Energy Systems Integration Research Program

Demand Response Enabling Technology Development Program

Annual Workshop

June 6, 2006

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California Energy Commission

Presentation Summary

- California Electricity Infrastructure Problems
- ESI Strategy
- Successful Research Solutions
- Future Directions

Problem: Fragile Transmission Requires Attention

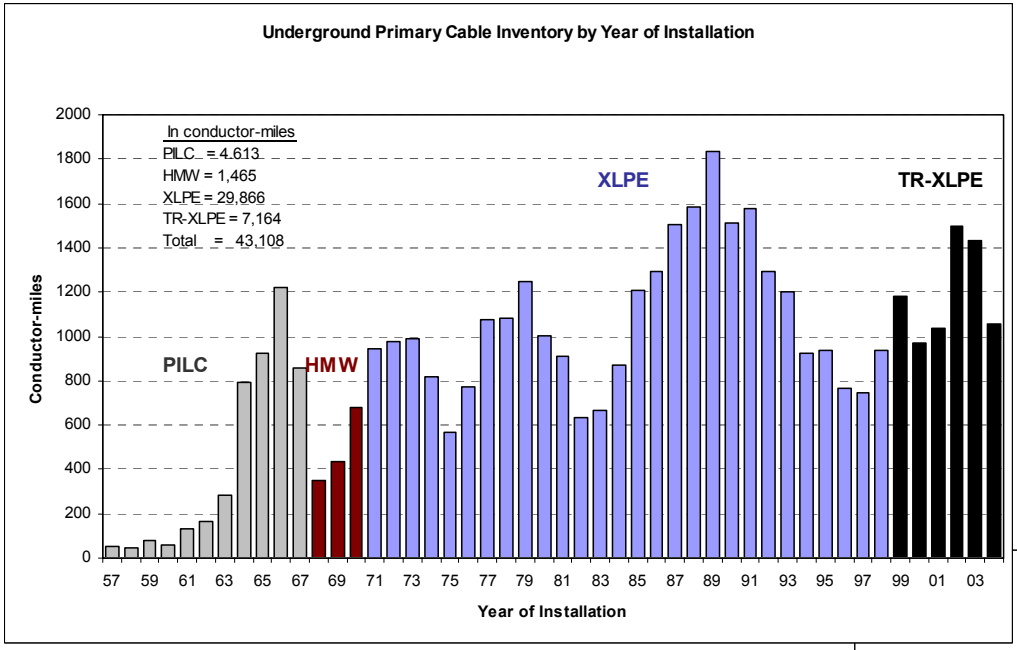
Western electric power trends create economic, reliability and environmental issues.

- Difficulty building new transmission:
  - Aging infrastructure is raising concerns about reliability
  - Increases congestion costs
  - Hampers access to low-cost, clean generation
  - Hampers attainment of renewable energy goals
- Power markets, and new generation technologies and electric-consuming appliances, are creating operational uncertainty and instabilities:
  - Impairing operator ability to plan, dispatch and regulate generation
  - Changing the dynamic behavior of the grid, increasing operational risk
- Increasing reliance on interconnection to a large, brittle power grid is:
  - Increasing risk of large wide-spread outages
- Extreme events, e.g., cascading blackouts, “Katrina,” are shaking confidence in institutions’ abilities to provide robust/resilient systems

The health, wealth and safety of California’s citizens are at stake: Cost of congestion (~ $100s millions/yr); cost of “no kWh” (~ $billions/yr), environmental costs of 32,000+ miles of HV lines, and ability to meet RPS goal of 20% by 2010

Problem: Today's Distribution System Is Obsolete

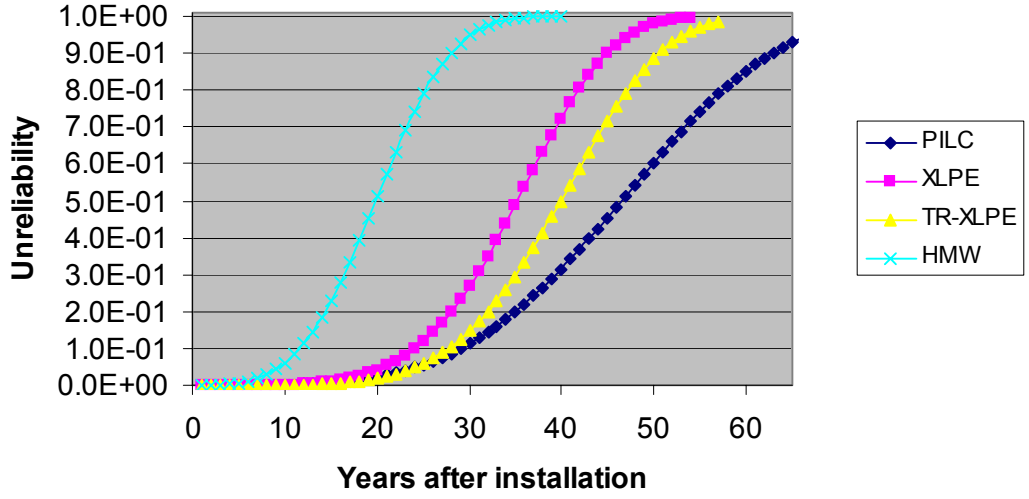
Looming reliability crisis distracts IOUS from paying attention to next generation of advanced, automated, DR and DG enabling distribution.



