Energy Efficiency and Renewable Energy: Challenges and Opportunities

Advanced Energy Conference

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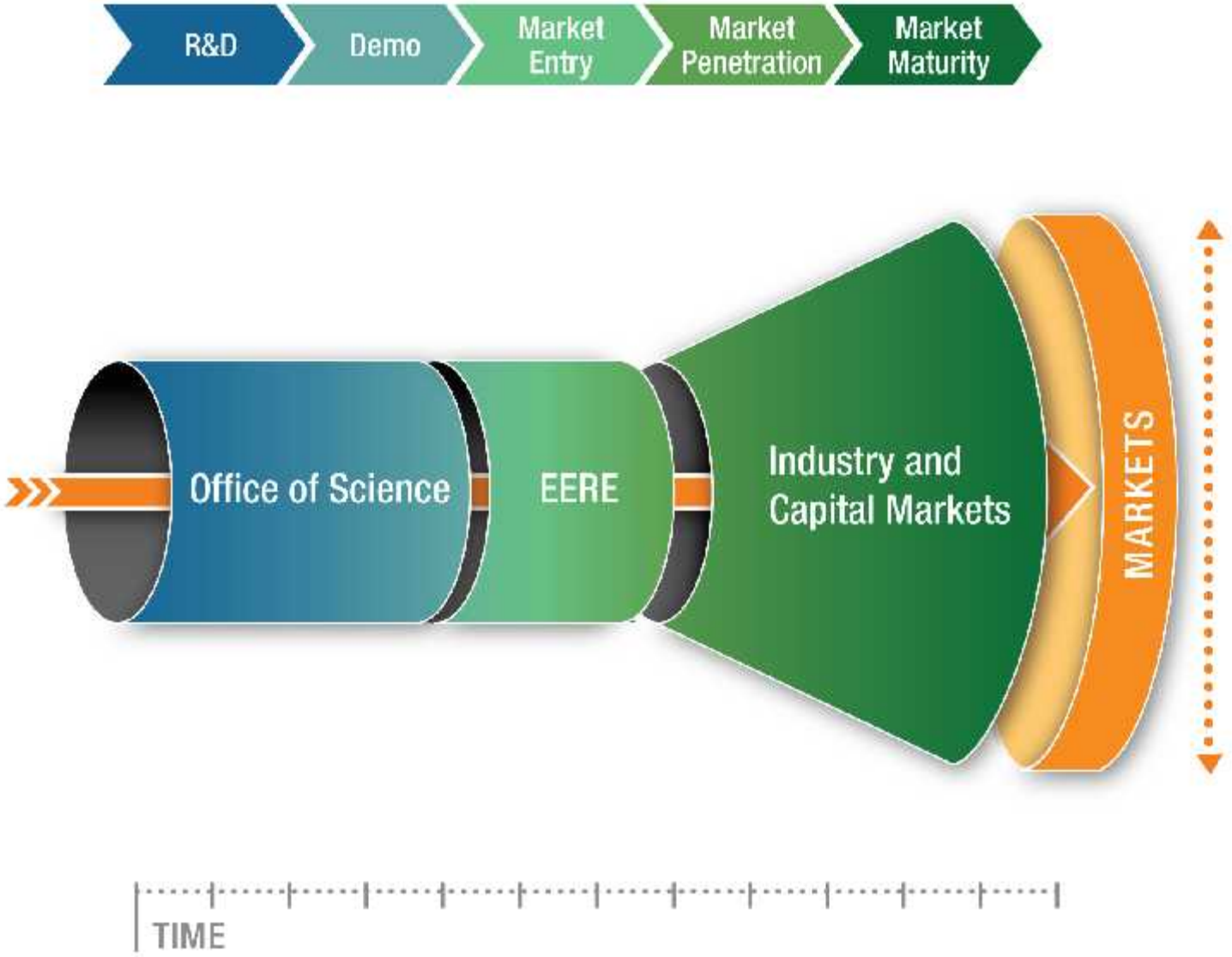
& Renewable Energy

DOE programs address technology innovation and capital needs across the development pipeline



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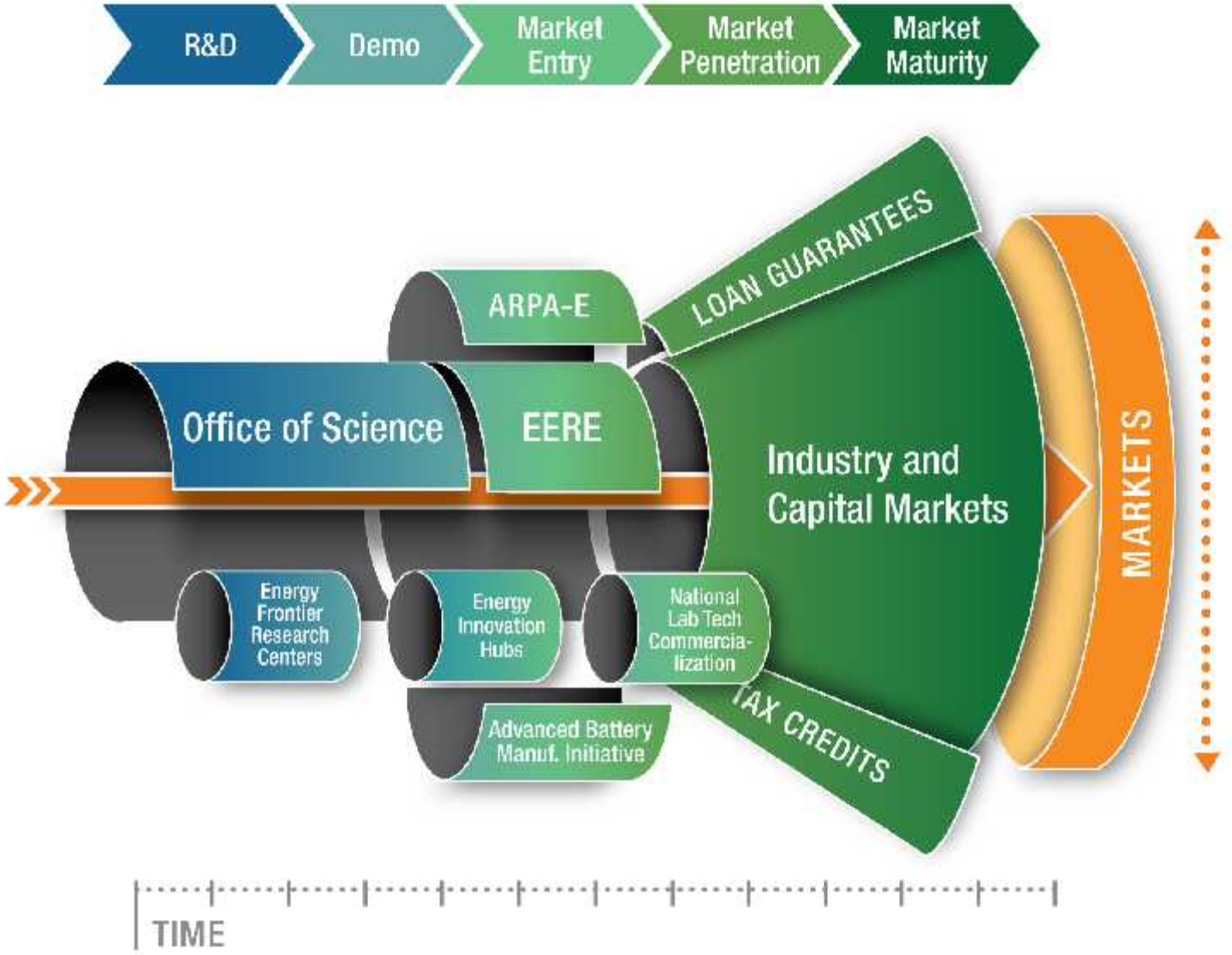


Energy Efficiency & Renewable Energy Technology Portfolio

Energy Efficiency

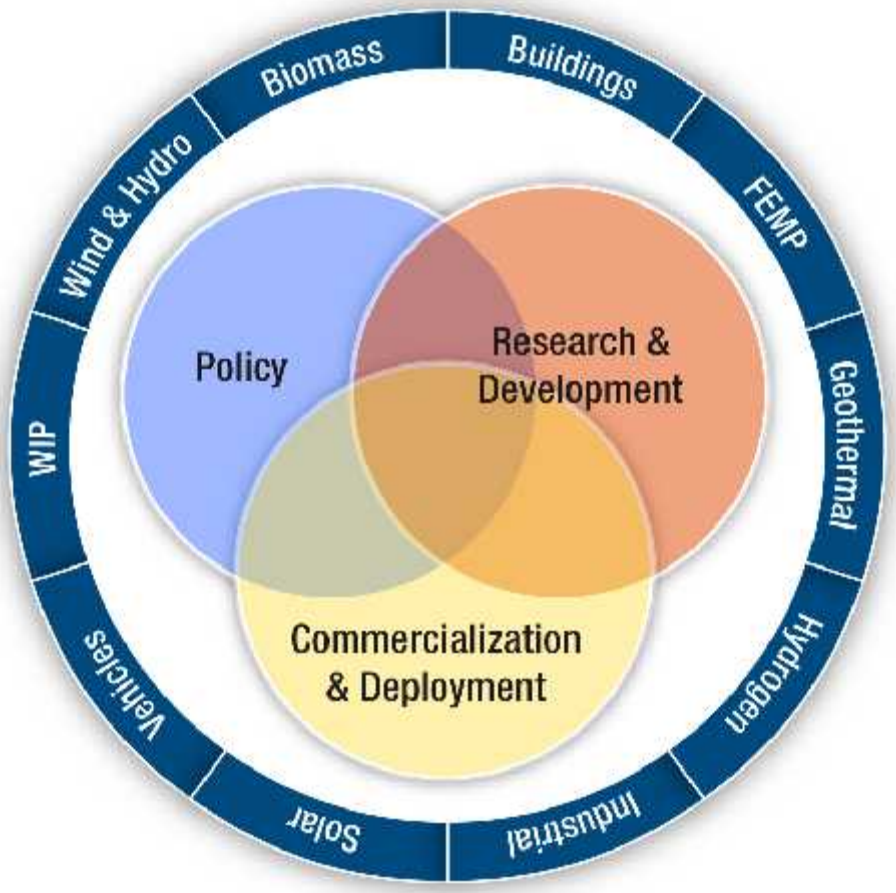
- Buildings
- Industrial
- Federal Energy Management
- Weatherization and Intergovernmental

Advanced Transportation

- Vehicles
- Fuel Cells
- Biomass

Electric Power Generation

- Solar
- Wind & Hydropower
- Geothermal



MISSION

Develop cost competitive clean energy technologies and practices, and facilitate their commercialization and deployment in the marketplace, to strengthen America's energy security, environmental quality, and economic vitality.

