Energy Efficiency: The First Fuel in the Race for a Clean and Secure Energy Future

Presented to the

AIChE-Knoxville-Oak Ridge Section

by

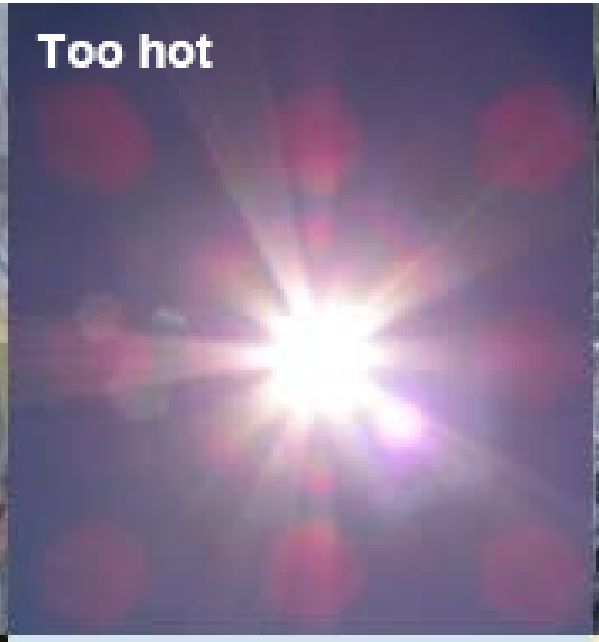
Robert A. (Bob) Hawsey

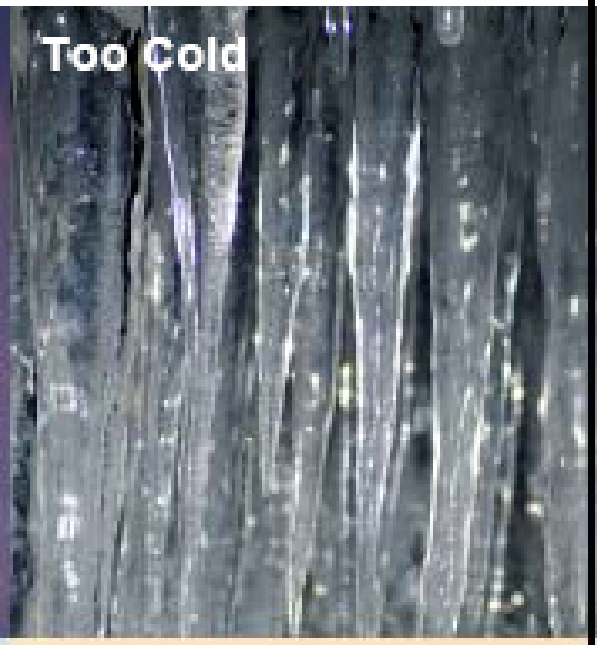
Director, Energy Efficiency and Renewable Energy