- Under grounding for aesthetics
- PG&E and SCE have over 60,000 miles of cable installed
- Design practices and cable construction limit useful life
- Average replacement cost $100/foot
- Techniques to effectively diagnose ineffective – so doing miniscule proactive replacement

- IOUs experiencing 600 UG cable failures per year each
- IOU assessments anticipate this could be >10x worse within 30 years
- Impact to customers - annual minutes of outage likely to increase 8x within 30 years

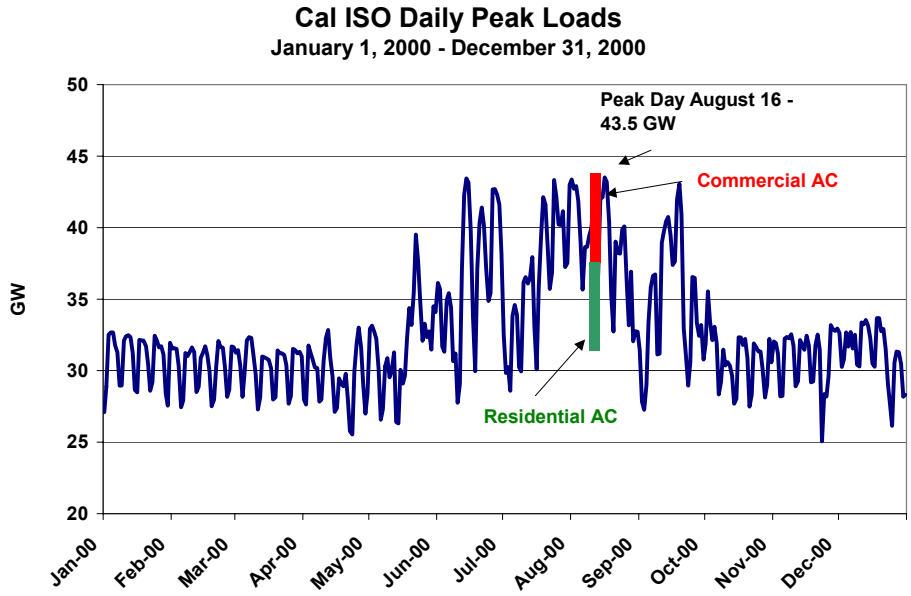
CABLE UNRELIABILITY

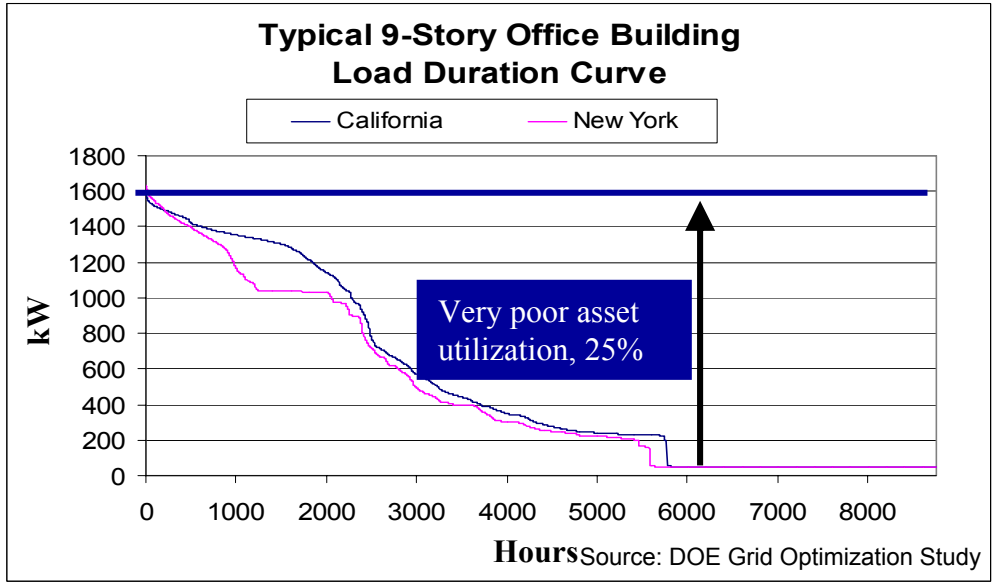


Problem: Load Growth Continue

Load growth in C&I, industrial and residential is driving peak loads to extremes on transmission and distribution systems.

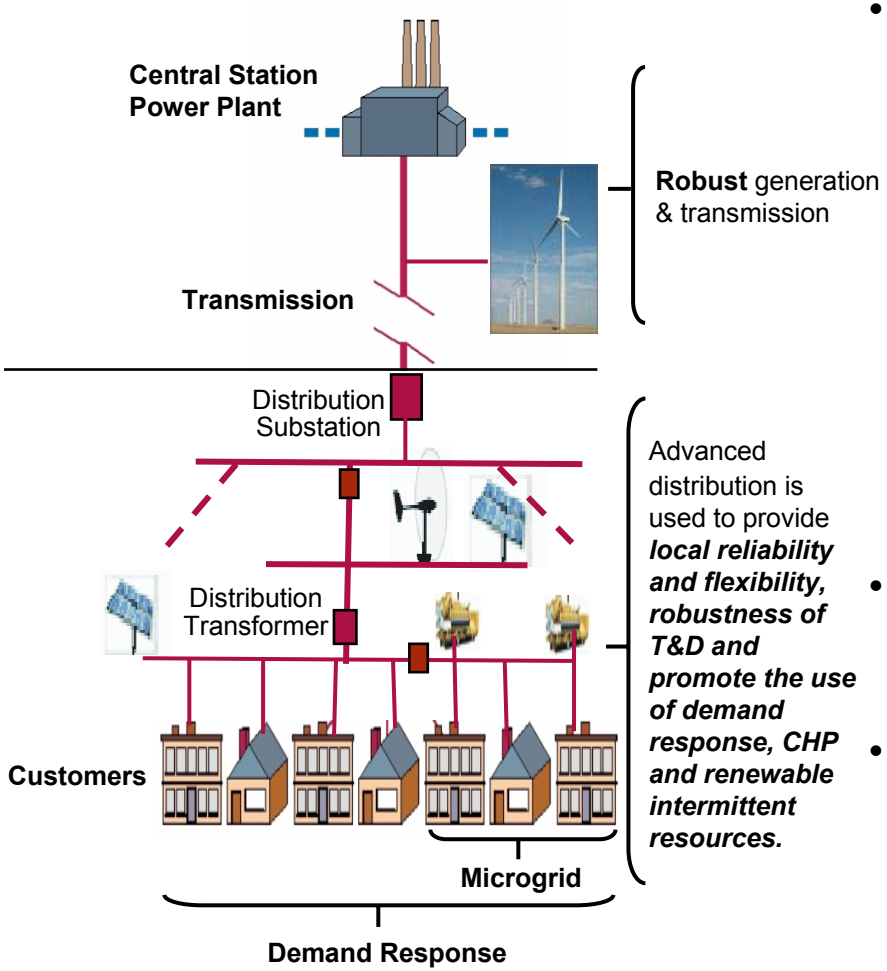
- A/C is ~ 1/3 of peak load
- California utilities anticipate spending **Billions** in coming decades as distribution system "turns over" and to meet load growth
- Investments made to meet highest 1-4% of peak
- Remainder of year system terribly under utilized – poor economic efficiency
- Why should we build to the 80 hours of year when system is peaked?
- Are there more economically efficient ways?





