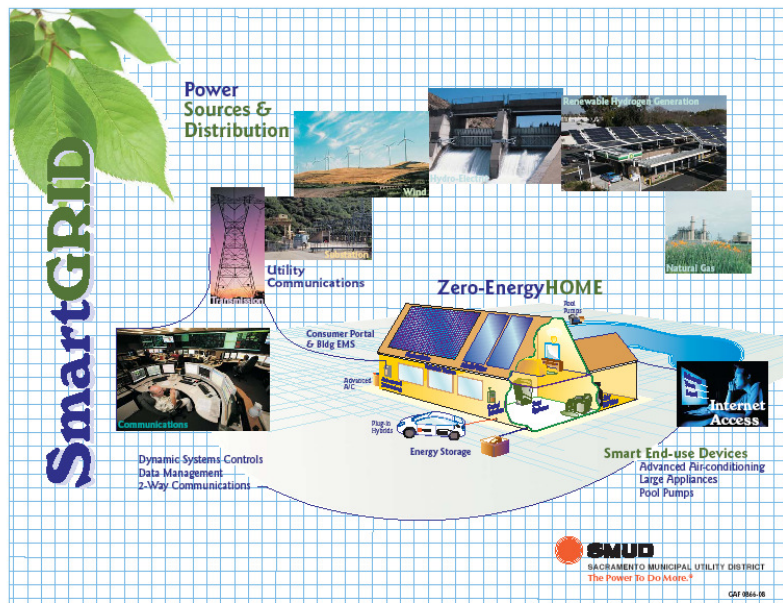
## SMUD Strategic Directive 9



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



## Smart Grid Vision





## Project Proposal



- ◆ Develop a large project that incorporates smart grid elements to test viability and cost effectiveness of an integrated system
- ◆ Select an area for installation of Smart Grid Technology suite (early subset)
  - ❖ Minimum of AMI and Dist. System Monitoring
- ◆ Develop packages of measures and cost-share for customers, both residential and commercial
- ◆ Work to get funds—grants (federal, state and foundation), SMUD incentives, federal tax credits and customer financing



## Project Elements



1. Energy Efficiency
2. Renewables/Distributed Generation
3. Energy Storage
4. Demand Response
5. Advanced Metering Infrastructure
6. TOU and CPP Rates
7. Distribution System Improvements



## 1. Energy Efficiency



- ◆ Implement broad spectrum energy efficiency
- ◆ Move toward net zero energy new homes and buildings
- ◆ Determine cost effectiveness of near net zero energy existing homes and commercial buildings
  - ❖ Develop cost effectiveness matrix showing all measures
  - ❖ Factor in carbon costs, increases in energy prices and expected cost reductions for emerging technologies that move to commercialization



## 2. Renewables/Distributed Generation



- ◆ Install PV on rooftops and/or bulk installations on parking lots or other open spaces
- ◆ Consider other distributed generation technologies such as waste to energy plants from waste collected in neighborhoods
- ◆ Identify cost-effective combined heating, cooling and power (CHP) projects
- ◆ Energy efficiency and renewables form the basis for net zero energy homes and commercial buildings



