Overview of the Department of Energy's Energy Efficiency and Renewable Energy Program: Industry driven basic technology research

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Golden, Colorado

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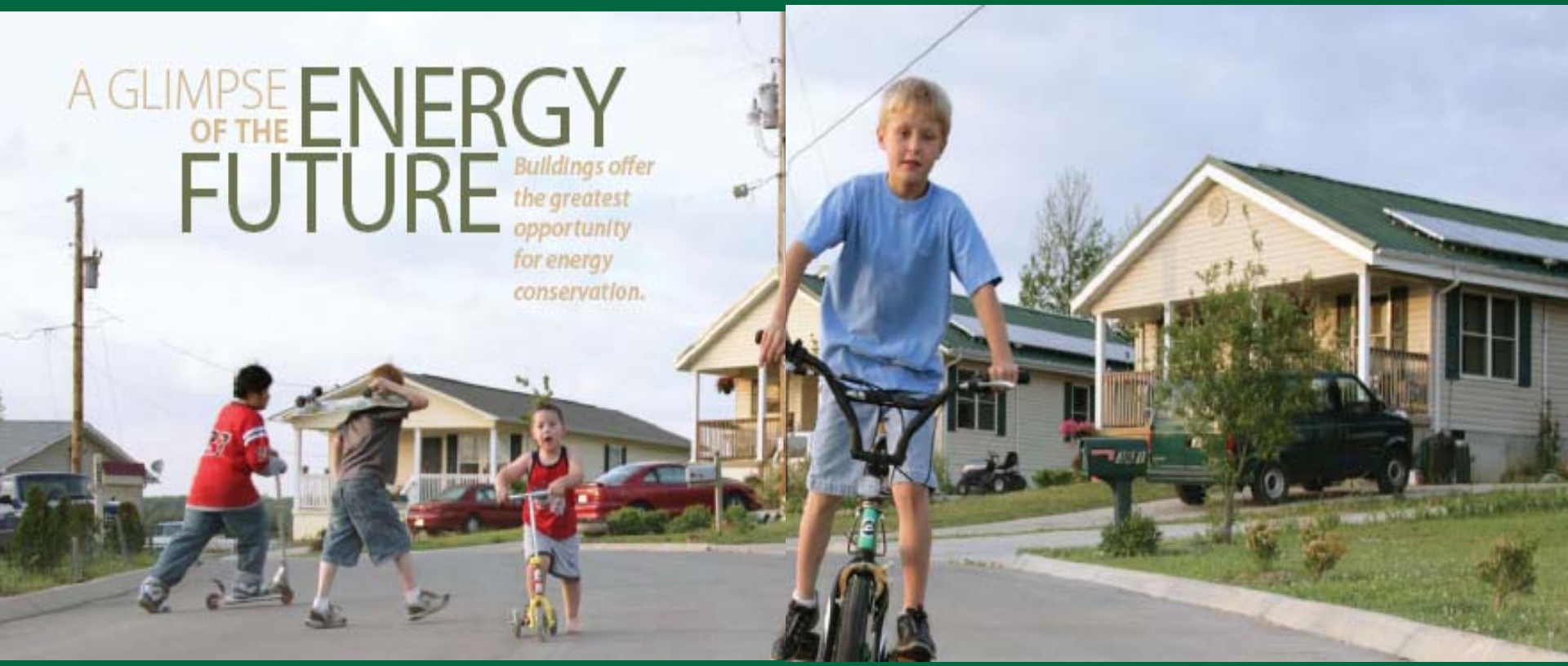
BOEING


A GLIMPSE OF THE ENERGY FUTURE
Buildings offer the greatest opportunity for energy conservation.

Energy efficiency may be the "first choice" and lowest-cost option to help meet increasing demand