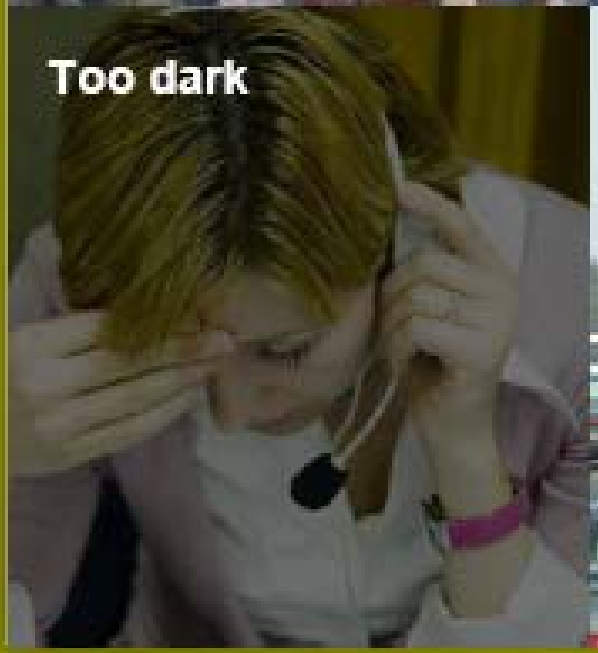
May 29, 2008

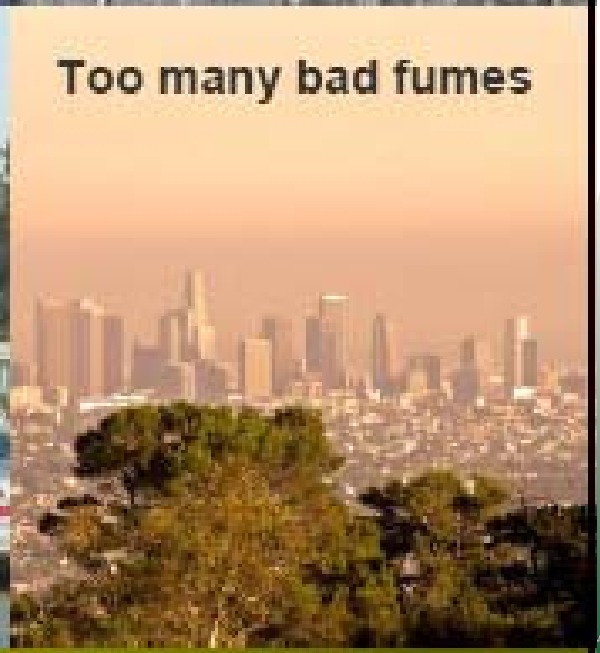
Change is Necessary

Planet Stress | Climate Stress | People Stress

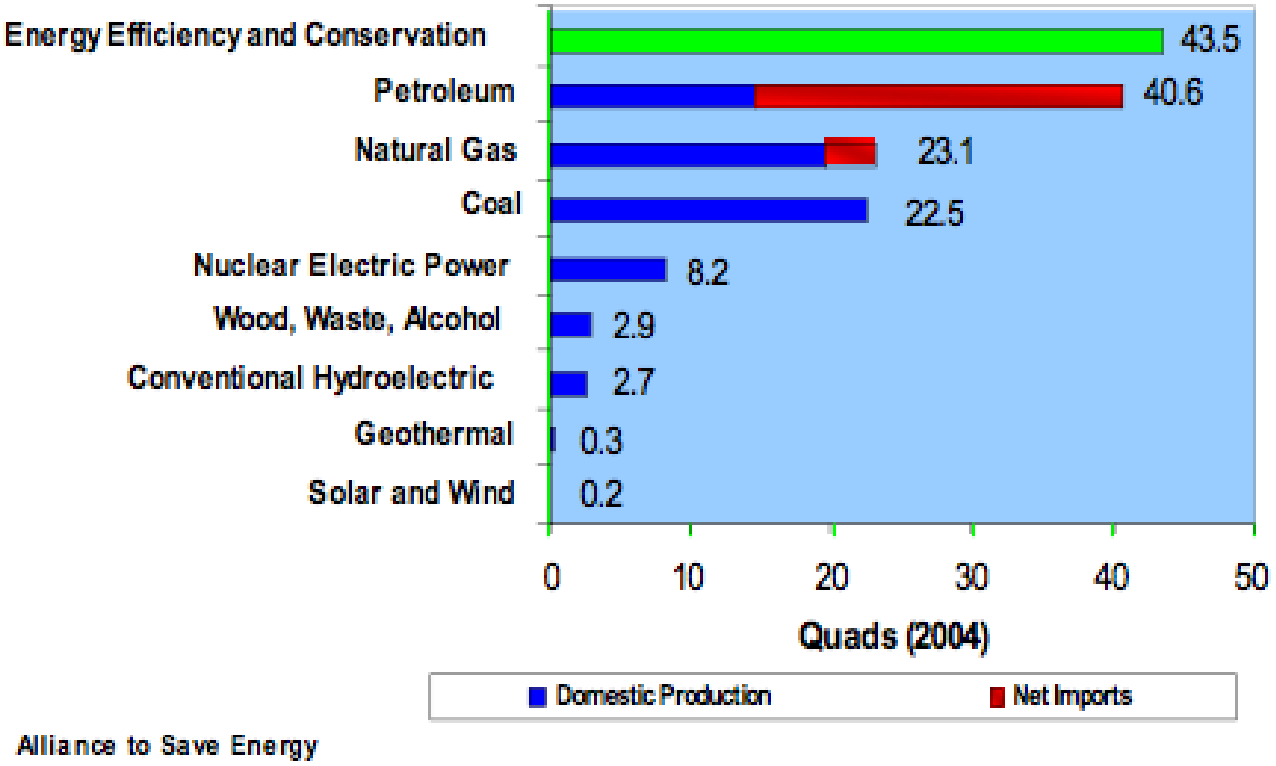






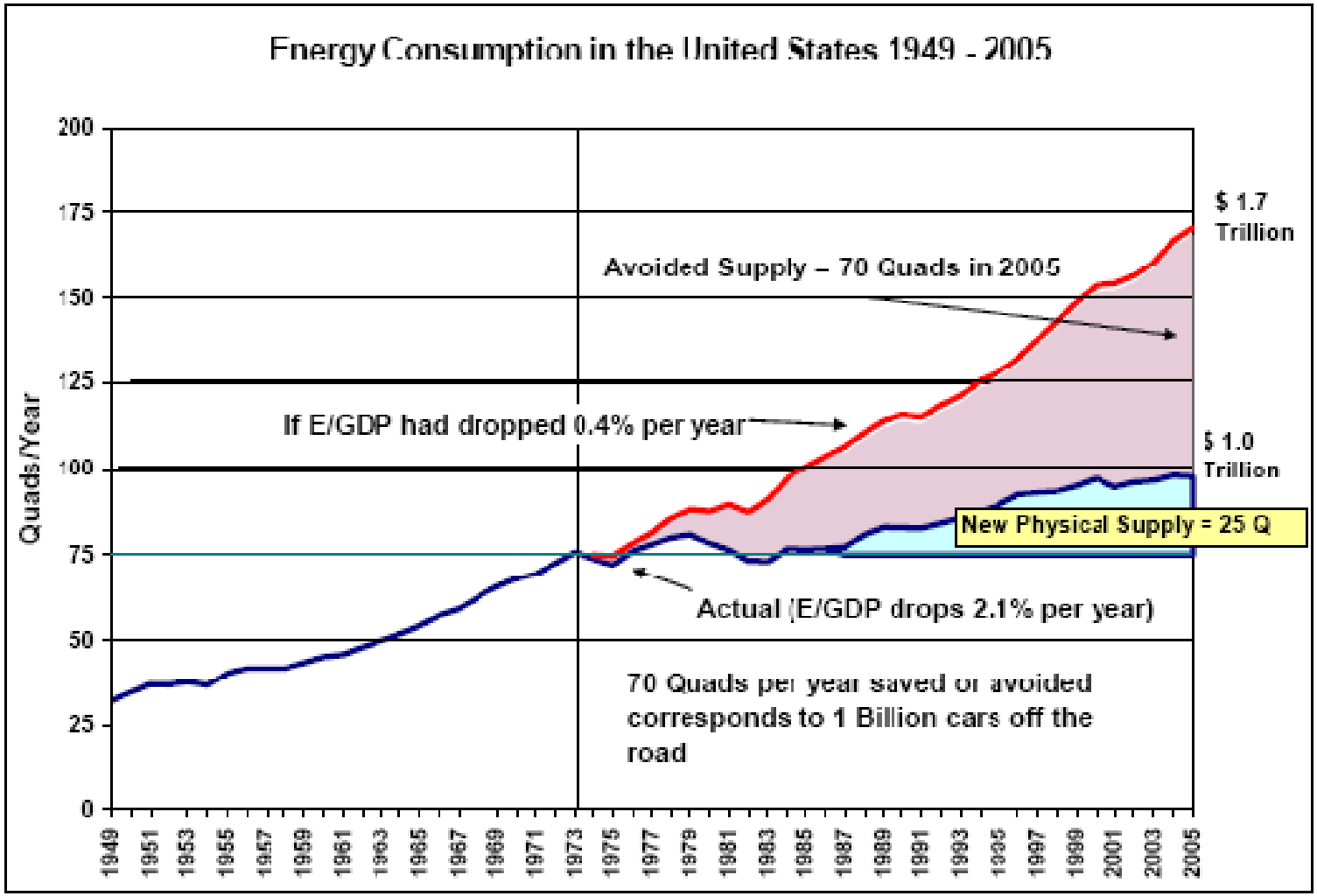


Energy efficiency and conservation improvements since 1973 have reduced U.S. annual energy consumption by 40+ quads

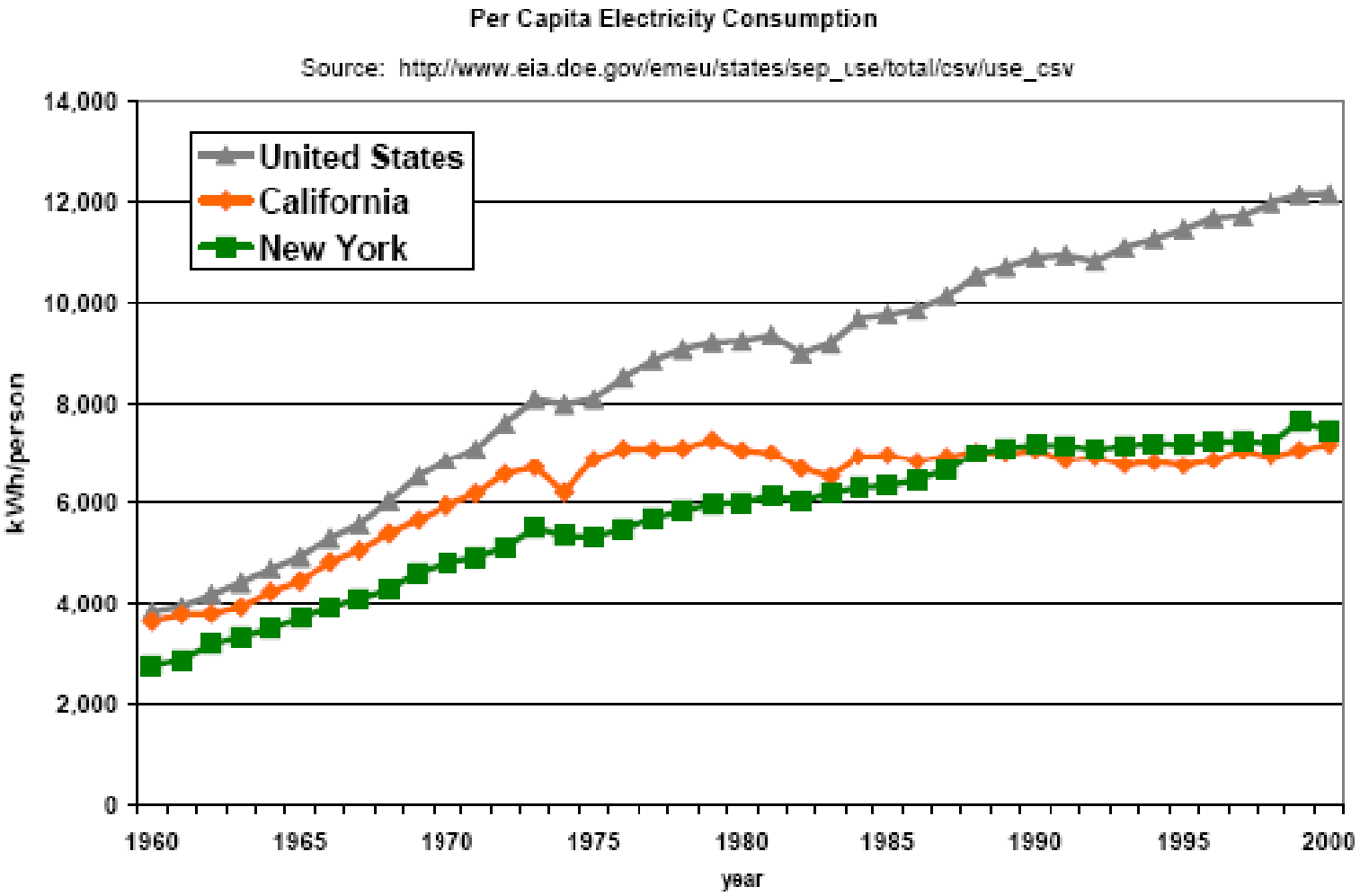


Roughly $400 billion energy savings per year.

The value of the energy savings has been enormous



State leadership has demonstrated enhanced energy efficiency



States with utility sector energy efficiency programs—public benefits or DSM

Blue states have public benefit funds that support EE

Green states have utility DSM under regulated structure

Energy Efficiency (EE) is an abundant "resource"

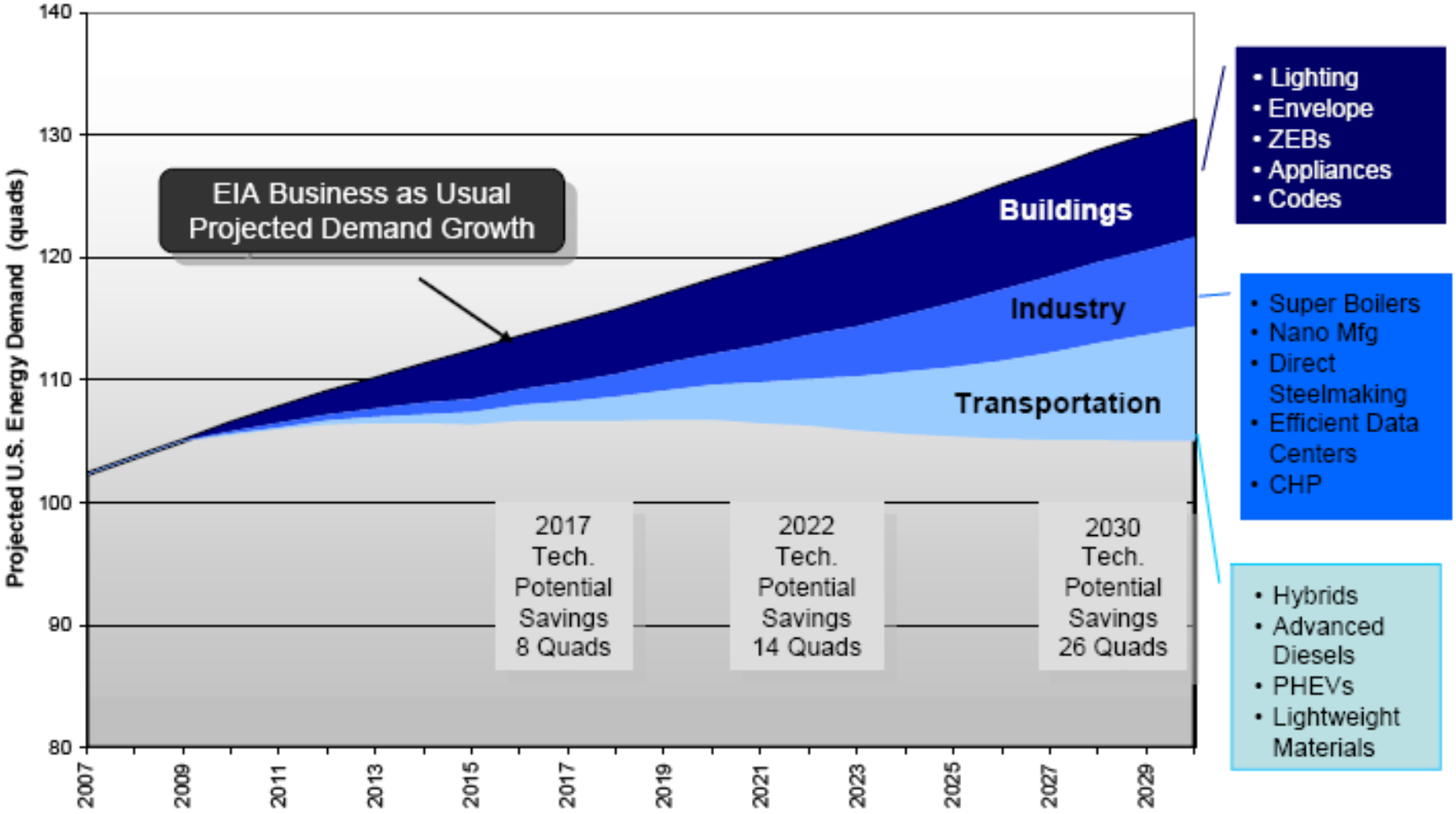
CHEAPER

- **Each $1 invested in Energy Star programs = $75 in energy cost savings and $15 of investment in new efficiency technologies**
- **Average Cost of Demand Side Management (EE) Programs= 2-4 cents/kWh**
  - **Lower cost than building any new generation, including renewables**