## Net Zero Energy Homes by 2020



## Home of the Future in Folsom, CA



1950 sf





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

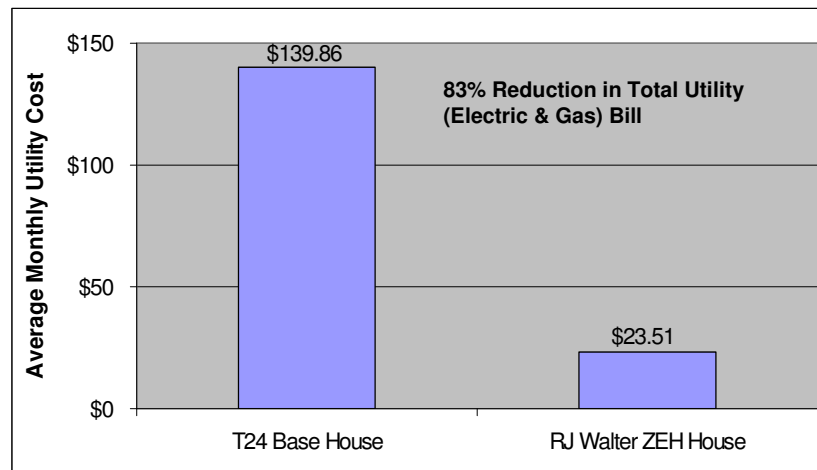


- Attic R38 ceiling assembly (low density foam)
- Wall 2x6/R19-R21 cavity/R12 insulating sheathing-R30
- Envelope .0002 SLA (4 ACH50)
- Windows 0.29 U-value, 0.27 SHGC
- Ducts Tight ducts, inside conditioned space
- FURN Solar Assisted Hydronic space heating
- A/C Aqua Chill Water Cooled AC (Home)  
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

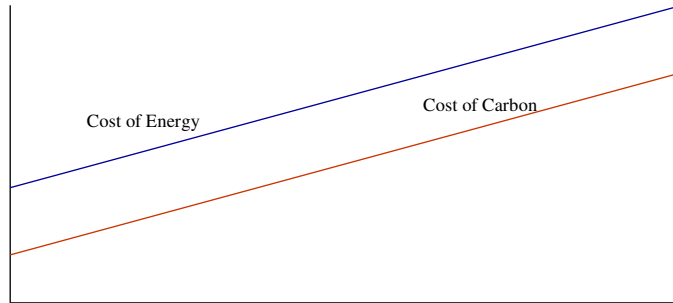




# Measure Cost Effectiveness



Cost Effective Measures



Cost Effective Measures

Marginally Cost Effective Measures

Non-Cost Effective Measures



# Net Zero Energy Commercial Buildings by 2030





### 3. Energy Storage



- ◆ Develop infrastructure standards for plug in hybrid and battery electric 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
- ◆ Thermal energy storage – ice and chilled water
- ◆ Compressed air
- ◆ Big need with increase in wind generation



### Compressed Air Energy Storage

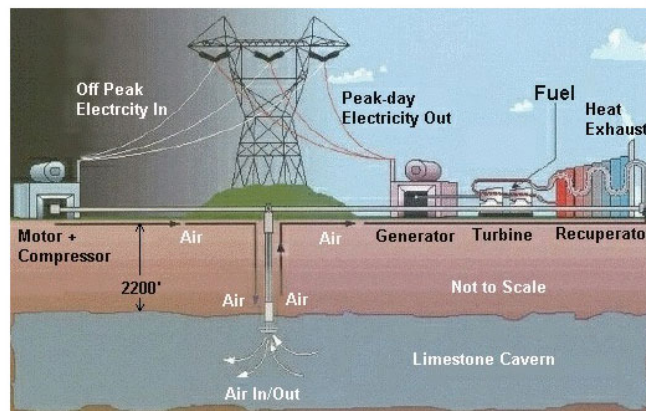


Photo Courtesy of CAES Development Company

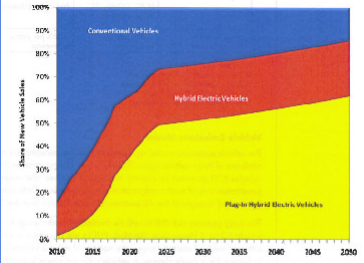
Less than 1\$/watt for 1991 project



## Projected SMUD PHEV Penetration Load Impacts



### EPRI PHEV Market Penetration Projection



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





## 4. 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)
- ◆ Thousands of points reducing small amounts of demand can add up to a large amount



## 2003 PowerStat Findings (Peak Corps with T-Stat)



Outdoor Temperature	Average kW Savings per Customer					
	Peak Corps Savings			PowerStat Savings		
	50%	67%	100%	50%	67%	100%
<=90°F				0.9	1.2	1.8
91°F -95°F	0.5	0.7	1.0	1.0	1.3	2.0
96°F -100°F	0.6	0.8	1.2	1.1	1.4	2.2
101°F -105°F	0.7	0.8	1.4	1.2	1.6	2.4
106°F -110°F	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**
  - ❖ **Difference in estimating methodologies**