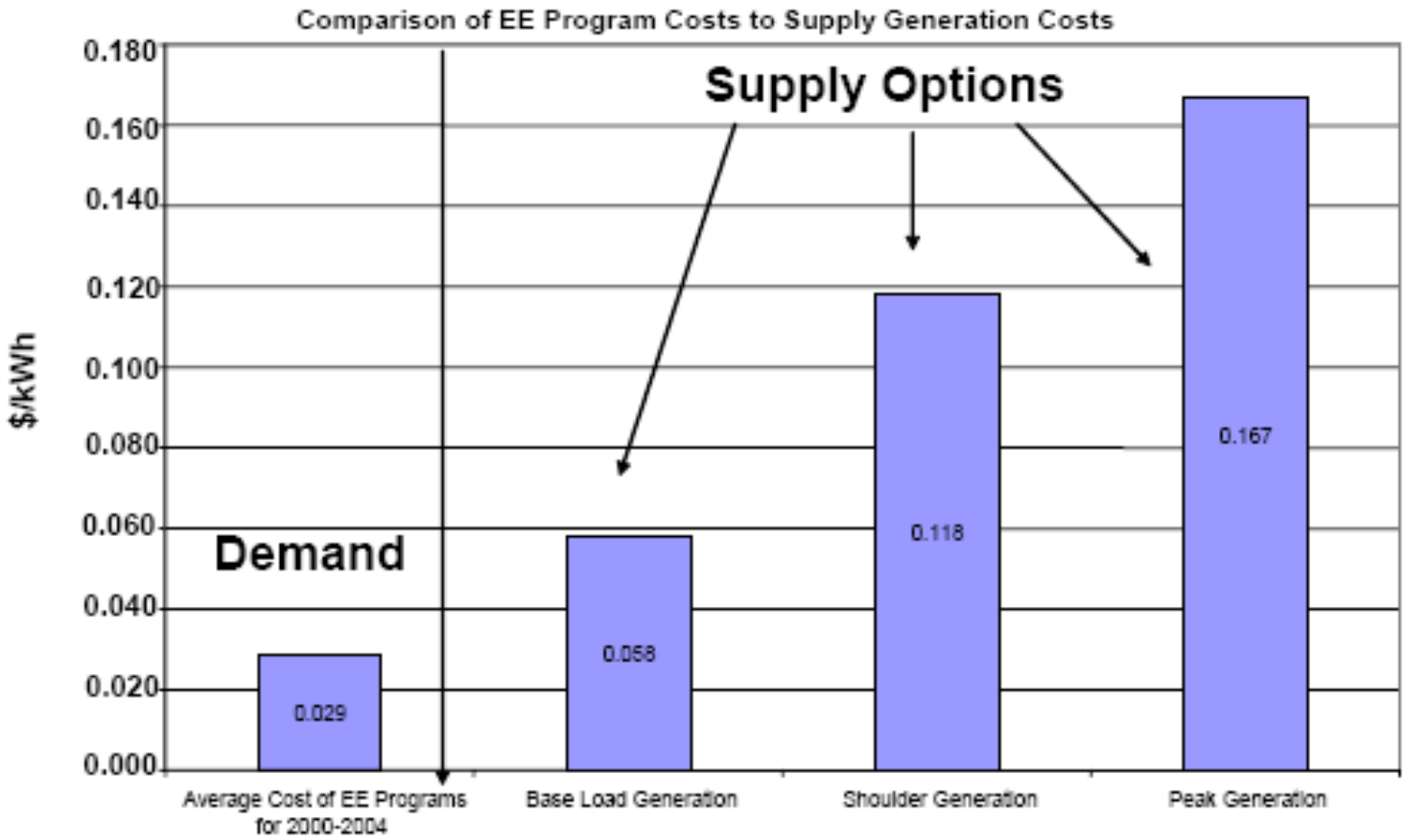
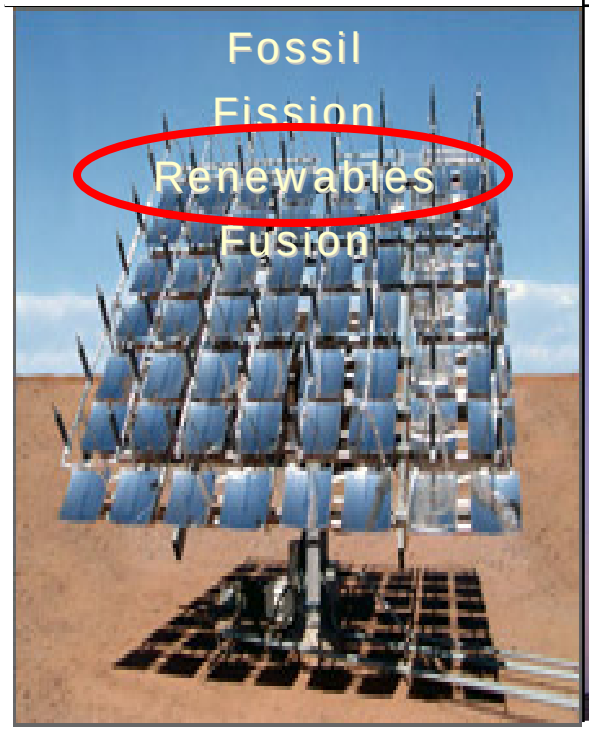
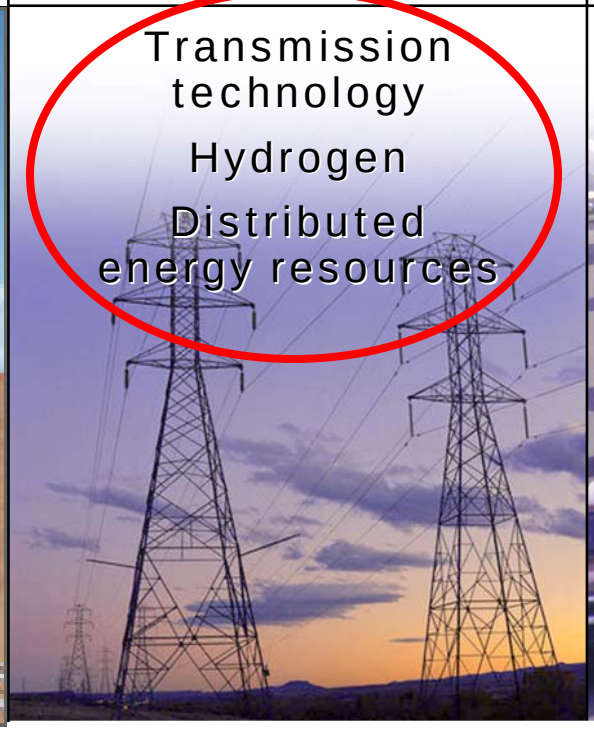


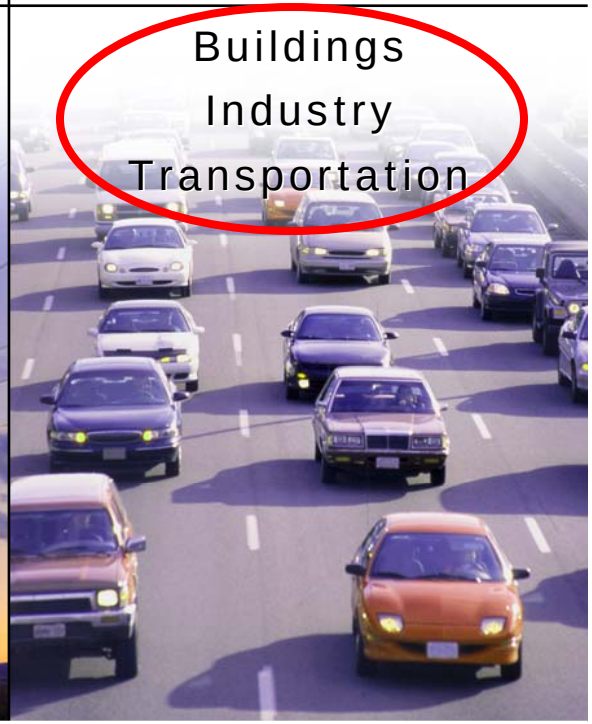
Figure courtesy of Art Rosenfeld, California Energy Commission

EERE programs are addressing the energy challenges of today . . . and tomorrow

Generation	Distribution	Consumption
Fossil Fission Renewables Fusion	Transmission technology Hydrogen Distributed energy resources	Buildings Industry Transportation