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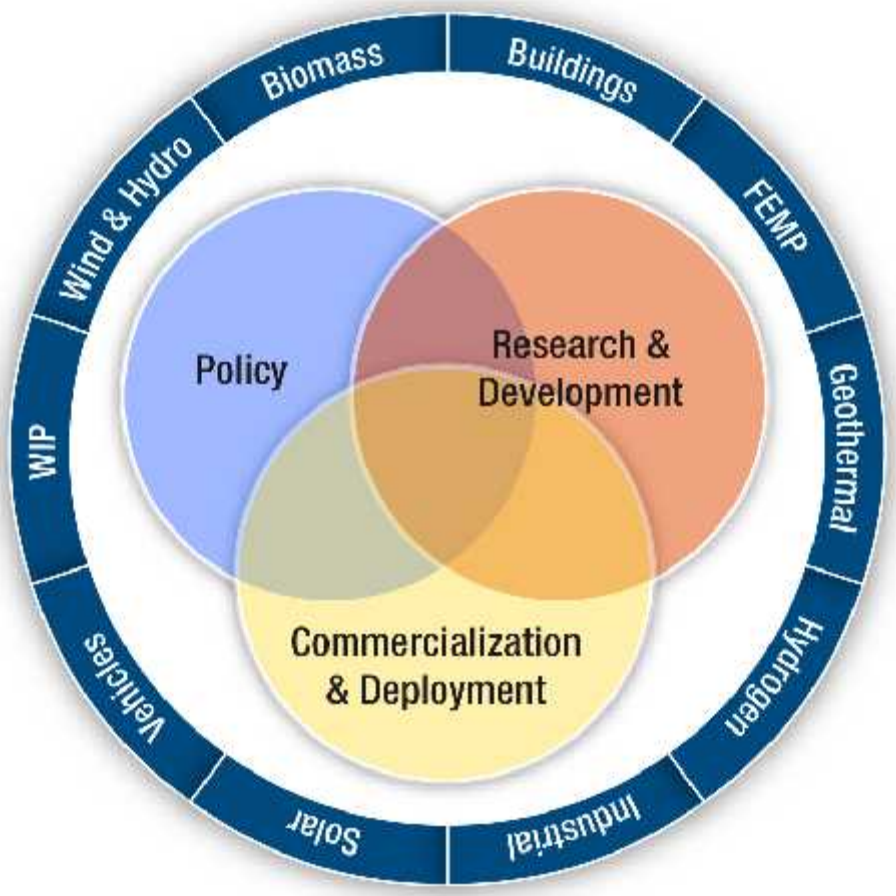

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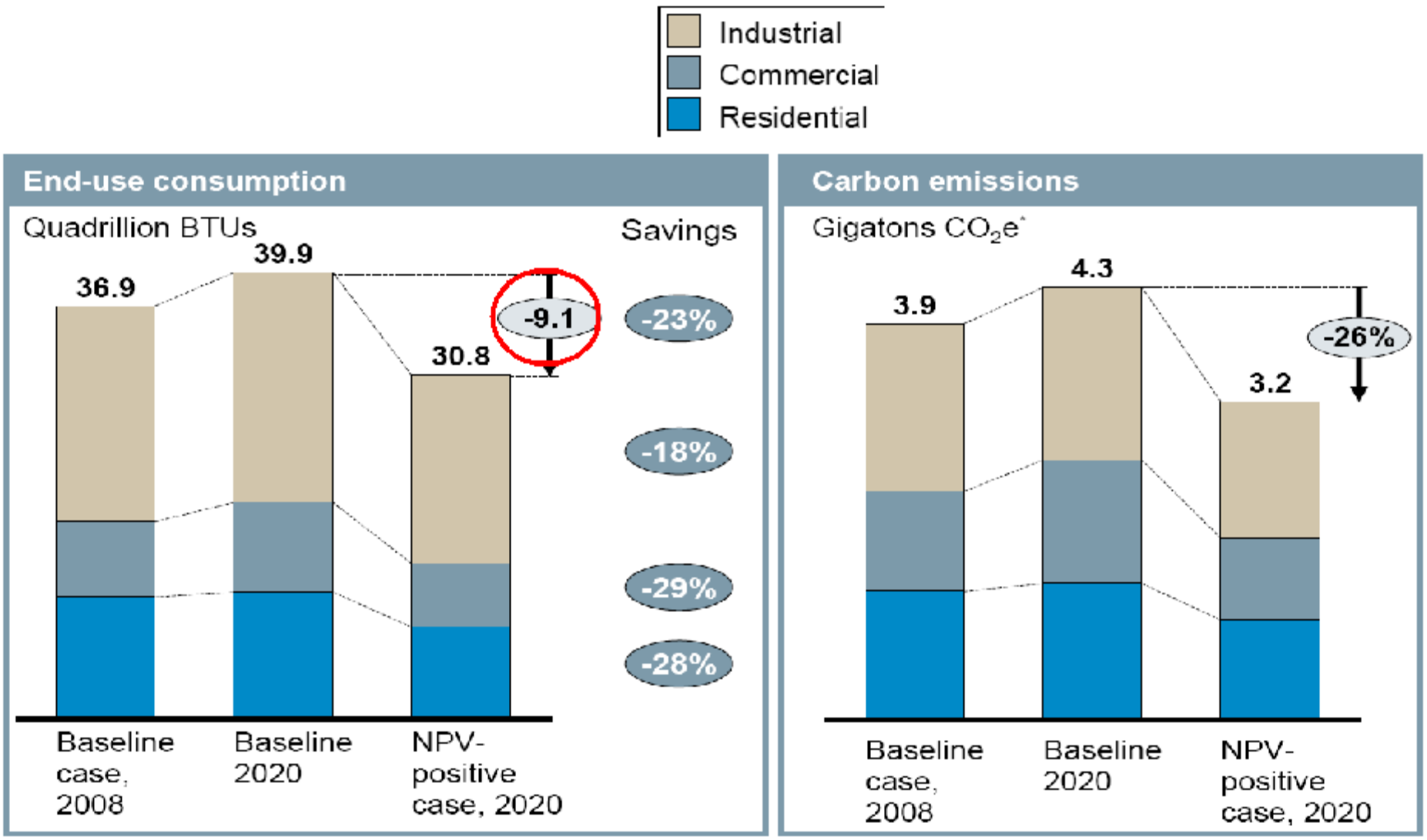
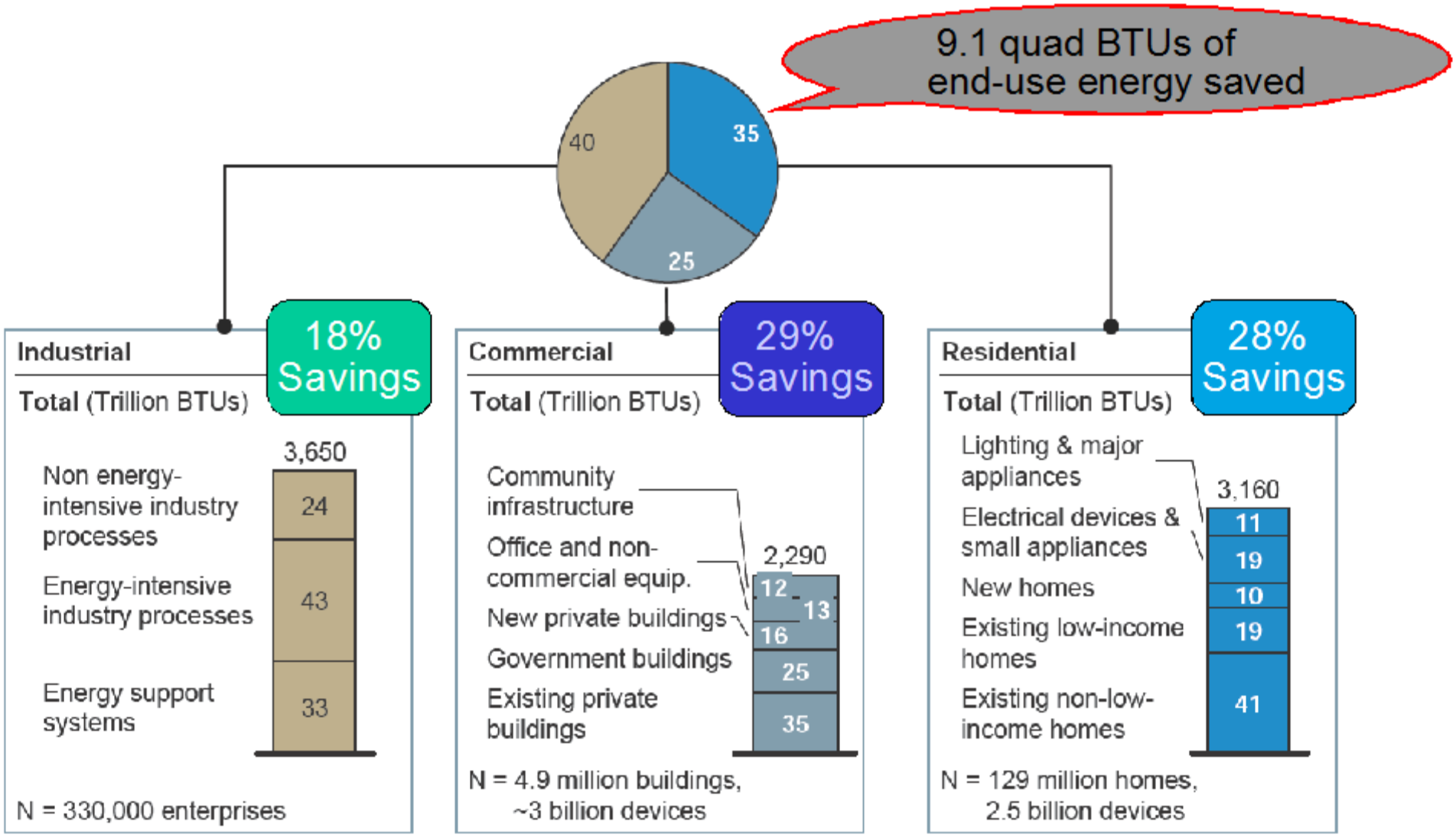
Cost-Effective Energy Efficiency Can Reduce Demand 23% by 2020



Source: McKinsey & Company, *Unlocking Energy Efficiency in the U.S. Economy* (July 2009)

* includes carbon emission abatement potential from CHP

Each Sector Contributes Substantial Savings



Source: EIA *Annual Energy Outlook* (2008); McKinsey & Company, *Unlocking Energy Efficiency in the U.S. Economy* (July 2009)

Why is Energy Efficiency So Hard to Unlock?