Solution: Creating a Blueprint for Change

A systems engineering approach can innovatively address these issues but it requires looking at the big picture in a holistic fashion.

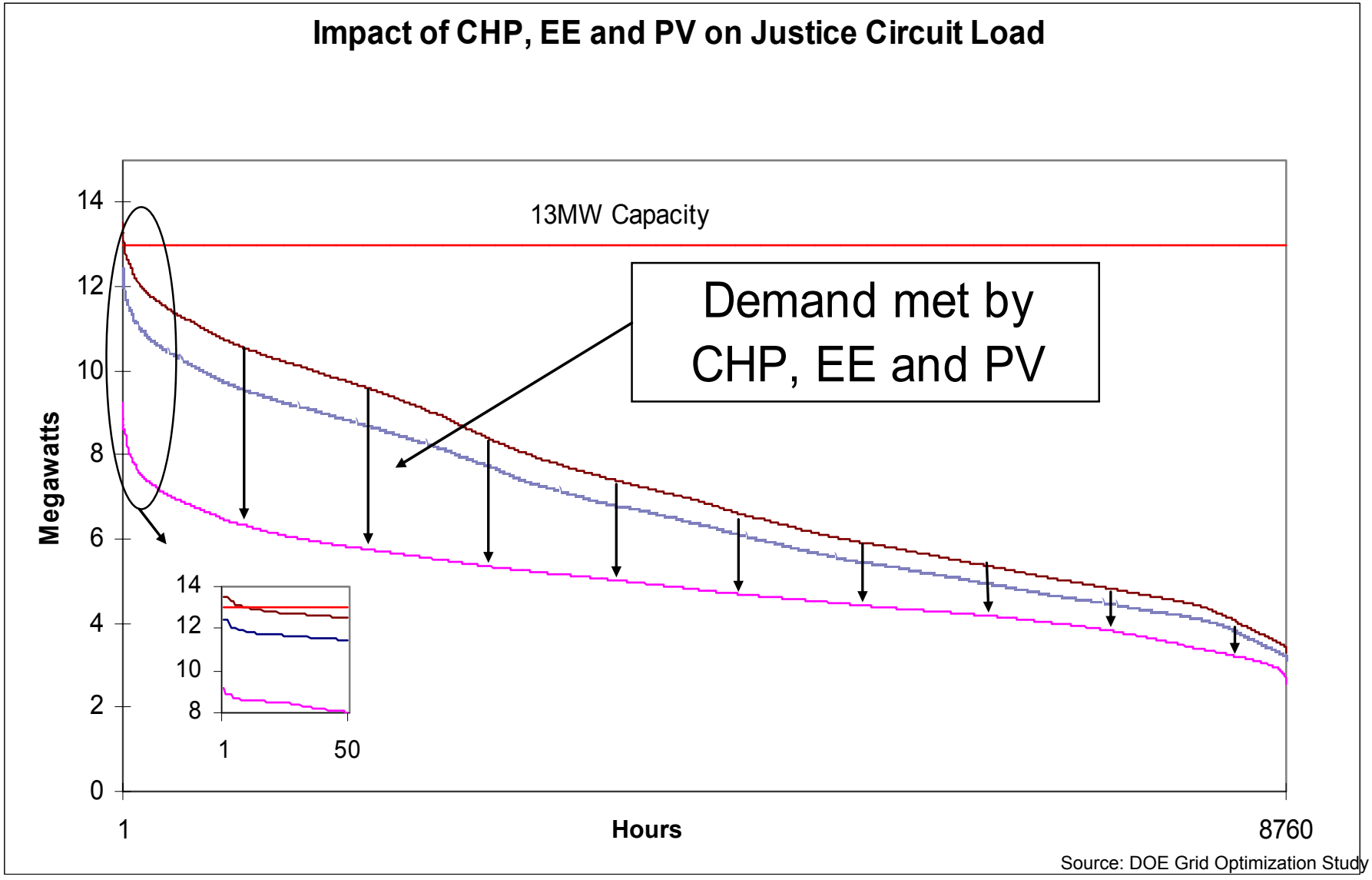


- Addressing all these issues necessitates a coordinated effort
  - Integrate EE, DR, DG-CHP, renewables (large and DG), and storage into energy system designs
  - Develop technology-ready T&D infrastructure
  - Optimize integration strategies to target peak load and grid utilization
  - Demonstrate the benefits to utilities, regulators and ratepayers
- ESI's Vision – a fully optimized electricity system where efficiency, reliability and environment are maximized
- Advances in the T&D system and on the load side can get us to this new vision for the future
  - sensors and monitoring
  - communication and controls
  - intelligent automated systems
  - real time operations of the T&D system

Science and technology can transform the 19th century electricity system into the 21st century information age.

Solution: New Analytical Approaches Show Promise

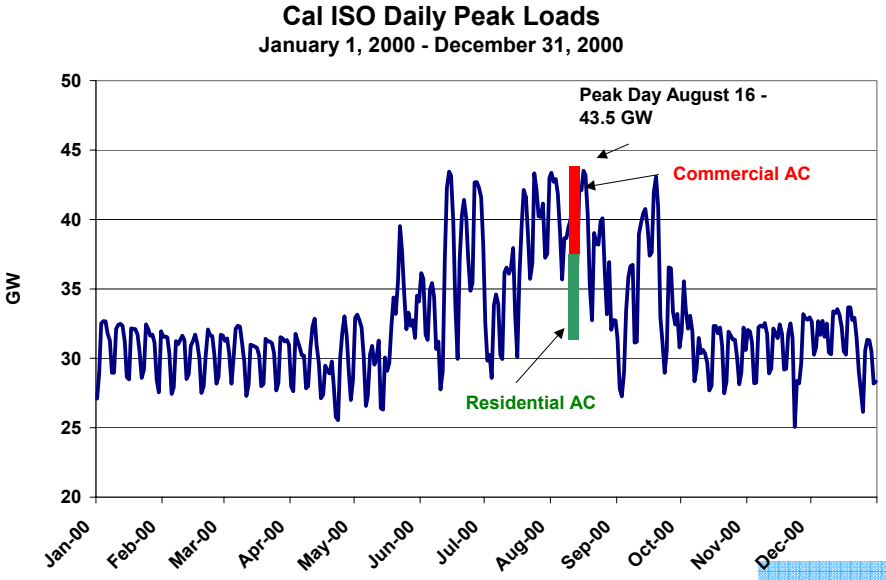
DOE funded research shows how integrated approach improves distribution utilization using California preferred resources.