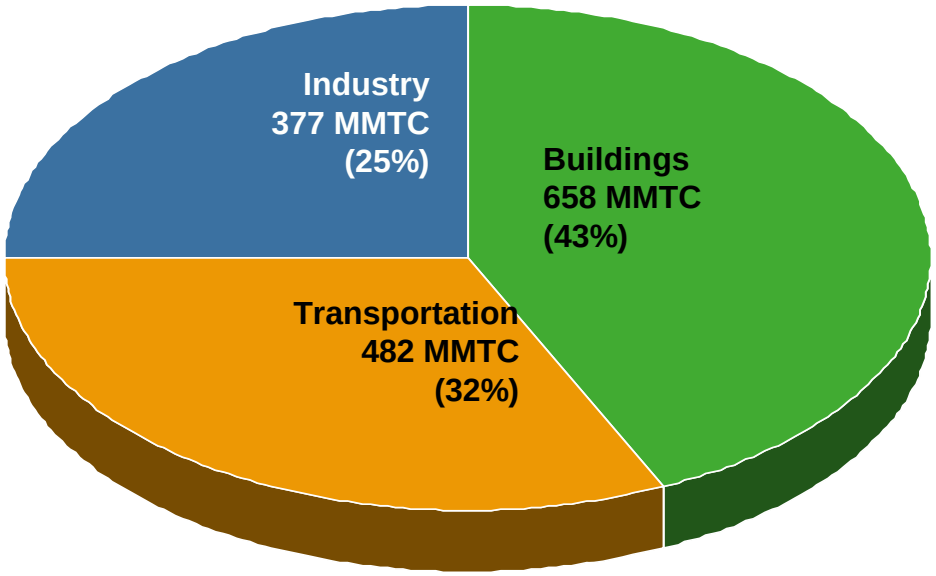






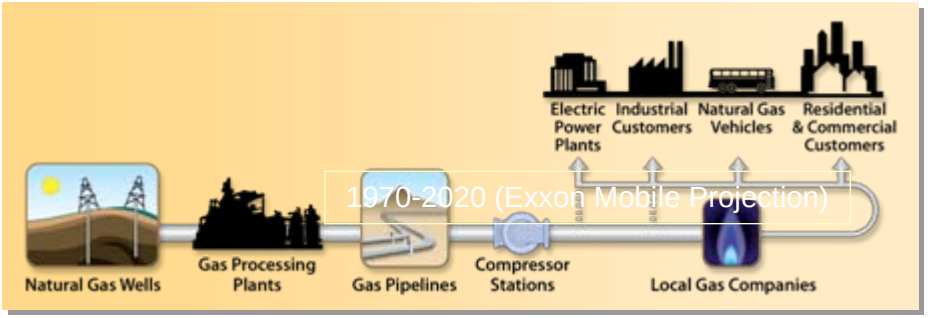
Supporting DOE's strategic goals for energy security and independence

Three "End-Use Sectors" of the U.S. Economy Contribute to Carbon Emissions



Buildings use 71% of U.S. Electricity

Buildings use 53% of U.S. Natural Gas



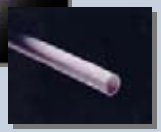
EERE transportation technology research-

Making Advances Against the Technical Barriers

Generation

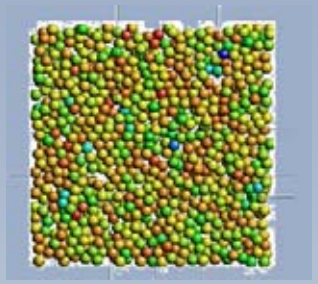
Alternative fuels

Refining



Hydrogen production

Storage and distribution



Hydrogen storage and transport

Batteries & Power electronics

Consumption

Internal combustion

Hybrid Electric Vehicle

Fuel cells

Transportation system analysis

Oak Ridge National Laboratory

The Vehicle Technologies Program Goal: Lower Petroleum Consumption

Developing more energy efficient and environmentally friendly automobile and truck technologies that will enable America to use less petroleum.

Benefits

- **Reduced dependence on oil through fuel substitution and higher efficiency in both passenger vehicles and commercial fleets**
- **Reduced greenhouse gas emissions**

Impacts	2030	2050
Oil Savings (MBPD)	2.90	6.3
Carbon Emission Reduction (MM tons of carbon/yr)	69	220

Top R&D Objectives: Priorities for Global Competitiveness

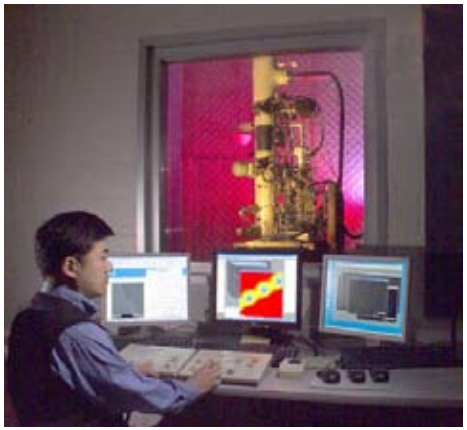
- **Batteries**
  - **15-year lifetime**
  - **1/3 today's cost**
- **Engines**
  - **Optimized engine design and control for biofuels**
  - **Advanced combustion for lower emissions, higher efficiency**
  - **Conversion of waste heat to electrical energy**
- **Hybrid Powertrains**
  - **Reduced cost for advanced motors and electronics**
- **Renewable Fuels**
- **Materials**
  - **Light-weighting**
  - **Recycling**

Washed Hardwood Kraft Lignin
Lignin content (%)
100%
95%
87.5%
75%

SAAB 9-5

User facilities: The High Temperature Materials Laboratory is an EERE national user facility

- **Funded by Office of FreedomCAR and Vehicle Technologies Program**
- **Six user centers to provide materials-related solutions for engine/vehicle systems being developed by FCVT and its industrial partners**
  - **Diffraction User Center**
  - **Machining, Inspection, and Tribology User Center**
  - **Materials Analysis User Center**
  - **Mechanical Characterization and Analysis User Center**
  - **Residual Stress User Center**
  - **Thermophysical Properties User Center**



Hydrogen, Fuel Cells, and Infrastructure Technologies Program

Production

Clean, Carbon-Free Domestic Fuel

from renewable electrolysis (using wind, solar, or geothermal energy)

Developing Low-Pressure, Materials-Based Storage

GOAL: Greater than 300-mile Driving Range

Storage

Education

Communicate the Benefits of Energy from Hydrogen

Codes & Standards

Effective Domestic and International Codes and Standards to Enable Commercialization

Delivery

By Pipeline and Truck

GOAL: Wells to Wheels Components for Safe and Efficient Transport

Fuel Cells

Materials and Components to Lower Cost and Increase Durability

GOAL: $30/kW & >5,000 hours

ITP is enhancing national energy security, competitiveness, and environmental quality by transforming the way U[illegible]ry uses energy.

