America's Energy Challenges

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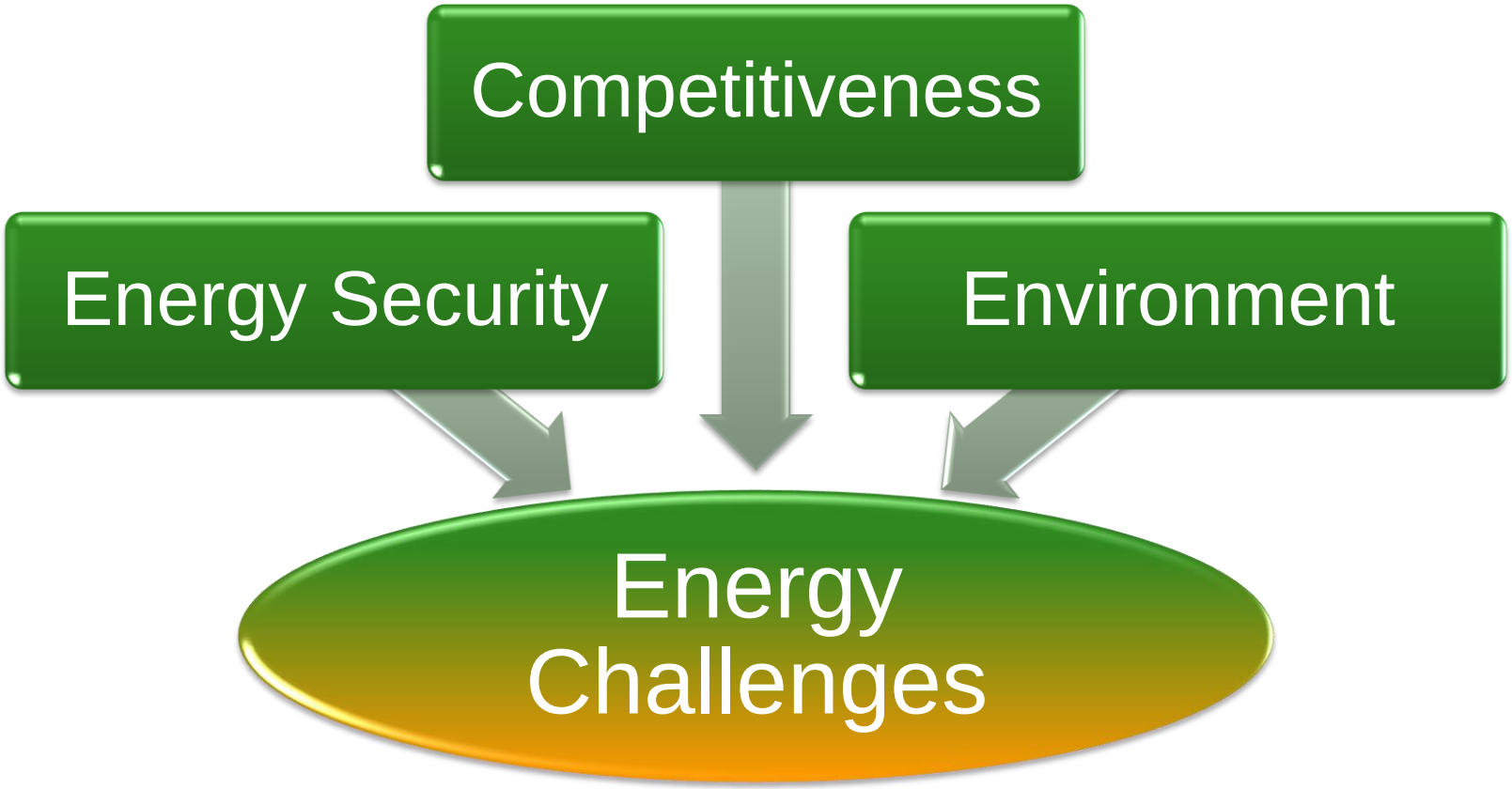
http://science.energy.gov/s-4

U.S. Energy Challenges



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Energy Challenge #1

ENERGY SECURITY

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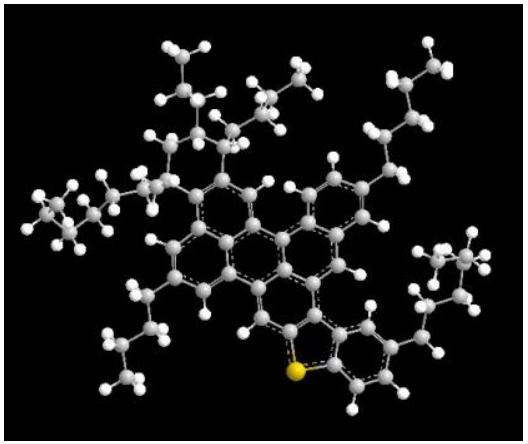
Energy Security

- The reliable and economic supply of fuels
- Transportation is powered almost exclusively by crude-derived liquid hydrocarbons
  - Energy density (50x better than the best battery)
  - Ease and economy of use
  - Existing infrastructure
  - Availability



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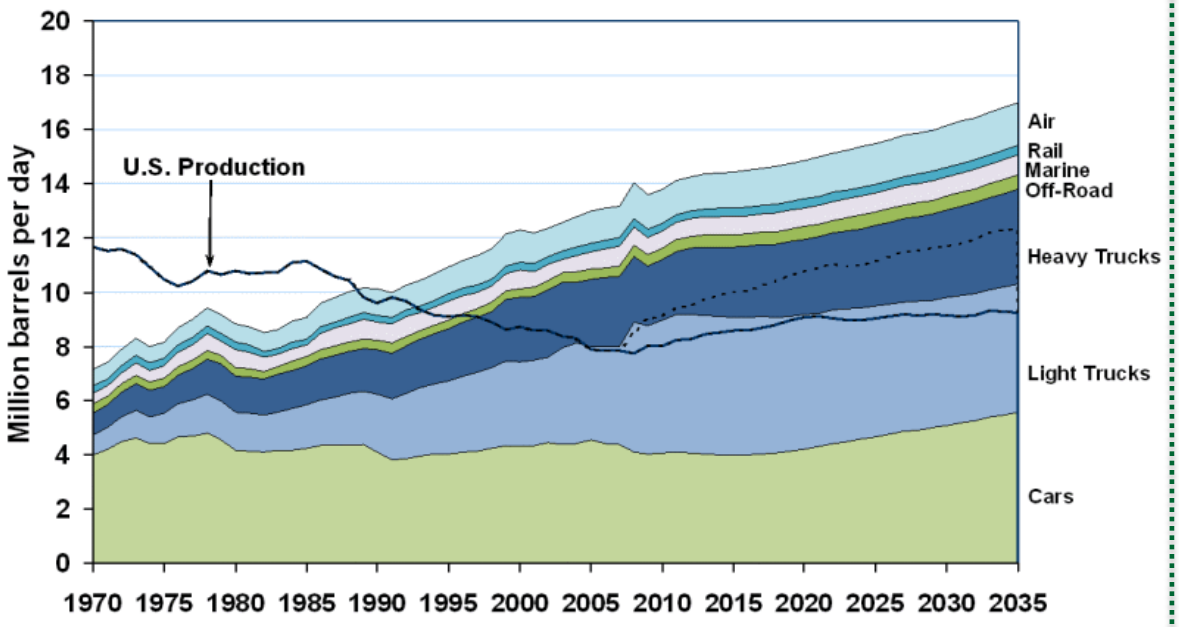
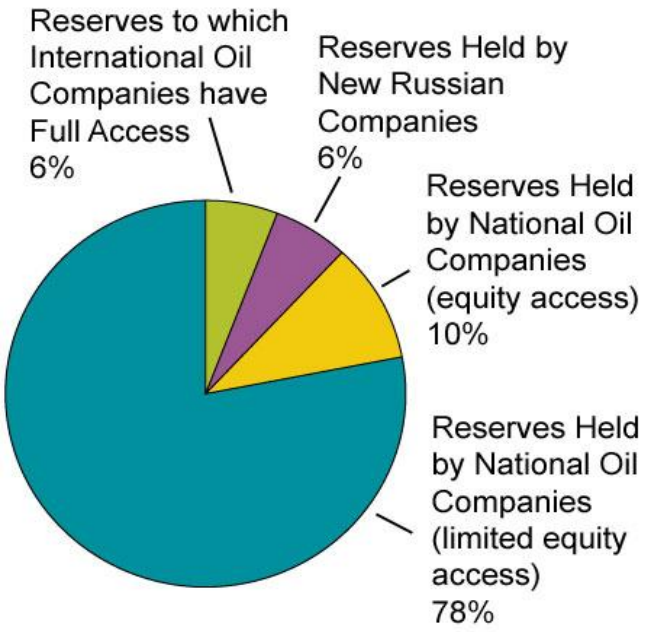
U.S. Petroleum Production and Consumption





U.S. Vehicle Market

- 240 M vehicles on the road
- Approximately 9 M new cars & light trucks for 2009; average is 15.7 M/yr 2002-2007
- Hybrid vehicles now ~3% of sales
- 13 M cars and light trucks taken out of use per year

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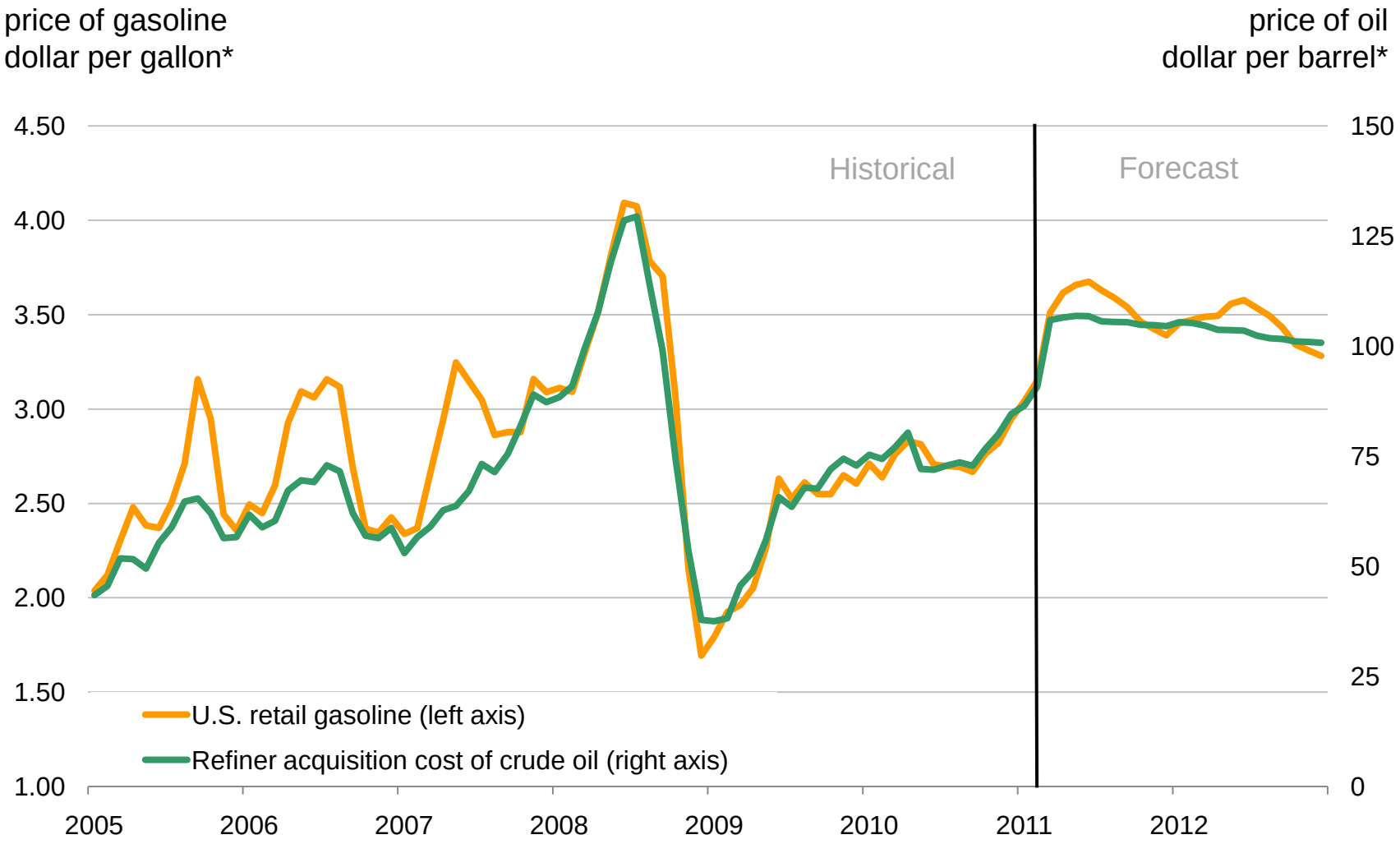
Gasoline prices reflect the cost of crude oil



*real 2009 dollars, monthly average

Sources: U.S. Energy Information Administration, Thomson Reuters

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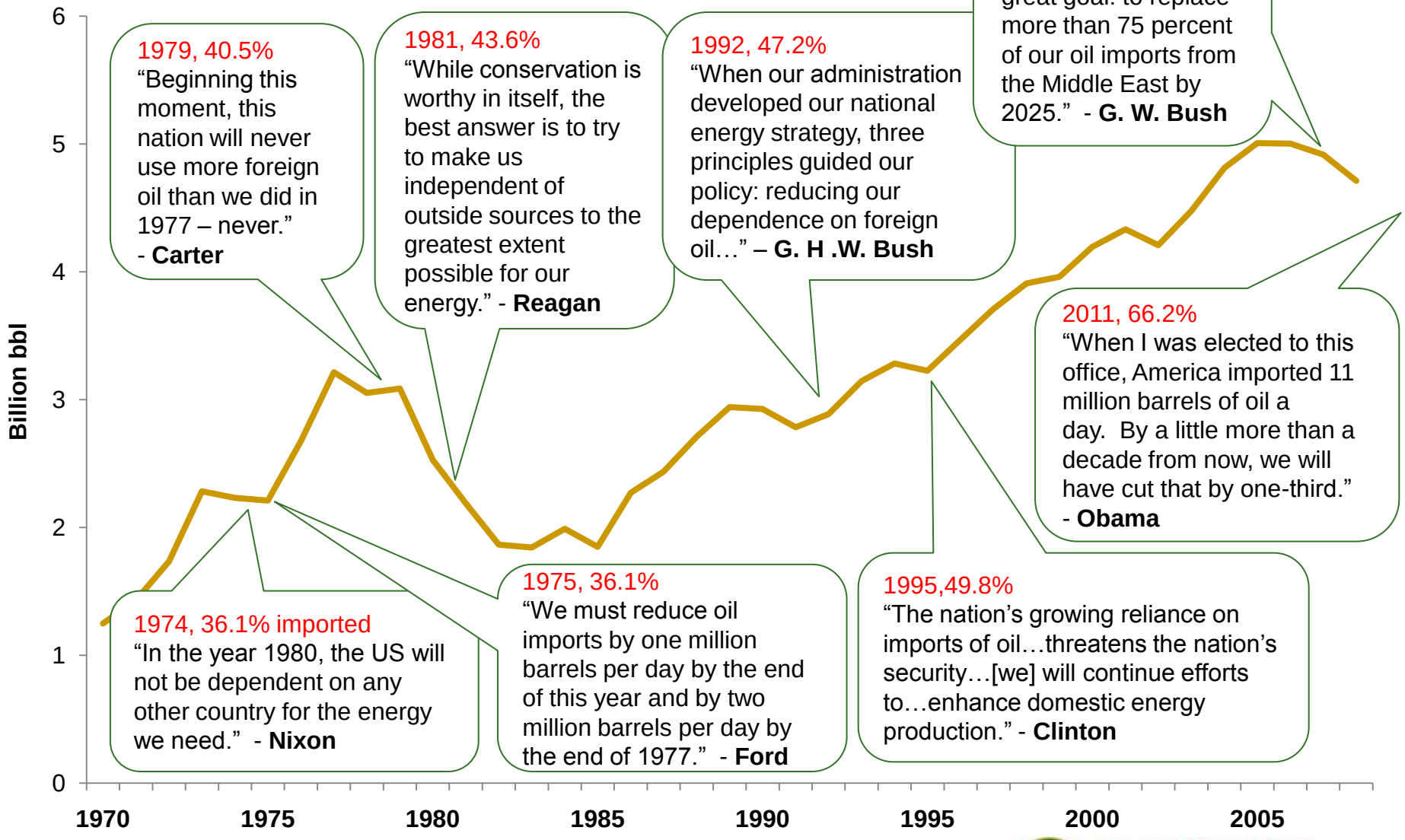
Annual US Oil Imports