Source: DOE Grid Optimization Study

ESI DR Successes - Pursuing Two Distinct DR Resources

AC is the low hanging fruit toward attaining 5% peak reduction by 2007.



For *commercial and industrial customers*, we're pursuing auto-DR that sends load dispatch signals to their EMS that subsequently executes preplanned shed strategies.

For *residential and light commercial customers*, we're pursuing programmable communicating thermostats that automatically respond to AC load reduction dispatch signals.

Commercial

>200 kW, ~20,000 meters, ~8 GW of A/C

- Policy ✓
- Auto DR ✓
- AMI ✓
  - … and industrial
  - >200 kW
  - Approx 20,000 meters
  - Approx 1 GW of A/C available for DR

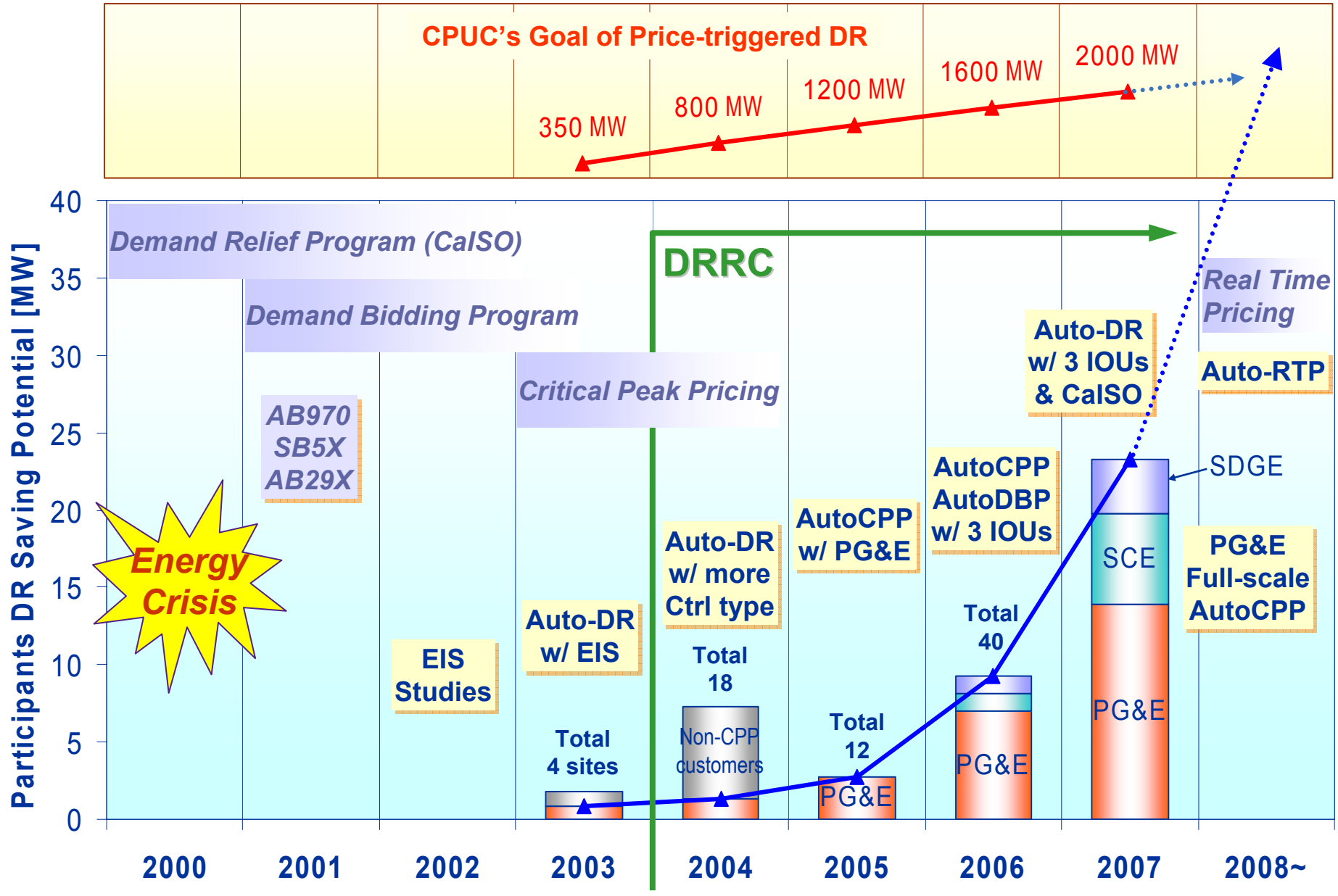
- AMI ✓
  - …and light commercial
  - Approx 11,000,000 meters
  - <200 kW
  - Approx 1 GW of A/C available for DR
- PCT ✓
- Policy ✓