FUNDAMENTAL ATTRIBUTES OF ENERGY EFFICIENCY

- **Requires outlay:** Full capture would require initial outlay of approximately $520 billion, plus program costs
- **Fragmented:** Potential is spread across more than 100 million locations and billions of devices
- **Low mind-share:** Improving efficiency is rarely the primary focus of any in the economy
- **Difficult to measure:** Evaluating, measuring and verifying savings, is more difficult than measuring consumption, impairing investor confidence

OPPORTUNITY-SPECIFIC BARRIERS

Structural

- **Agency:** Incentives split between parties, impeding capture of potential
- **Transaction barriers:** Unquantifiable incidental costs of deployment*
- **Pricing distortions:** Regulatory, tax, or other distortions
- **Ownership transfer issue:** Owner expects to leave before payback time

Behavioral

- **Risk and uncertainty:** Regarding ability to capture benefit of the investment
- **Lack of awareness/information:** About product efficiency and own consumption behavior
- **Custom and habit:** Practices that prevent capture of potential
- **Elevated hurdle rate:** Different options treated differently

Availability

- **Adverse bundling:** Combining efficiency savings with costly options
- **Capital constraints:** Inability to finance initial outlay
- **Product availability:** Insufficient supply or channels to market
- **Installation and use:** Improperly installed and operated

OPPORTUNITY-SPECIFIC SOLUTION STRATEGIES

- **Information and education**
- **Incentives and financing**
- **Codes and standards**
- **Third party involvement**

COMPONENTS OF AN OVERARCHING STRATEGY

- **Recognize energy efficiency as an important energy resource** while the nation concurrently develops new energy sources
- **Launch an integrated portfolio** of proven, piloted, and emerging approaches
- Identify methods to **provide upfront funding**
- **Forge greater alignment** among stakeholders
- **Foster development** of next-generation energy efficiency technologies

* Financial transaction barriers and actual quality trade-offs are factored into the initial NPV-positive potential calculation as real costs.

Source: McKinsey & Company, *Unlocking Energy Efficiency in the U.S. Economy* (July 2009)

The Retrofit Ramp-Up (R2) Program

U.S. Department of Energy
Energy Efficiency and Renewable Energy

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

What is it?

- Funded by $400 million "competitive" portion of ARRA EE Block Grants.
- Closes December 14.
- Proposed structure: a few (4-8) high-dollar ($50-$150 million) awards.

What will it fund?

- Large-scale building retrofit programs that reach *whole neighborhoods*.
- Programs will include partnerships with private and public sector entities.
- Programs will use highly leveraged financial models to become self-sustaining after the grant.

Why is it needed?

- Building retrofits make economic sense, *but retrofit rates are tiny* (<1%).
- Inconvenience, lack of information, and lack of financing are key barriers.

R^2 will demonstrate and test integrated approaches to overcoming these obstacles and delivering a value proposition that makes owners say yes.

R^2 will help make building retrofits as common as car tune-ups.

DOE is working with HUD to ensure that energy efficiency can be part of the home buying process

- The Federal government currently backs 86% of all new home loans (including FHA, Fannie and Freddie). This is a major opportunity to bring energy efficiency retrofits to a large number of US homes.

- HUD has supported Energy Efficient Mortgages (EEMs) for many years, but uptake is small (~1000/year). DOE and HUD are working to streamline the application and energy-audit process for obtaining an EEM.

- HUD spends $2 billion annually on utility bills for federally supported public housing: a major opportunity for energy and cost savings. DOE and HUD are working to find cost-effective retrofit solutions for multi-family housing to reduce these costs.

Buildings R&D for Energy Efficiency

- **Lighting**:
  - LED lighting—materials, device structures, phosphors, encapsulants.
  - Conventional lighting—non-Hg fluorescent lamps; multi-photon phosphors, etc.
- **Cooling Technologies**: Building A/C & Refrigeration (7.5Q—utility peak load); Industrial A/C & process cooling (~1.6Q); Transportation A/C (1.0—vehicle load); Eliminate use of HFC refrigerants
  - Thermoelectrics; Magnetocalorics; Electrocalorics; Thermionics; New Vapor Compression Cycles; Absorption Cycles; Dehumidification materials; Heat Pumps; Heat Exchangers; Phase-Change Materials for Thermal Load Shifting
- **Building Shells**:
  - Insulants; Phase-change materials for thermal storage; Advanced Membranes
  - Windows: Electrochromics; High Insulation
  - Spectrally-selective paints and roof coatings
- **Building Design Tools, Construction, Intelligent Operation**:
  - Building-Integrated Sensor Networks/Controls; System Integration; Passive Design; Cradle-to-Cradle Materials Design/Use
- **Water Heating**: Building water heating (3.6Q); industrial water heating:
  - Building-Integrated solar water heaters that are low-cost, long-life, freeze-tolerant, and operate at line pressure.
  - Low-cost, high reliability electric- or gas-powered heat pump water heaters.
- **Others**:
  - Low-wattage standby devices; low-cost adjustable speed motor drives with integrated sensors/controllers

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Energy Efficiency

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Advanced Transportation

- **Vehicles**
- **Fuel Cells**
- Biomass

Electric Power Generation

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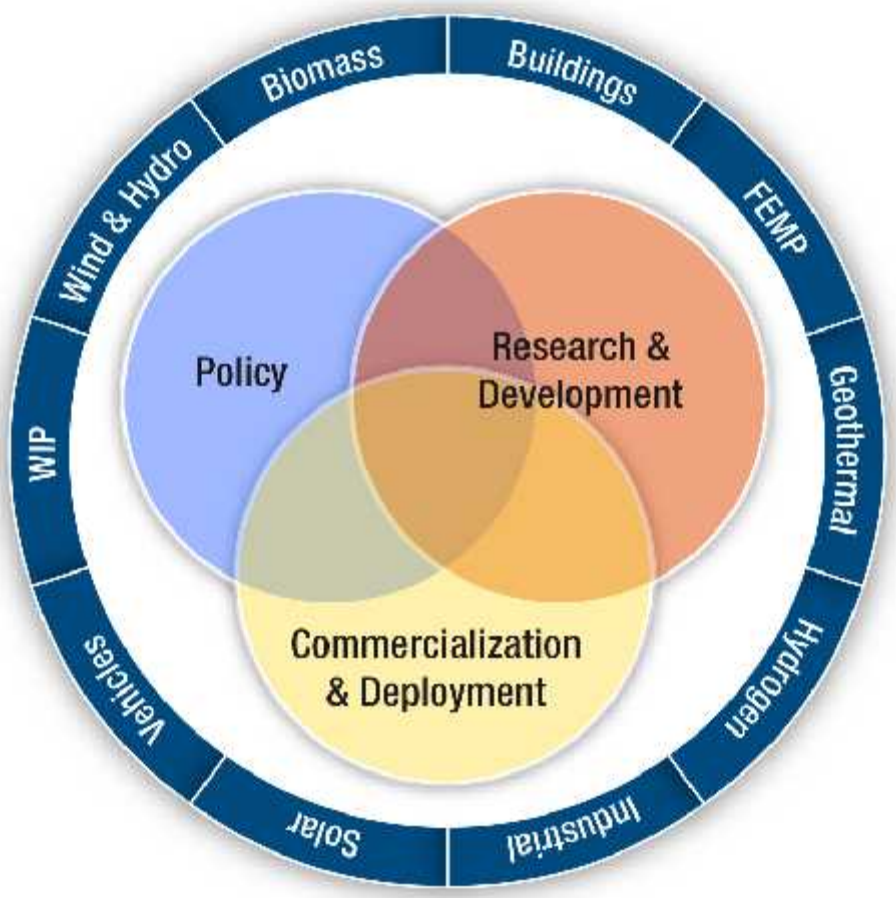

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Hybrid-Electric Systems

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Petroleum Displacement through Fuel Substitution and Improved Efficiency

Types of Vehicles and Benefits

HEV →

Toyota Prius → **50 MPG**
- 1 kWh battery
- Power Rating: 80kW
- System Cost: $3000

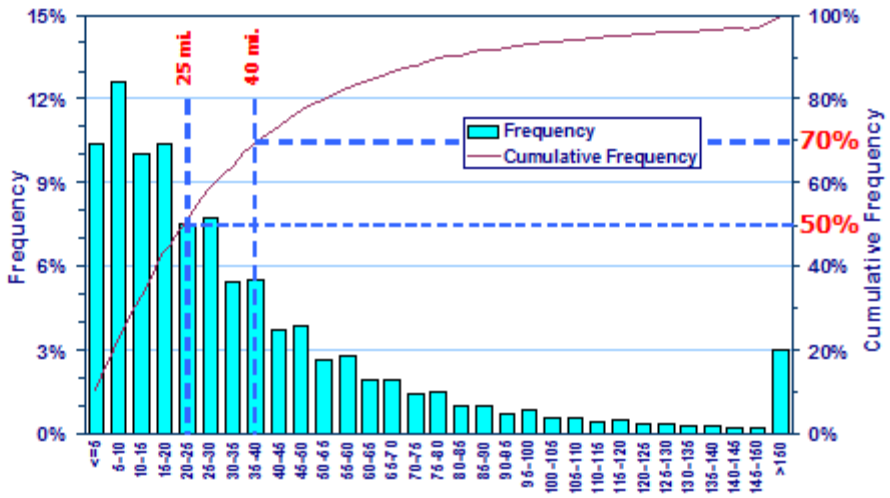
PHEV →

Chevy Volt → **100 MPGe**
- 16 kWh battery
- Power Rating: 170kW
- System Cost: est. $16,000