Partnerships

Collaborative research & development

Delivery of energy-efficient practices and technologies

Core activities reduce industrial energy intensity through applied R&D and technology delivery.

ITP R&D Areas: Focus on Energy Efficiency

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

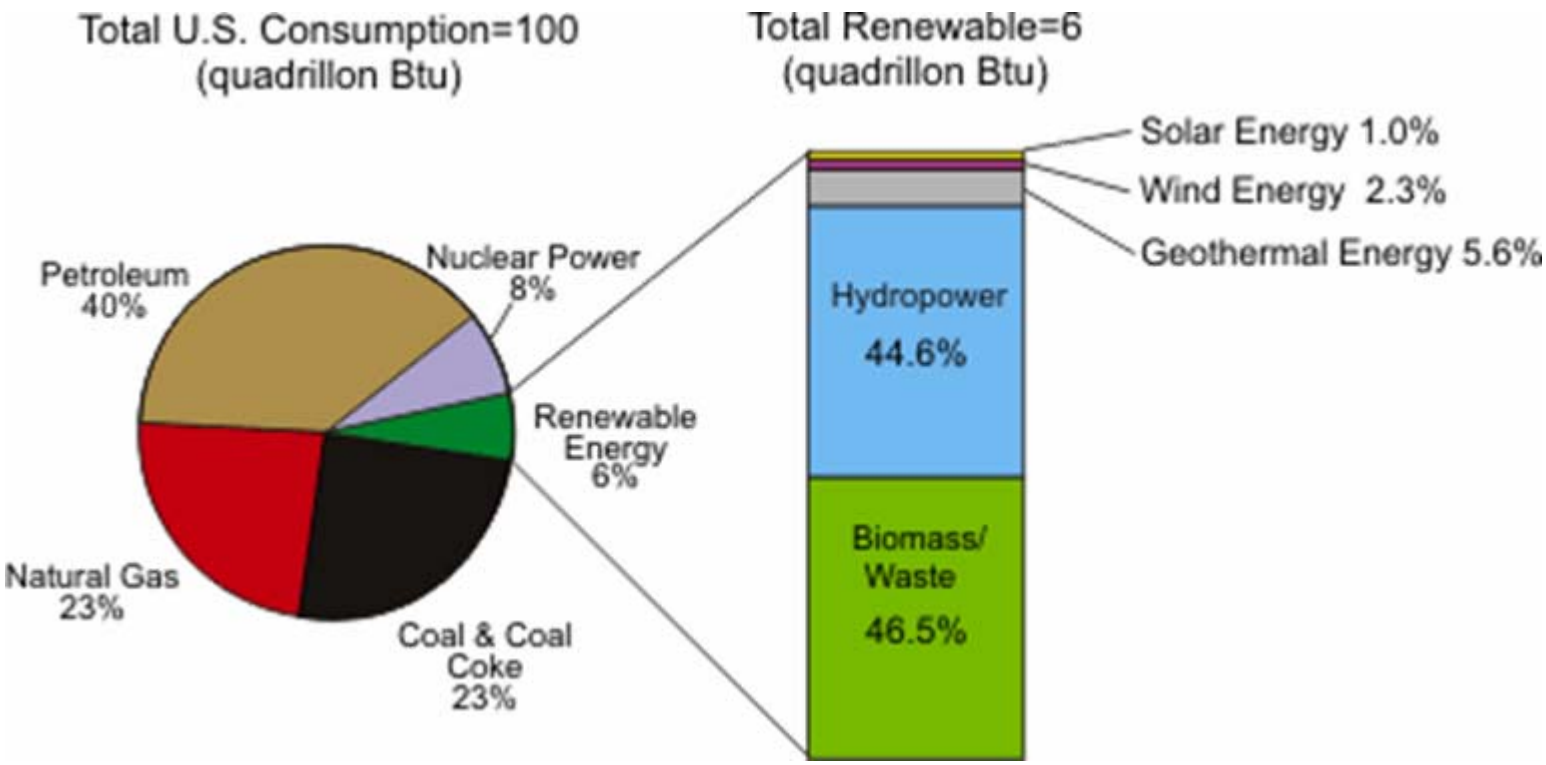
- SuperBoiler
- Isothermal Melter
- Ultra-hard materials
- Industrial wireless technologies

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.