Residential

<200 kW, ~11,000,000 meters, ~8 GW of A/C

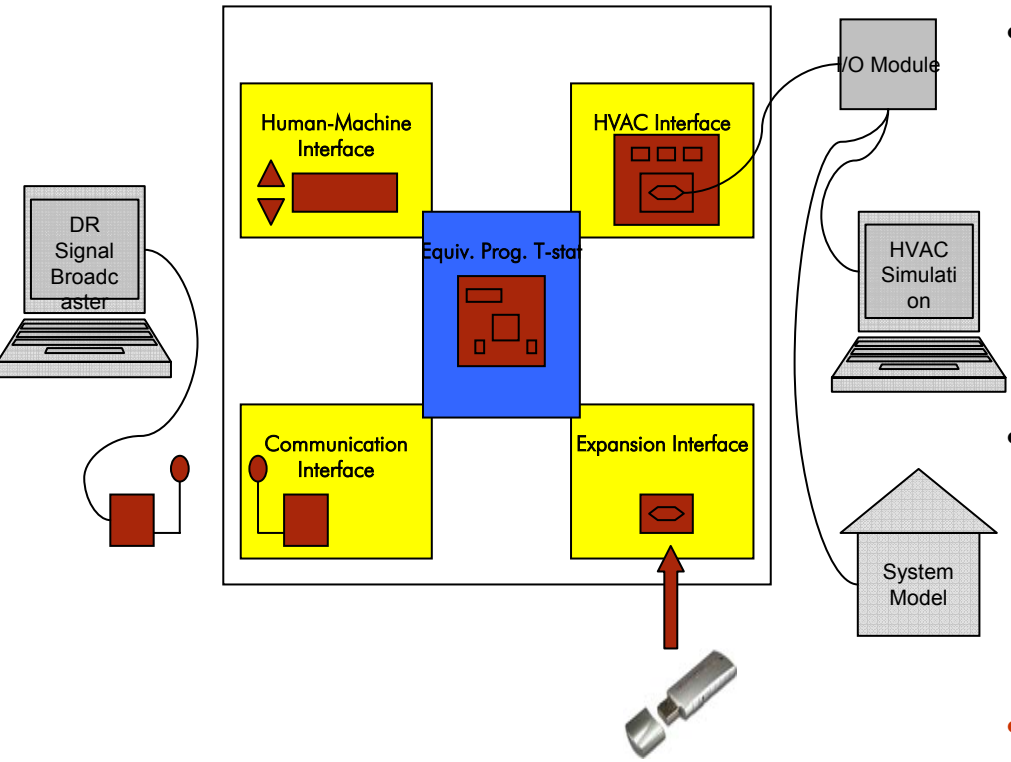
Larger Customer DR Successes

Auto DR is step to attaining EAP goal of 5% peak load reduction by 2007.



Small Customer DR Successes

ESI R&D is informing 2008 Building Standards by showing feasibility of Programmable Communicating Thermostats (PCT).



- E3 analysis assumed that the "minimum" PCT consumer cost was $150 over today's programmable thermostat
  - Analysis found PCTs at that cost were cost effective in all climate zones (marginally in one zone)
- ESI's research Proof-of-Concept PCT showed possible to make PCT approximately equal to consumer costs for today's programmable thermostat and proved it's feasible
- California consumer savings potential >$1 B

Bill of materials for the Proof-of-Concept PCT around $20 – we anticipate DRETD will drive this down to $2.

Looking forward, ESI believes these technologies can address transmission, distribution, security and other research areas.

Questions & Answers

Backup Slides

California's Public Interest Energy Research (PIER) Program

- PIER was established in 1997 as part of electricity restructuring
  - Maintains capacity for applied energy research of benefit to electricity ratepayers
  - $62.5 M annual funding for research provided by surcharge on IOU ratepayers
  - Between 300-400 active projects
- PIER was expanded in 2005 by CPUC rule to include $12 M of natural gas research
  - Expected to grow to $24 M by 2009
- Recent Legislation adds transportation

PIER Completes 2006-2011 Electricity Investment Plan

California Energy Context

California provides clean, affordable, reliable and resilient sources of energy where consumers have choices that meet their needs, businesses prosper, and the state's beauty and environmental integrity are preserved.

PIER Mission Statement

The PIER program provides advanced energy innovations in hardware, software, systems, exploratory concepts, supporting knowledge and balanced portfolio of near-mid-long term energy options for a sustainable energy future in California

PIER Vision Statement

Sustainable energy choices for utilities, state and local government, and large and small consumers in California

PIER Values

Legislative Mandate

- Improves the quality of life of Californians by protecting public health and providing environmentally sound, safe, reliable, and affordable energy services and products
- Undertakes public interest energy RD&D projects that are not adequately provided for by competitive and regulated energy markets
- Advances energy science & technology of value to Californians