- QUICKER
  - **In 2001, California cut peak electricity use by 10% in less than a year by implementing energy efficient technologies and practices**
- CLEANER
  - **The watt that's never generated produces NO ENVIRONMENTAL FOOTPRINT**
- EHANCES ECONOMY and SECURITY
  - **Minimizes Needs for Imported Energy**
  - **Creates New Jobs**
  - **Helps Keep Energy Prices Lower by Reducing Demand During Peak Periods**

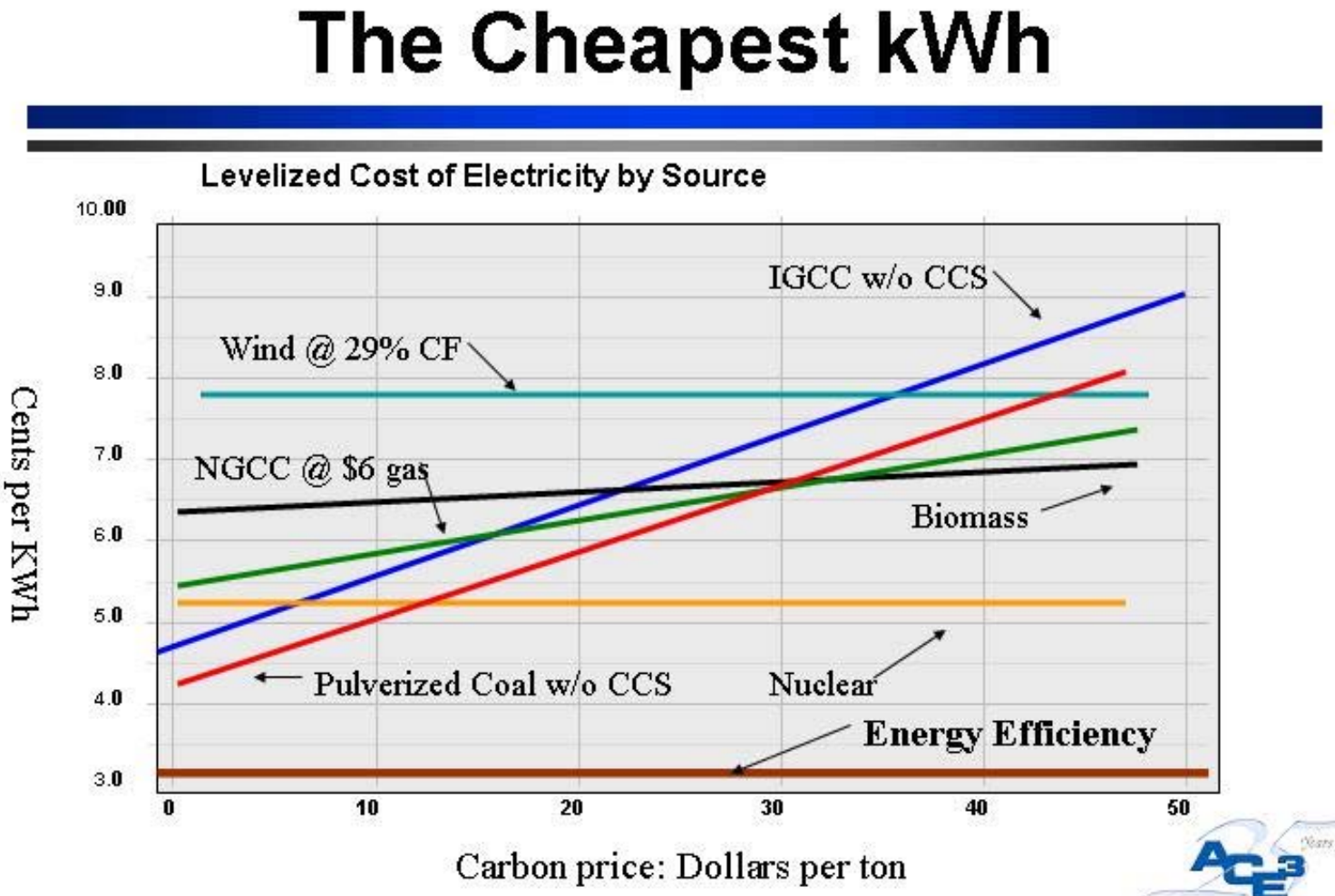
Source: Alliance to Save Energy

Energy Efficiency Has the Technical Potential to Level Energy Demand Growth

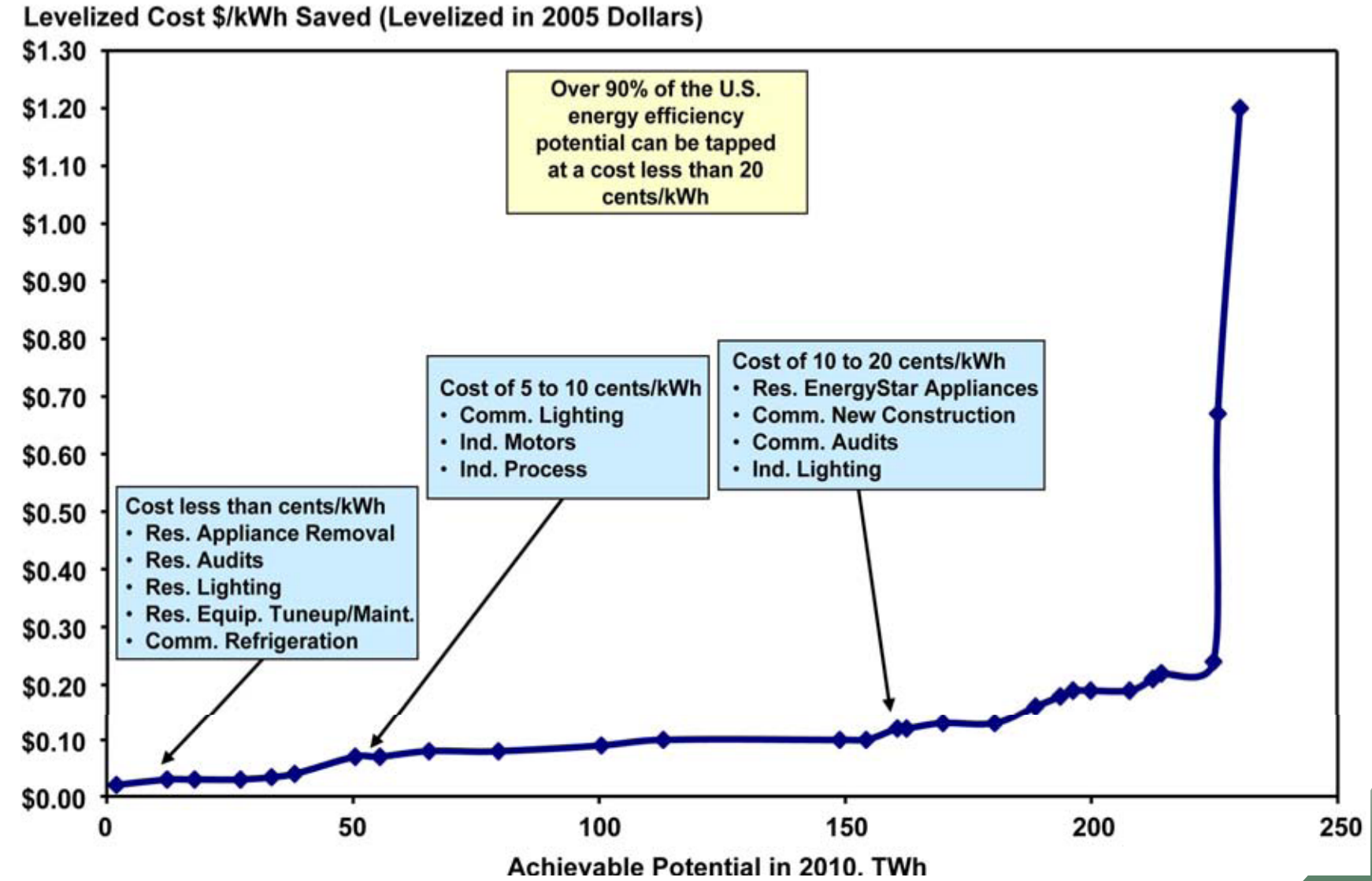


Sources: DOE Scenario Projections; from speech by A. Karsner, Dec 2007

Energy Efficiency is now the “first choice” and usually the lowest-cost option...and carbon has yet to be constrained or priced to a significant extent in the USA (but it will)



What's the cost of energy savings through efficiency gains?



Wikler, Greg, "Assessment of U.S. Energy Efficiency Potential," Global Energy Partners, 2006.

Industry is taking note- First there was General Electric's "Eco-Imagination" and then Dow Chemical Company announced...