## 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 78°F for cooling	42%
Shifting became a habit in summer only	40%
Reprogrammed critical peak offsets	10%

### Appliances Used

Appliance	Time-of-Use Period			
	Low	Med	High	Crt
Ran AC	55%	60%	56%	23%
Washed/dried 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%

- ◆ On hot days customers will give up everything except TV and computer



## 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
- ◆ Offers education plus PCTs with new critical peak rate or direct load control program to small commercial customers
- ◆ Collaboration with Heshong Mahone Group, Roger Levy Associates, Mithra Moezzi, Residential Control Systems and E-Radio, funded by PIER and SMUD



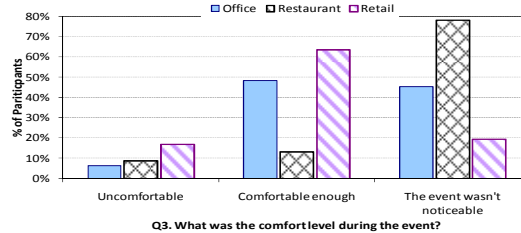
### ◆ 2008-9 Near Zero Energy Home Display Pilot (Standard Tiered Rate)

- ◆ 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

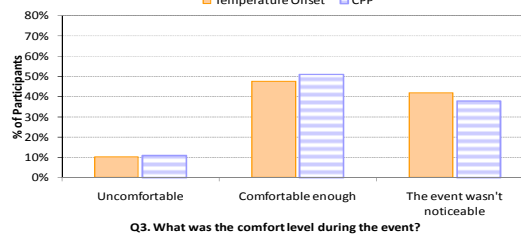




## 2008 Summer Solutions Findings – Comfort Level



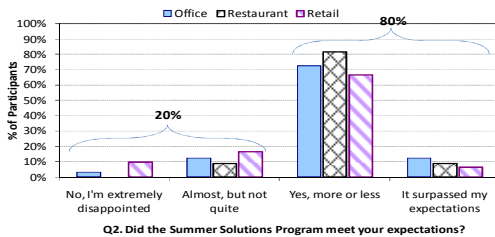
**90% of customers are comfortable during events**



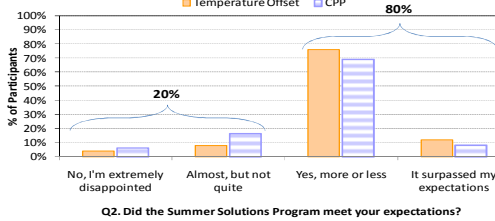
**50% don't notice events—restaurants notice events less than offices and retail**



## 2008 Summer Solutions Findings - Satisfaction



**80% of customers were satisfied with the DR program they were on**



**No difference in satisfaction among business types or program types**



## 2008 Summer Solutions Findings – Load Savings



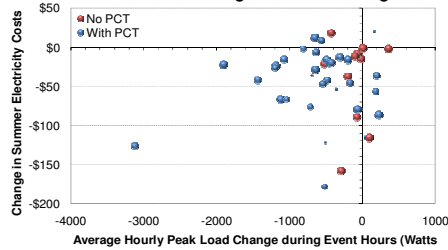
Average Load Drop During Events

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

Summer Bill Savings vs. Load Change



Customers with PCTs saved more peak energy and money than those without PCTs



## 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

#### ❖ 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 of these

#### ❖ Collaboration with Heshong Mahone Group and various technology vendors, funded by PIER and SMUD



## 5. Advanced Metering Infrastructure



◆ Enables time differentiated rates and critical peak pricing opportunities



◆ Enables communication with appliances and equipment for demand response



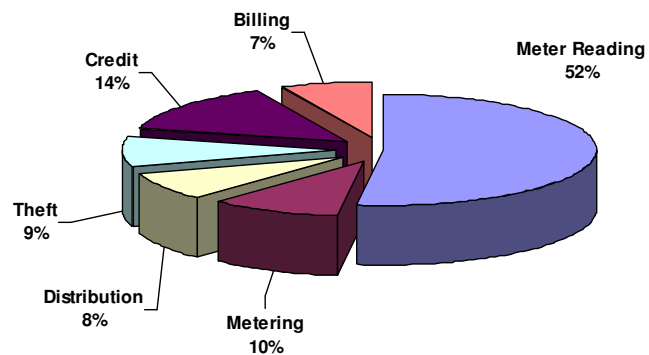
◆ Enables loading information and automation all along the supply chain