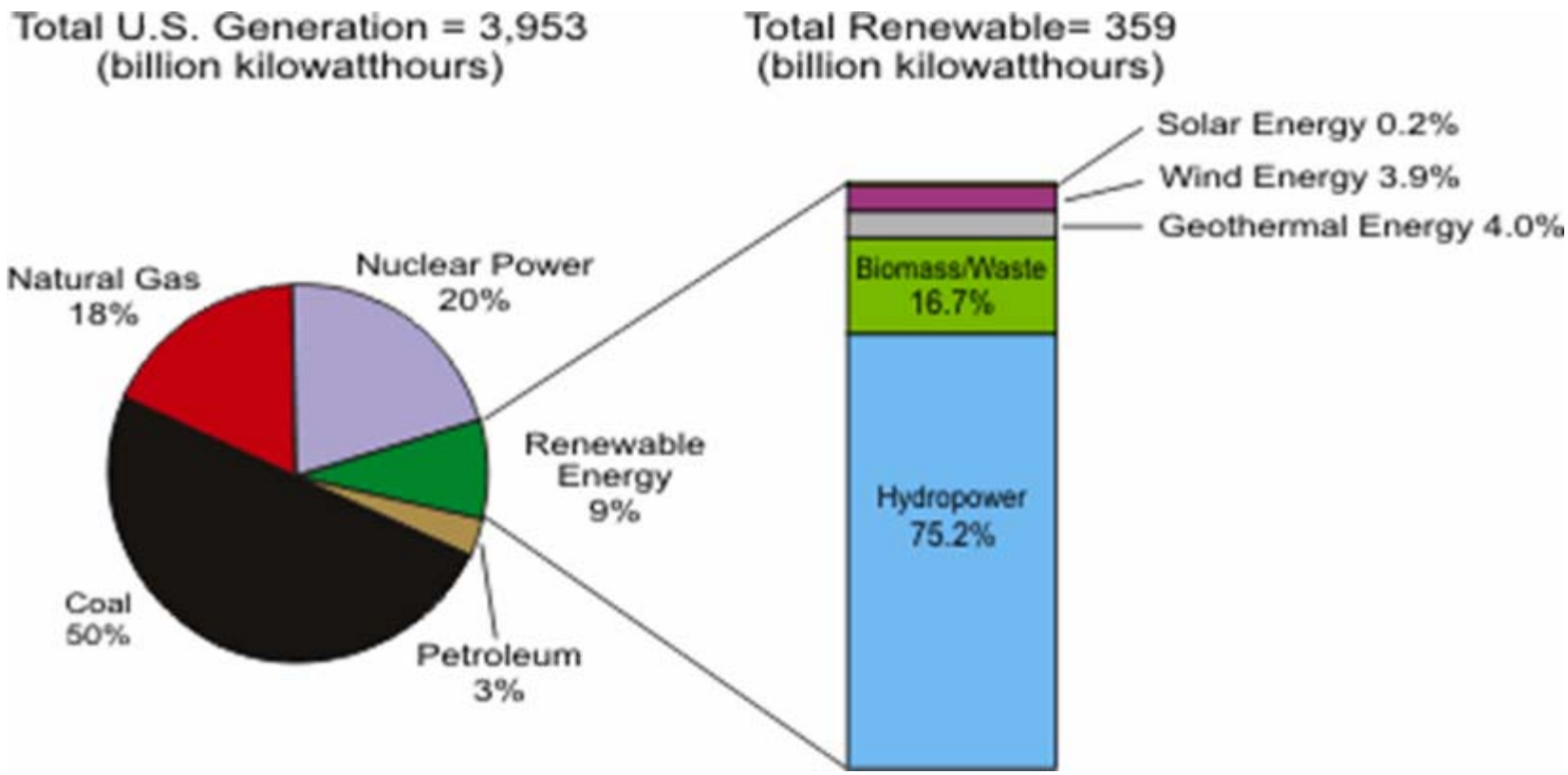
- Accelerate market adoption
- Process Integration R&D
- Technology Validation

Contribution of renewable energy to U.S. energy consumption, 2004



Source: Energy Information Admin.

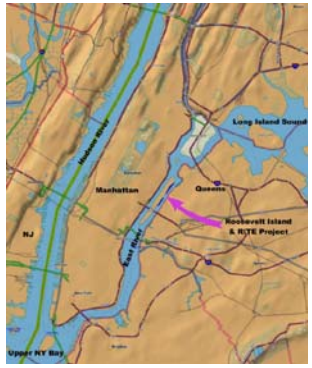
Where does our electricity come from? (2004 data)

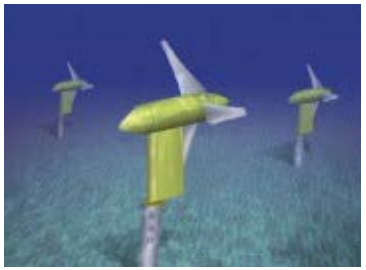


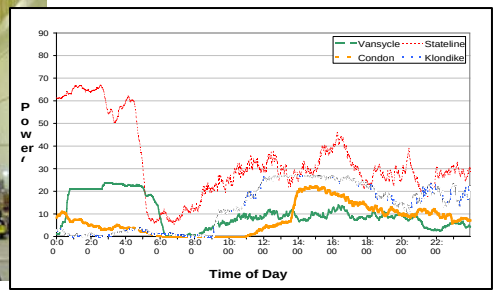
Source: Energy Information Admin.

EERE Hydropower- a program in transition

- new DOE directions of wind-hydro integration, hydrokinetic turbines, wave energy technologies
  - More testing and demonstration are needed to understand design tradeoffs (energy vs environment)
  - Research opportunities include environmental science and hydraulic engineering, computational fluid dynamics, and advanced materials
  - Hydropower is an important part of the Energy~Water Nexus







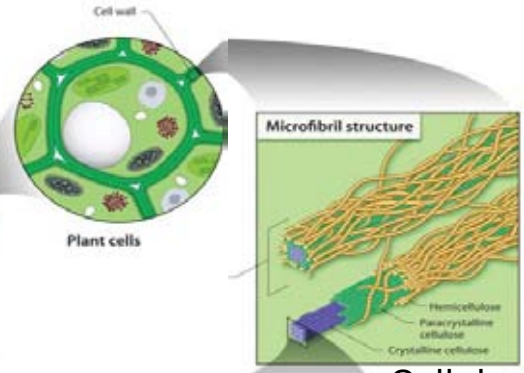
The GOAL is Low Cost & Environmentally Sustainable Systems For Producing Biomass

- Crop residues
- Perennial crops – switchgrass, poplar, willow
- Forest residues
- Urban wood residues

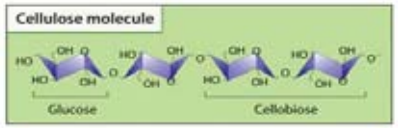
Biomass Program

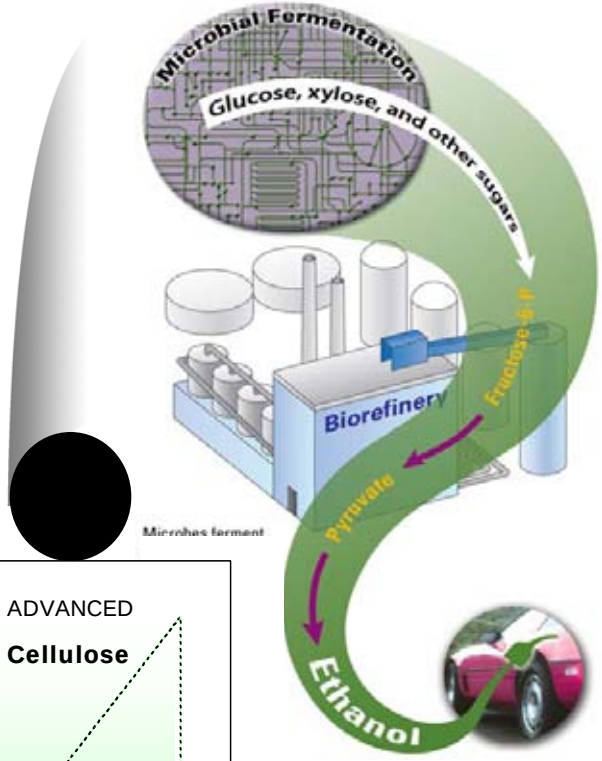
BASIC TRANSFORMATION:

CELLULOSE → SUGARS → ETHANOL

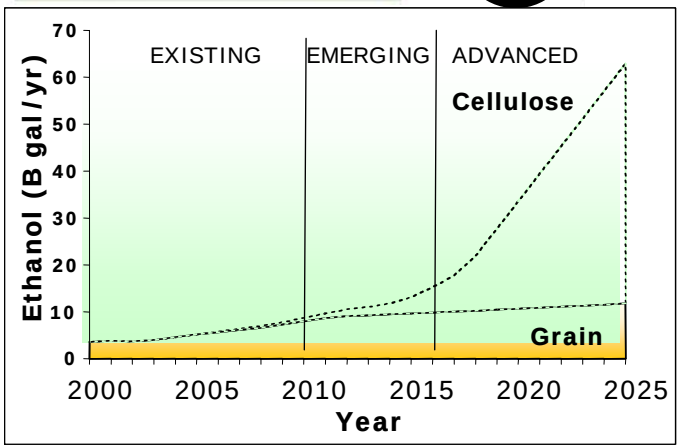


Cellulose





Perennial energy crops - switchgrass



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PV fits nearly everywhere

Boston

210-KW system at SMUD substation

The Pentagon

Rural water pumping in N. Dakota

Roof shingles- no more ugly panels!

EERE is developing 4 major areas of solar technology

64-MW Solar One- Boulder City, NV

- **Concentrating solar**
  - **CSP systems use reflective materials that concentrate the sun's heat energy to drive a generator that produces electricity.**
- **Photovoltaics**
  - **PV systems use semiconductor materials that convert sunlight directly to electricity.**
- **Solar heating**
  - **Solar collectors absorb the sun's energy to provide low-temperature heat used directly for hot water or space heating for residential or commercial buildings.**
- **Solar lighting**
  - **Parabolic collectors focus sunlight into a fiber optic system to illuminate building interiors with sunlight.**

What kinds of materials are being researched in the EERE Solar Technologies Program's Thin Partnerships?

- Amorphous and Thin-Film Silicon
  - modules with 6% to 8% efficiencies exist today
- Copper Indium Diselenide (CuInSe2-alloys, or "CIS')
  - With 19.5% efficiency under standard test conditions, the best CIS cell is about as efficient as the best polycrystalline-silicon cell.
- Cadmium Telluride (CdTe)
  - CdTe thin-film technology is being actively commercialized. CdTe cell efficiencies are over 16% in the laboratory; commercial module efficiencies are in the 7%-10% range in the first manufacturing plants.
- Environment, Safety, and Health (ES&H)
- Thin-Film Module Reliability
  - Studying and testing the reliability of thin-film modules to assure 30-year outdoor reliability.

Photo credit: Applied Materials, Inc.

Wind power is becoming affordable, even for homeowners

- Southwest Windpower's "Skystream"
  - Sits on a 35-ft. pole
  - Costs ~$8500 (1/3 the cost of a few years ago)

GE's 3.6-MW system for utility use

EERE Wind Technology Research

- Advanced Rotor Development
  - Blade development
  - Aerodynamic code development and validation
  - Aeroacoustics research and testing
- Site-specific design
  - Inflow characterization
  - Design load specification
- Generator, Drive Train
  - and Power Electronics
- Systems and Controls
- Structural Testing
- Dynamometer Testing
- Field Testing

NREL's 50-m test stand near Boulder

EERE is putting nanotechnology to work to make energy efficient products and processes... at national laboratories

Moving nanoscience into energy and technology applications

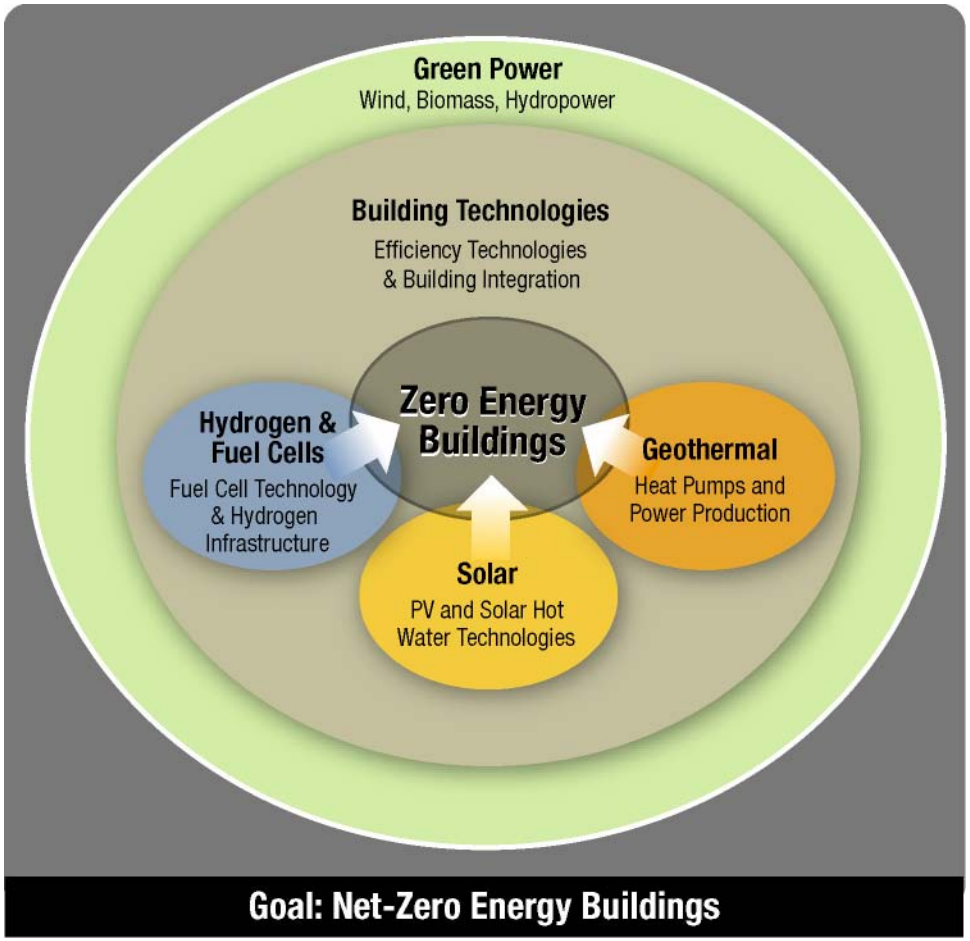
- **Designing next-generation processes**
- **Partnering for development**
- **Enhancing technology transfer**