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Energy Challenge #2

U.S. COMPETITIVENESS

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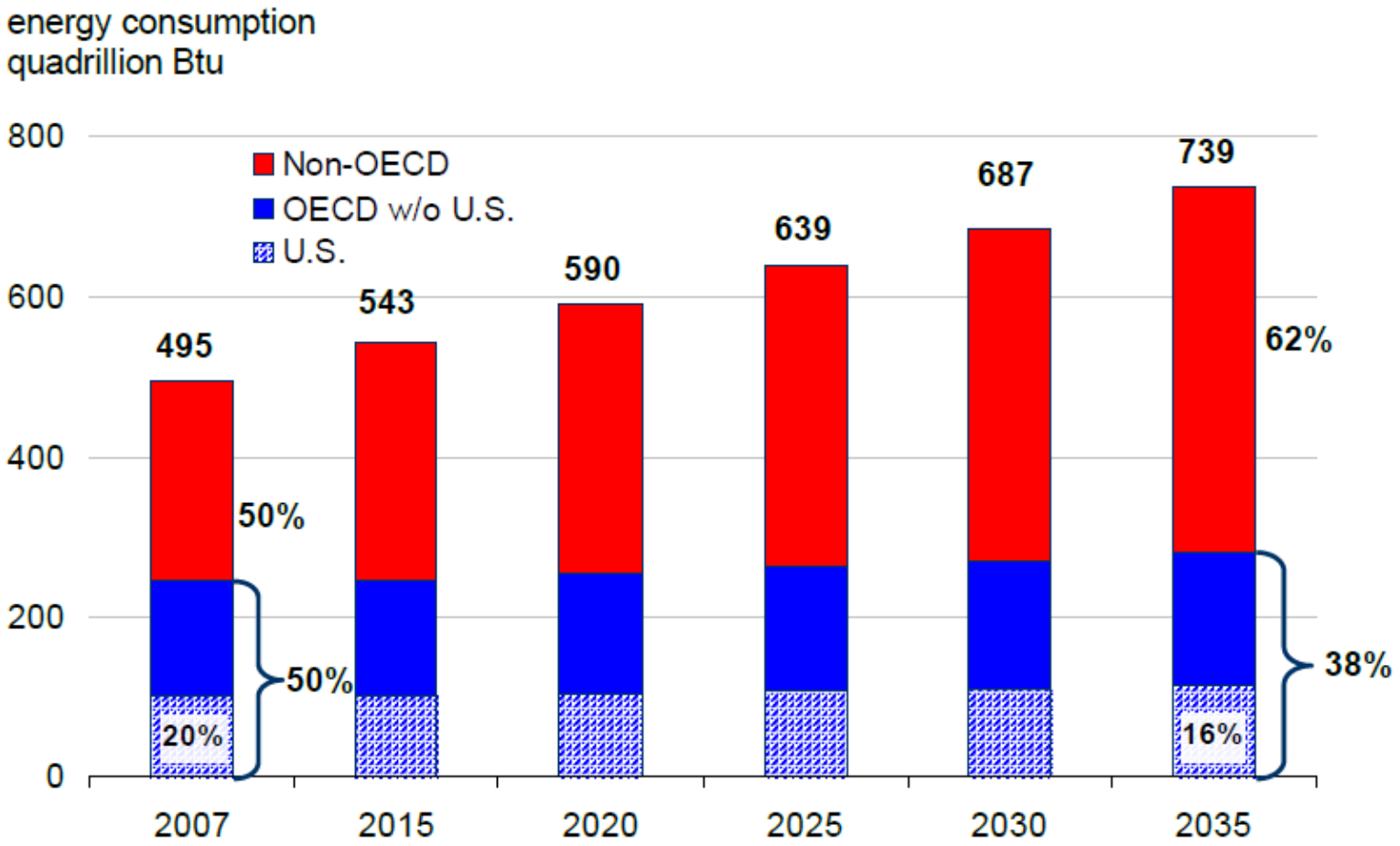
Development and population growth drive a strong increase in energy consumption



Source: EIA, *International Energy Outlook 2010*

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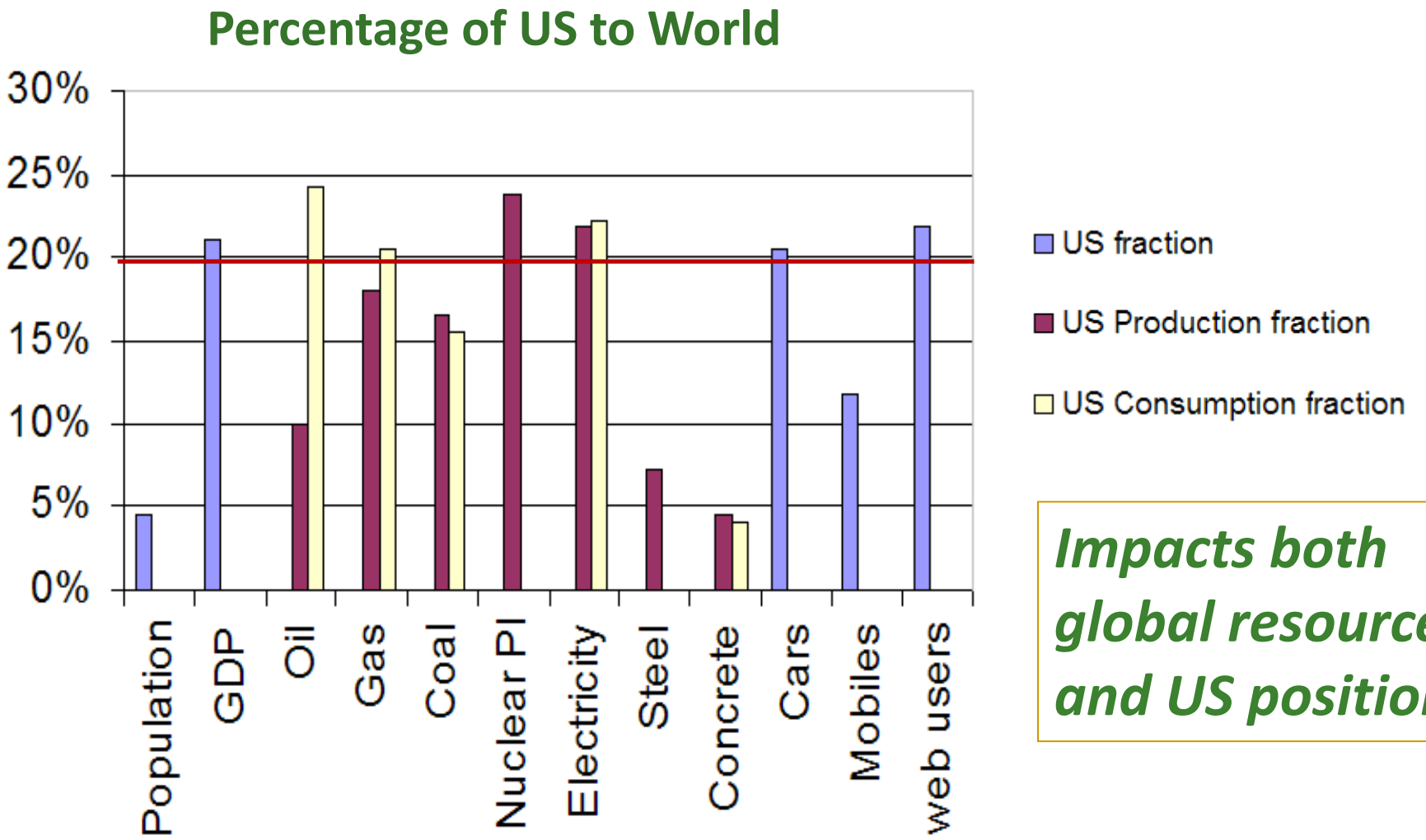
The US is 4% of people and ~20% consumption



Impacts both global resources and US position

Source: CIA World Factbook 2008

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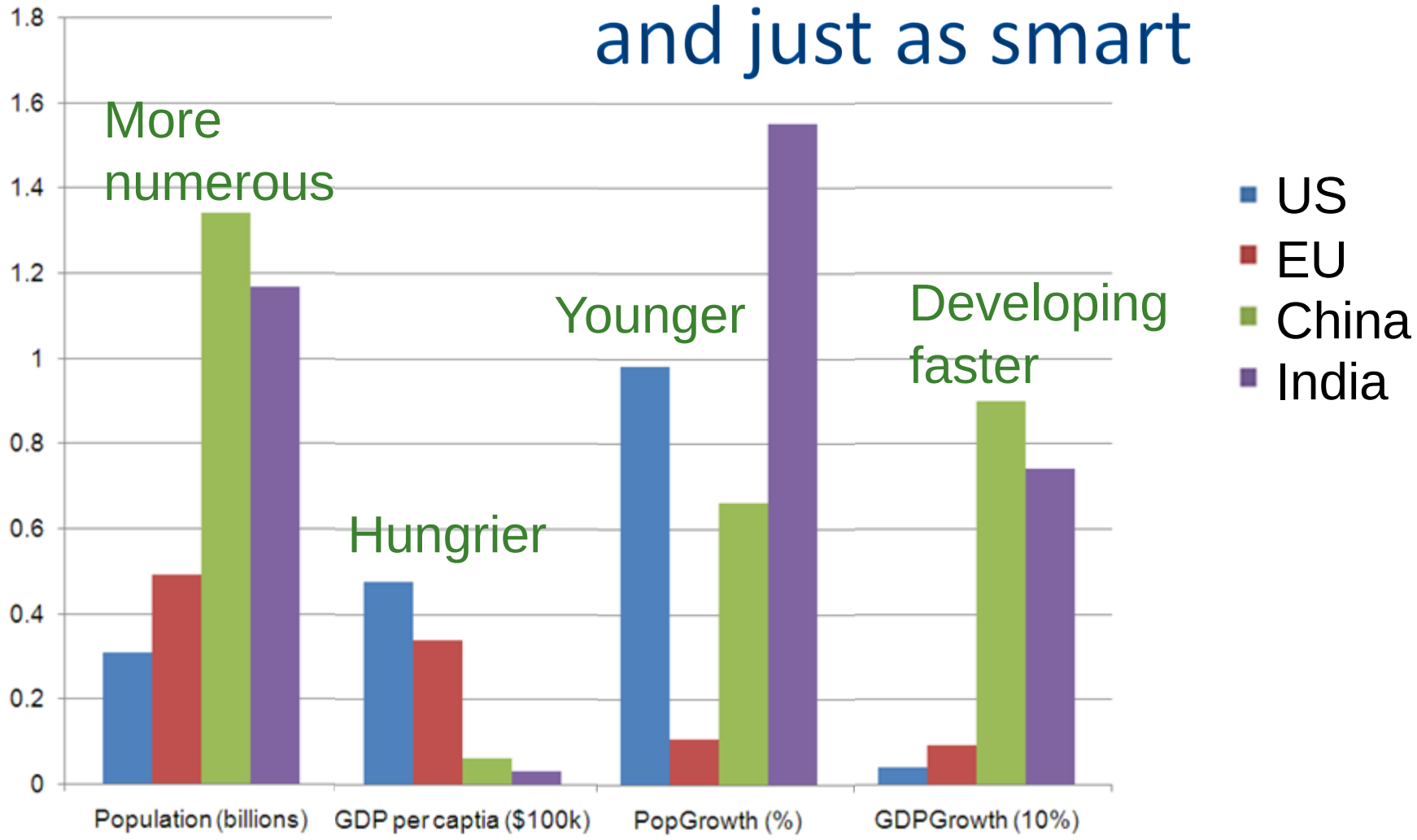
Compared to the US/EU

the rest of the world is…



Source: CIA World Factbook, population 2009 est, 2008 US dollars

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Clean Energy Leadership

"In the 1980s, America was home to more than 80 percent of the world's wind capacity, and 90 percent of its solar capacity. We owned the clean energy economy. But today, China has the most wind capacity. Germany has the most solar. Both invest more than we do in clean energy. **Other countries are exporting technology we pioneered and chasing the jobs that come with it** because they know that the countries that lead the 21st century clean energy economy will be the countries that lead the 21st century global economy."