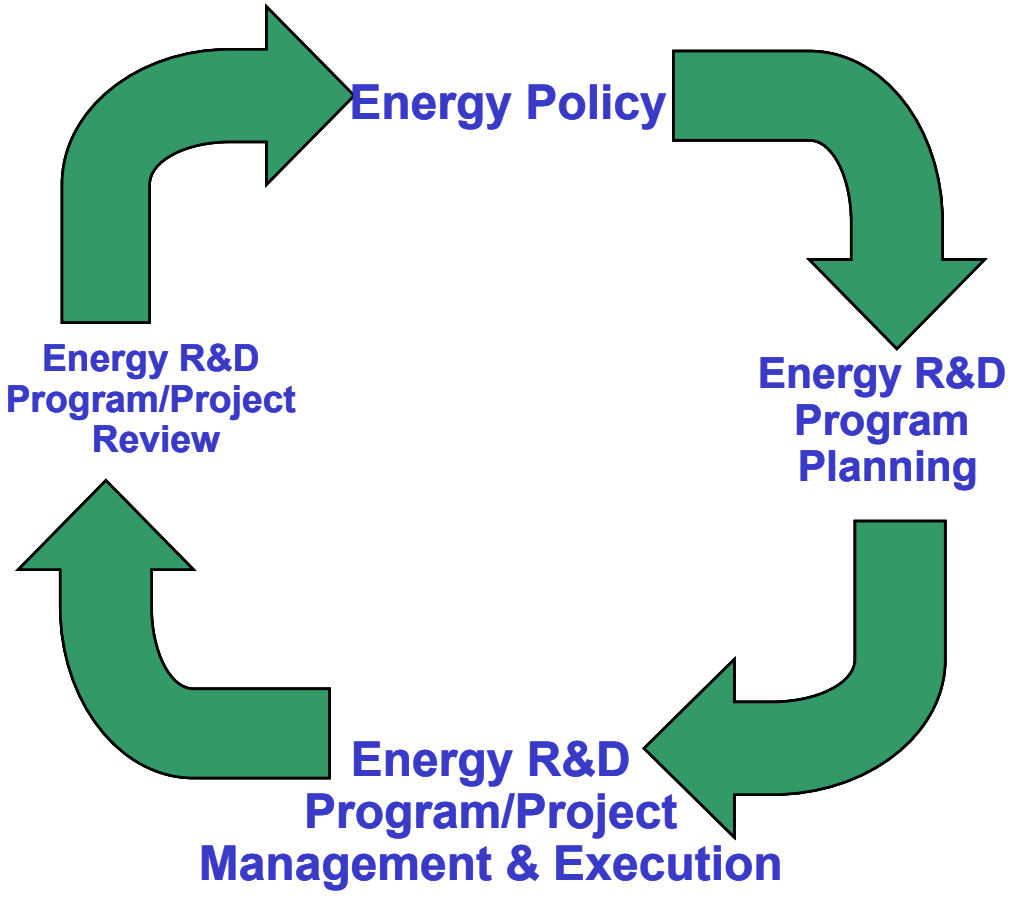
Processes

- Responds to energy problems important to Californians
- Informs and responds to state policy
- Provides environmental stewardship and natural resource conservation
- Anticipates energy issues that California will face
- Provides leadership to develop affordable, innovative and useful solutions
- Maintains integrity, objectivity and trust as California's gateway for new energy technologies
- Strives towards excellence in solutions, management and administrative processes
- Attracts, retains and motivates the most talented staff
- Balances a portfolio of incremental, breakthrough and radical innovations

Stakeholder Collaboration

- Works with stakeholders to plan research and transfer technology
- Maximizes resources through valuable partnerships
- Funds the best and brightest researchers

The PIER Energy Policy – Energy R&D Cycle Begin with the End in Mind



- PIER R&D is always carried out within the context of CA Energy policy and addresses needs not met by the private sector
- PIER R&D aims to provide advanced technology that improves the lives of Californians, which means that PIER must interact with the marketplace
- PIER R&D planning, management, and evaluation is designed and carried out with the intent of
  - Meeting policy goals, or revising policy goals
  - Engaging with users and manufacturers throughout the R&D process
- PIER R&D addresses critical technical, market, and policy risks.

California Energy Policy Framework

2005 Integrated Energy Policy Report (IEPR)

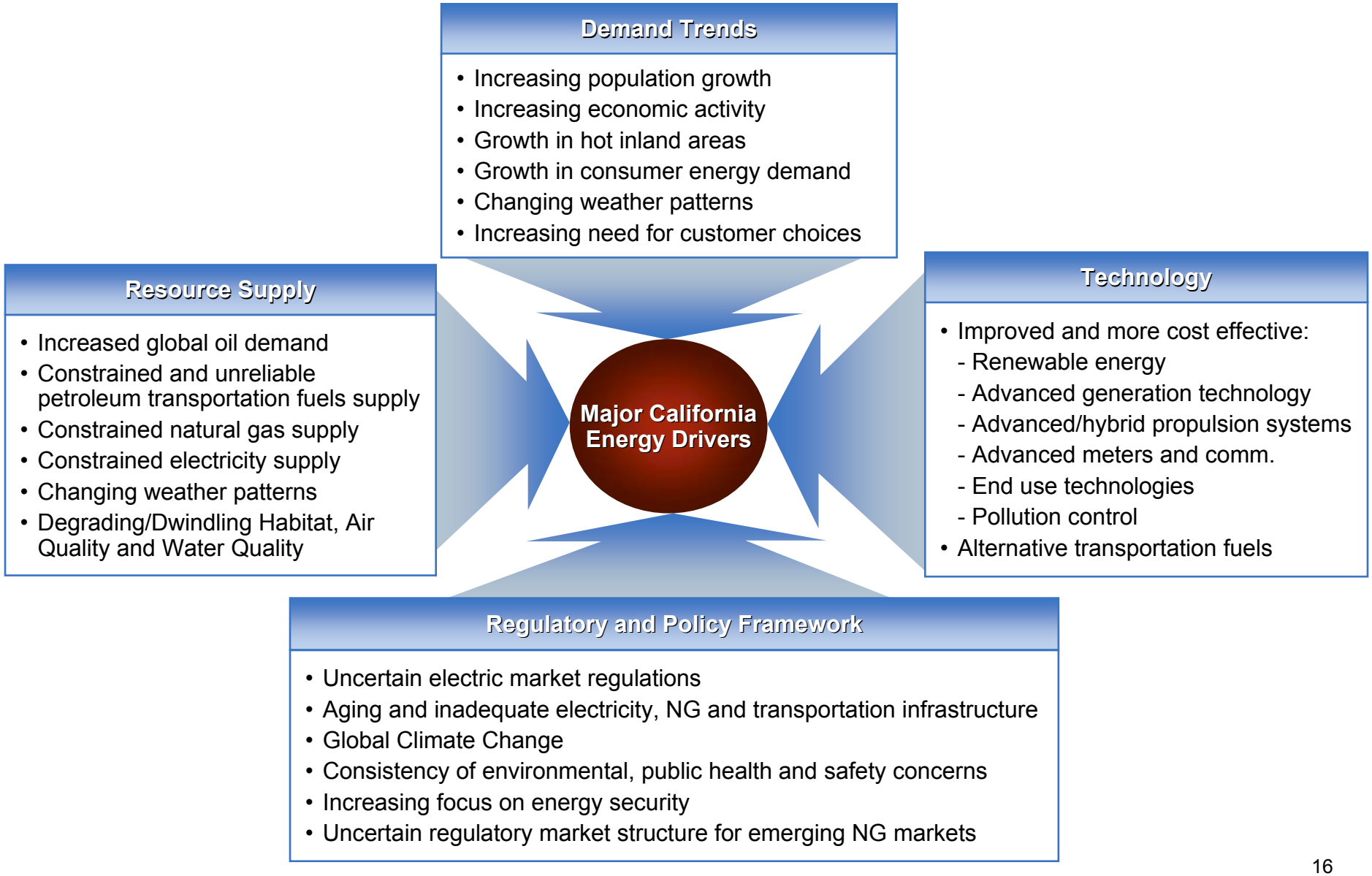
1. Demand-Side Resources, Distributed Generation and Other Electricity Supplies
2. Integrated Water and Energy Strategies
3. Renewable Resources for Electricity
4. Electricity Needs and Procurement Policies
5. Transmission
6. Natural Gas
7. Transportation Fuels
8. Global Climate Change
9. Border Energy

Energy Action Plan II (EAP)