## AMI Business Case



### AMI Financial Benefits





## 6. TOU and CPP Rates



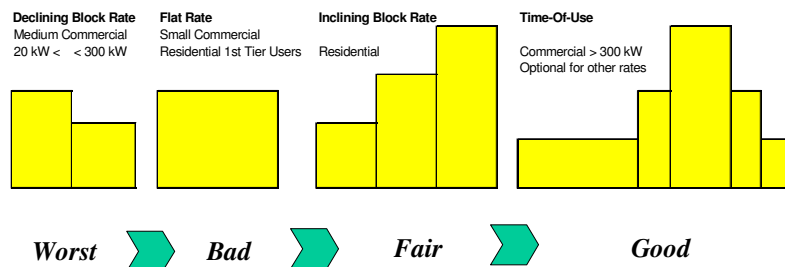
- ◆ Encourages customers to reduce peak loads
- ◆ Reflects utility cost of energy



## Rates Discussion



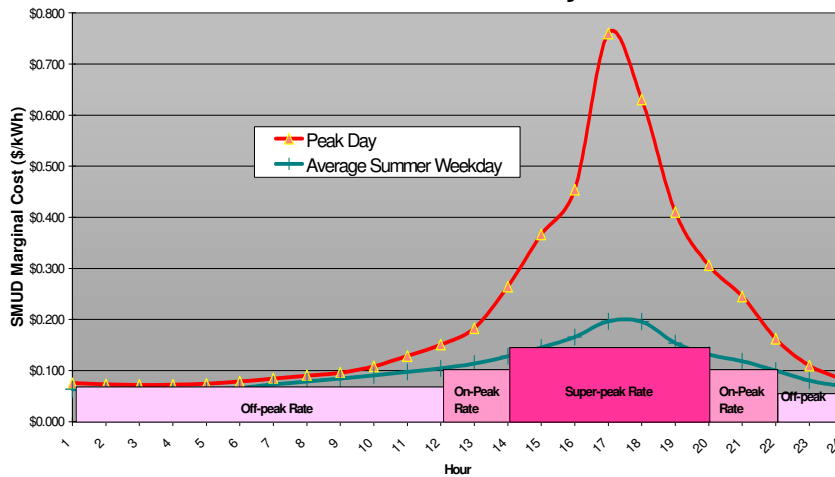
- ◆ Current rates range in how efficiently they signal underlying costs