EV →

Nissan Leaf → **All Electric**
- ≥ 40 kWh battery
- Power Rating: ≥ 110kW
- System Cost: est.$36,000

50% Travel ≤25 mi./day; 70% ≤40 mi./day



Source: 2001 National Household Travel Survey

Critical Technologies & Barriers

Batteries: Provide the necessary power and energy to propel the vehicle **Barriers:** Reducing cost, extending Life, improving safety

Power Electronics and Electric Machines: Manages and controls electrical energy in the system and converts electrical energy into mechanical energy **Barriers:** Increasing the specific power and improve the volumetric power, reducing cost, extending reliability, improving thermal management

Targets and Status

Goals	*2009 Status*
2014 PHEV: Battery that has a 40-mile all-electric range and cost $3,400 ***2015 PEEM***: Cost for electric traction system no greater than $12/kW peak by 2015	**Status:** $8000-$12,000 for a PHEV 40-mile range battery **Status:** Current cost of the electric traction system is $40/kW

EERE's $2B Electric Drive Vehicle Battery and Component Manufacturing Initiative

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Designed to accelerate transition to the next generation of hybrid vehicle transportation

- Supporting the President's goal of 1 million PHEV's by 2015
- 50% Cost Share
- Solicitation Categories
  - **$1.5B**
    - Cell and Battery Pack Mfg Facilities
    - Battery Material Supplier Mfg Facilities
    - Battery Recycling Facilities
  - **$0.5B**
    - Electric Drive Component Mfg Facilities
    - Electric Drive Subcomponent Mfg Facilities
- Status
  - Selections announced in August 2009

President Obama Announces the Battery & Electric Drive Component Grant Program Selections at Navistar International, August 5, 2009

Integrated Battery Supply Chain

Material Suppliers → Cell Manufacturer → Battery Assembler → End User

Automotive Fuel Cell Technology Continues Steady Progress

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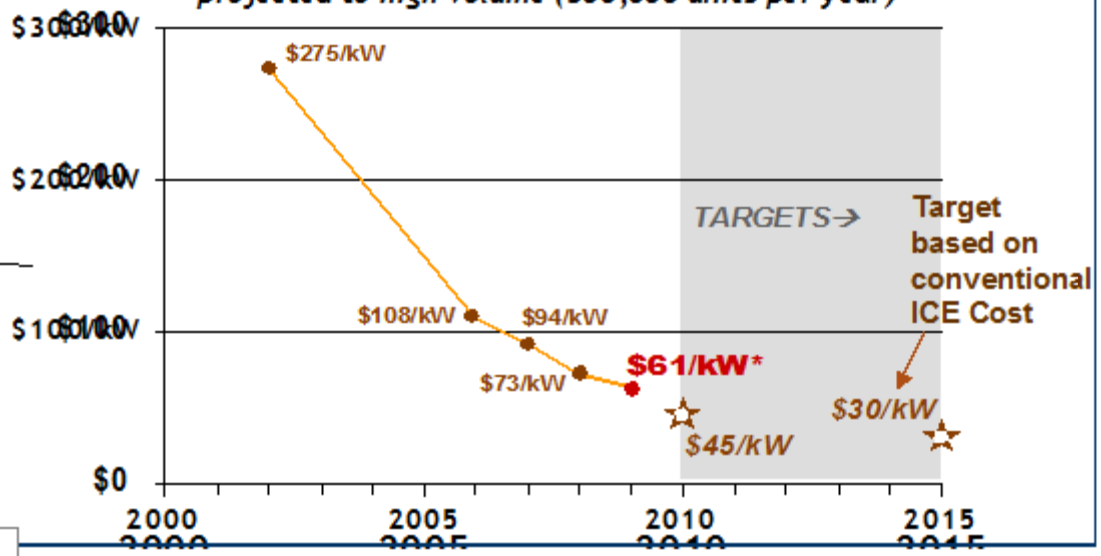
Further reductions in cost by:

- ***Reducing platinum group metal content from 0.35 to 0.18 g/kW***
- ***Increasing power density from 715 to 833 mW/cm²***
  - → **These advances resulted in $10/kW cost reduction over past year.**

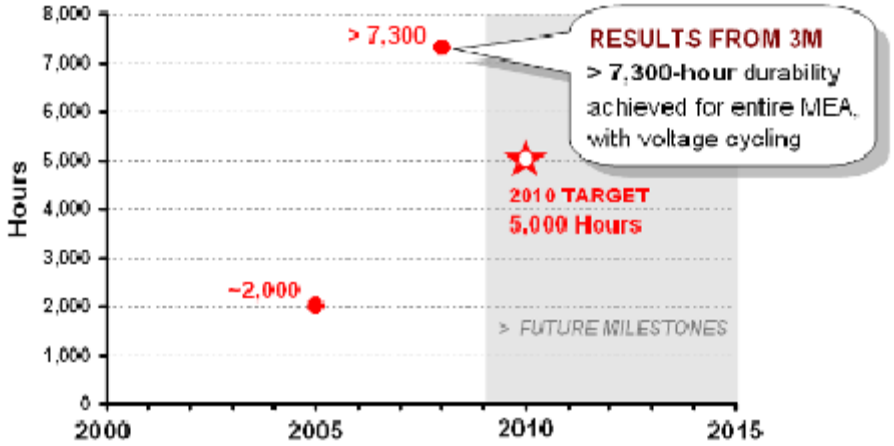
And improvements in durability

Projected Transportation Fuel Cell System Cost

- projected to high volume (500,000 units per year) -



Durability of Automotive Membrane Electrode Assembly (MEA) (in the lab)



From Laboratory to Highway: Fuel Cell & Hydrogen Technologies Validated in Real-World Operation

- 140 fuel cell vehicles and 20 fueling stations demonstrated
- > 2.3 million miles traveled, > 115,000 kg H_2 produced & dispensed
- Analysis by NREL shows:
  - **Efficiency:** 53 – 59% **(>2x higher than gasoline engines)**
  - **Range:** ~196 – 254 miles
  - **Fuel Cell System Durability:** ~ 2,500 hrs (~75,000 miles)

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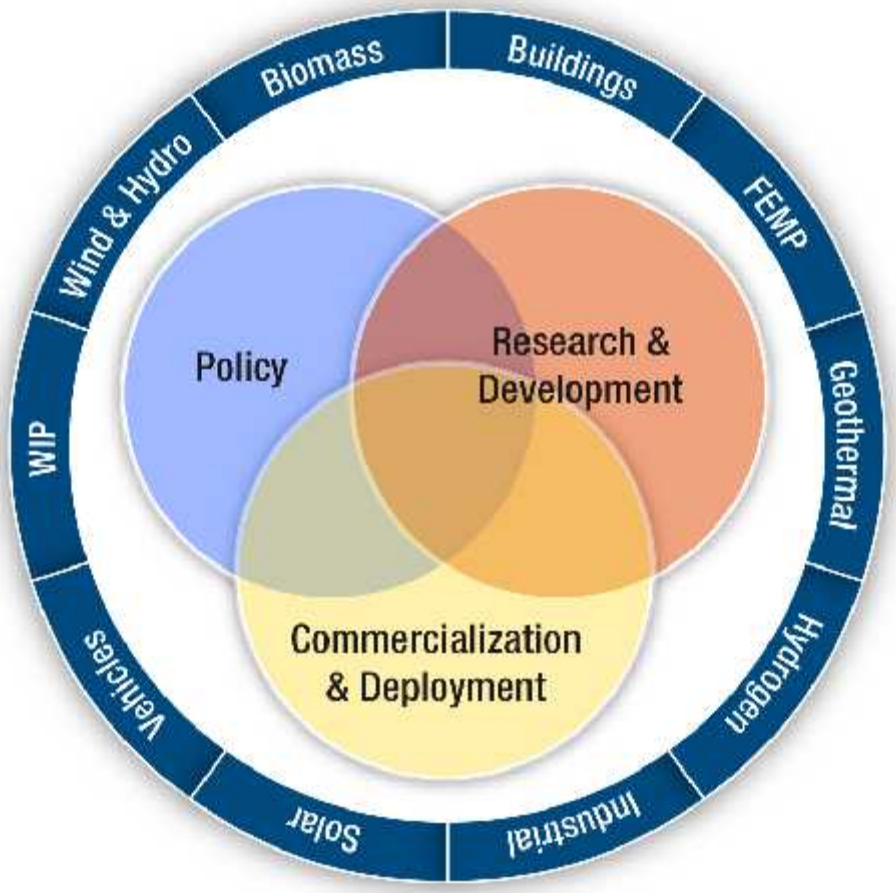