–President Obama, March 2011

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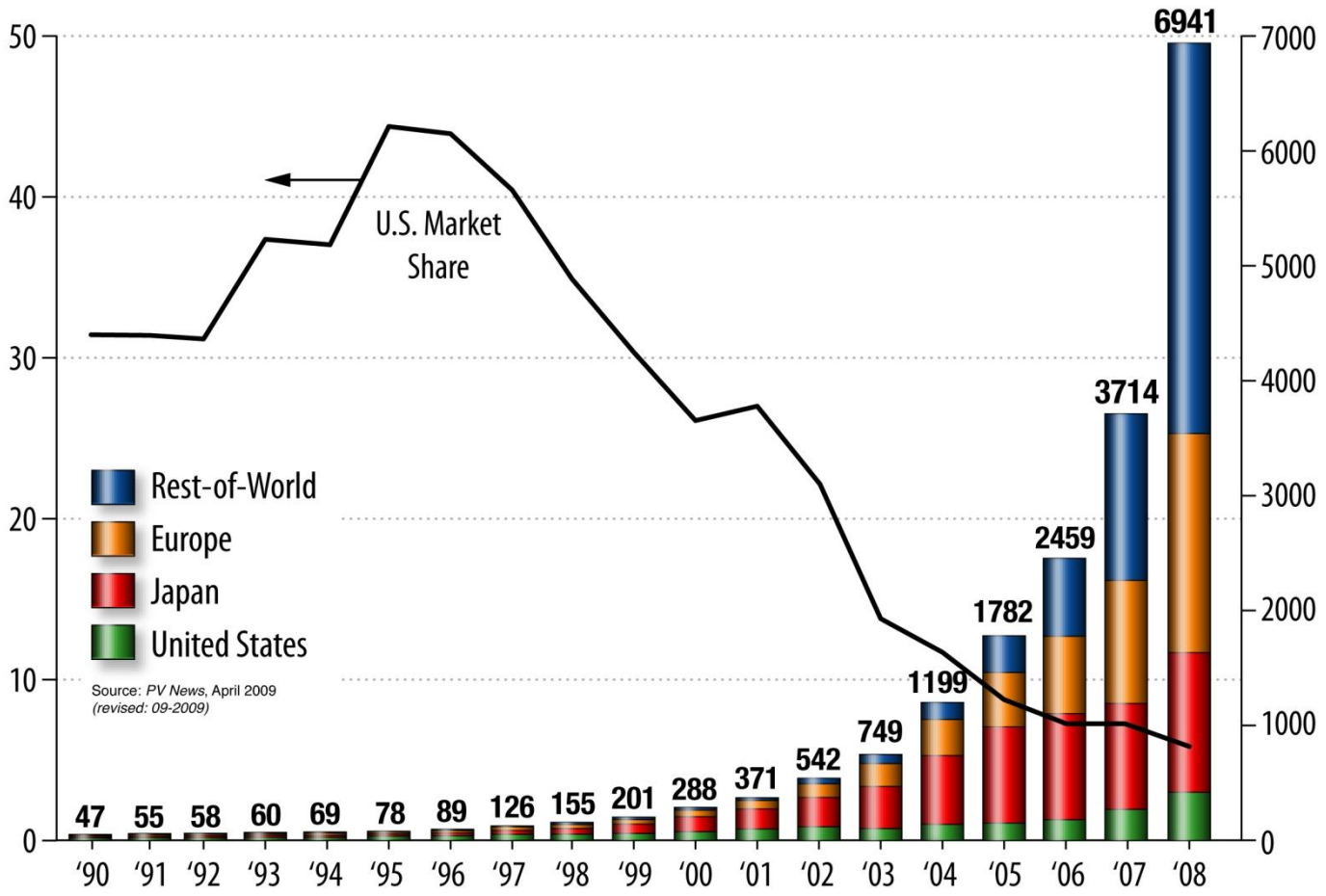
Worldwide shipments of Solar Photovoltaics (MW)



The situation is similar in other areas:

- Fuel-efficient automobiles
- Batteries
- Electricity Transmission
- Power Electronics
- Nuclear Power

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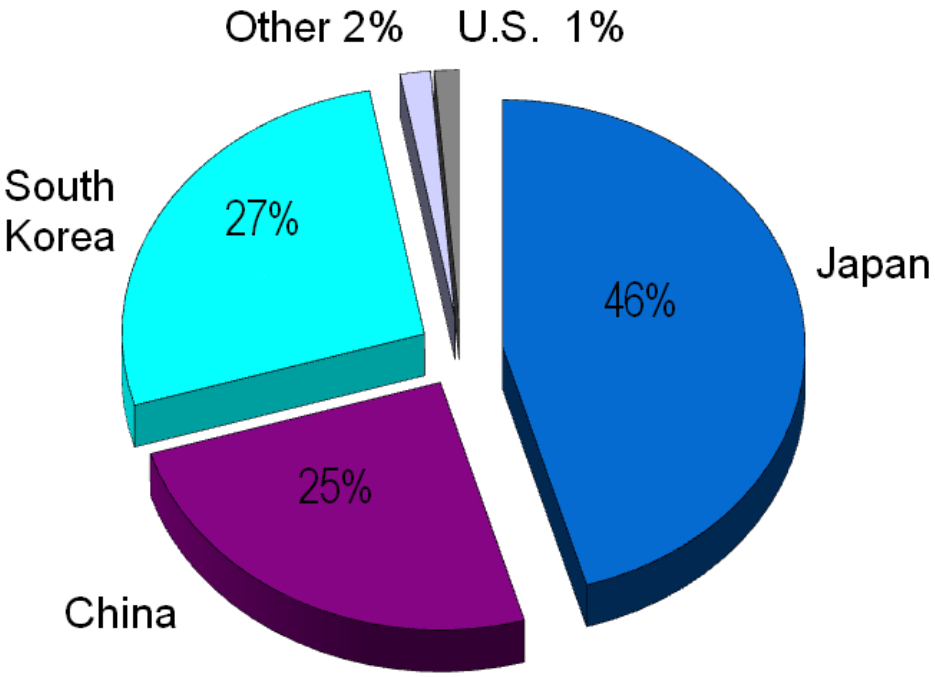
Battery Manufacturing

Global Lithium-ion Battery Manufacturing (2009)
(largely for consumer electronics)



"And a modest, $2 billion investment in competitive grants for companies to **develop the next generation of batteries** for these cars has jumpstarted a big new American industry. Soon, America will be home to **40% of global manufacturing capacity for these batteries**."

–President Obama, March 2011

Source: H. Takeshita, 26th International Battery Seminar, Ft Lauderdale, FL, March 2009.

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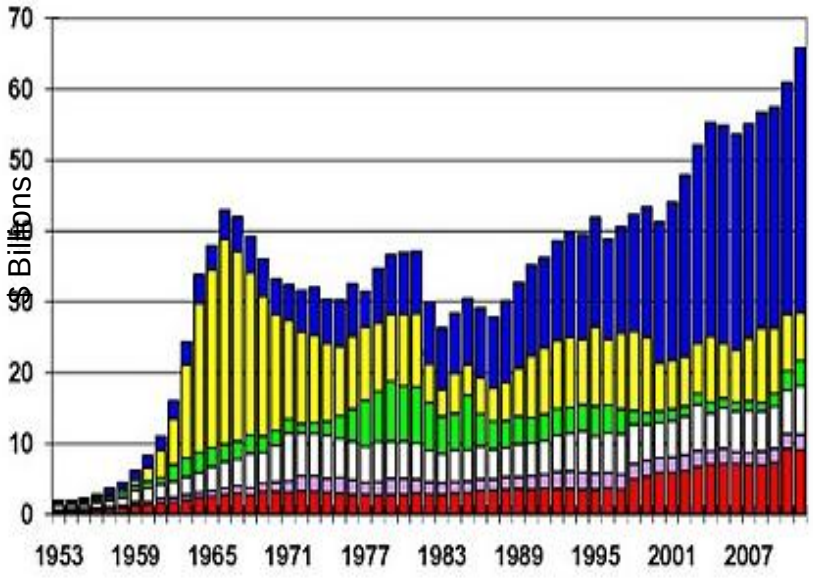
Federal Energy R&D has been relatively small and turbulent

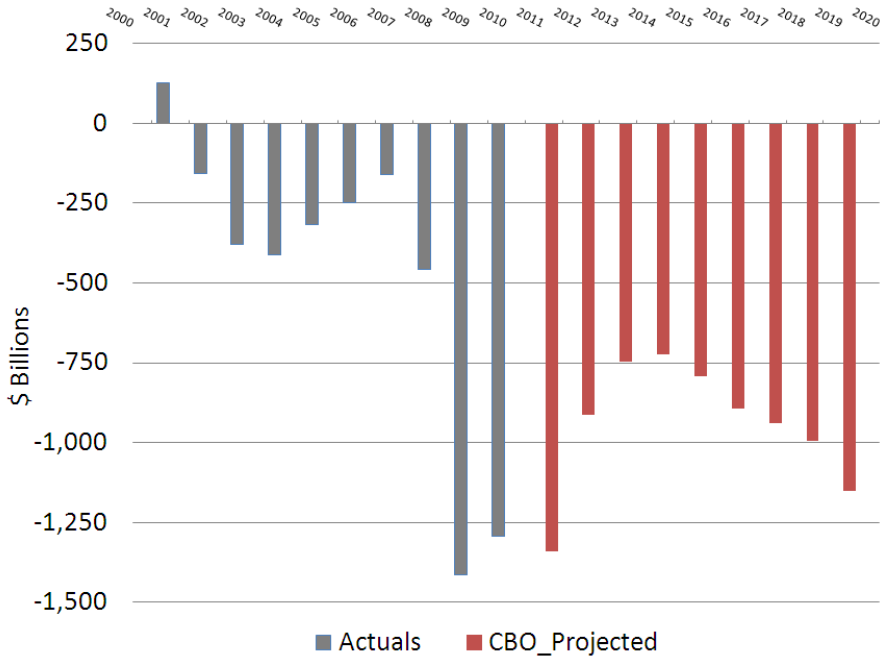
Trends in Non-Defense R&D by Function, FY1953-2011



Note: Defense R&D totaled $80.5 billion in FY2010

Health | Energy | Nat Res/Env
Space | Other | Gen Science

Federal Deficit



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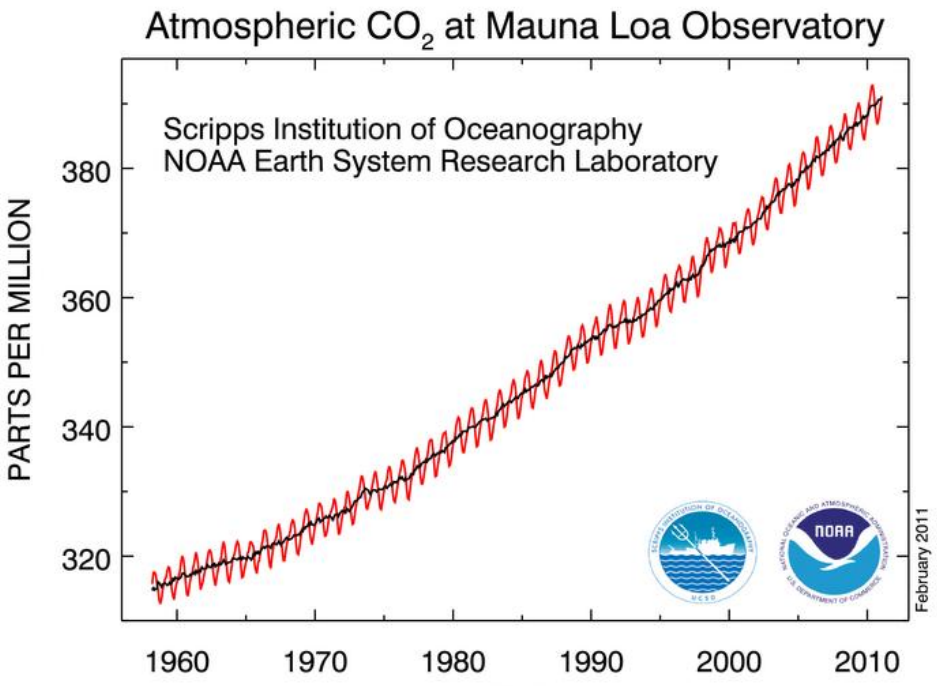
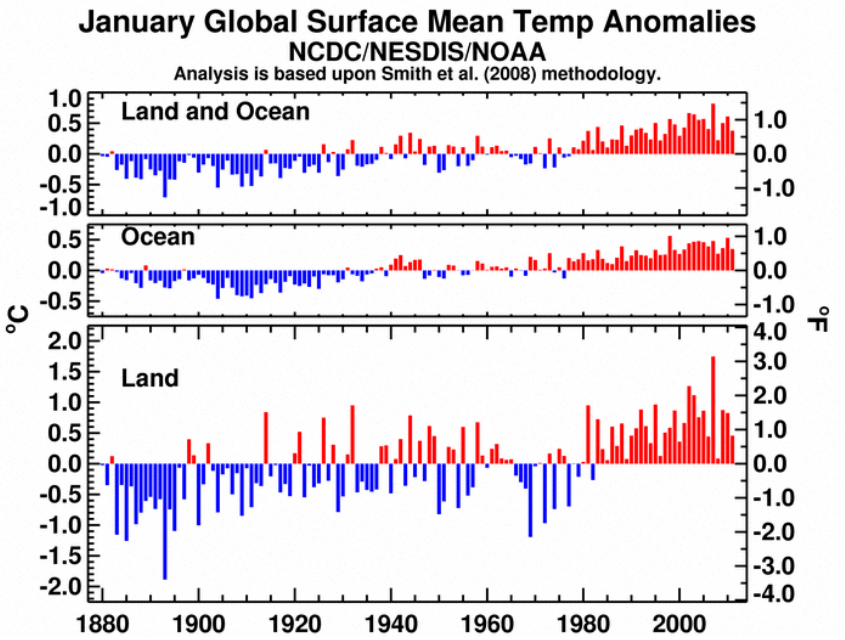
Energy Challenge #3

ENVIRONMENT

Growing atmospheric concentration of CO_2





Challenges in stabilizing atmospheric CO_2

- Concentration is rising at an accelerating rate; 550 ppm reached by 2050
- Global emissions are growing at 2-3% per year

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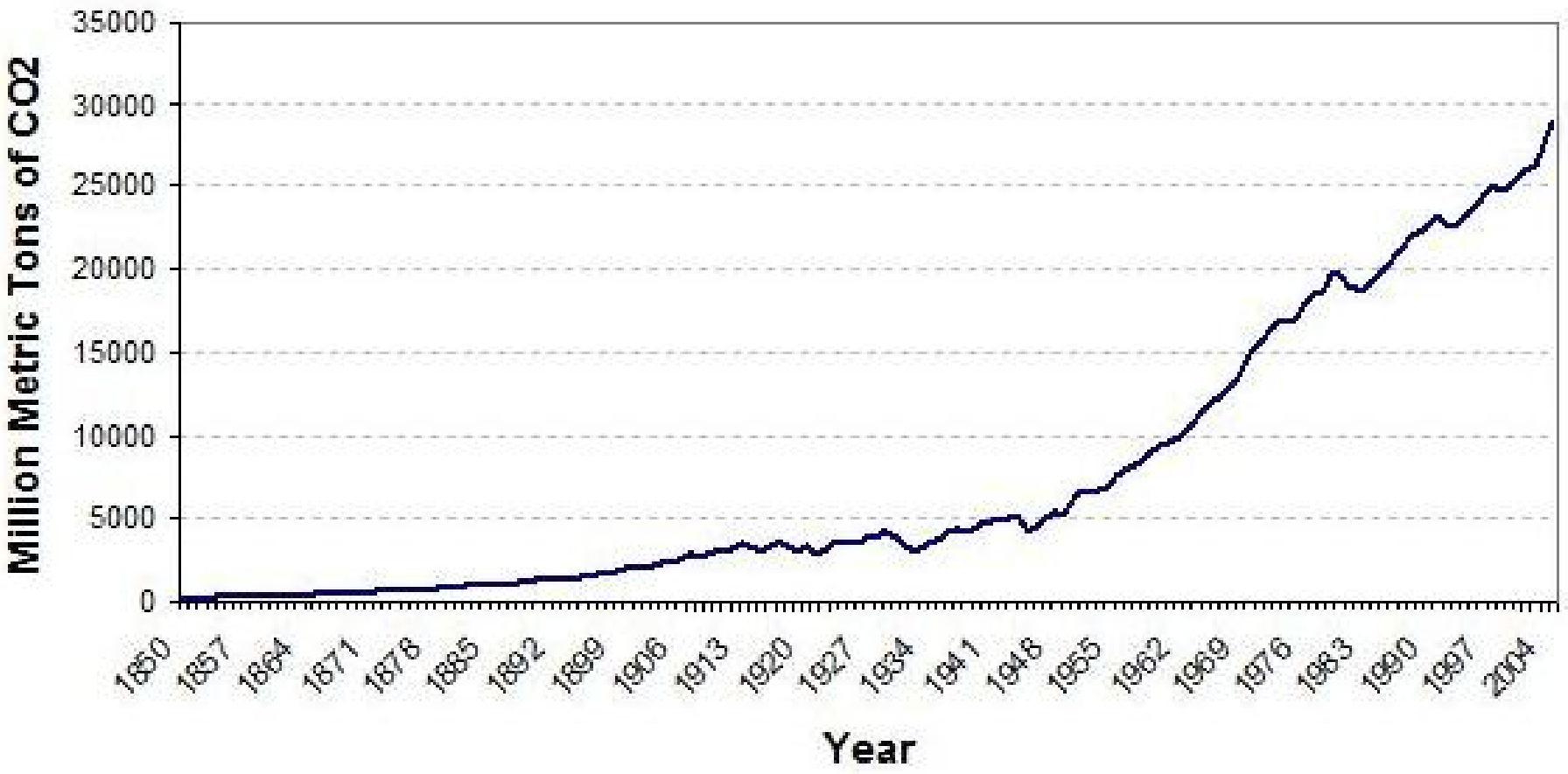
Growing Global CO_2 Emissions (1850-2004)



*from Fuel Burning, Cement Manufacture, and Gas Flaring

Source: Marland et. al (2007) Global, Regional, and National CO_2 Emissions. In Trends: A Compendium of Data on Global Change. CDIAC U.S.A.