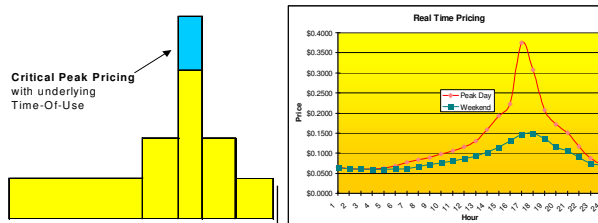
# TOU Rates Compared to Peak Profile

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



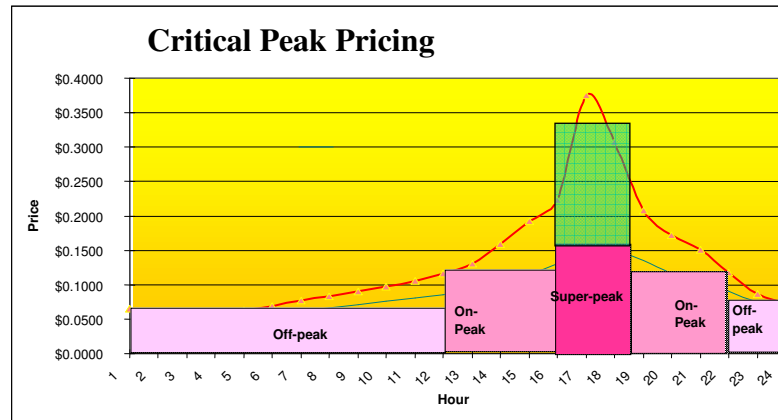
# Pricing Potential

◆ Alternative rate structures are better at matching costs





## Pricing Potential



## 7. Distribution System Improvements



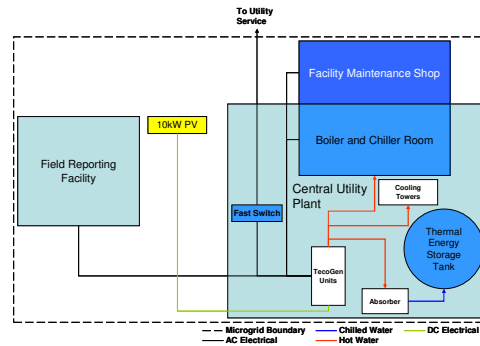
- ◆ **Integrated communications** allow for real-time control, information and data exchange to optimize system reliability, asset utilization, and security
- ◆ **Sensing and measurement technologies** evaluate equipment health, grid integrity, energy theft, congestion relief, and control strategies
- ◆ **Advanced control technologies** enable rapid diagnosis of and precise solutions to grid disruptions or outages
- ◆ **Improved interfaces and decision support** provide operators and managers with tools and training to operate a smart grid



## 310 kW field demonstration of CEC/CERTS Microgrid for central utility plant to demonstrate:



- ◆ Real world performance
- ◆ Allow our central plant and Field Reporting Facility to operate independently of the grid
- ◆ 3-100 kW natural gas-fired engines + 10 kW PV system
- ◆ Waste heat from engines will provide additional energy efficiency by reducing the need for boilers and providing chilled water for air conditioning (absorption chiller)
- ◆ Autonomous local control for fast events (No central controller)
- ◆ Economic value to customers and utility
- ◆ Numerous technical challenges will be evaluated
- ◆ Construction in 2009, operational in 2010



## PIER/SMUD Microgrid Project – AR&DGT



- ◆ Allows capability to function on the grid or independently as a 'microgrid'
- ◆ Allows customers to maintain power during electrical outages
- ◆ Enhances reliability
- ◆ Will appeal to hospitals, data centers, manufacturers, research facilities, etc.
- ◆ Microgrids can vary in scope, size, and ownership
- ◆ 3-year project totals \$2,984,224
  - ❖ \$1,586,290 from PIER
  - ❖ \$1,397,934 in SMUD cost share (labor & equipment)



## CSUS/SMUD Partnership



- ◆ Smart Grid Home/Center
  - ❖ \$1 million outside funding available
  - ❖ Need to scope project and determine cost-share
- ◆ Possible energy storage
  - ❖ 1 MW Sodium Sulfur battery
  - ❖ Flywheels
  - ❖ Other?
- ◆ Development of Smart Grid Campus



## Next Steps



- ◆ Staff developing a series of individual proposals/plans that can be shopped individually or in aggregate
- ◆ Developing net zero energy homes and commercial buildings on three fronts—
  - ❖ Working with CEC (PIER) to help fund net zero energy existing homes and commercial buildings (EE & DG)
  - ❖ Budgeted R&D program
  - ❖ Deep EE retrofits
- ◆ Multiple demand response projects underway
- ◆ Complete AMI deployment
- ◆ Develop energy storage projects to simulate plug in hybrid vehicle charging and generating
- ◆ Continue automating distribution system





## 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
- ◆ Work simultaneously on multiple strategies (silver buckshot)—energy efficiency, renewables and DG, energy storage, demand response, AMI and rates to maximize benefits
- ◆ Need to determine cost effectiveness of various measures and mass deploy those that are cost effective