World-class facilities, equipment, and expertise for nanoapplications

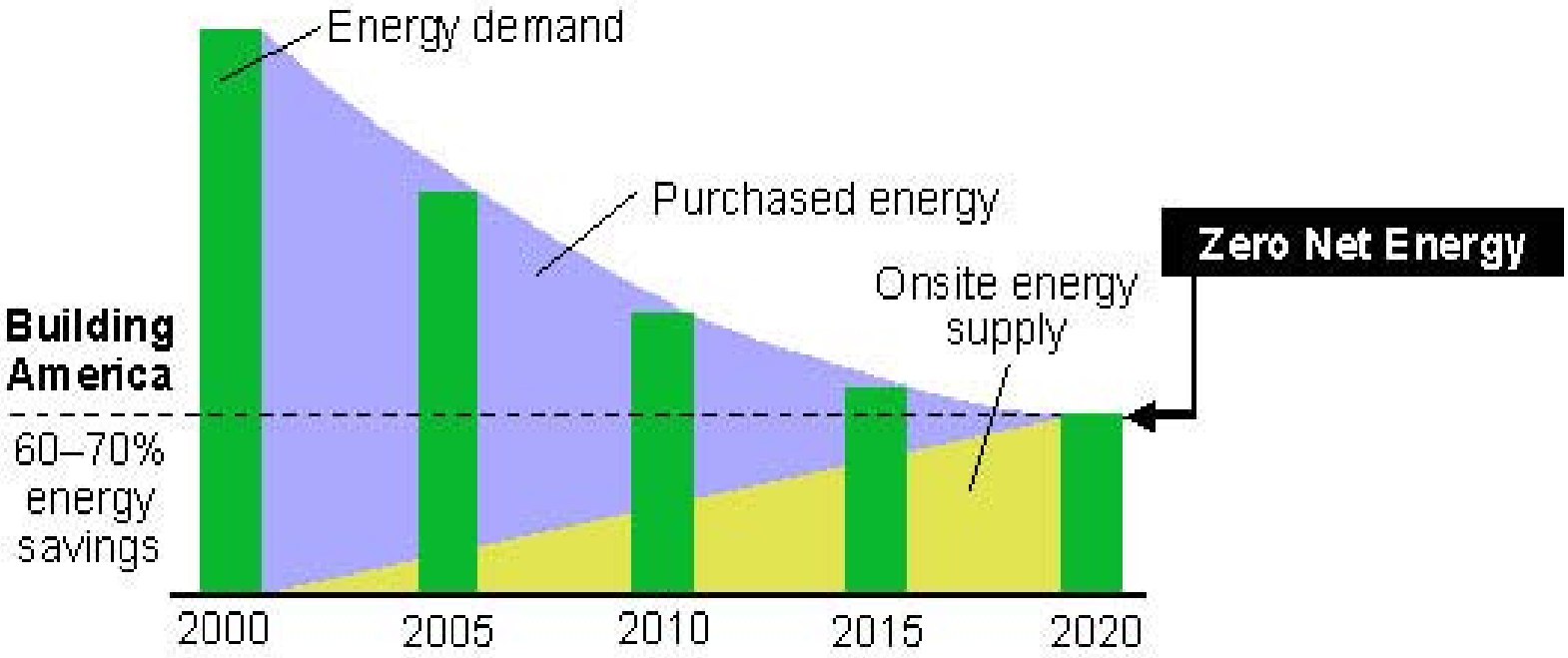
- **Materials fabrication and processing**
- **Characterization**
- **Responsible nanomanufacturing**
- **Rapid prototyping and scale-up research**

Building Technologies: Platform for Integration

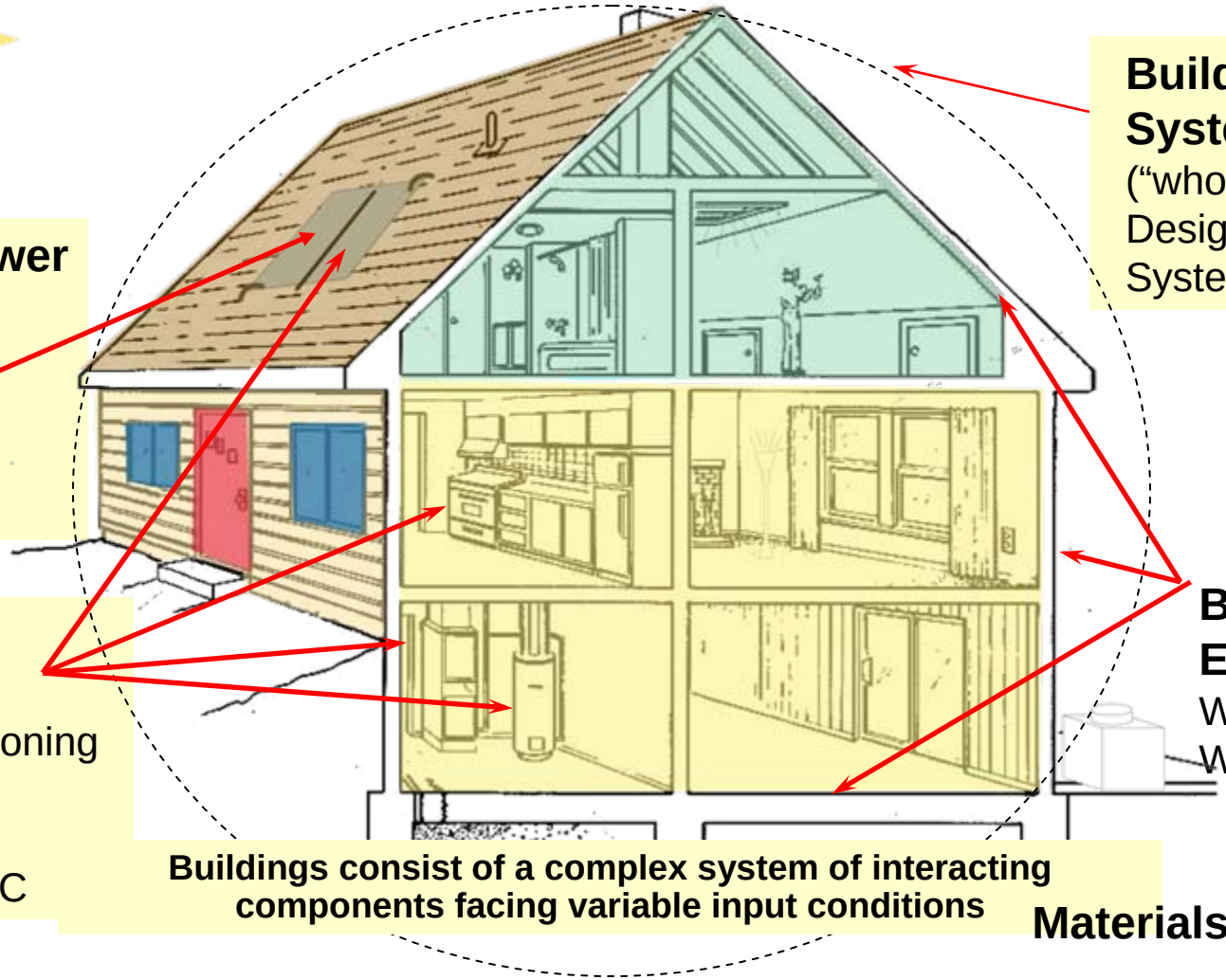
- Zero energy homes by 2020
- Zero energy buildings by 2025
- Buildings as renewable energy deployment platforms