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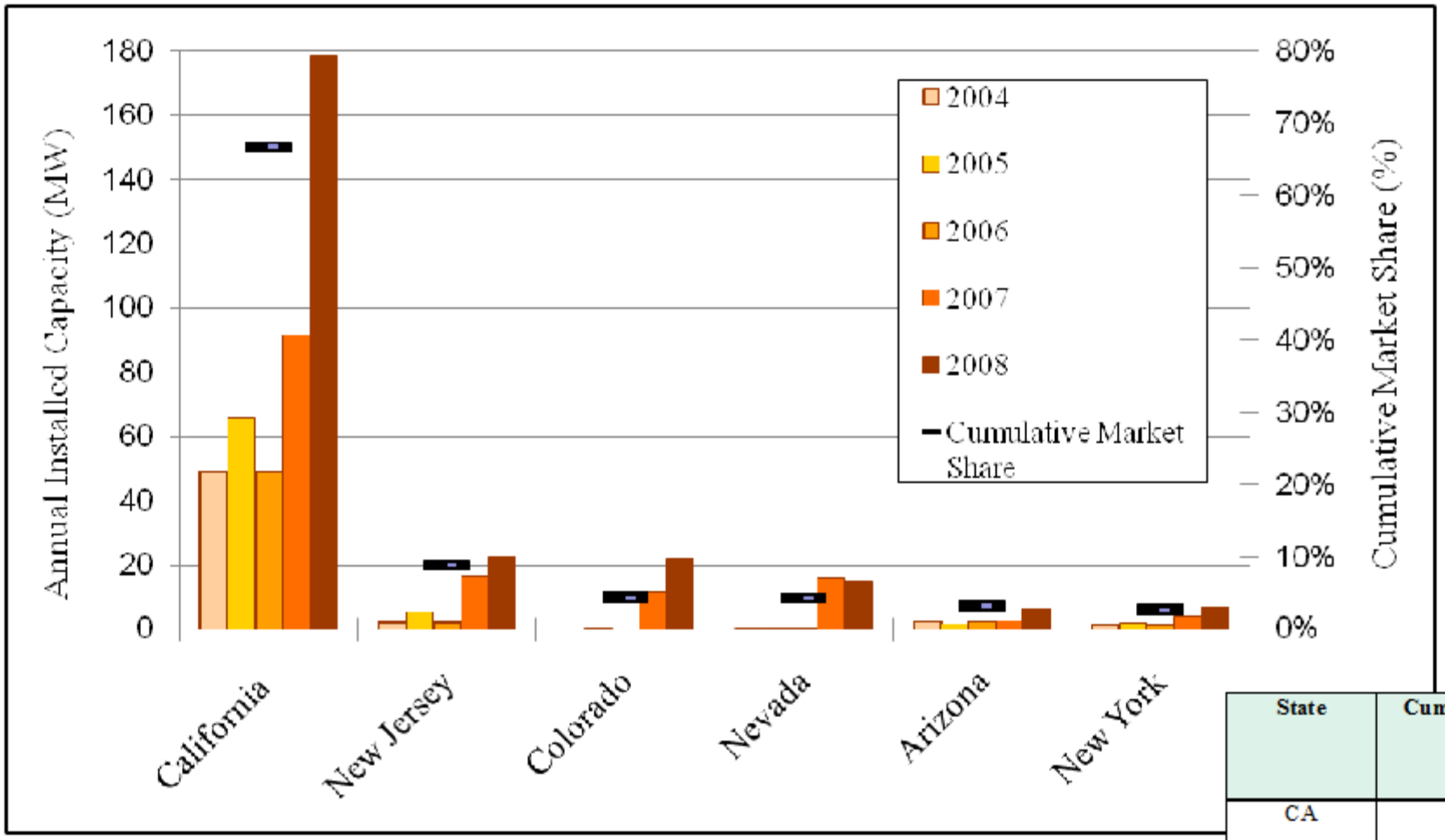
California leads in grid-connected PV capacity installed in U.S.

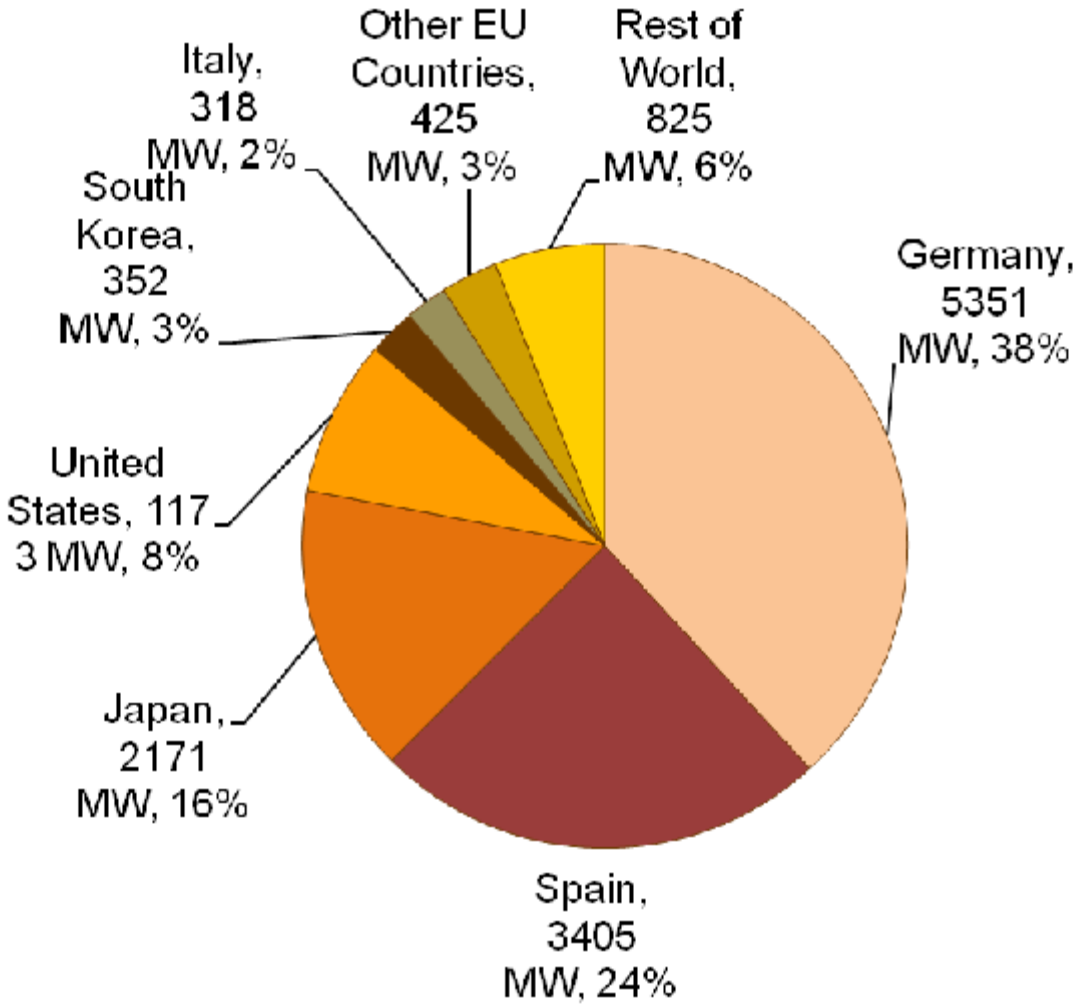


State	Cumulative Market Share	Rank
CA	67%	1
NJ	9%	2
CO	4.5%	3
NV	4.3%	4
AZ	3.2%	5
NY	2.8%	6

U.S. grid-connected PV capacity installed through 2008 was approximately 792 MW, with the top six states being California (528 MW), New Jersey (70 MW), Colorado (35 MW), Nevada (34 MW), Arizona (25 MW), and New York (21 MW).

Source: Larry Sherwood/Interstate Renewable Energy Council (IREC).

U.S. is 4th in global cumulative installed PV capacity

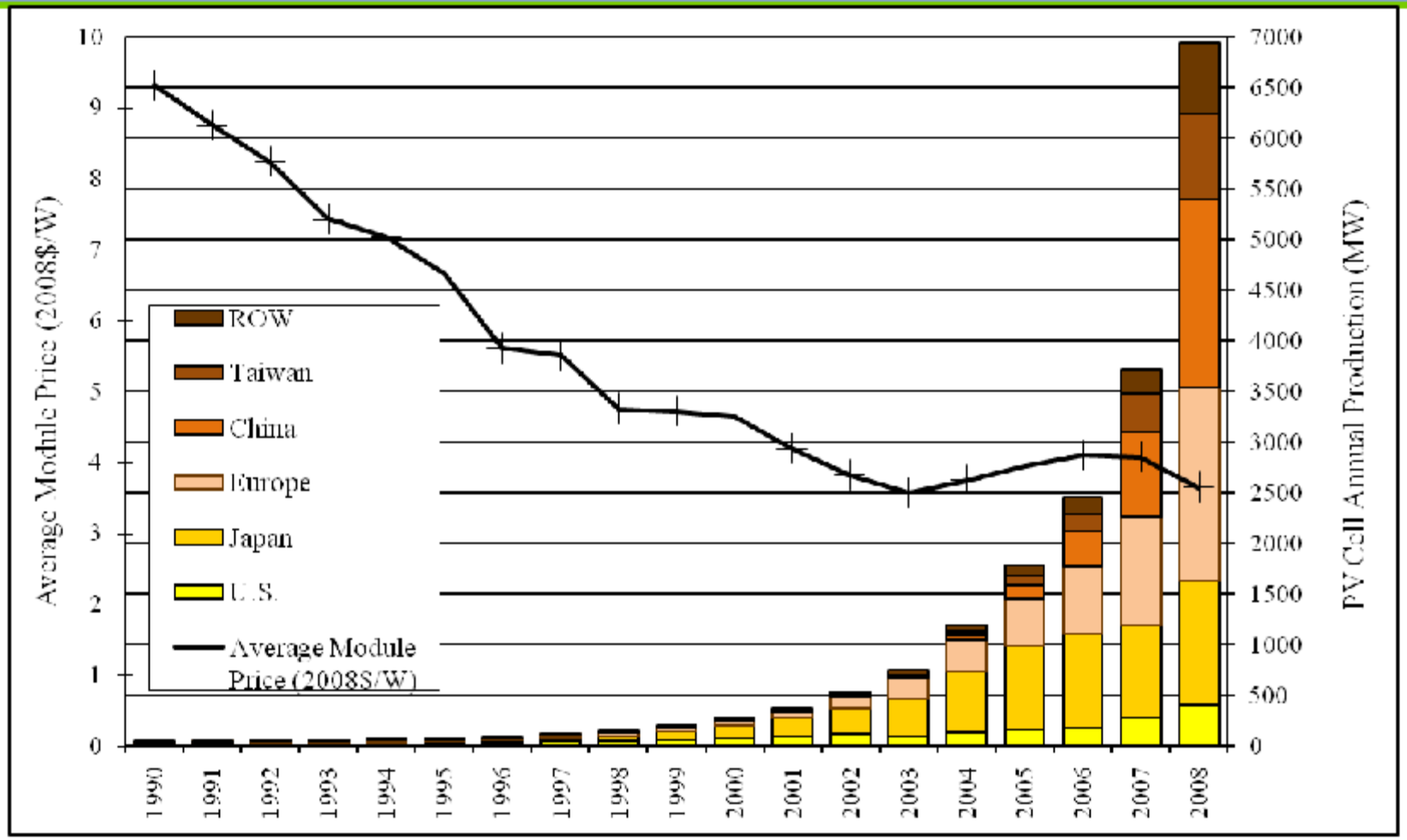


Country	Rank
Germany	1
Spain	2
Japan	3
United States	4
South Korea	5
Italy	6

- Global cumulative installed PV capacity (on-grid plus off-grid) through 2008 was estimated to be over 14 GW, a 79% increase over the 2007 cumulative installed capacity of 7.8 GW.
- Rest of World installed capacity was estimated based on PV shipment data market share in 2008.