Efficiency and The Triple Bottom Line

Good for Business:
Saves Money, Enhances Global Competitiveness, Preserves Jobs, Creates Prosperity for Shareholders

Good for the Environment:
Fewer GHG Emissions, Part of the Solution to Global Climate Change

Good for Society: Reduces Demand, Lowers Energy Bills, Promotes Energy Security

Courtesy: John Dearborn, The Dow Chemical Company

The industrial sector's dependence upon natural gas has created a national problem

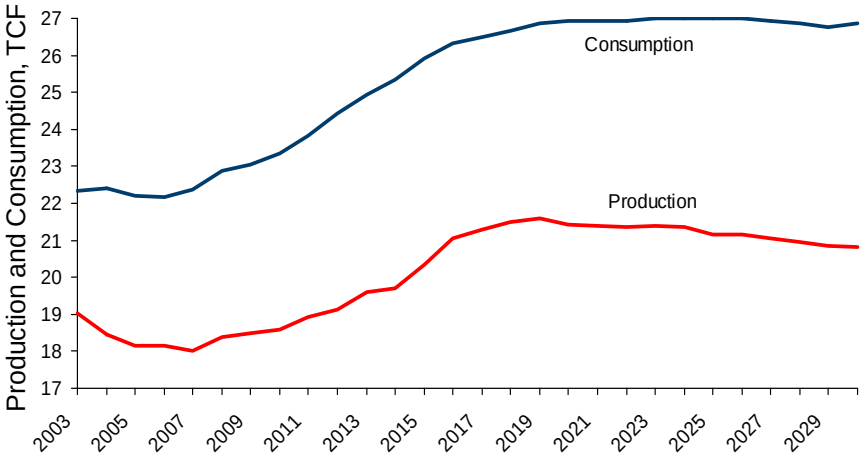
- **Rapid increase in natural gas prices has had particularly adverse impact on industrial sectors**
  - **Very high (150% - 300%) increases from historic price levels**
  - **Supply is constrained**
  - **Problem is acute in North American market, providing economic incentives to relocate**
- **Example: Chemical manufacturers are shutting down domestic production and moving plants to Asia & Middle East**
  - **50% of methanol, 45% of ammonia, and 15% of ethylene capacities have been shut down since 2000**
  - **U.S. import of fertilizers increased to 45% from 10% 15 years ago**
  - **In 2005 8,400 jobs were lost in the chemical industry**
  - **Industry went from an 80-yr trade surplus ($20B in 1995) to trade deficits beginning in 2002**

Energy efficiency and alternative energy sources will be required to achieve energy assurance

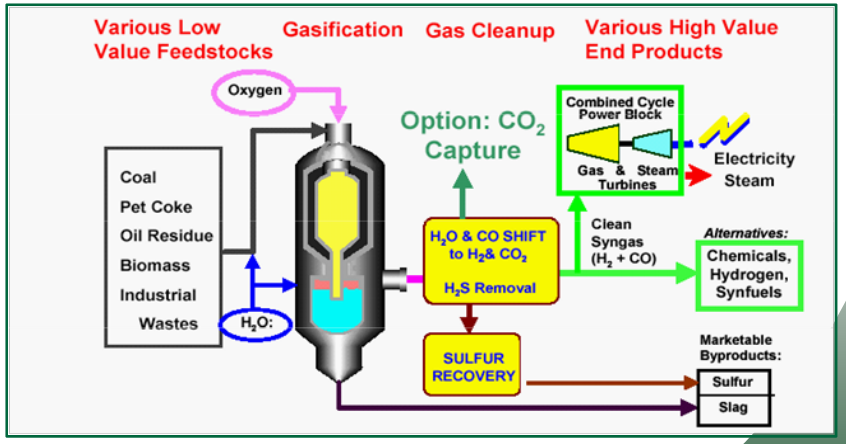
Working with industry to solve energy problems---

- Save Energy Now industrial plant assessments
  - Utilities becoming involved
- Developing new technologies to reduce industrial energy consumption
- Developing new energy sources

U.S. Natural Gas Production & Consumption



Gasification of Alternative Fuel and Feedstocks



Industrial technologies R&D Areas: Focus on Energy Efficiency improvement

Industrial Reaction and Separation

Develop technologies for efficient reaction and separation processes

- Oxidation Processes
- Microchannel Reactors
- Hybrid Distillation
- Alternative Processes
- Advanced Water Removal

High Temperature Materials Processes

Develop energy efficient high-temperature process technologies for producing metals and non-metallic minerals

- Advanced Metal Heating and Reheating
- Advanced Melting
- Efficient Heat Treating
- High Efficiency Calcining
- Next-Generation Steelmaking

Industry Specific Application

Technology Demonstration to Reduce Technical Risks

- SuperBoiler
- Isothermal Melter
- Ultra-hard materials
- Industrial wireless technologies

Fuel & Feedstock Flexibility

Promote energy diversity and independence by increasing the range of fuels competitively available to industry, the largest natural gas consuming sector in U.S.

- Accelerate market adoption
- Process Integration R&D
- Technology Validation

New Ultra-Thin Coating Process Extends Service Life of Materials & Reduces Energy Consumption

Metal Infusion Surface Treatment (MIST)

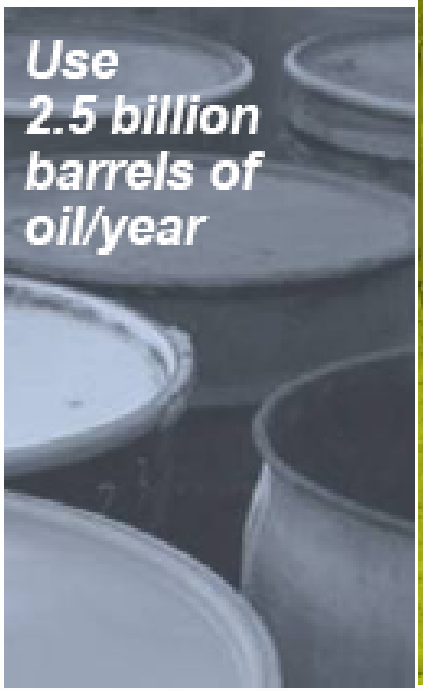
- **C^3 formed a new company in 2002 and began marketing MIST in 2005. Markets include**
  - **Aluminum die-casting (implemented by 35 companies to date)**
  - **Hot rolled steel**
  - **Cutting tools**
  - **Future applications in spark plugs & catalytic converters**
- **MIST extends product life 10 – 50 times and uses 10 – 100 times less material than traditional processes, increasing production rates, reducing manufacturing costs, and reducing energy use**
  - **Will save hot rolled steel industry $300M/yr**
  - **Estimated energy savings of 2.7 x 10^{12} BTU/yr for aluminum die-casting**
- **ORNL teamed with C^3 to develop & characterize process**

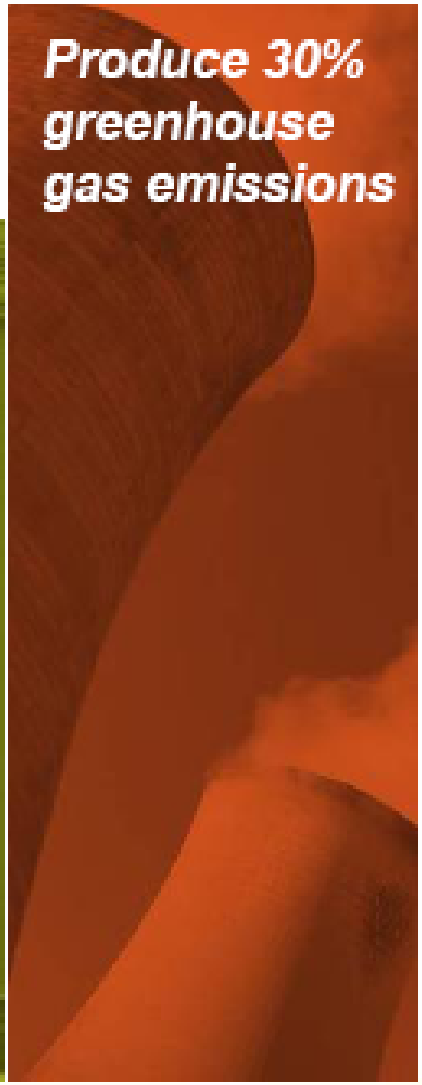
Accelerating Nanotechnology Commercialization

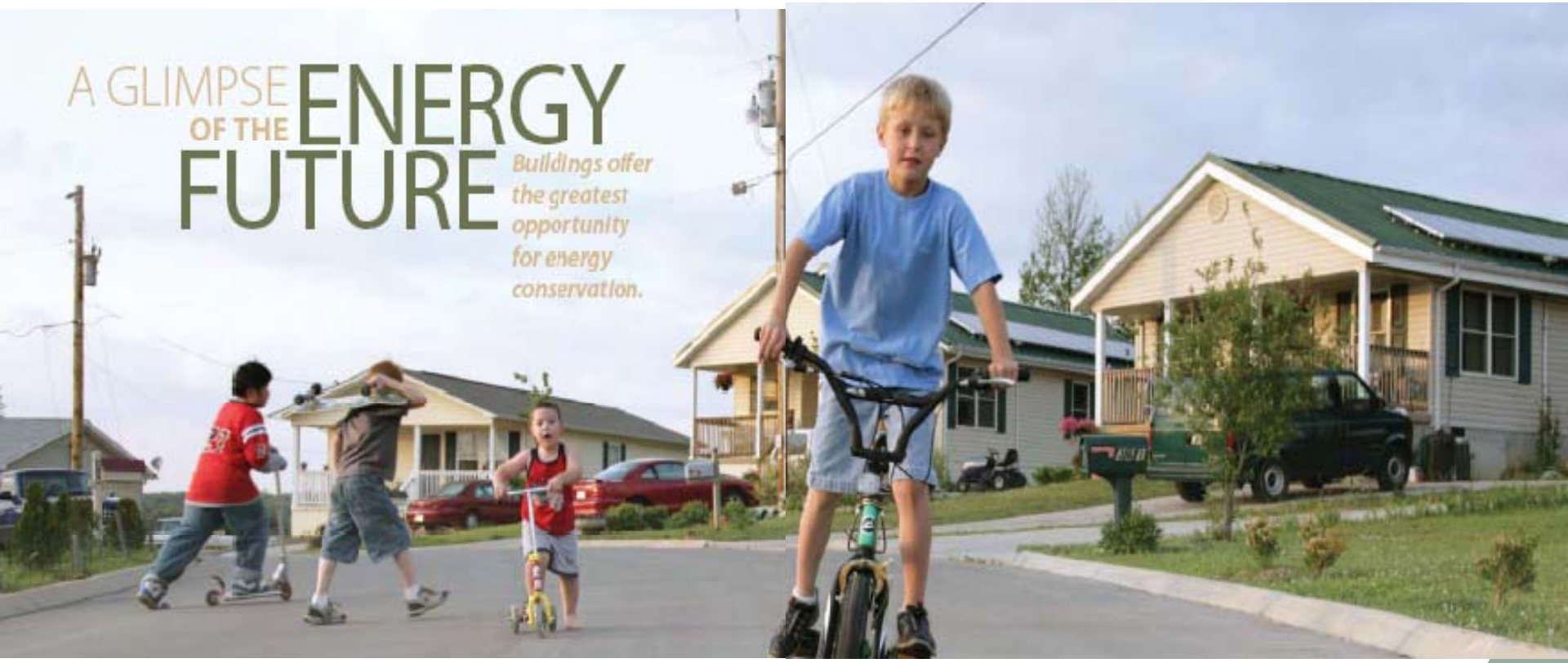
C^3: *Startup Company in 2002 →*
Projected $MM Business in 5 Years