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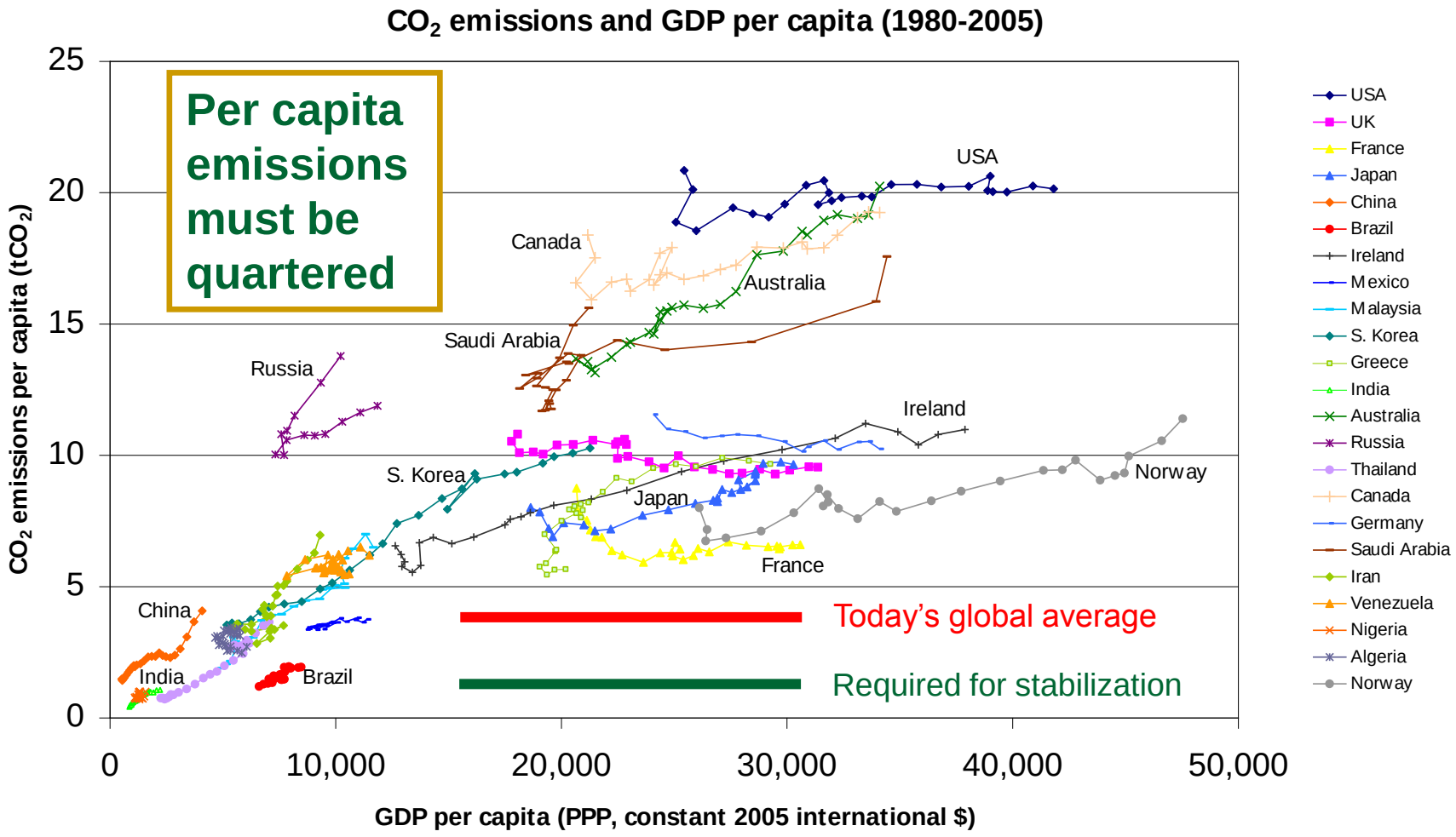
CO_2 emissions and GDP per capita



Source: DOE EIA database (2008)
Russia data 1992-2005, Germany data 1991-2005

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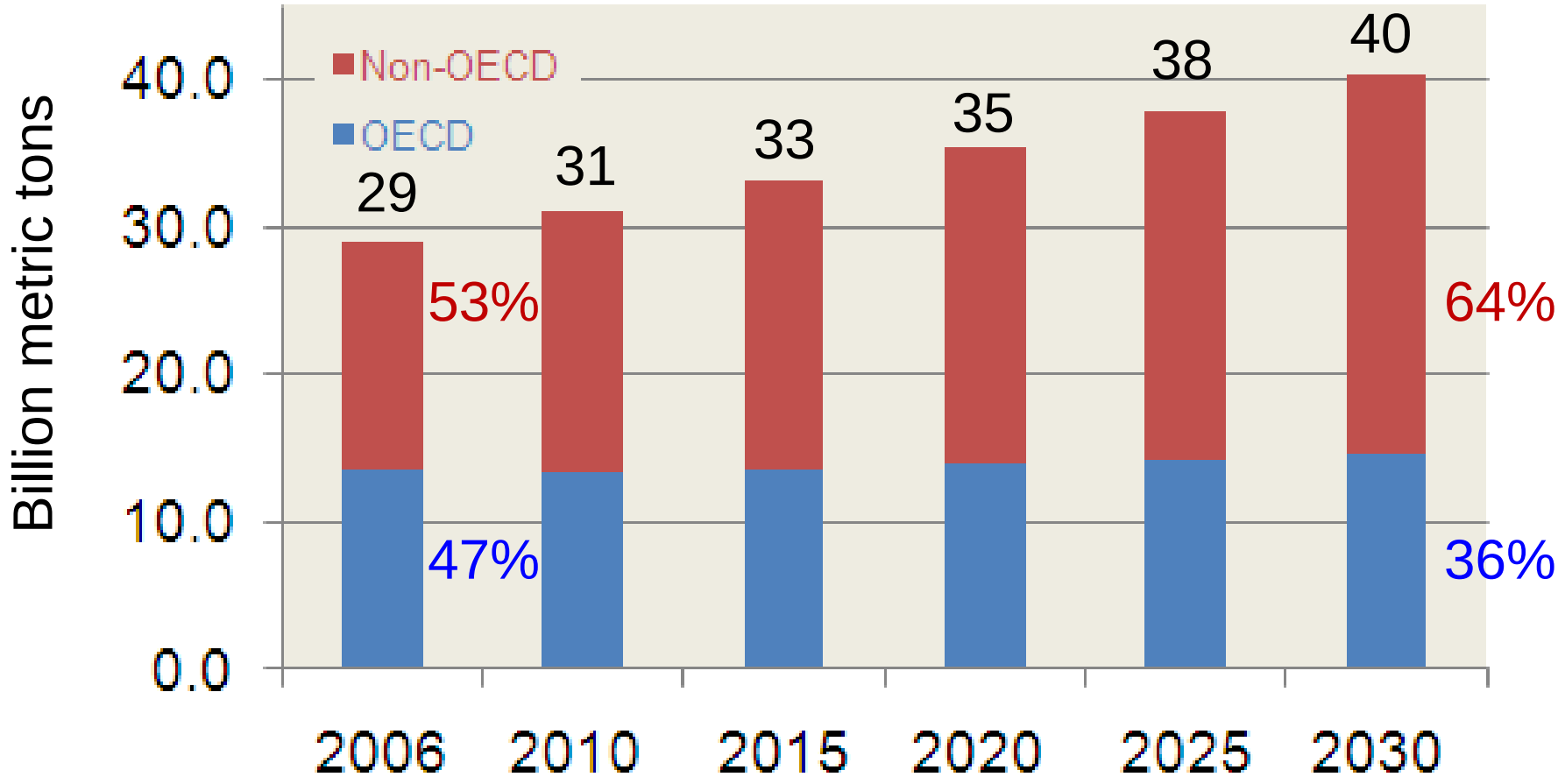
GHG emissions are projected to grow

Absent new policies, global energy-related CO2 emissions grow 39% by 2030 in EIA's reference case



Source: EIA *International Energy Outlook 2009*, Reference Case

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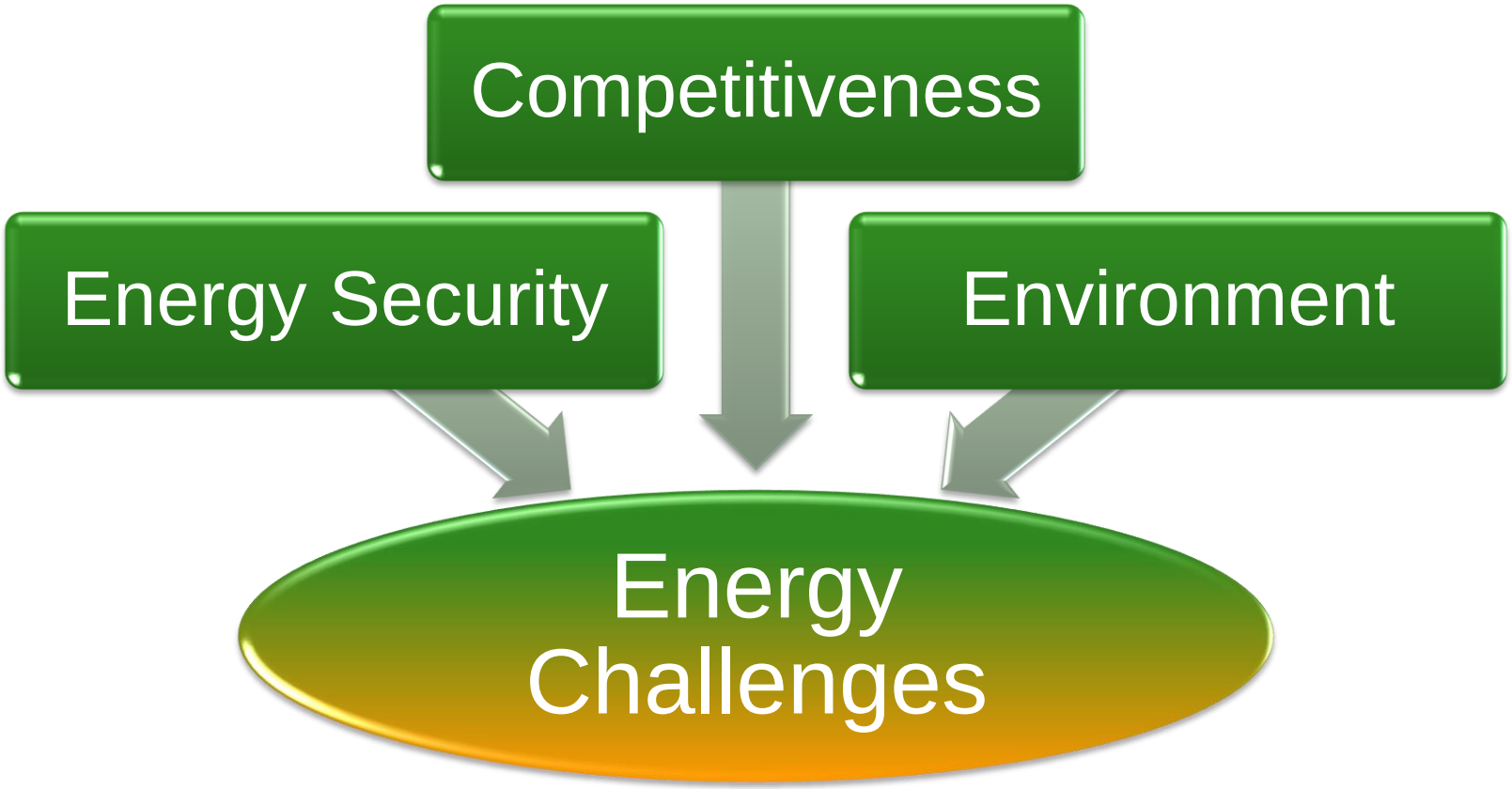
U.S. Energy Challenges



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Administration Goals

Transport

- 3.7 M bbl/day reduction in crude imports (~25% of daily transport use)
- Support deployment of 1 million electric vehicles (EVs) on the road by 2016

Stationary

- By 2035, 80% of America's electricity will come from clean energy sources

Environmental

- From a 2005 baseline, reduce energy-related greenhouse gas emissions 17% by 2020 and 80% by 2050

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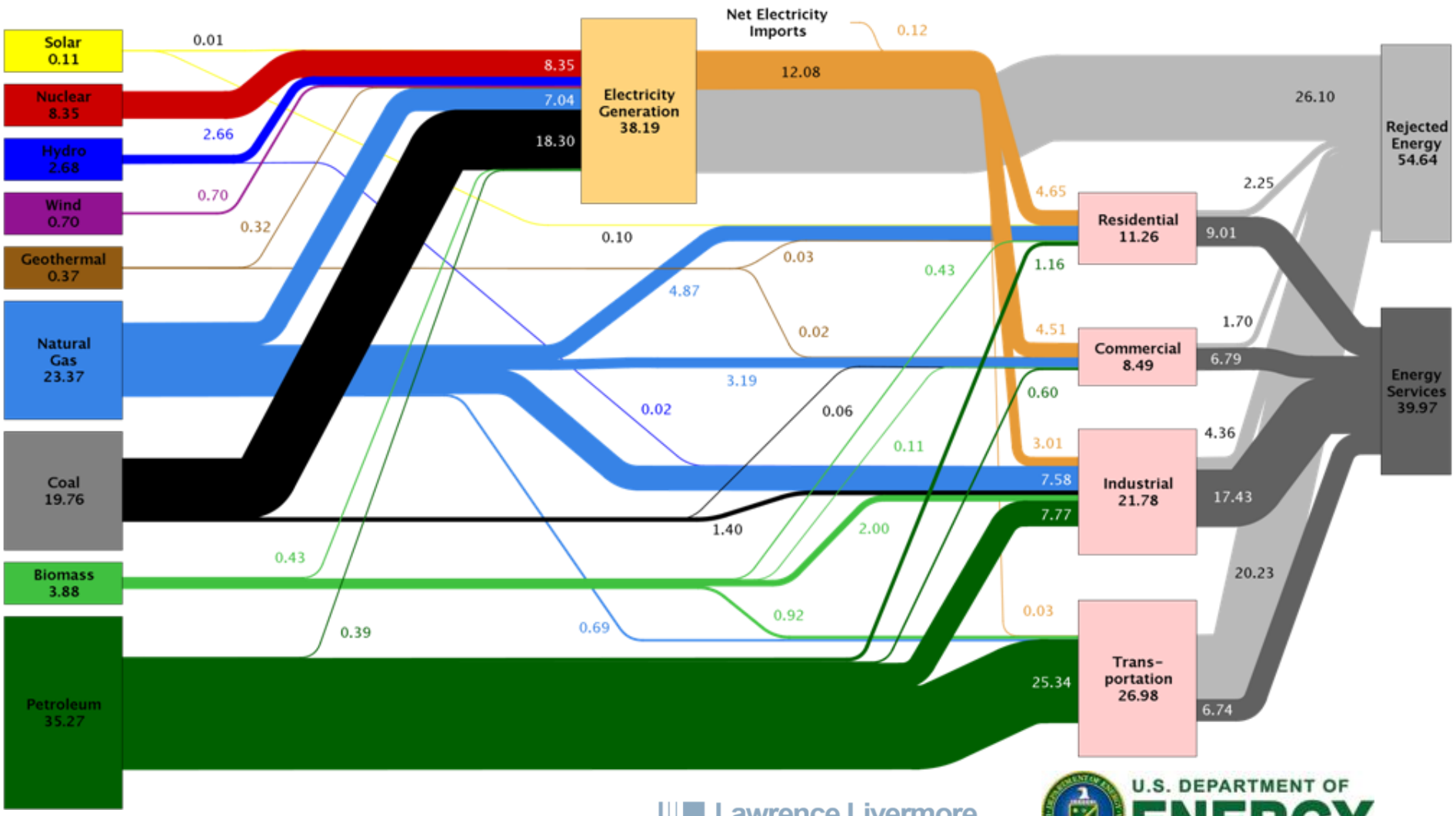
ENERGY ESSENTIALS