A Next Generation of Building Technologies Could Enable Net "Zero Energy" Homes



Opportunities for improved efficiency in buildings are enormous.



Building Systems
("whole-systems")
Design tools
System Integration

On-Site Power Systems
Building Integrated Photovoltaics
Fuel Cells

Building Equipment
Space conditioning
Lights
Appliances
BIPV, PEM-FC

Building Envelope
Windows, Walls, Floors

Buildings consist of a complex system of interacting components facing variable input conditions

Materials Intensity

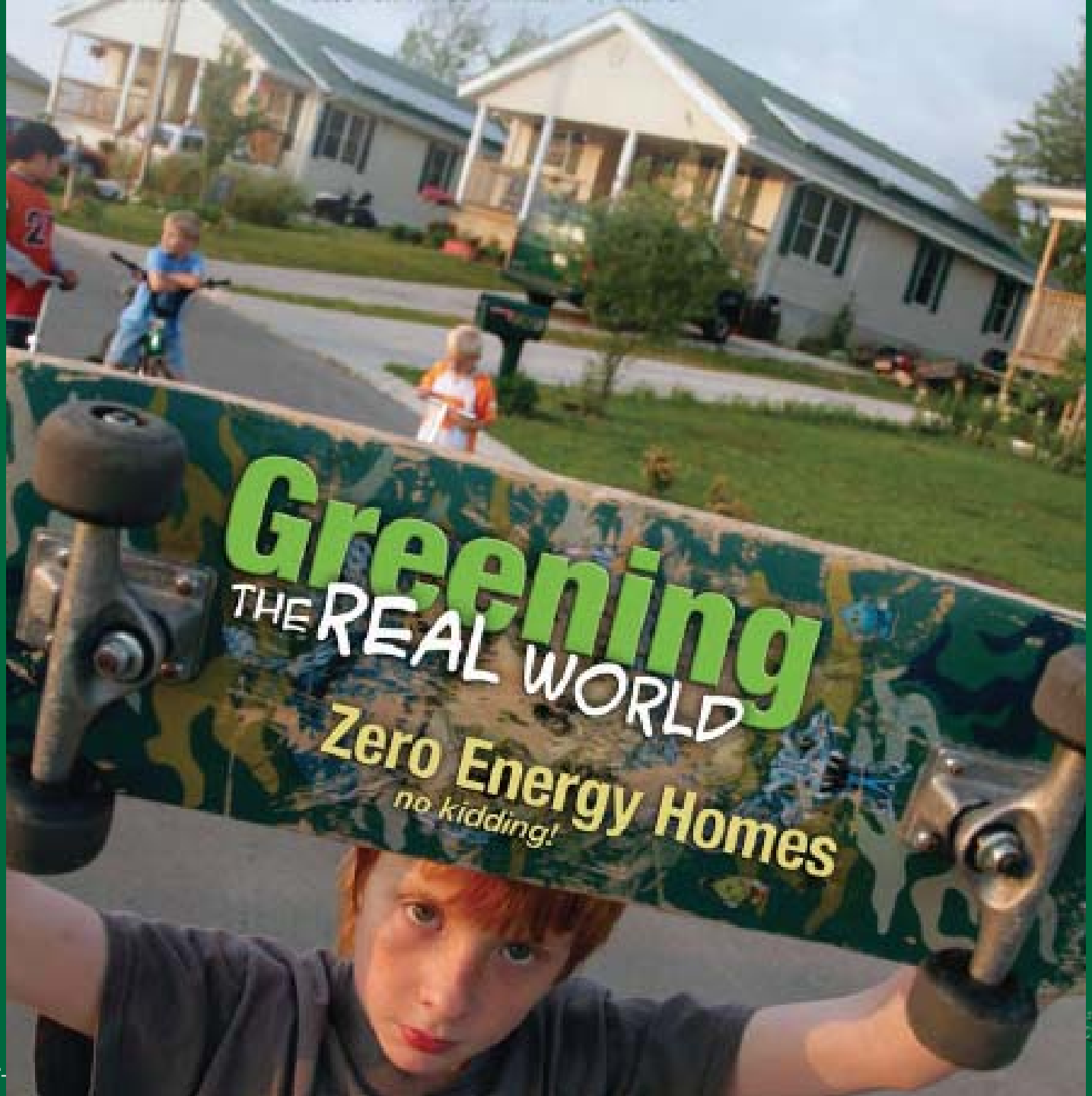
Combined cooling, heat & power- an efficient option for clean distributed generation

Powered by clean natural gas
Biofuels
Hydrogen

Dell Children's Medical Center
(JOULE Milestone – 70+% efficiency)

Verizon Communications

Ritz Carlton San Francisco


Greening
THE REAL WORLD
Zero Energy Homes
no kidding!

OAK RIDGE
National Laboratory