Change is Necessary

Buildings Add to the Stress







Towards true net zero energy buildings: develop deep-savings components to enable zero-energy, demand-responsive buildings

Whole-house energy savings: 40% use; 40% peak periods

Integration of today's technology

Heat pump water heater: 50% energy savings

Ground-source IHP: Saves 50% on H, C, WH, D

Air-source IHP: Saves 50% on H, C, WH, D in mild areas

Appliances, suites, whole-home E-mgmt

ZEHcore wall and SIPs save energy and cost

Partner TBA

Whole-house energy savings: 70% use; 80% peak periods

Integration of emerging technologies from partners

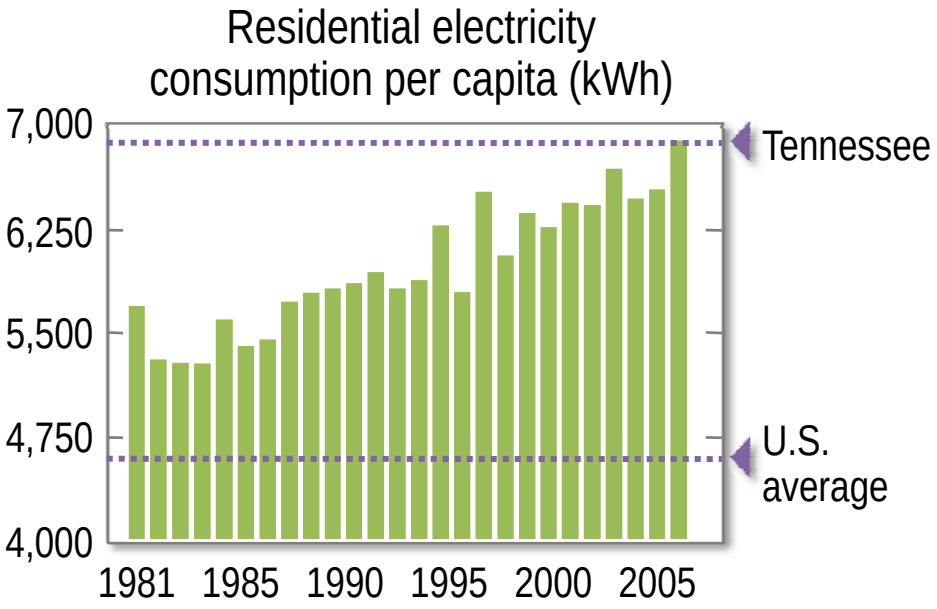
Zero-energy homes shown (zero-energy buildings similar)

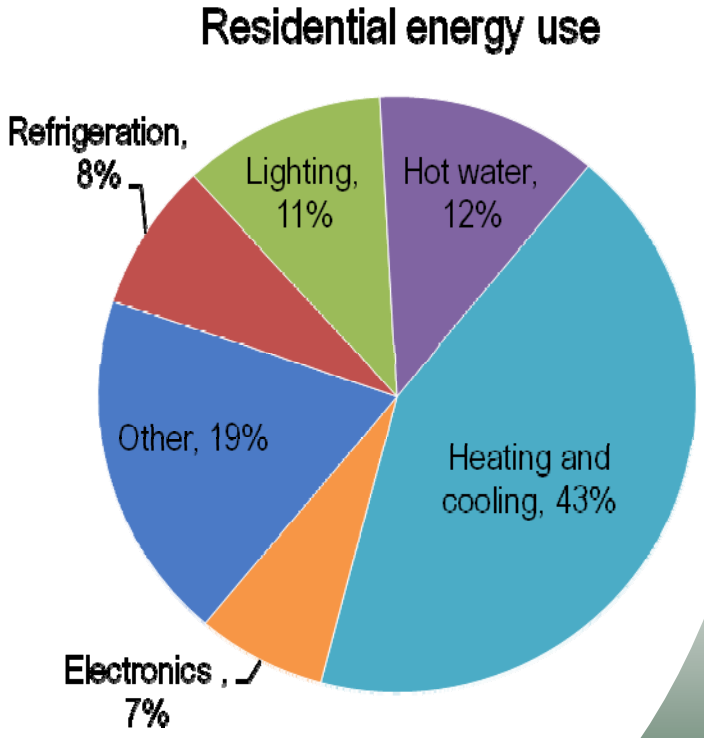
Demand response: reducing peak period load while maintaining quality of life

- **Study by Cowart (2001) showed DR saved the construction of 29-1GW electric plants between 1985-1994 at cost of just 3 cents/kWh**
- **Aspects of demand response include**
  - **Load reduction can be via physical or financial curtailment**
  - **Requires products and programs to enable demand reduction during peak periods**
    - **The highest 5% of a utility's peak demand (load) may occur less than 50 hours per year and cost ~10X the retail rate**
- **Linking consumption with actual costs creates opportunities for energy efficiency and can lower overall costs**
  - **Customers can't respond (manage their usage) if they don't know what it is**
  - **Will all loads eventually be able to respond to a price signal?**

Residential electricity use per capita: Tennesseans are second in the nation

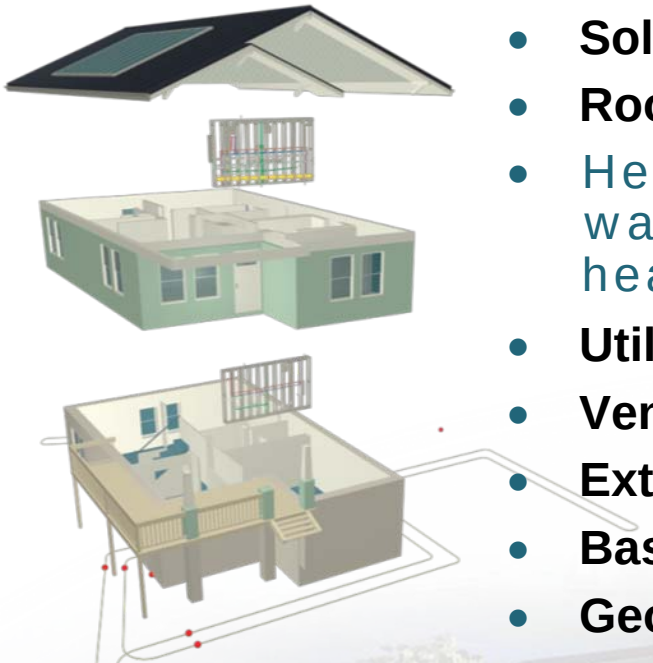
- ~2.6M residential customers (meters) for electricity in Tennessee
- Energy consumed in Tennessee homes
  - Electricity: 62%
  - Natural gas: 30%
  - Petroleum products: 5%
  - Wood: 3%





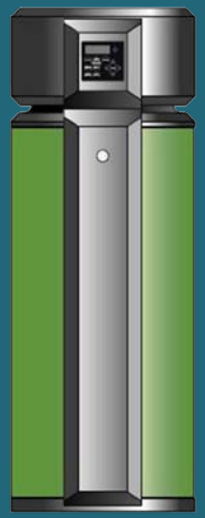
Residential energy consumption:

Advanced technology is becoming available



- **Solar panels**
- **Roofing**
- Heat pump water heater
- **Utility walls**
- **Ventilation**
- **Exterior walls**
- **Basement**
- **Geothermal**

- 65% of Tennessee homes have electric water heaters
- Converting them all to heat pump water heaters would:
  - Reduce energy use by 3.5 billion kWh per year
  - Save Tennessee residents $260M per year

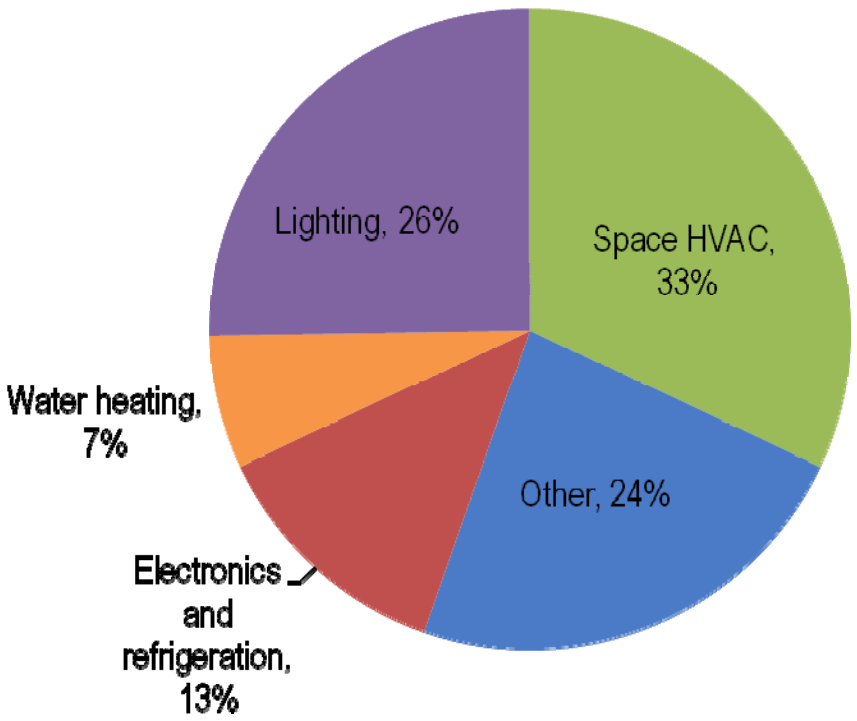


Homes can be built in Tennessee today that save 60-70% on energy

Commercial energy consumption:

Dramatic near-term reductions can be achieved

~430,000 light-to-medium commercial and industrial electrical customers (meters)



Typical commercial building energy consumption

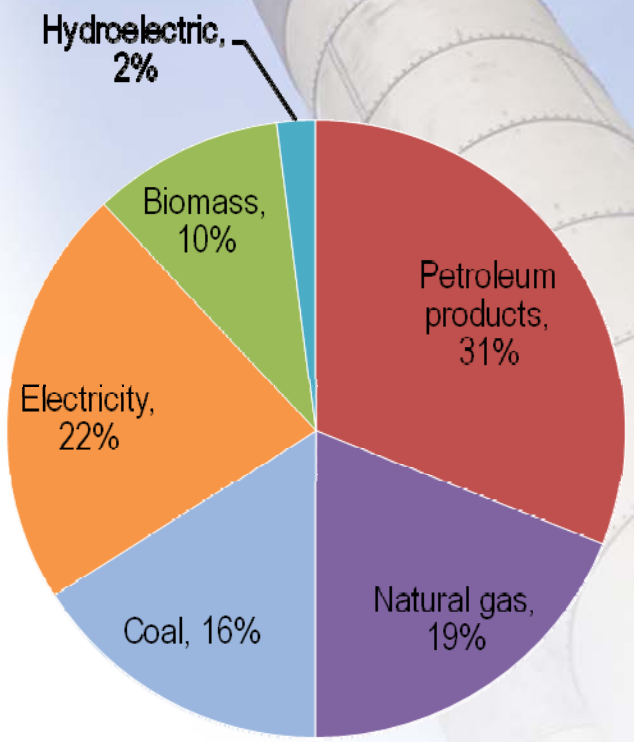
- Lighting:
  - Incandescent and old fluorescent (T12) to new T8, T5, dimmable
  - Occupancy sensors
  - Daylighting
  - LEDs in wide application
- Space HVAC:
  - Energy service contracting
  - Cool roofs
  - Energy management systems
  - Ground source heat pumps
- Water heating:
  - Recycle waste heat from HVAC
- Other
  - Active indoor air quality sensing and controls
  - EnergyStar equipment and appliances

Deploy proven technologies in schools and commercial buildings

- **Cool roofs**
  - **Georgia elementary school: Energy savings of $14,500 per year**
  - **Converting 2,366 Tennessee K–12 schools would save $19M per year**
- **Ground source heat pumps**
  - **All Sumner County schools are using geothermal technology**
  - **Converting 2,366 Tennessee K–12 schools would save $122M per year**
- **These and other upgrades can be readily deployed in commercial buildings**
  - **Projects routinely save 20%**
  - **Payback from savings: 10 to 15 years**
  - **Total savings in Tennessee could exceed $500M per year**

Tennessee's industrial sector is powered primarily by fossil energy

~440 heavy commercial/ industrial customers	
Transportation equipment	28%
Computer and electronics manufacturers	12%
Food	12%
Chemicals	12%
Machinery	8%
Metal products	~7%
Plastics and rubber	~7%
Primary metals	~7%
Other (includes electrical equipment and paper manufacturing)	~7%



Sources of industrial energy, 2005

12th in the nation in industrial energy consumption

There are opportunities to reduce industrial energy use and carbon emission

- **Most energy goes to process heating and steam**
- **In 2006–2007, Tennessee Industrial Technology Program assisted 15 Tennessee industrial plants**
  - **Free DOE program: "Save Energy Now"**
  - **Industrial Assessment Center at Tennessee Tech**
- **Teams found large average potential savings per plant:**
  - **$1.4M per year**
  - **3.3% reduction in energy**
  - **12,600 metric tons of CO_2 per year**
- **One Tennessee plant found the opportunity to reduce energy consumption by 40%**

Transportation in Tennessee consumes 29% of the state's energy

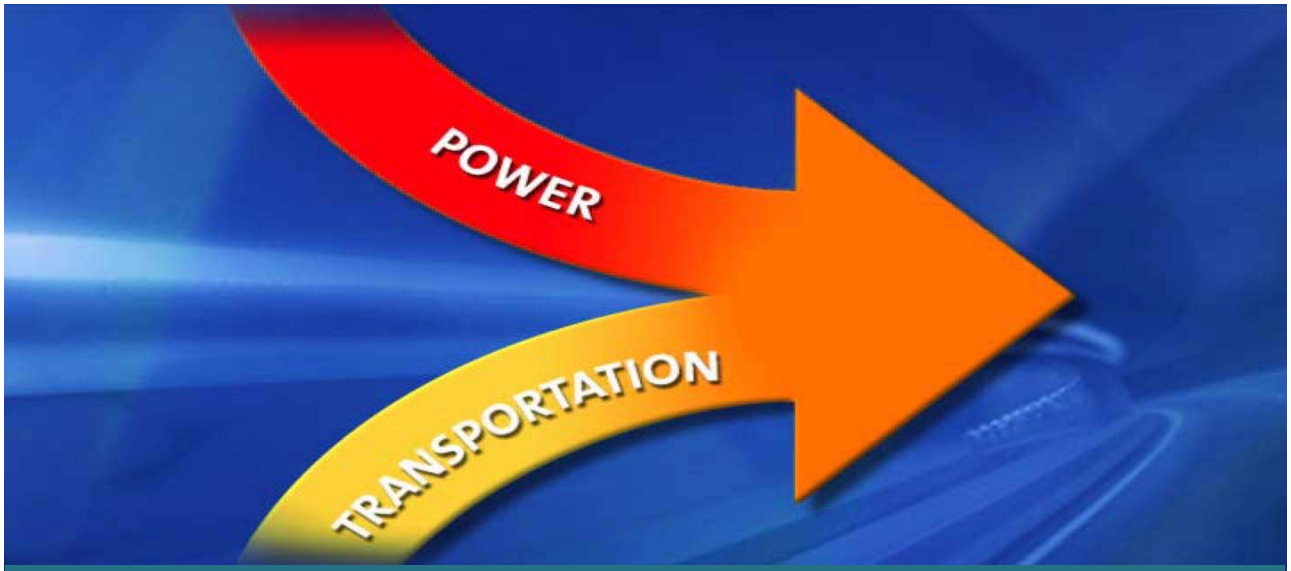
- Petroleum fuels 96% of the transportation sector
  - 5.1 million light trucks and cars (2006)
  - 7,803 alternative fueled vehicles
- From 1980 to 2005, annual vehicle miles of travel in Tennessee increased from 34 billion to 70 billion
  - 56% of trucks on the interstate are passing through Tennessee
  - 30% of all traffic on rural interstate is trucks
- In 2005, Tennesseans bought:
  - 3.1 billion gallons gasoline
  - 1.1 billion gallons diesel
- Estimated CO_2 emissions: 38.4 million metric tons
  - The average vehicle emits 6.7 tons of CO_2 each year

Tennessee can lead in transportation solutions

Today		2030
Average mileage: ~25 mpg	Improve vehicle efficiency through R&D and manufacturing partnerships (HTRC)	Average mileage: ~35 mpg (2020 CAFE), reduced emissions
B20 and E85 becoming available in Tennessee	Expand alternative fuels (BESC BioEnergy Science Center; UTBI Biofuels Initiative)	Cellulosic-based ethanol readily available
Hybrid vehicles in limited use	Develop next-generation vehicles and infrastructure (TVA; TDOT)	Plug-in hybrid electric vehicles: 25% of market

Chevy Volt concept car:
PHEV, 50–100 mpg (equivalent)

We are headed towards a more-electric, more efficient transportation system…



Transportation & Electricity Convergence

…but there's a growing need for the utility and auto industry to collaborate

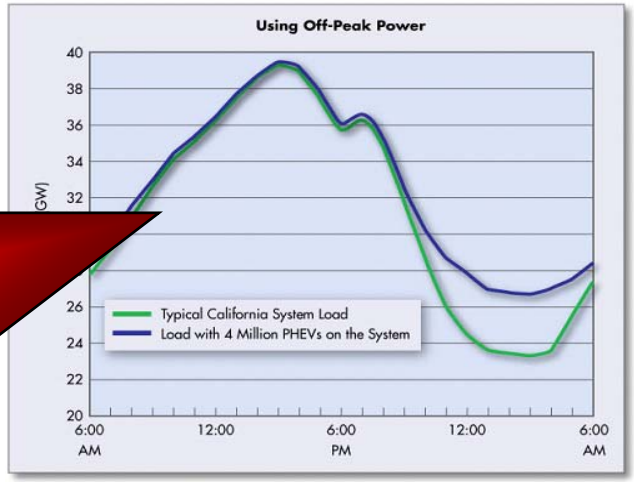
Courtesy of Southern California Edison

…Why Plugging In Makes Sense

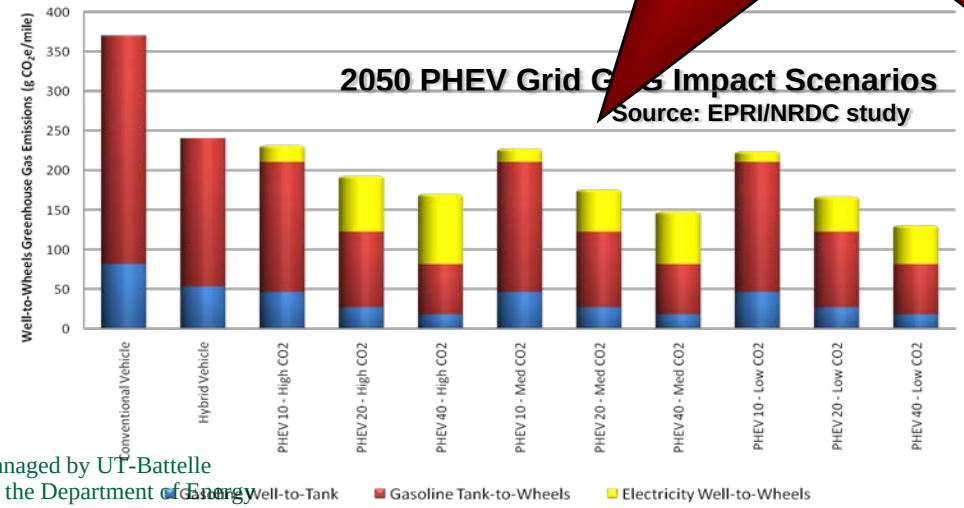
1 **Electricity is 25-50% the cost of A gallon of gasoline equivalent (gge)**