Estimated U.S. Energy Use in 2009: ~94.6 Quads



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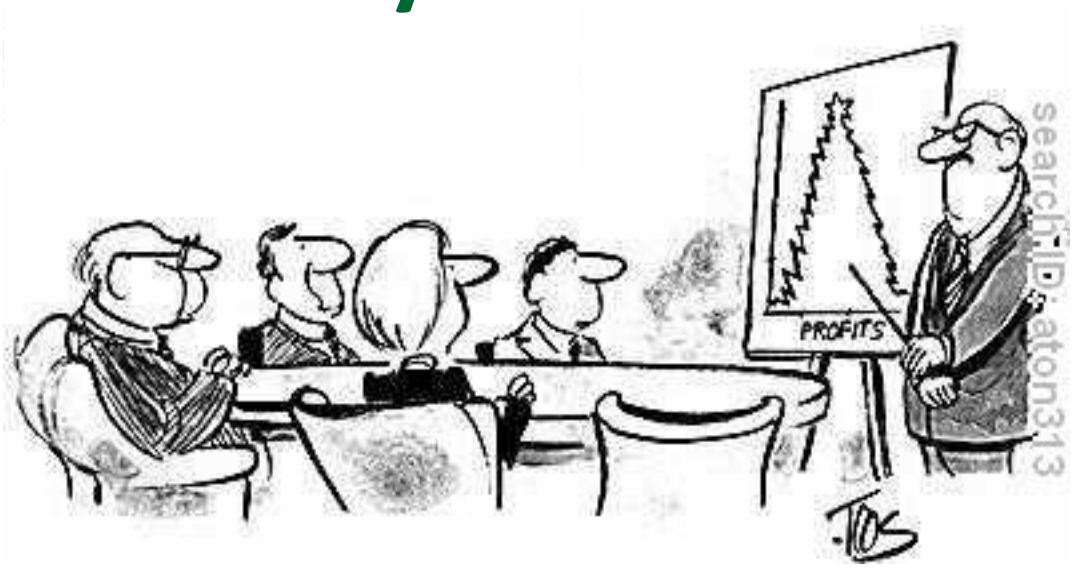
https://flowcharts.llnl.gov/

Energy Essentials: The System

- US energy **system** is big and expensive
- Almost entirely in the hands of the for-profit sector
- Federal, State, and local governments have regulatory influence; often inhibiting supply innovation
- The government does not have sufficient capital to scale energy innovation on its own



- Industry's goal is legal and predictable profit
- Therefore: Energy supply innovation will scale only when profitable or mandated

We get only the energy transformation government enables

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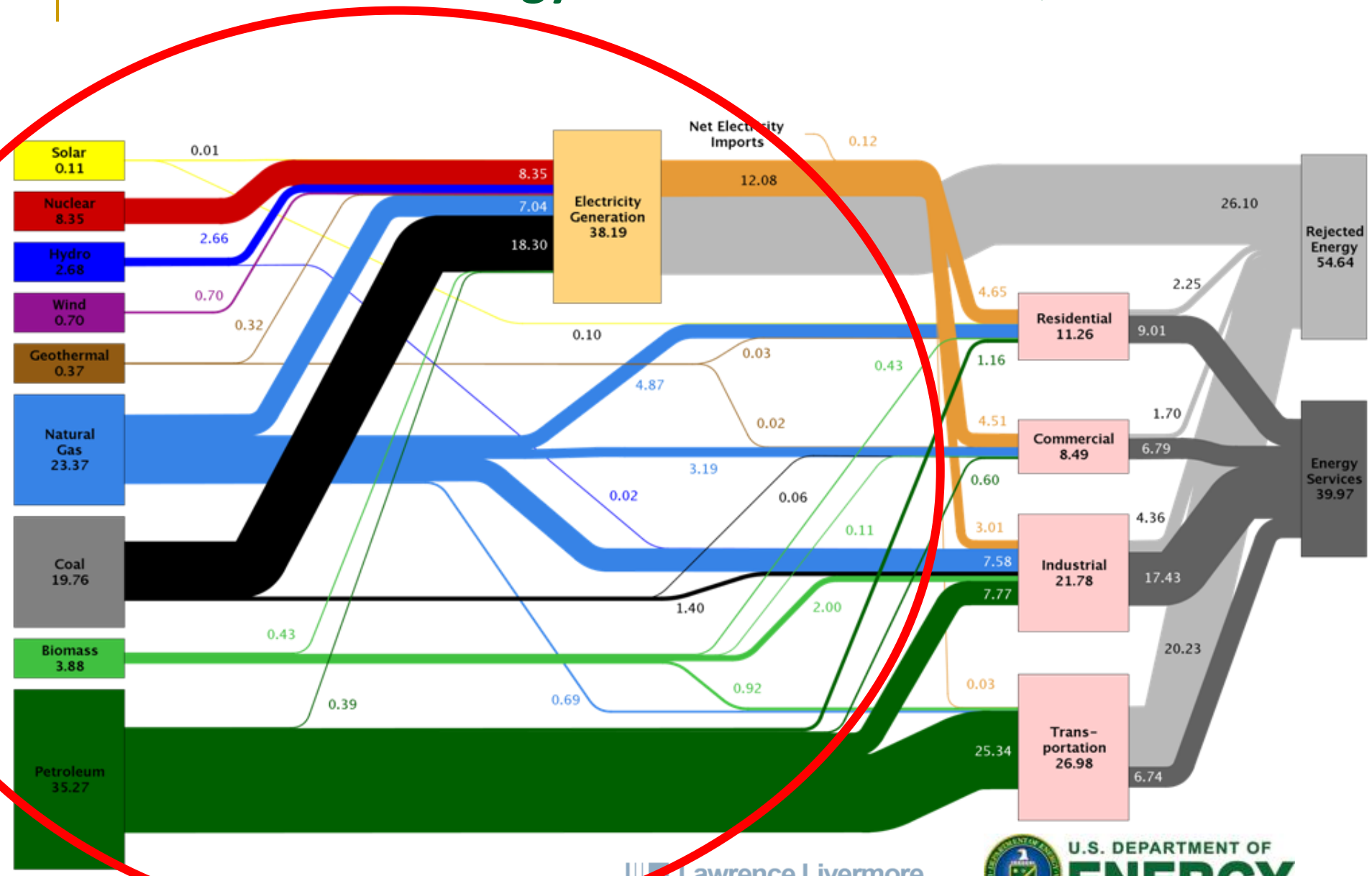

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Energy Essentials: Supply

- Fewer, long-lived centralized facilities with distribution networks
- Power and fuels are commodities with thin margins
- Markets with government regulation and distortion
- Transport and Stationary are disjoint
- Change has required decades

Transport

Powered by oil

Stationary Power

- Requires boiling large amounts of water
- Sized for extremes (storage is difficult)
- Numerous sources with differing…
  - CapEx and OpEx
  - Emissions
  - Base/Peak/Intermittency

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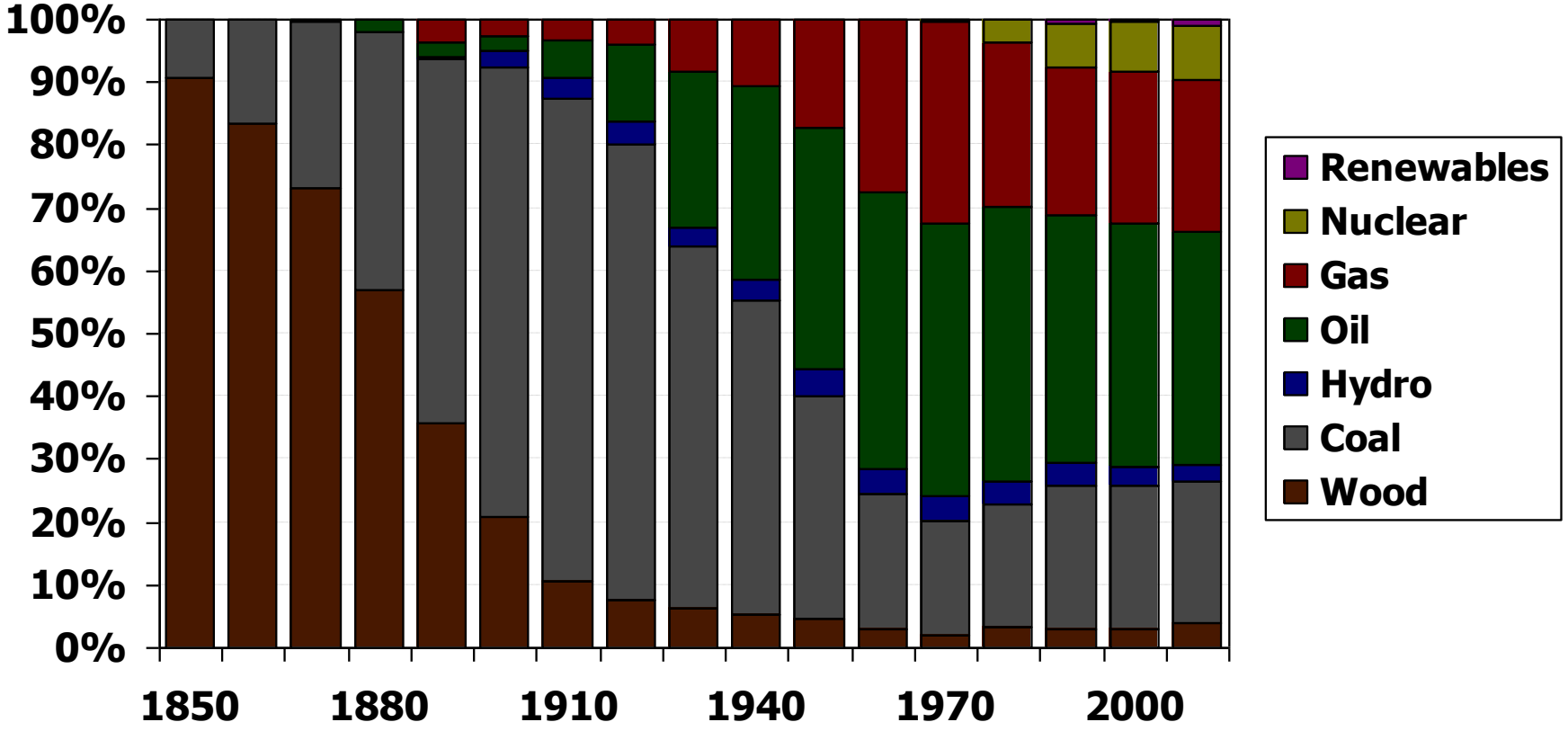
Energy supply has changed on decadal scales

US energy supply since 1850



Source: EIA

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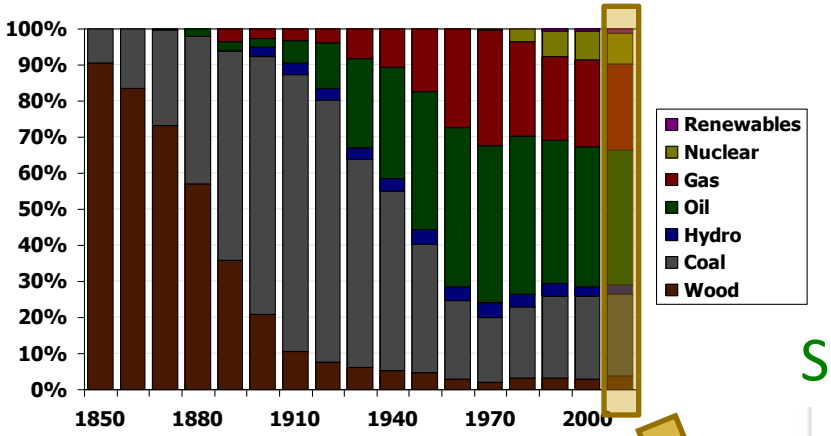
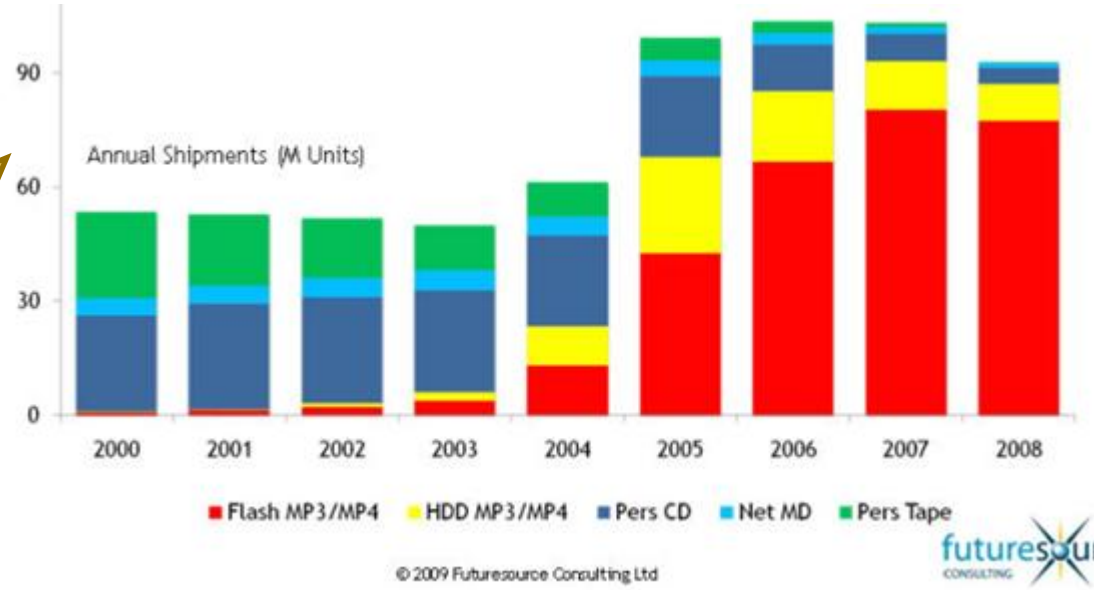
IT moves much faster than energy