1. Energy Efficiency
2. Demand Response
3. Renewables
4. Electricity Adequacy, Reliability and Infrastructure
5. Electricity Market Structure
6. Natural Gas Supply, Demand, and Infrastructure
7. Transportation Fuels Supply, Demand, and Infrastructure
8. Research, Development, and Demonstration
9. Climate Change

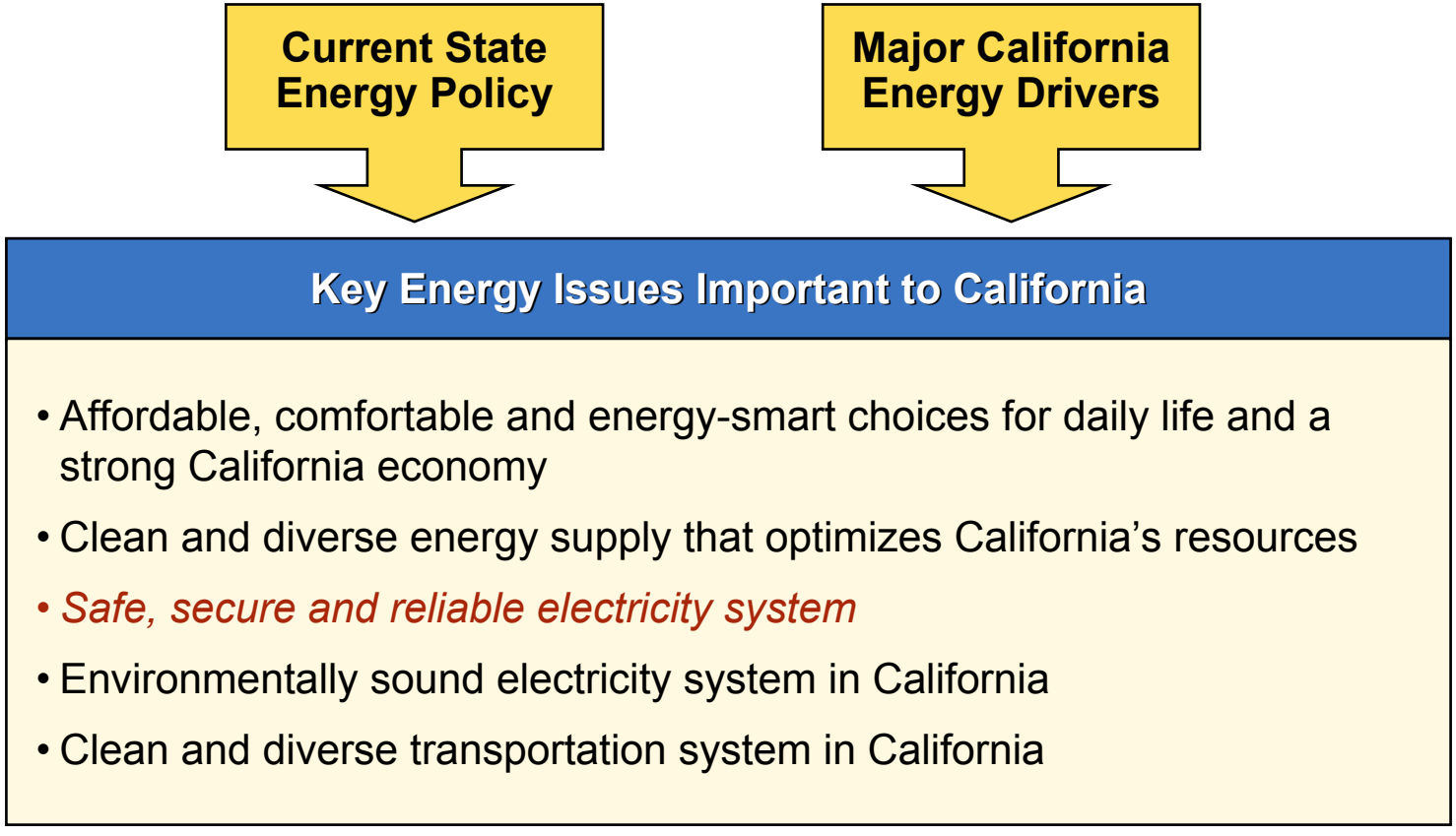
The Five Year Plan Captures Significant Trends & Drivers

25 Trends and drivers grouped into four major categories.



The Five Year Plan Highlights 5 Energy Issues Important to California

As directed by policy, and incorporating emerging issues from major drivers, PIER identified five key energy issues.



Electricity Five Year Plan

Integrated Electricity System that is Reliable and Secure

PIER Strategic Objectives	1. Enable optimal integration of renewables, distributed generation, demand response, and storage to the power system. 2. Improve capacity, utilization, and performance of transmission and distribution system. 3. Improve cost and functionality of components to integrate demand response, distributed generation, and electricity storage into the system. 4. Improve security and reliability of electricity system. 5. Support improvement of tariffs and regulations for demand response, distributed generation, storage, and renewables. 6. Facilitate transmission siting process. 7. Develop knowledge base for future decision-making and informed delivery, integration, and infrastructure policy relative to electricity.
Primary Solutions	• Increase the intelligence and responsiveness of the transmission and distribution system to more effectively enable optimal integration and use of renewables, demand response, distributed generation, and storage. • Support integration of intermittent and remotely located renewables into the system. • Improve cost and functionality of demand response, storage, and distributed generation integration components. • Analysis of appropriate market mechanisms for renewables, demand response, distributed generation, CCHP, storage, transmission, distribution, and security (rates and tariffs, markets and utility planning, incentives, regulation, financial). • Provide new technologies and tools to expand capability of existing transmission and distribution (real time ratings and operations, better asset utilization). • Develop an electric system (cyber and physical) that is resilient to natural and man-made events, self-diagnosing and self-healing.
Secondary Solutions	• Develop a regulatory business case for increased utilization of automation, demand response, renewables, and distributed generation on the distribution system that promotes efficiency and reliability while reducing cost. • Provide new planning tools and processes for technical and policy participants, which will result in successful and timely expansion of the transmission system through existing and new corridors (economic transactions that result from transmission congestion). • Develop the analysis and enabling technologies to provide varying levels of electricity service.
Tertiary Solutions	• Analyze the environmental and economic implications of shifting from solely central station power to distributed generation and central station power. • Analyze technical and economic interdependencies between electricity and natural gas infrastructure. • Develop new transparent distribution planning models.