Sources: International Energy Agency, Trends in Photovoltaic Applications 2008; EurObserv'ER, Photovoltaic Barometer 2008; Navigant Consulting, Solar Outlook, February 23, 2009; Renewable Energy Policy Network for the 21st Century (REN21) Renewables Global Status Report 2009 Update.

U.S. is 5th in PV Cell Annual Production



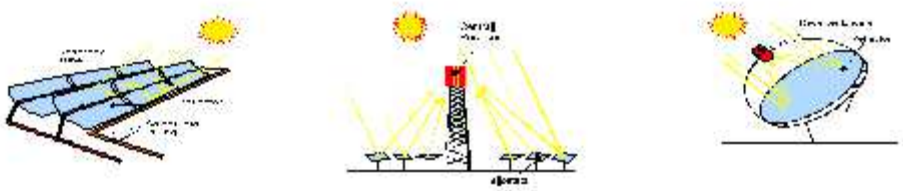
Region/ Country	Rank
Europe	1
China	2
Japan	3
Taiwan	4
U.S.	5

- Global PV cell production reached 6941 MW in 2008, an 87% increase over the 2007 level of 3715 MW. The five year compound annual growth rate from 2003 to 2008 was 56%.
- From 1990 to 2008, the average global price of PV modules used for power applications (modules greater than 75 W) dropped from $9.32 to $3.65 (2008 U.S.$).

Sources: Prometheus Institute, PV News, 1993-2009; Navigant Consulting, PV Manufacturer Shipments & Competitive Analysis 2009

DOE's Solar Energy Technologies Program seeks

Photovoltaics



Concentrating Solar Power Technologies

Market Status:

In 2008, total installed solar photovoltaic (PV) capacity reached 1,100 MW with 30 percent annual growth for the past 6 years.

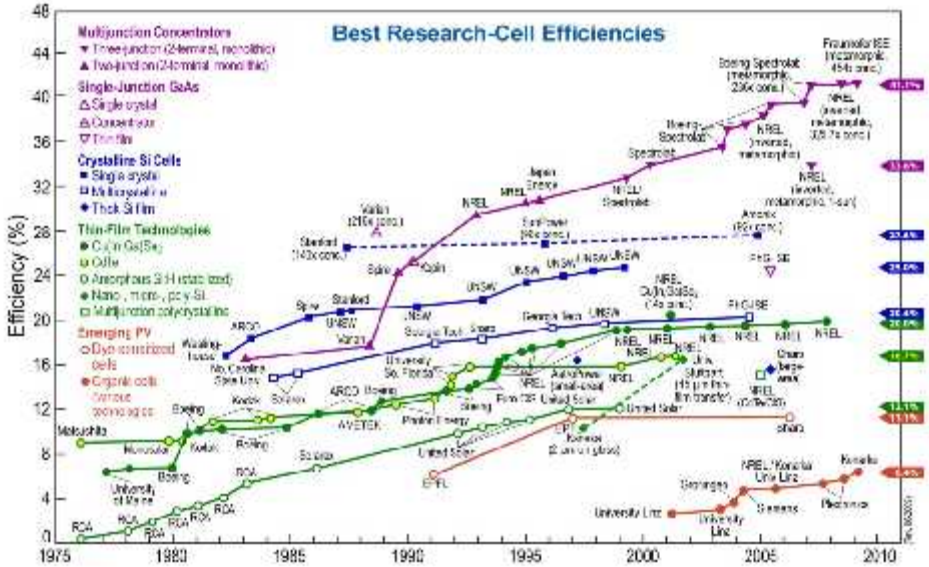
In 2007, the first large-scale concentrating solar power (CSP) plant in 15 years came online in Nevada.

Solar Program RD&D Focus:

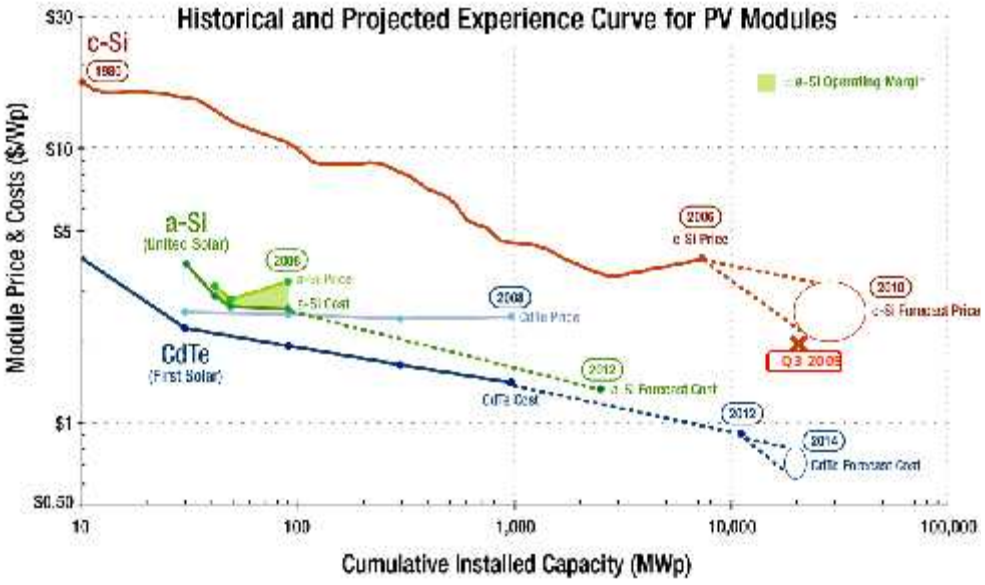
- Funding solar research across the entire value chain
- Transforming solar markets through initiatives that break down market barriers and promote the adoption of solar power
  - Solar America Cities
  - Codes and standards
  - Workforce Development
- Developing thermal energy storage for concentrating solar power applications

The Program has broadened its focus in response to technology

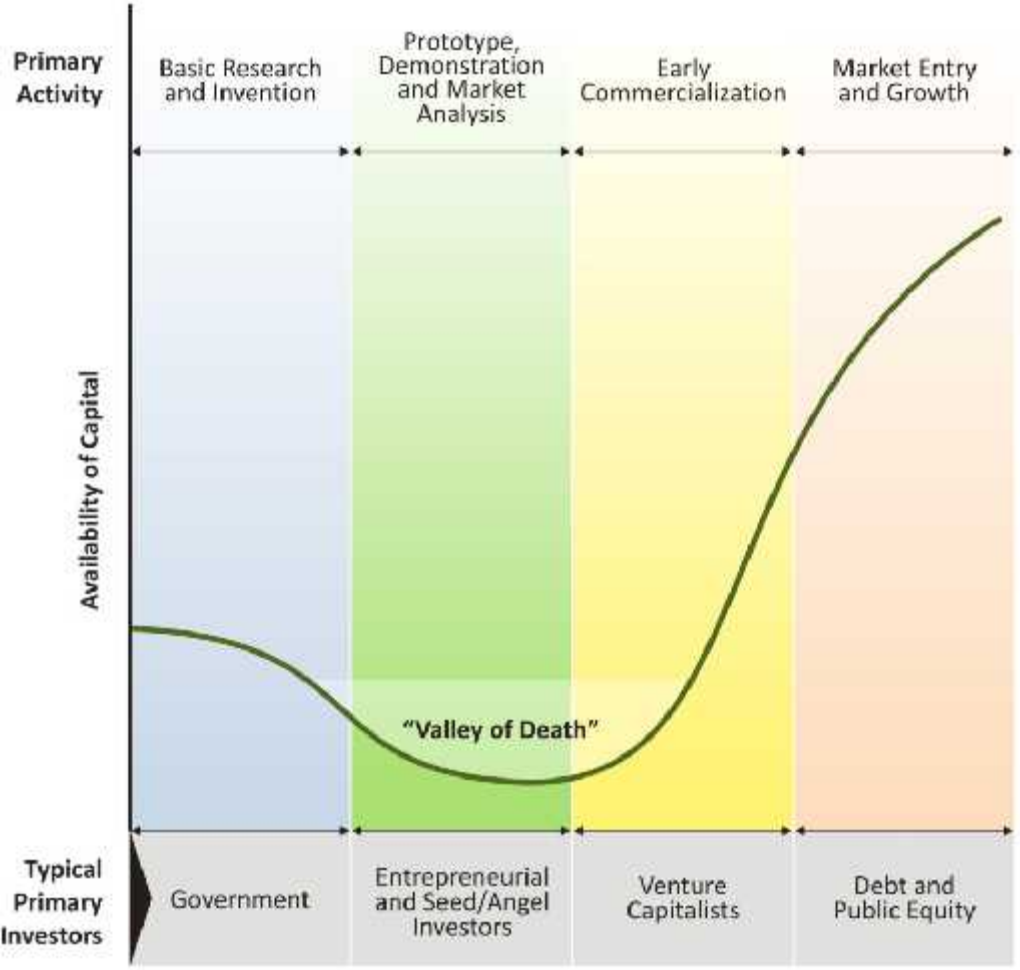
Cell efficiency was primary focus prior to 2005



Greater focus over past 3 yrs on module/system cost



Entrepreneurs: How to cross the "Valley of Death"



- Significant government and university sources for R&D – low capital requirements.
- Venture capital and public debt and equity markets available for growth and expansion.
- Significant capital required for Prototype, Demonstration, and Market Validation – significant commercial risk.
- Cleantech material investments require higher capital levels than IT, biotech, or software. Significant market risk due to government policy.
- Present economic and financial conditions have constrained conventional funding and "widened" the valley.