Sales of Personal Audio/Video since 2000



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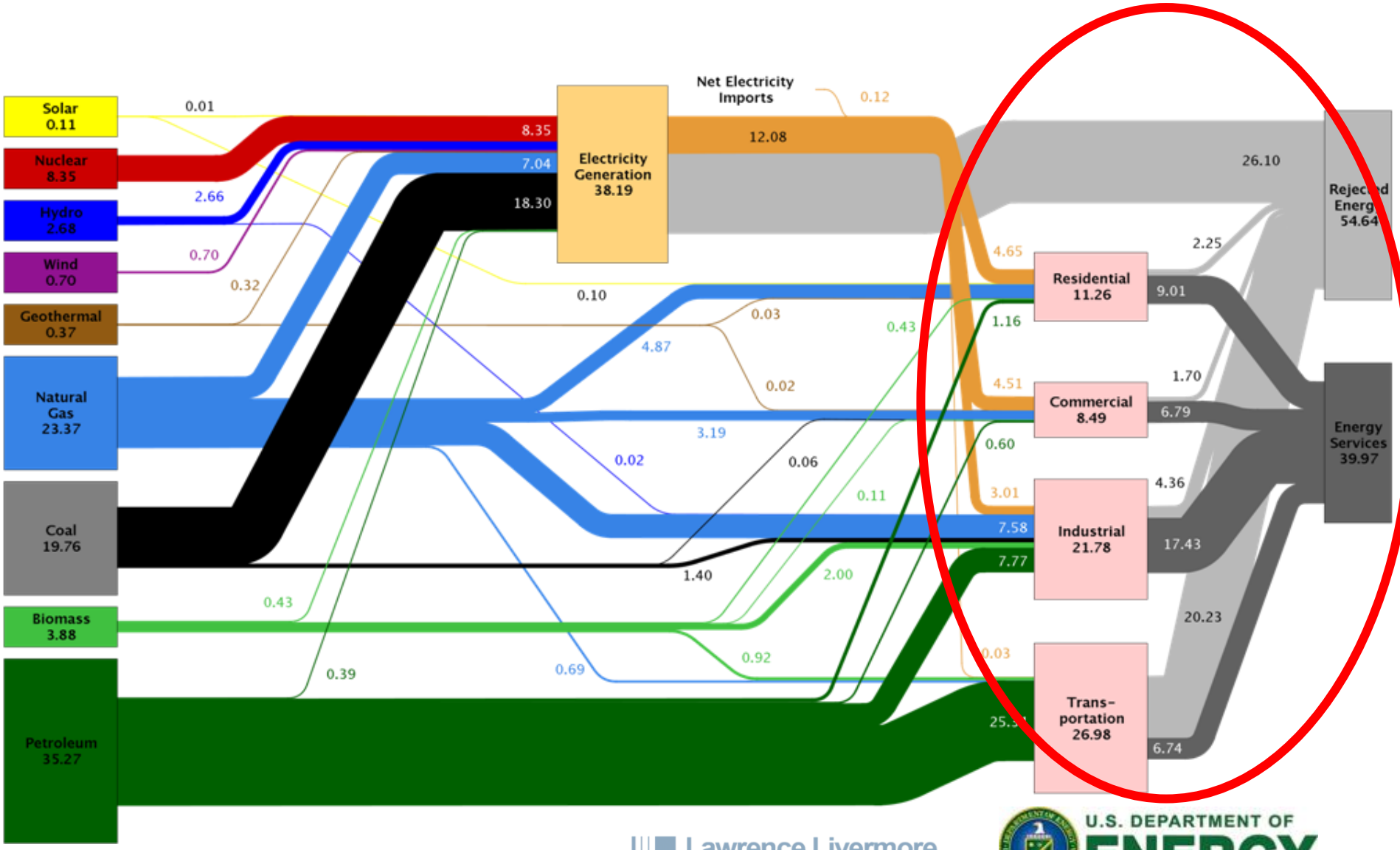

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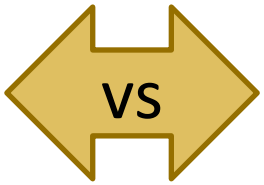
Energy Essentials: Demand

Demand

- Many distributed players, shorter-lived assets
- User benefit (economics, convenience, personal preference)
- Responds to the right signals: price, standards, behavior
- Little attention to system optimization for stationary use

~12 million Light Duty Vehicles per year

Lifetime ~10-15 years



2008: 5 new coal plants,
94 new gas plants,
101 new wind farms

Lifetime: decades

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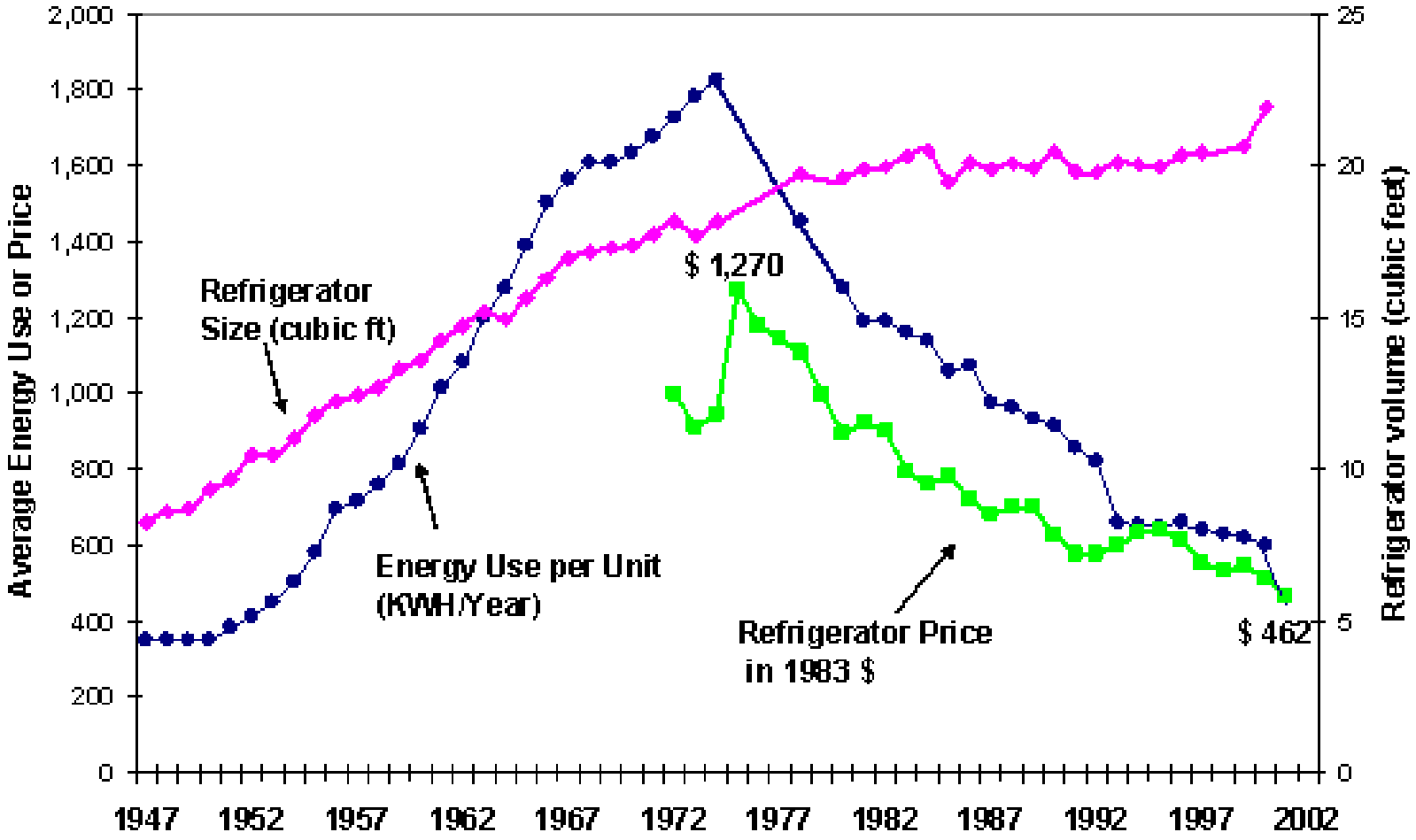
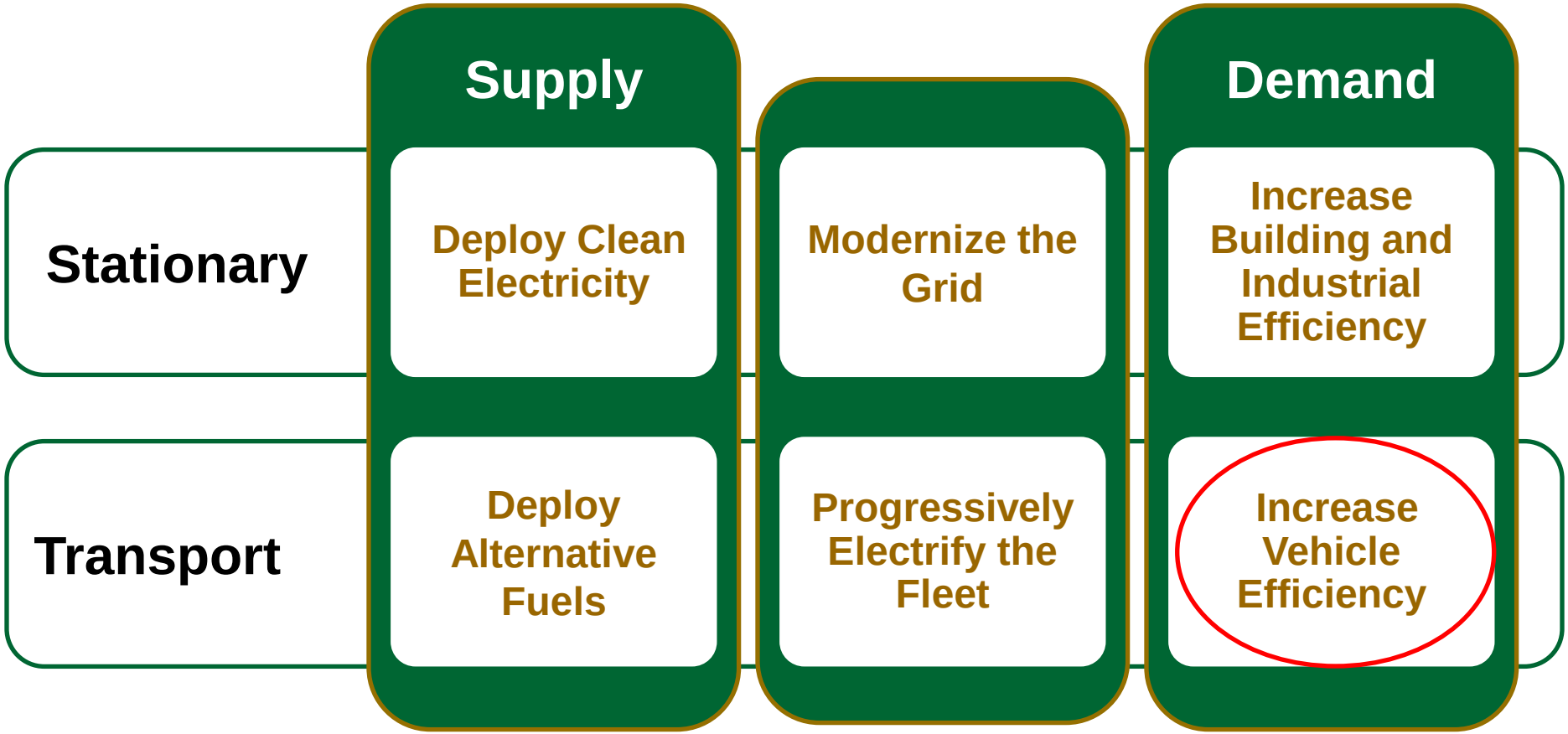
U.S. Refrigerator Use vs. Time



Six Strategies



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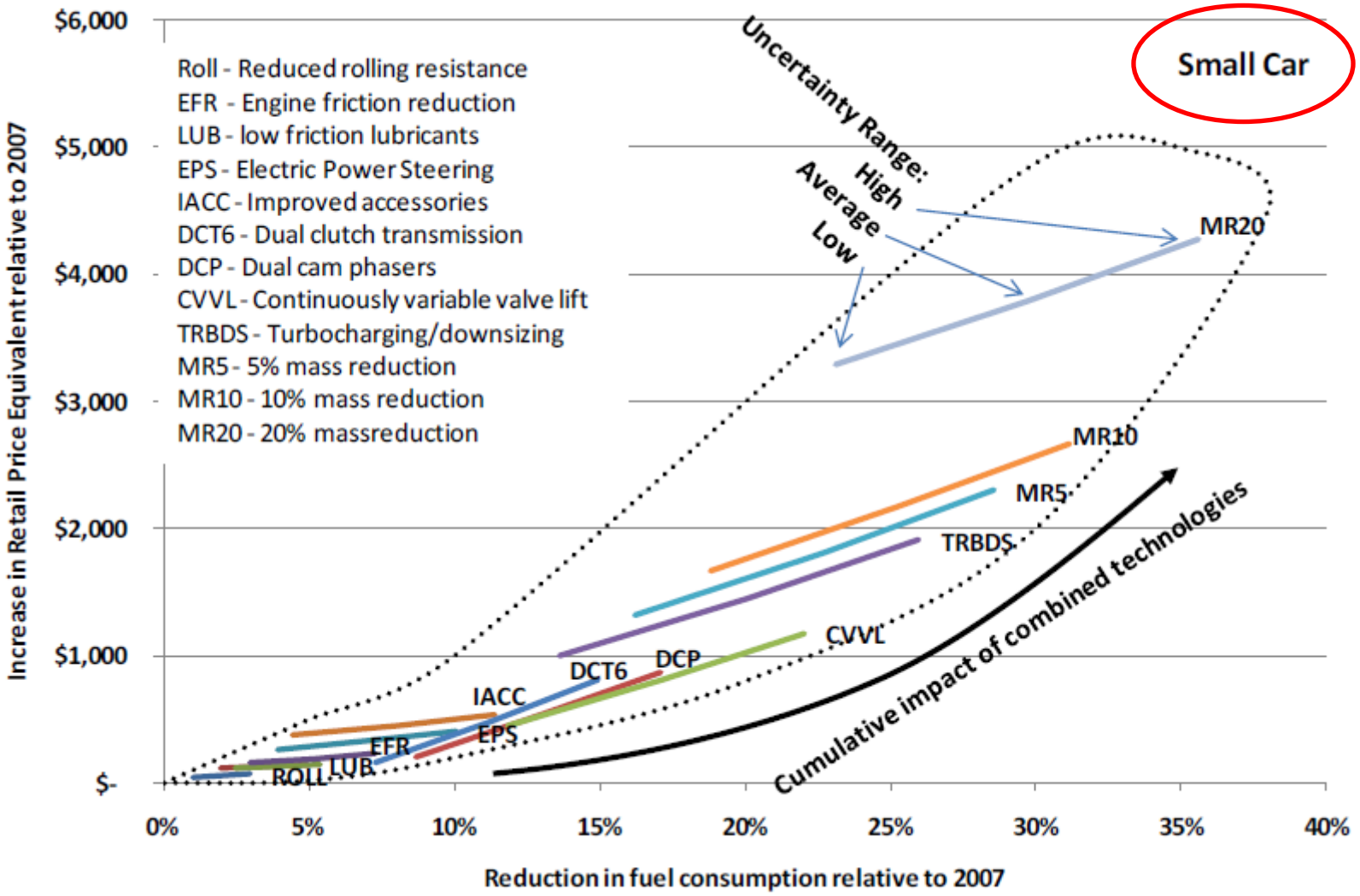