Made In The USA

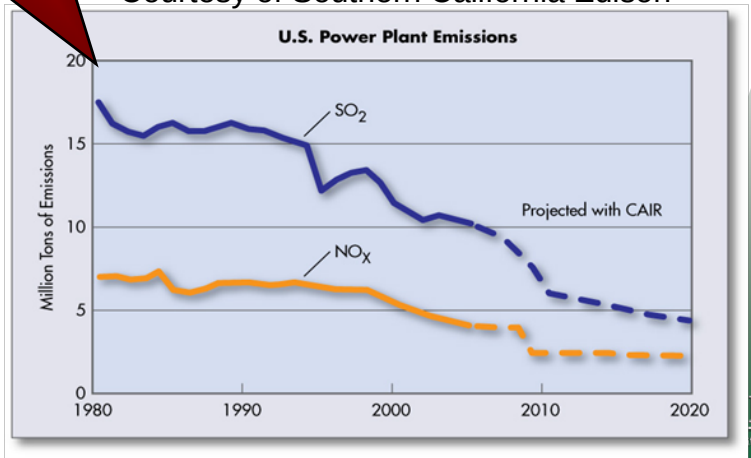
2 **U.S. grid has significant excess capacity (off-peak)**



3 **Vehicle GHG a… …sions f… …when grid-connected**



Courtesy of Southern California Edison



Automaker Plug-in Programs

Toyota Prius

Volvo Recharge

Ford Escape

Chevy Volt

Daimler Sprinter

Audi Metroproject

Daimler Smart

Courtesy of Southern California Edison

Automaker Plug-in Programs (2007)

Toyota Prius

Volvo Recharge

Ford Escape

Eight years after the “commercial” introduction of the Prius and Insight <1% of all new US cars and light trucks sold is a hybrid (and people are still paying over sticker price)…

We have decades to go with PHEVs unless other factors accelerate market development ---including vehicle-to-grid for demand response

Daimler Sprinter

Audi Metroproject

Daimler Smart

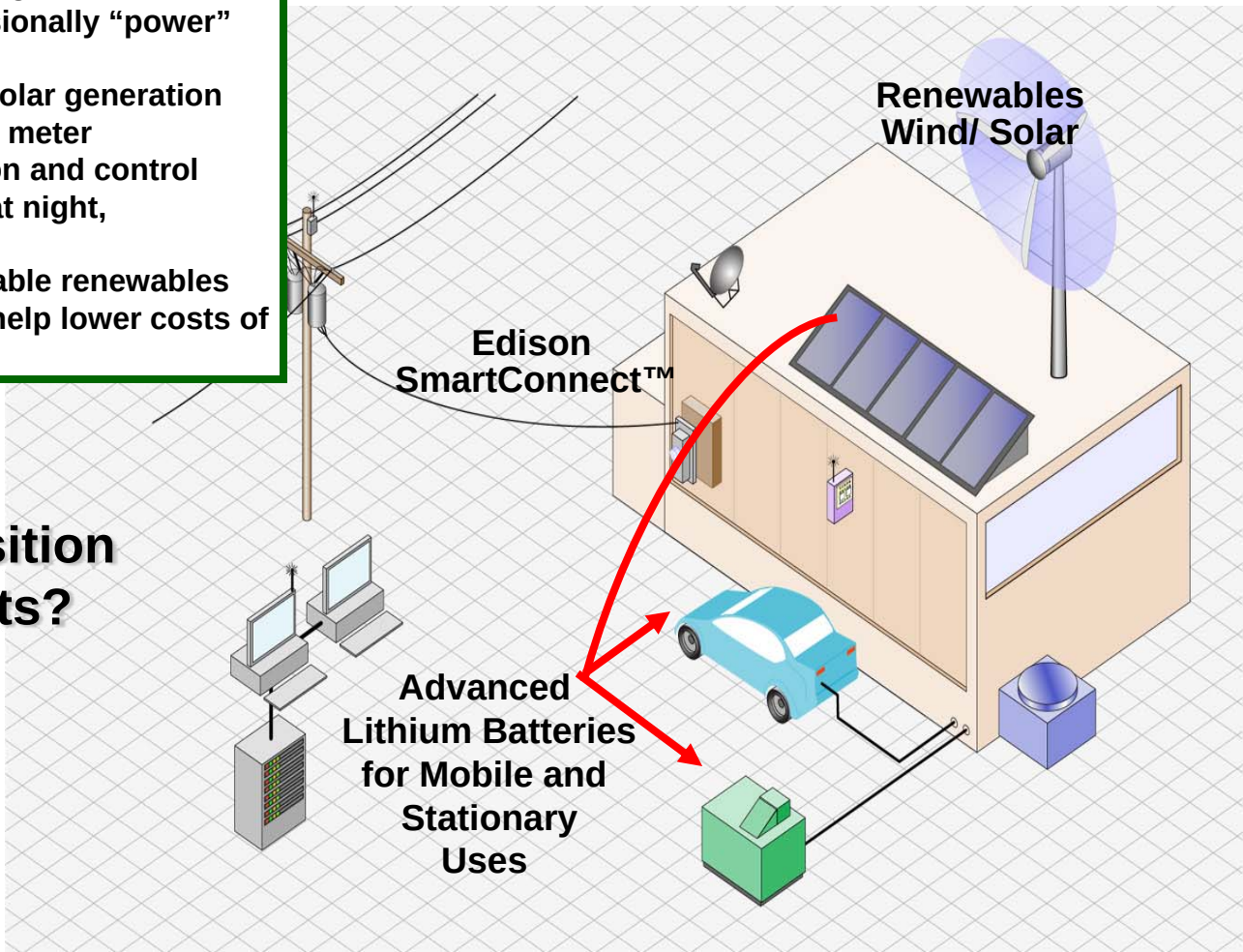
Courtesy of Southern California Edison

Southern California Edison's Near Term Transportation Vision

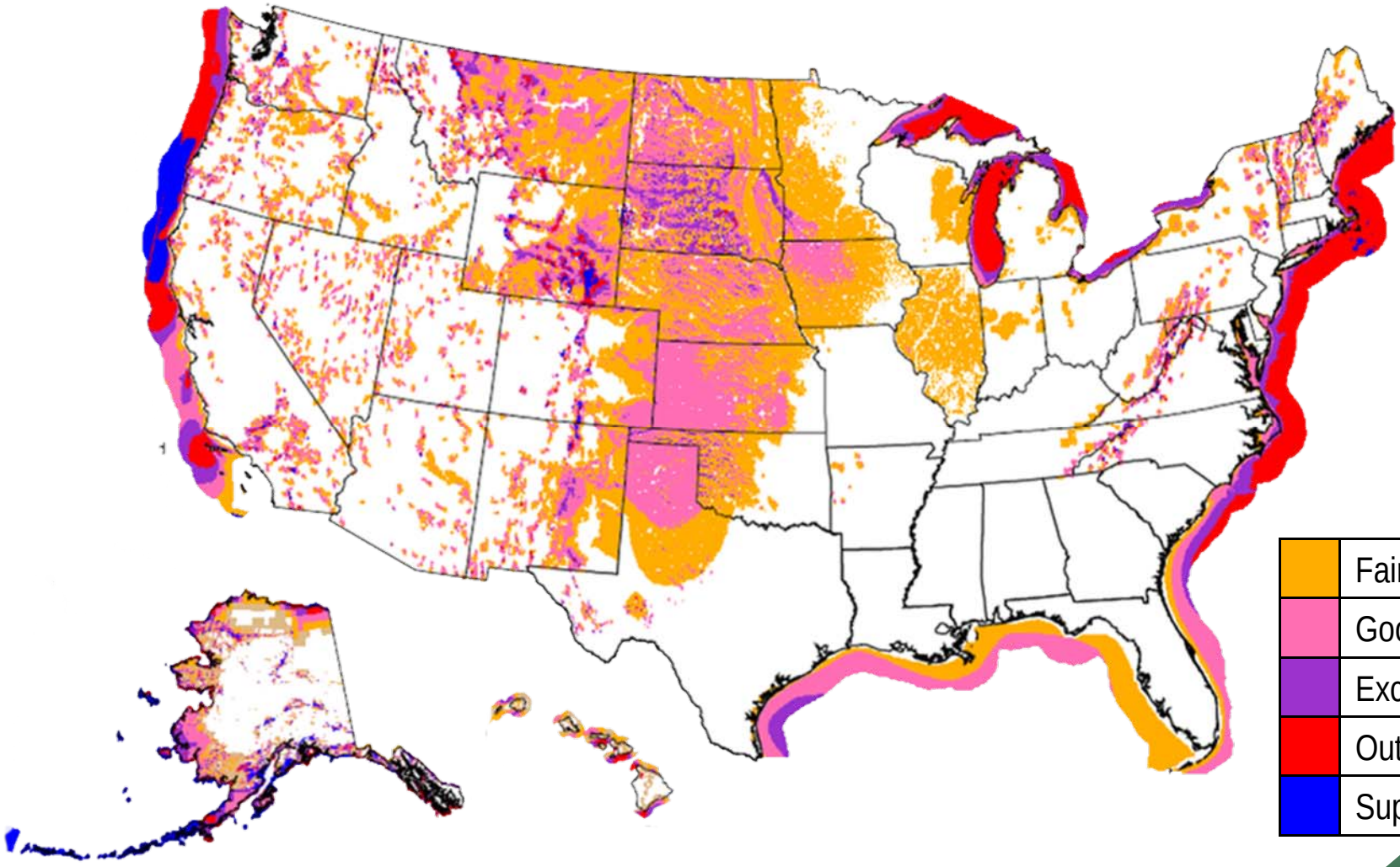
Exploring Customer Value From "Plugging In"

- Low cost off-peak energy for "fueling"
- Batteries to "drive" wheels & occasionally "power" the house
- On-site energy storage from wind/solar generation
- Edison's SmartConnect ™ advance meter providing both customer information and control
- New uses for generation capacity, at night, lowering future electricity rates
- Night time energy use may help enable renewables
- New uses for "new" batteries may help lower costs of future hybrid batteries

Lower PHEV acquisition & Ownership Costs? Utility Value?