Significant need for new and novel sources of capital and partnerships to accelerate Cleantech through commercialization

ARRA Funding for Fuel Cells helps cross Valley of Death

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$41.9 million from the American Recovery and Reinvestment Act to fund projects to deploy more than 1,000 fuel cells — to help achieve near term impact and create jobs in fuel cell manufacturing, installation, maintenance & support service sectors.

FROM the LABORATORY to DEPLOYMENT:

DOE funding has supported R&D by all of the fuel cell suppliers involved in these projects.

COMPANY	APPLICATION
Anheuser-Busch	Specialty Vehicle
Delphi Automotive	Auxiliary Power
FedEx Freight East	Specialty Vehicle
GENCO	Specialty Vehicle
Jadoo Power	Backup Power
MTI MicroFuel Cells	Portable
Nuvera Fuel Cells	Specialty Vehicle
Plug Power, Inc.	CHP & Backup Power
PolyFuel, Inc.	Portable
ReliOn Inc.	Backup Power
Sprint Comm.	Backup Power
Sysco of Houston	Specialty Vehicle

...n cost-share
fu... ...dcipants—for a
total of nearly $114.3 million.

Other Programs to Address the Valley of Death

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- Loan Guarantees
  - $6.0B for credit subsidies under ARRA
  - Includes both novel and commercialized technologies (Sec 1705)
  - Projects must be started by September 2011
- Tax Credits
  - ARRA Section 1603 (with IRS)
    - Developers forego ITC or PTC tax credit and take 10% or 30% of qualified investment as cash grant
  - ARRA Section 1302/EPACT 48C (with Dept of Treasury)
    - $2.3B for 30% tax credits supporting $7.7B of manufacturing capital investment
    - Applications closed on October 16, 2009. Notification expected by January 15, 2010
- Grants in Lieu of Tax Credits
  - Gives corporations the option to receive a 30% cash grant from the Treasury in lieu of the Investment Tax Credit (ITC)

EERE ARRA State Funding to New York

Energy Efficiency and Renewable Energy

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- Weatherization Assistance Program - $394M
  - For low income weatherization
  - Up to $7500 per home
  - Administered through State Energy Office down through Community Action Organizations
- State Energy Program - $123M
  - Adopt emerging renewable energy and energy efficiency technologies
  - Administered through State Energy Office
- Energy Efficiency and Conservation Block Grants - $175M
  - For state and local energy efficiency projects and programs

See http://www.energy.gov/newyork.htm

Current & Upcoming Opportunities

Buildings

- Energy Efficient Building Systems Innovation Hub
  - Anticipated Funding Opportunity Announcement (FOA) in 1st quarter of 2010

Vehicle Technologies

- FOA on various topics in January:
  - Natural gas engine development ($5M as required by the FY10 appropriations language)
  - Batteries innovative concepts ($ TBD)
  - Thermoelectrics ($4.5M/yr over three years)
  - Engine Efficiency Improvements ($1.5M/yr over three years)
  - Magnesium alloy lightweighting coordinated projects with Canada
  - Carbon Fiber R&D

Fuel Cell Technologies

- FOA in December 2009
  - fuel cells for stationary & auxiliary power and refueling infrastructure for early market applications (~ $23M over 3 years)

Solar Energy Technologies

- PV Supply Chain and Cross-Cutting Technologies
- Web-Based Photovoltaic (PV) Database
- Solar Regional Analysis Network
- PV Manufacturing Initiative ($100M over 5 years)

Wind Technologies

- NREL Request for Proposals for Wind for Schools, which is a project of DOE's Wind Powering America initiative. See http://nrel.gov/business_opportunities/solicitations_rfps.html

Thank You

Contact Information:

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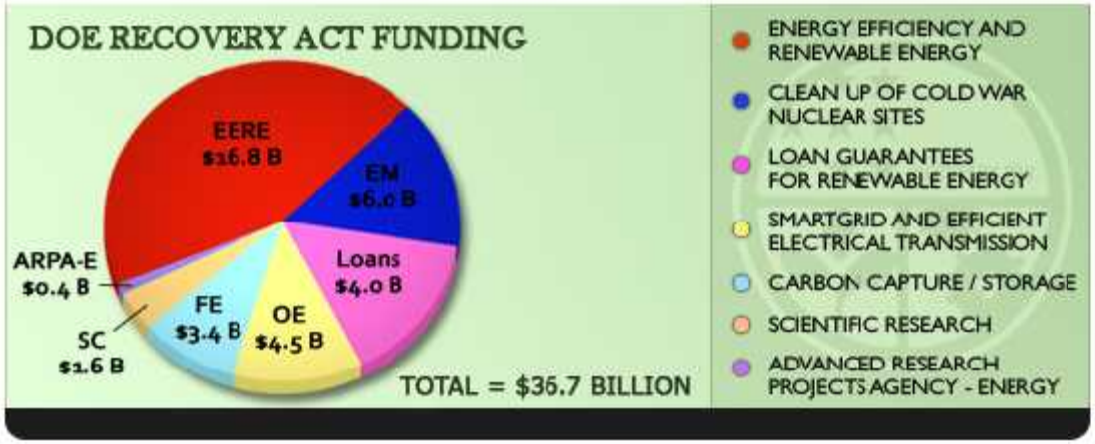
Additional Information

The American Recovery and Reinvestment Act (ARRA)

- Funded $787B for US economy, infrastructure, and for energy, health, and education needs.
- The Department of Energy was given over $36.7B directed to
  - Promote Energy Efficiency
  - Deploy Renewable Power
  - Modernize the Grid
  - Reduce Oil Consumption
  - Restore America's Scientific Leadership
  - Reduce Legacy Environmental Footprint
  - Reduce Greenhouse Gas Emissions

President Obama signs the American Recovery and Reinvestment Act – February 17, 2009



Breakdown of DOE's ARRA funding

Recovery Act Funding – Renewables

Smart Grid Technologies

Smart Grid Investment Grants ($3.4 billion)

Smart Grid Demonstration Program ($615 million)

High Penetration PV Deployment ($17.5 million)

Smart Buildings ($75 million)

Renewable Energy

Renewable Energy Projects (Department of Treasury and DOE) ($3 billion)

Community Renewable Energy Deployment ($22 million)

Biomass

Pilot & Demonstration-Scale Biorefineries ($480 million)

Commercial-Scale Biorefineries ($176.5 million)

Fundamental Research ($110 million)

Ethanol Infrastructure Research ($20 million)

Solar

PV Technology Development ($51.5 million)

Deployment ($40.5 million)

CSP R&D ($25.6 Million)

PV Technology Research, Development and Design ($22 million)

Solar Energy Grid Integration ($5 million)

Wind/Water Power

Wind Turbine Drivetrain RD&T ($45 million)

University R&D ($24 million)

National Wind Tech. Center upgrades ($10 million)

Technology Development ($14 million)

Large Blade Wind Test Facility (MA) ($25 million)

Modernize Existing Hydropower Infrastructure ($32 million)

Geothermal

Geothermal Demonstration ($140 million)

EGS Technology R&D ($80 million)

Validation of Innovative Exploration Techniques ($100 million)

National Geothermal Data System ($30 million)

Geothermal Heat Pumps ($50 million)