Cumulative retail price equivalent and fuel consumption reduction relative to 2007 for spark ignition powertrain without hybridization (NRC2010)

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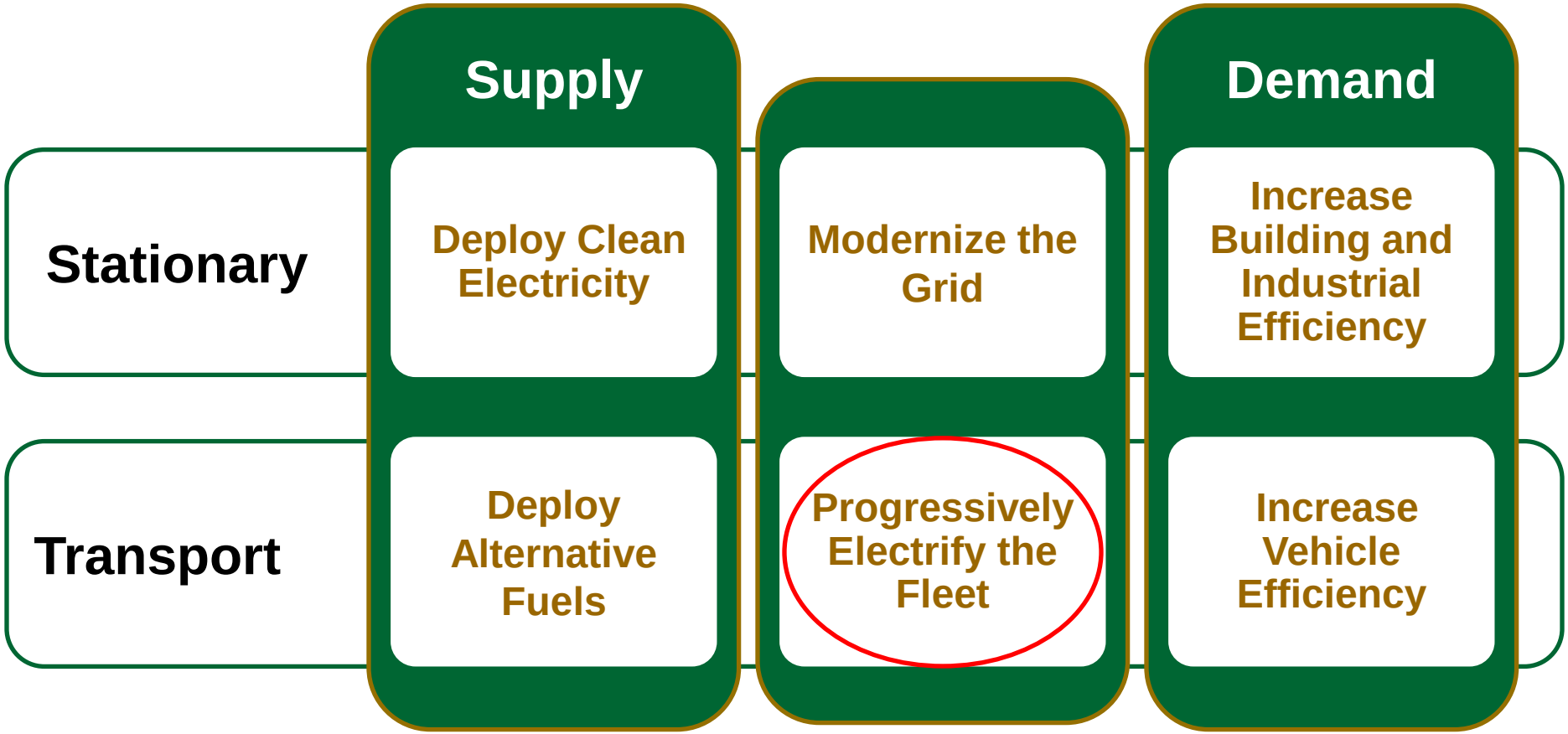

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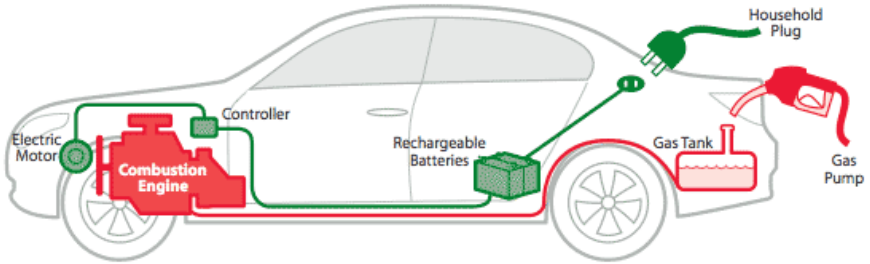
Progressively Electrify the Fleet

Internal Combustion Engine (ICE) → Hybrid Electric Vehicle (HEV) → Plug-in Electric Hybrid Vehicle (PHEV) → Battery Electric Vehicle (BEV)



Challenges with Batteries and Motors

Batteries
- Cost
- Performance
- Physical Characteristics

Adequate supply chain
- Rare-earth elements in permanent magnet motors
- Lithium in batteries
- OEM & component manufacturing capacity

Charging
- Infrastructure
- Standardization of chargers and grid interface
- Charging times
- Consumer behavior

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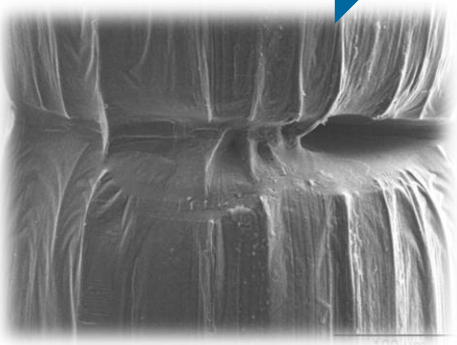
Battery Evolution: R&D to Commercialization

The energy storage effort is engaged in a wide range of topics,
from fundamental materials work through battery development and testing

Advanced Materials Research

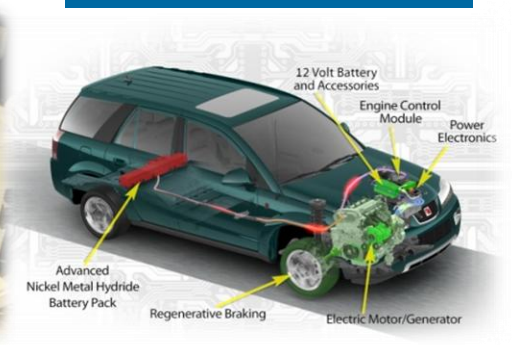


- High energy cathodes
- Alloy, Lithium anodes
- High voltage electrolytes
- Lithium air couples

High Energy & High Power Cell R&D

- High rate electrodes
- High energy couples
- Fabrication of high E cells
- Ultracapacitor carbons

Full System Development And Testing



- Hybrid Electric Vehicle (HEV) systems
- 10 and 40 mile Plug-in HEV systems
- Advanced lead acid
- Ultracapacitors

Commercialization

Lab and University Focus

Industry Focus

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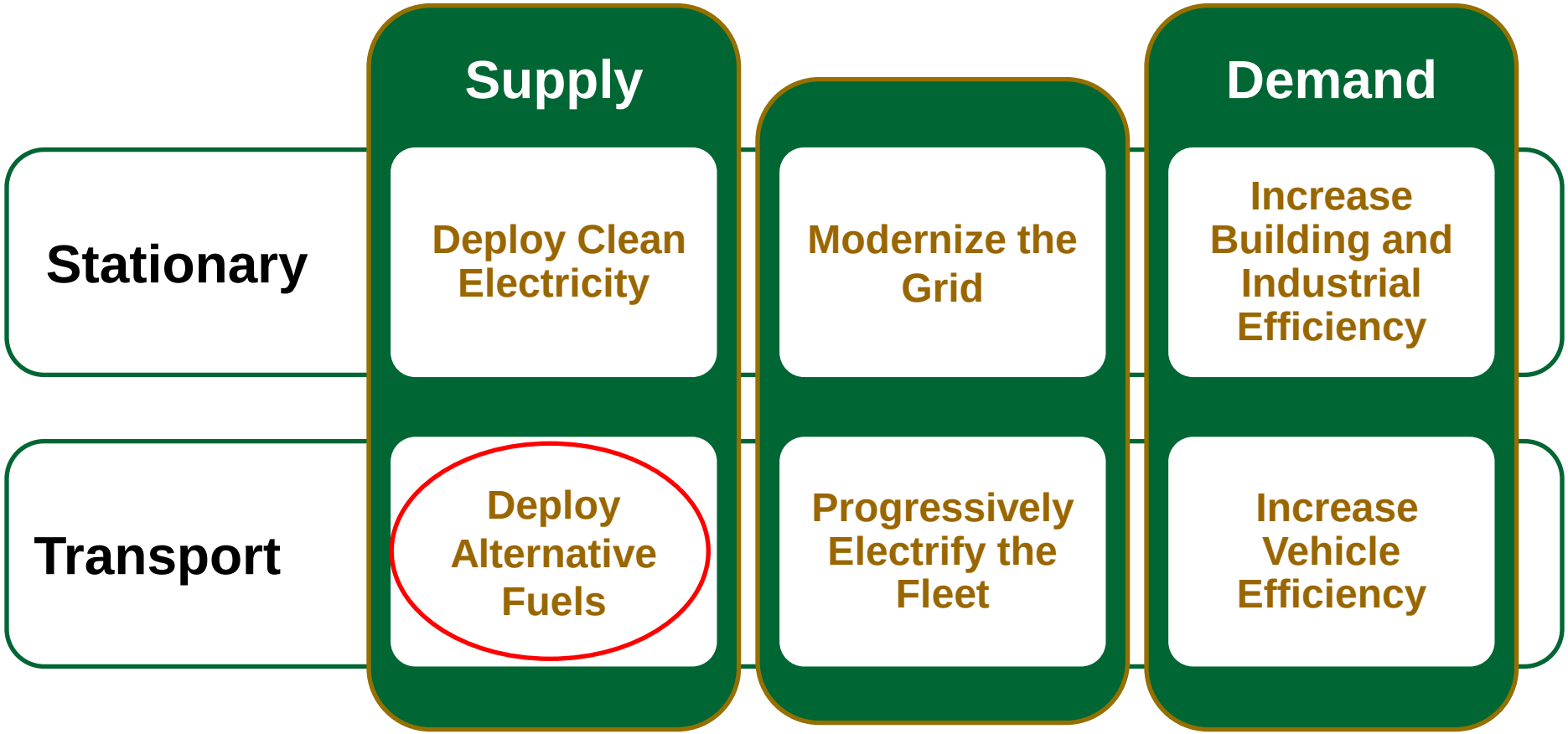

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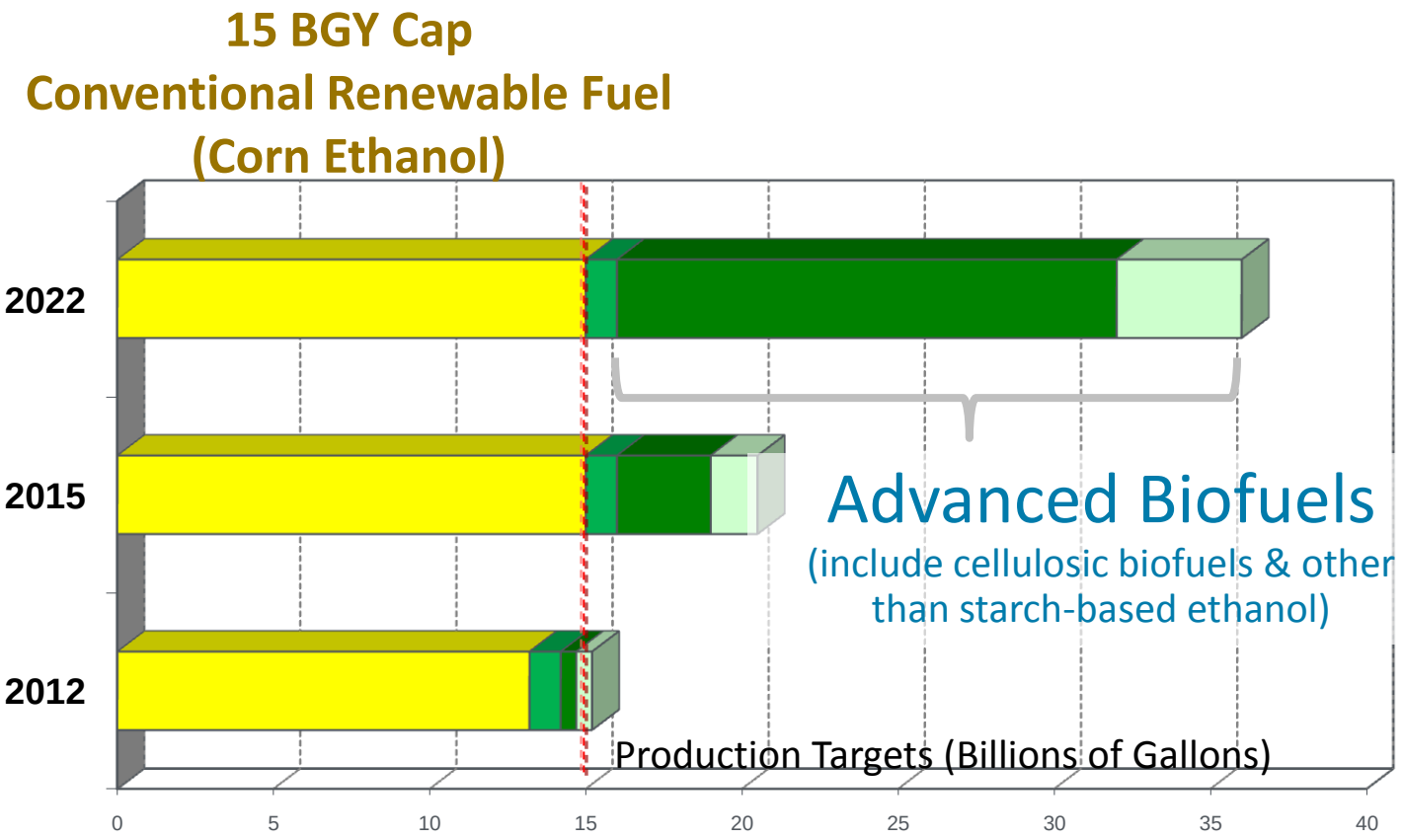
EISA RFS2 Mandates



Renewable Fuel Standard (RFS2)

- Conventional (Starch) Biofuels
- Biomass-based diesel
- Cellulosic Biofuels
- Other Advanced Biofuels