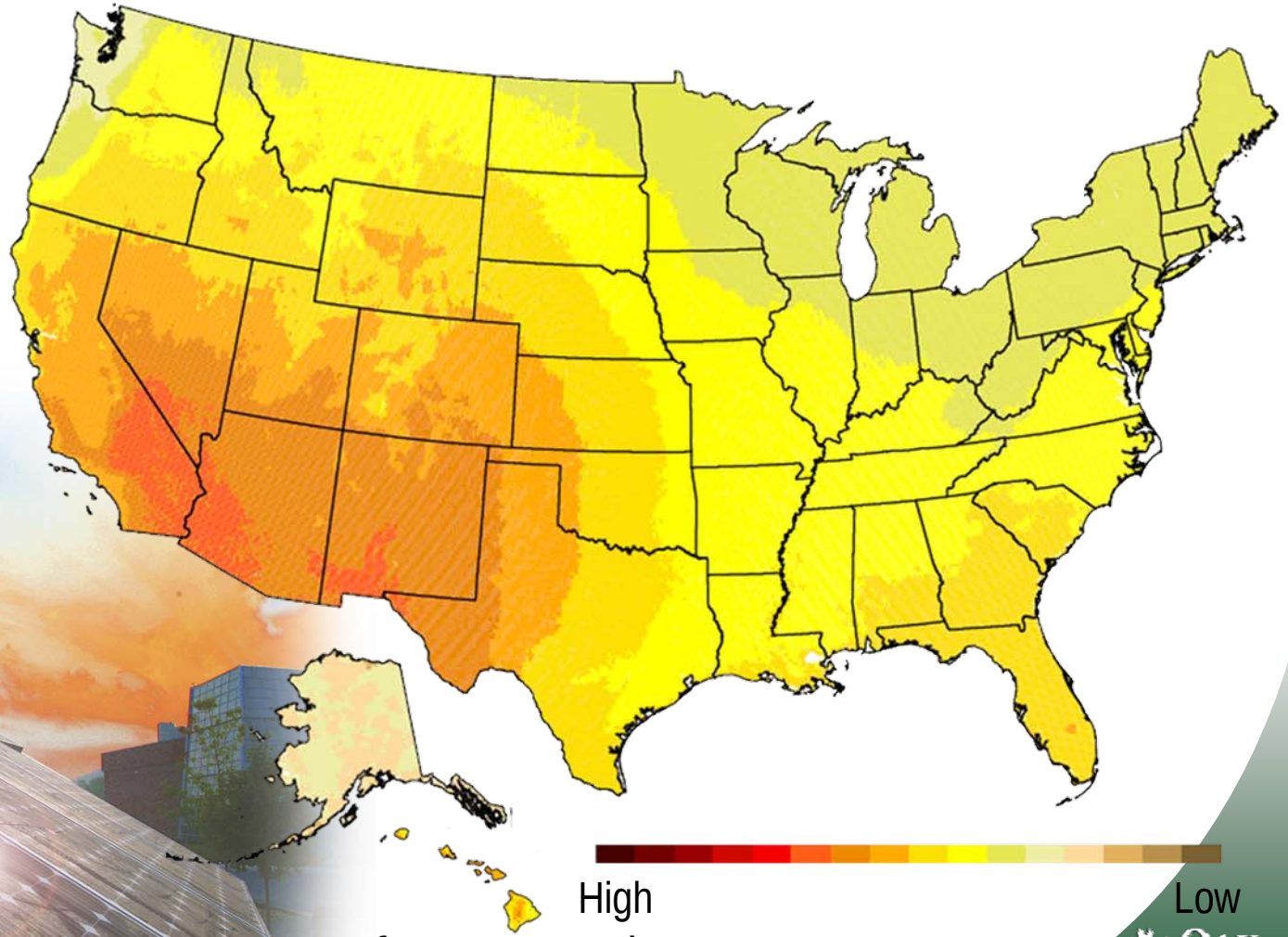


Tennessee has limited potential for wind power*



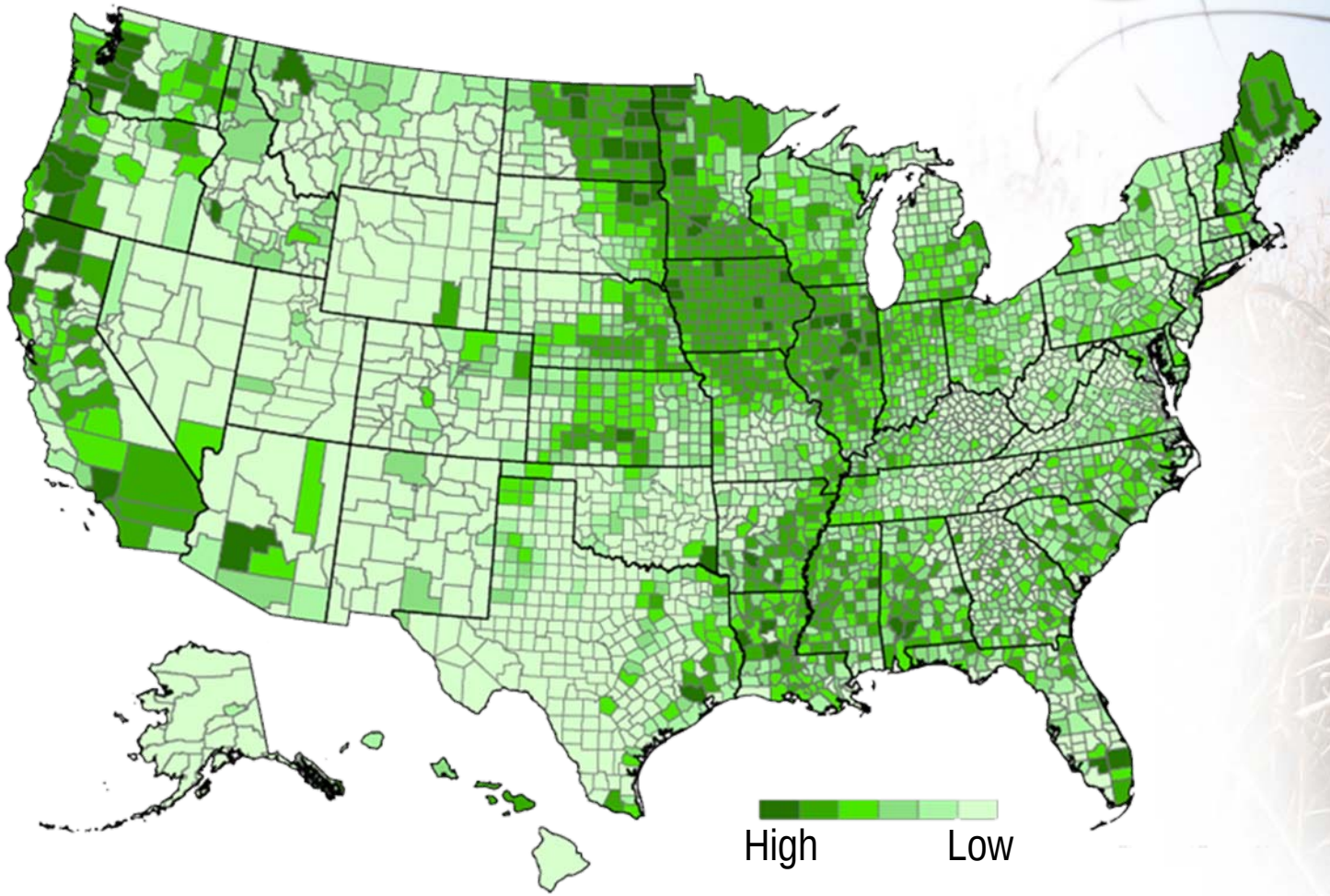
* After NREL wind resource assessment

Tennessee has some potential for solar energy*



* After NREL solar resource summary

Tennessee is developing its biomass potential*



* After NREL biomass resource assessment


SAAB 9-5

What are the potential global benefits of energy efficiency?

- Doubling the rate of energy efficiency improvement (from avg. 1.25%/yr to 2.5%/yr) would:
  - Allow the world to hold CO_2 concentrations below 550 ppm
  - Avoid $3.0 trillion worth of new generation
  - Save consumers $500 billion per year by 2030
  - Eliminate the same amount of energy supplied by 2,000 coal power plants
  - Return the globe to 2004 energy consumption levels
  - Drive business productivity improvements and new employment opportunities

Source: Realizing the Potential of Energy Efficiency (UN Foundation, July 2007)

What's next for energy efficiency and demand reduction?

- **Several new states to issue energy policy plans that include energy efficiency targets**
  - **"smart grid" experiments underway in southern states**
  - **Experiment in the Pacific Northwest suggests a 15% DR opportunity if customers are aware of the price points**
- **Traditionally low-price, fuel-rich utilities (TVA, Southern, Duke, AEP) are issuing plans for demand reduction and energy efficiency**
- **Southeast Energy Efficiency Alliance is gathering the 11 southern states together to determine meaningful targets for this region**
  - **Led by Gov. Bredesen (D-TN) and Gov. Crist (R-FL)**
- **Climate change no longer a debate---spurring action at the state and federal level**
  - **"Carbon will be priced and constrained in the near future…" Deputy Sec. of Energy Clay Sell, April 2007, Washington D.C.**

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