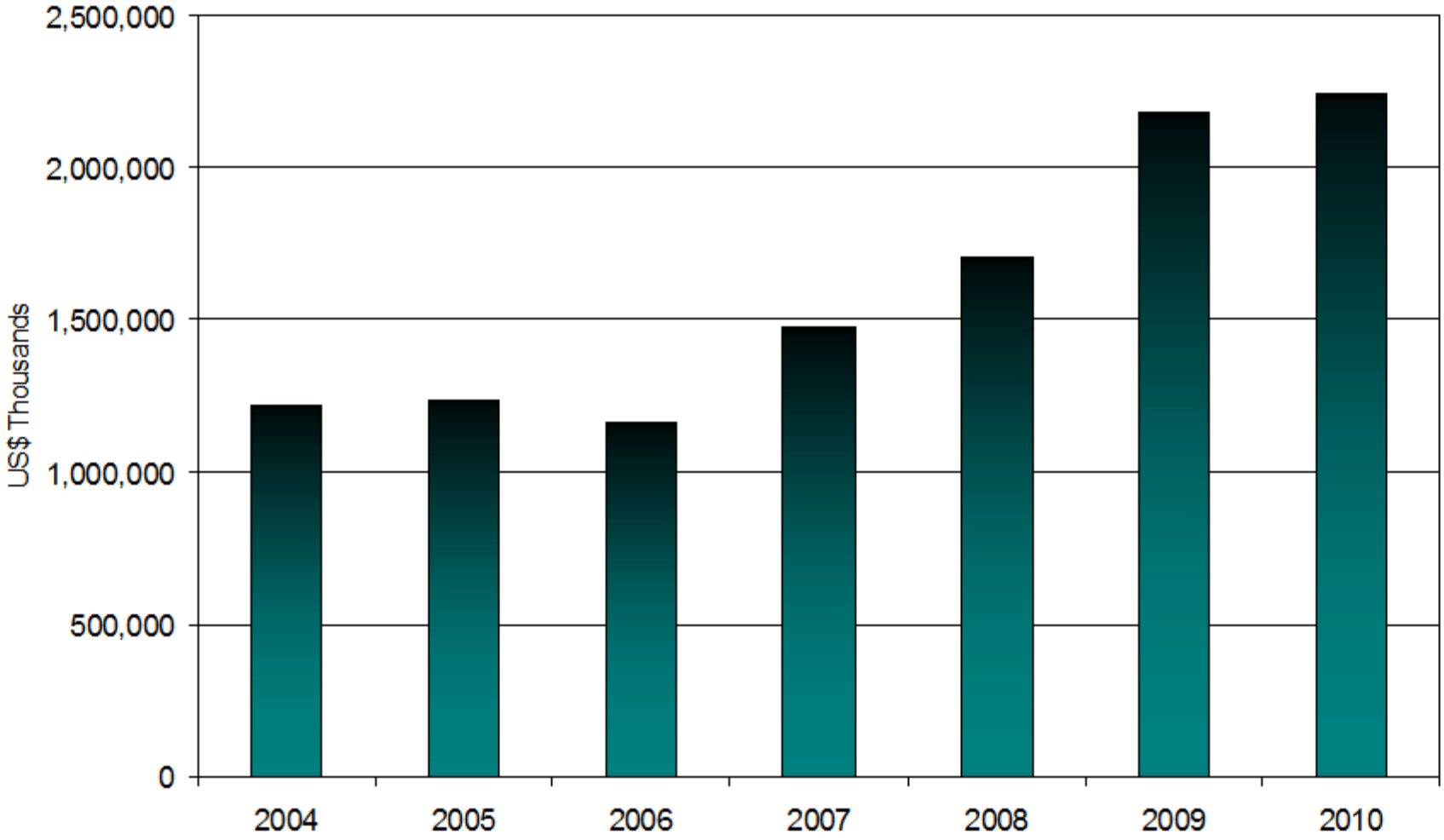
EERE ARRA Funding for State Programs

- Weatherization Assistance Program - $5B
  - For low income weatherization
  - Up to $7500 per home
  - Administered through State Energy Office down through Community Action Organizations
- State Energy Program - $3.1B
  - Adopt emerging renewable energy and energy efficiency technologies
  - Administered through State Energy Offices
- Energy Efficiency and Conservation Block Grants - $3.2B
  - For state and local energy efficiency projects and programs

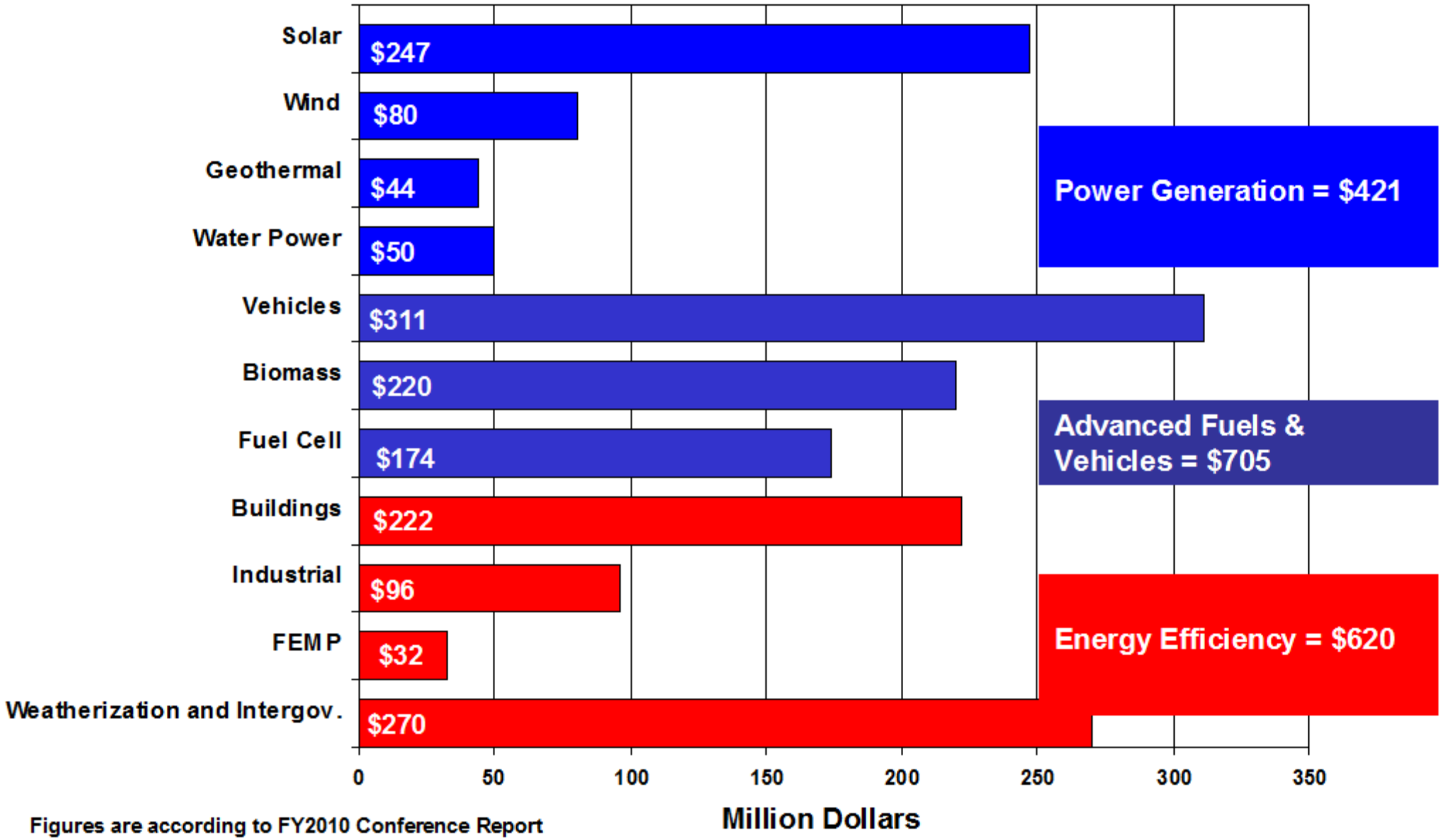
Accelerate Cleantech Commercialization

	FY2007	FY2008	FY2009 Omnibus	FY 2009 ARRA
Appropriation	$4.0 billion	$38.5 billion	$8.5 billion	$60 billion (est)
Authorization	EPACT 1703			EPACT 1705
Uses	New or significantly improved technologies			Commercial and novel technologies
Credit Subsidy	Borrower pays			$6.0B appropriated
Term	Available until used			Projects must be started by September 30, 2011.
Carveouts	No carve-out stipulated by Congress	• **$10.0 billion** for energy efficiency renewable energy and advanced transmission and distribution technologies • **$18.5 billion** for advanced nuclear power facilities • **$2.0 billion** for "front end" nuclear fuel cycle facilities • **$6.0 billion** for coal based power generation, industrial gasification and carbon capture and sequestration • **$2.0 billion** for advanced coal gasification	The FY 2009 Omnibus Budget provides an additional $8.5 billion in loan authority for renewable projects.	• No carve-outs were stipulated, but three project categories were listed: 1. Renewable energy installations and manufacturing facilities for renewable energy components 2. Electric power transmission systems 3. Advanced biofuel projects

Energy Efficiency and Renewable Energy Budget History FY 2004-FY2010



Fiscal Year 2010 Budget ($2.24 B)



Figures are according to FY2010 Conference Report

Note: Bar chart does not include Facilities and Infrastructure ($63), Program Direction ($140), and Program Support ($45)

EERE's Strategic Program Directions

U.S. Department of Energy
Energy Efficiency and Renewable Energy

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Program Priorities	
Biomass	Investing over $1.4 billion to achieve cost competitiveness and commercialization of cellulosic and other advanced biomass feedstocks and biofuels through applied research, next generation pilot scale development, commercial scale biorefinery demonstrations and targeted infrastructure activities.
Buildings	Implementing a systems approach in deploying technologies for "net-zero" energy buildings that produce as much energy as they consume. Builder's Challenge, the Commercial Buildings Initiative, and accelerated building codes and appliance standards implement this new approach.
FEMP	Doubled energy efficiency investment in Federal building through $1 billion of private-party performance contracting. New ESPC contracts will support up $80 billion in energy savings at federal facilities and increase individual contract ceilings to $5 billion over the life of the contract.
Geothermal	Program renaissance emerged on foundation of Enhanced Geothermal Systems (EGS) that allows geothermal energy to be harnessed nationwide providing up to 10% of our Nation's future electricity.
Fuel Cells	Added focus on near-term stationary and early market applications to create economies of scale, accelerate learning-by-doing, and reduce cost of technology for transportation market.
Industrial	Concentrating on the Save Energy Now program, which through energy assessments has resulted in savings of over $100 million and 75 trillion Btus of natural gas.
Solar	Achieve grid parity with PV and other solar technologies by 2015 through advanced R&D over the entire supply chain. Re-invigorate Concentrated Solar Power program through launch of energy storage research and demonstration.
Vehicles	Focusing on fuel flexible Plug-in Hybrid Electric Vehicles through greatly enhanced battery research activities and new utility partnerships.
Weatherization/SEP	Developed stronger ties with States and utilities by providing technical assistance and by developing "best practices" and model policies for faster and larger scale adoption of efficiency and renewable energy.
Wind & Water Power	Assessed feasibility for wind energy to provide 20% of our Nation's electricity which led to new industry vision. Launched new program in wave, tidal and current energy.

Renewable Energy Snapshot

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- Renewable energy installations in both the world and in the United States have nearly tripled between 2000 and 2008.
- Including hydropower, renewable energy represents nearly 11% of total installed capacity and more than 9% of total generation in the United States in 2008.
- In the United States, growth in sectors such as wind and solar photovoltaics (PV) signify an ongoing shift in the composition of our electricity supply. In 2008, cumulative wind capacity increased by 51% and cumulative solar PV capacity grew 44% from the previous year.
- Worldwide, wind energy is the fastest growing renewable energy technology—between 2000 and 2008, wind energy generation worldwide increased by a factor of almost 7. The United States experienced even more dramatic growth, as installed wind energy capacity increased almost 10 times between 2000 and 2008.
- In the United States, renewable energy has been capturing a growing percent of new capacity additions during the past few years. In 2008, renewable energy accounted for more than 43% of all new grid-connected electrical capacity installations in the United States—a large contrast from 2004 when all renewable energy captured only 2% of new capacity additions.
- Asset financing investments in renewables* for 2008 were $72.5 billion and for 2009 were $34.8 billion (Source: New Energy Finance)

*Figures include new build Asset Financing in clean energy (wind, biofuels, biomass, geothermal, mini-hydro, marine, & solar projects only). The figures exclude re-financing and project acquisition deals, bridge/construction type financing, and small scale projects.