ESI Strategic Objectives Aligned With Policy Drivers

IEPR, EAP, California Solar Initiative, Renewable Portfolio Standard all identify needs that ESI is focused on finding solutions for.

Integrated Electricity System that is Reliable and Secure

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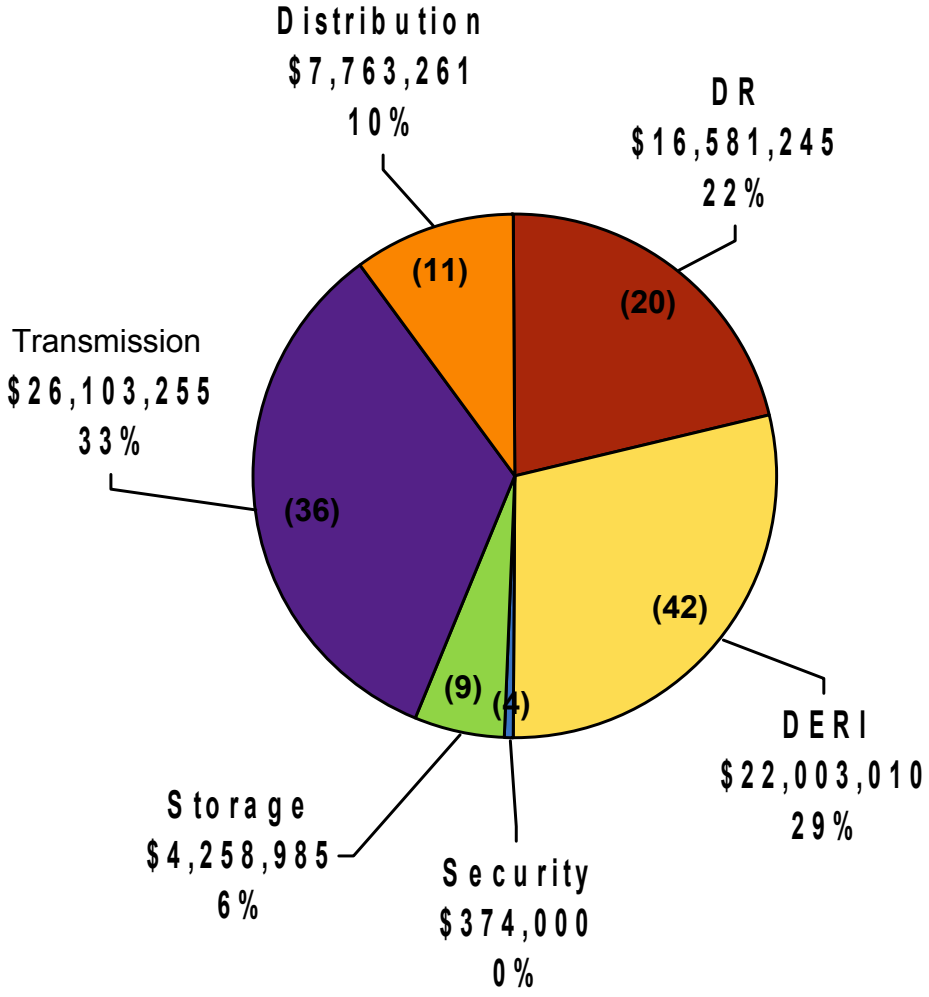
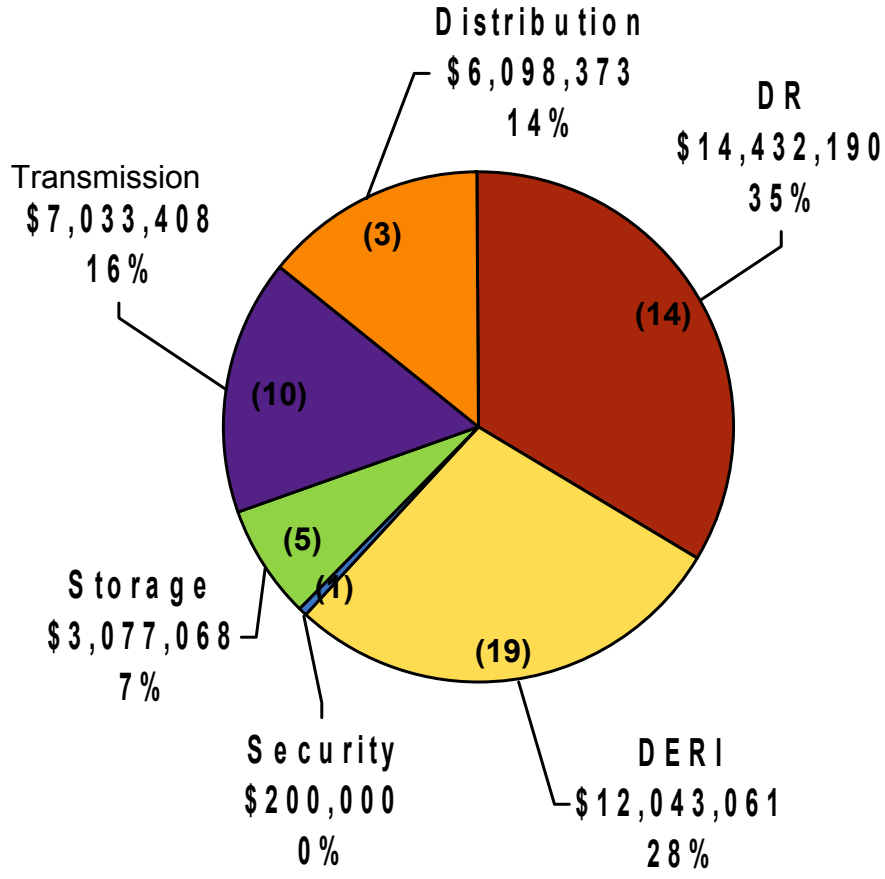
Our comprehensive portfolio of T&D, DR, DER Integration, Storage and Security research projects is supporting these strategic objectives.

ESI Portfolio

Transmission, DR and DER Integration continue to be predominant areas of investment for ESI.



122 Active & Completed projects totaling $77,083,756



52 Active projects totaling $42,884,100