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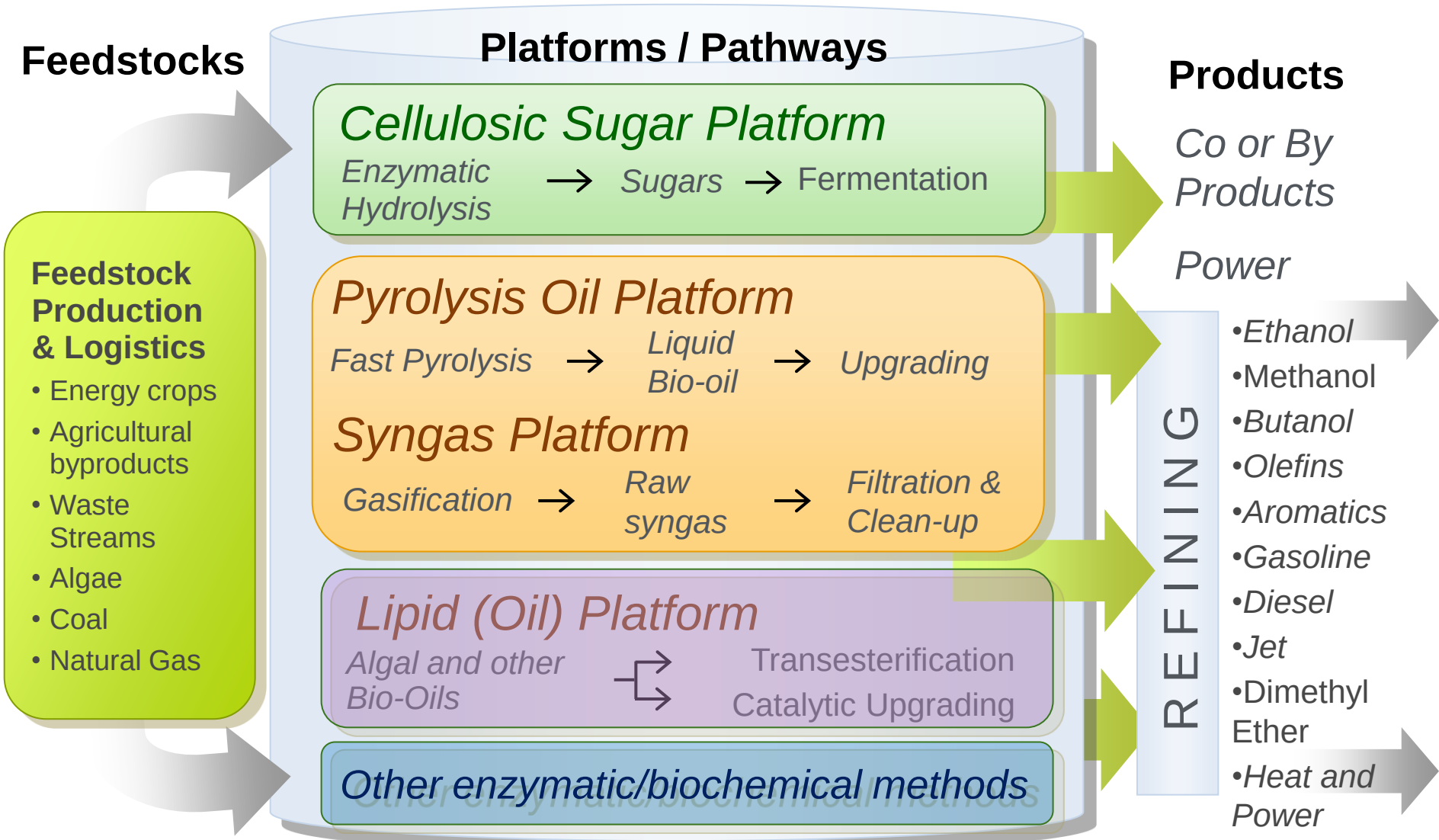
Deploy Advanced/Alternative Fuels



Deploying Advanced/Alternative Fuels

Challenges

- Scale
- Capital intensity
- Environmental impact

Technology Opportunities

- Gasification units
- Separation processes
- Catalysts
- CCS
- Feedstock
- Logistics

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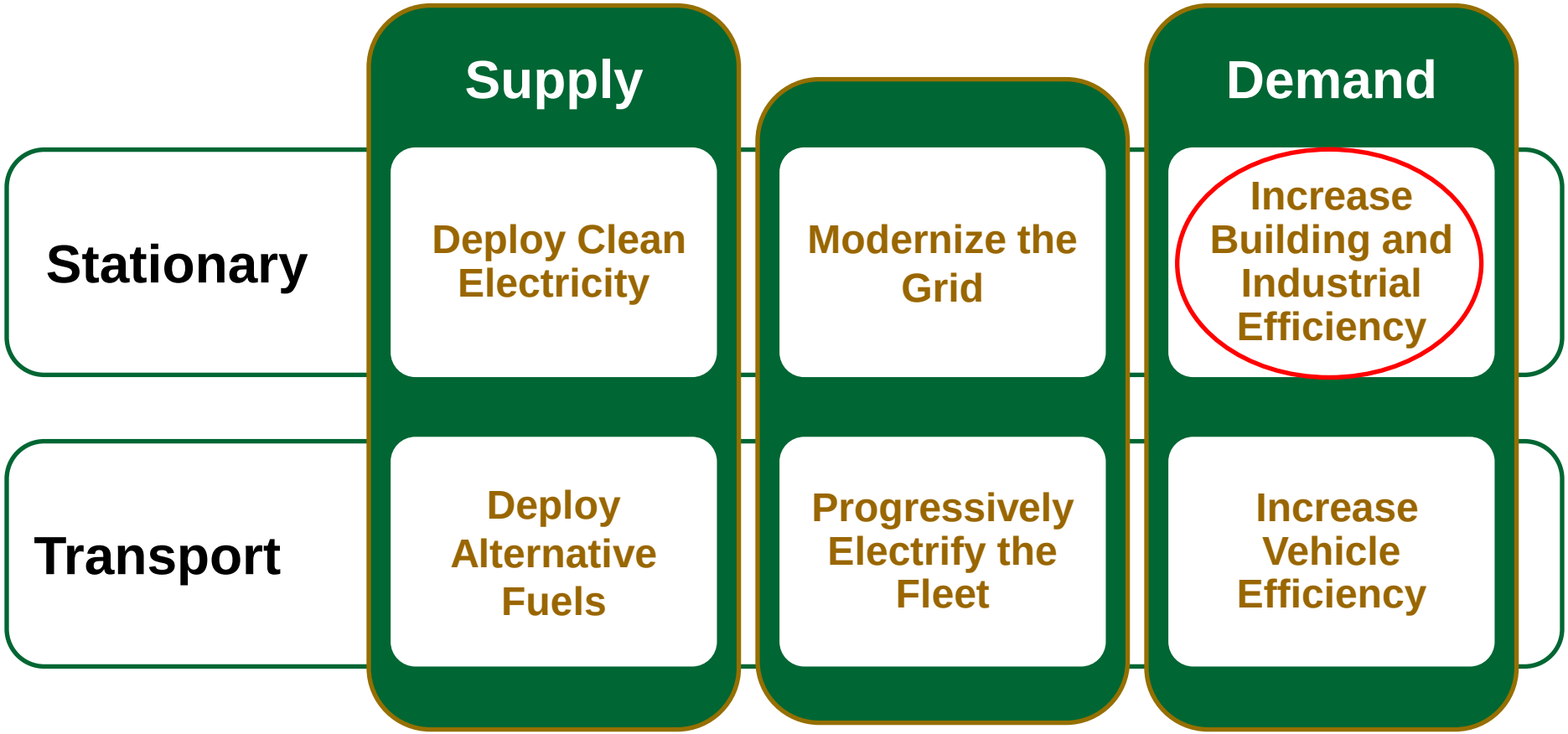

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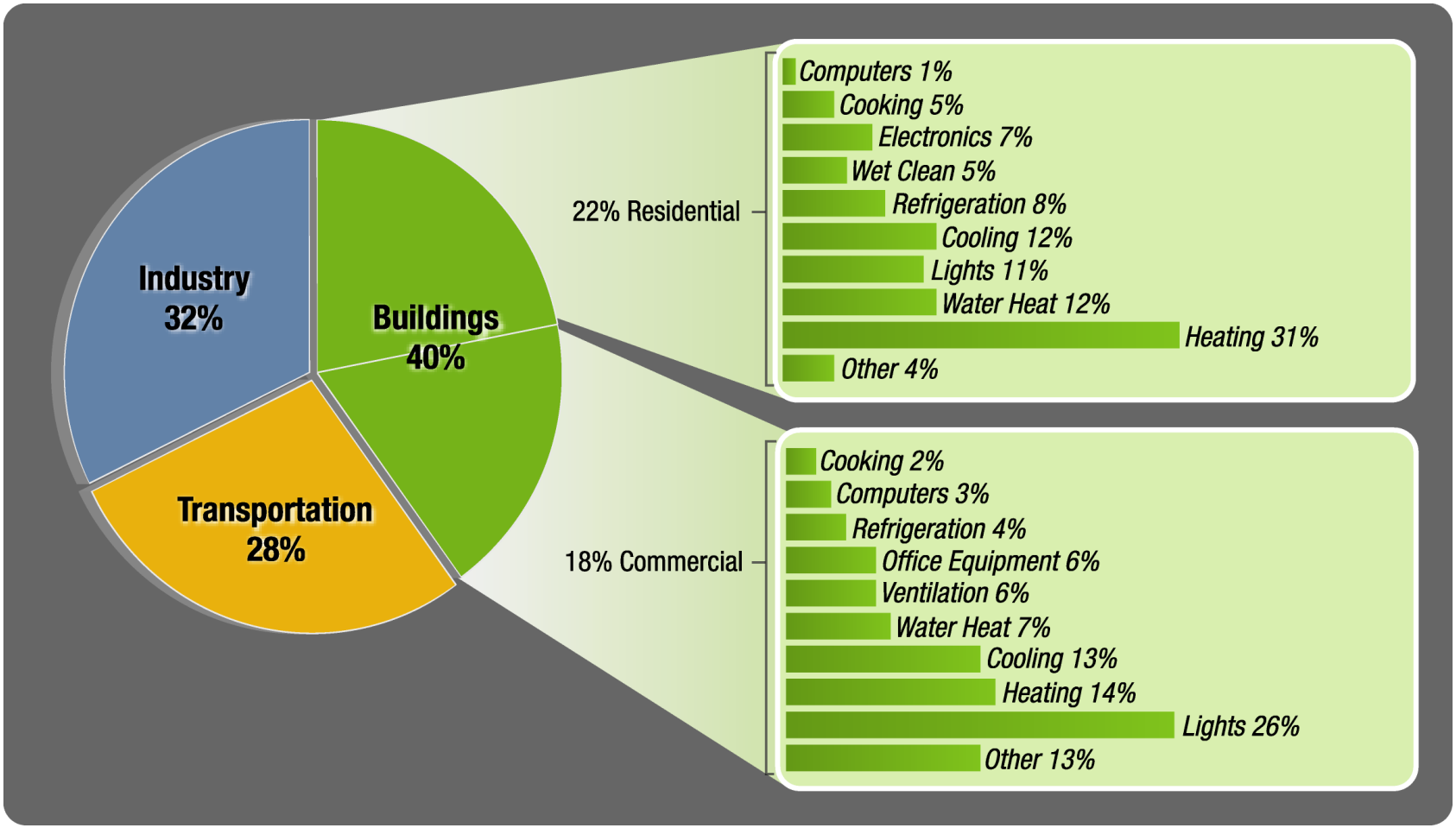
Categories of US energy consumption

Buildings use about 40% of total US energy



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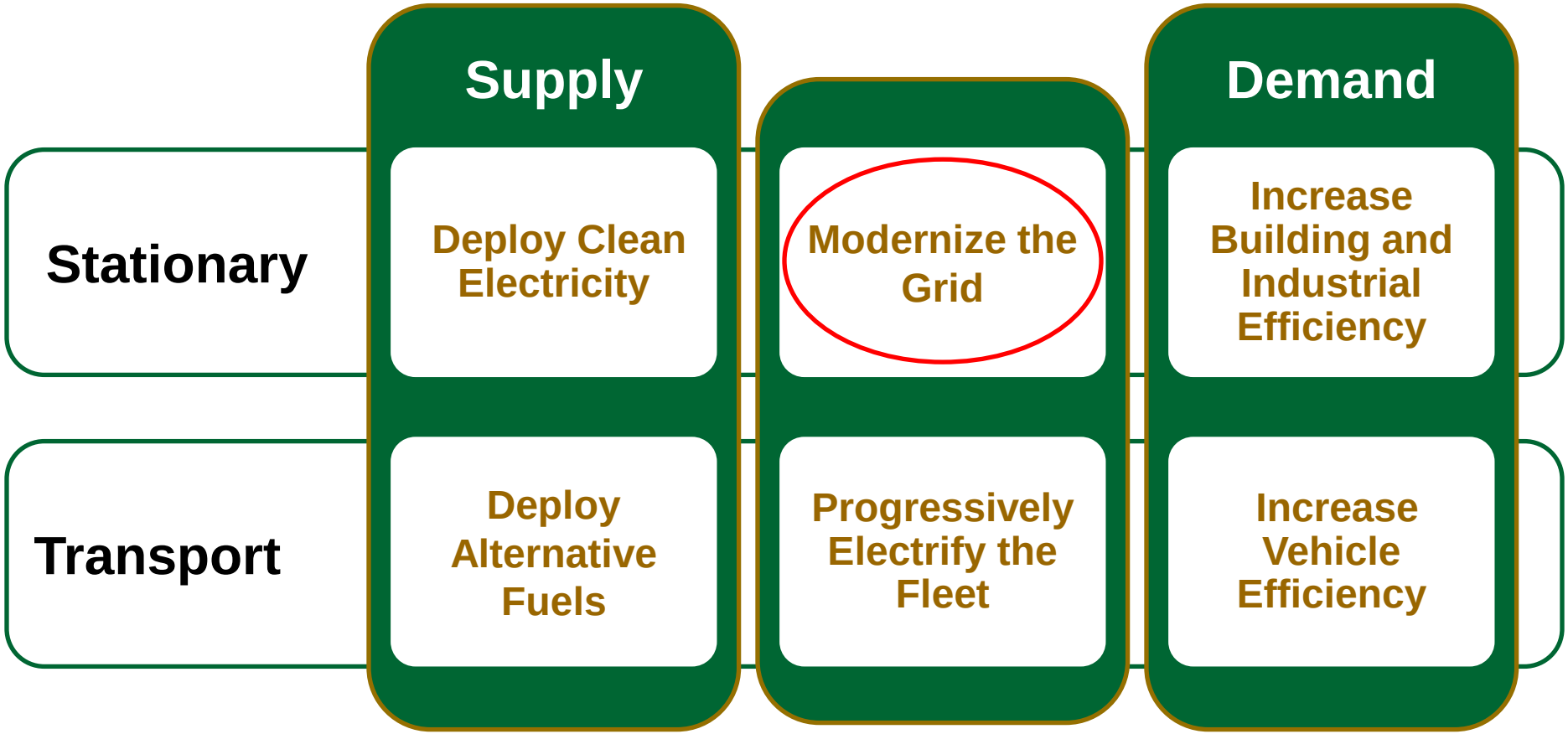

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The U.S. Grid

- **The numbers**
  - **> 200,000 miles of transmission lines distribute approx. 1 TW of power**
  - **Over 3,500 utility organizations**
- **Desiderata**
  - **Reliability**
  - **Efficiency**
  - **Security**
  - **Flexibility to integrate intermittent renewables**
  - **Two-way flow of information and power**
  - **Growth to handle growing demand**
- **Challenges**
  - **Active management is required to balance generation, transmission, and demand at all times**
  - **Excursion from ideal operation can be catastrophic**

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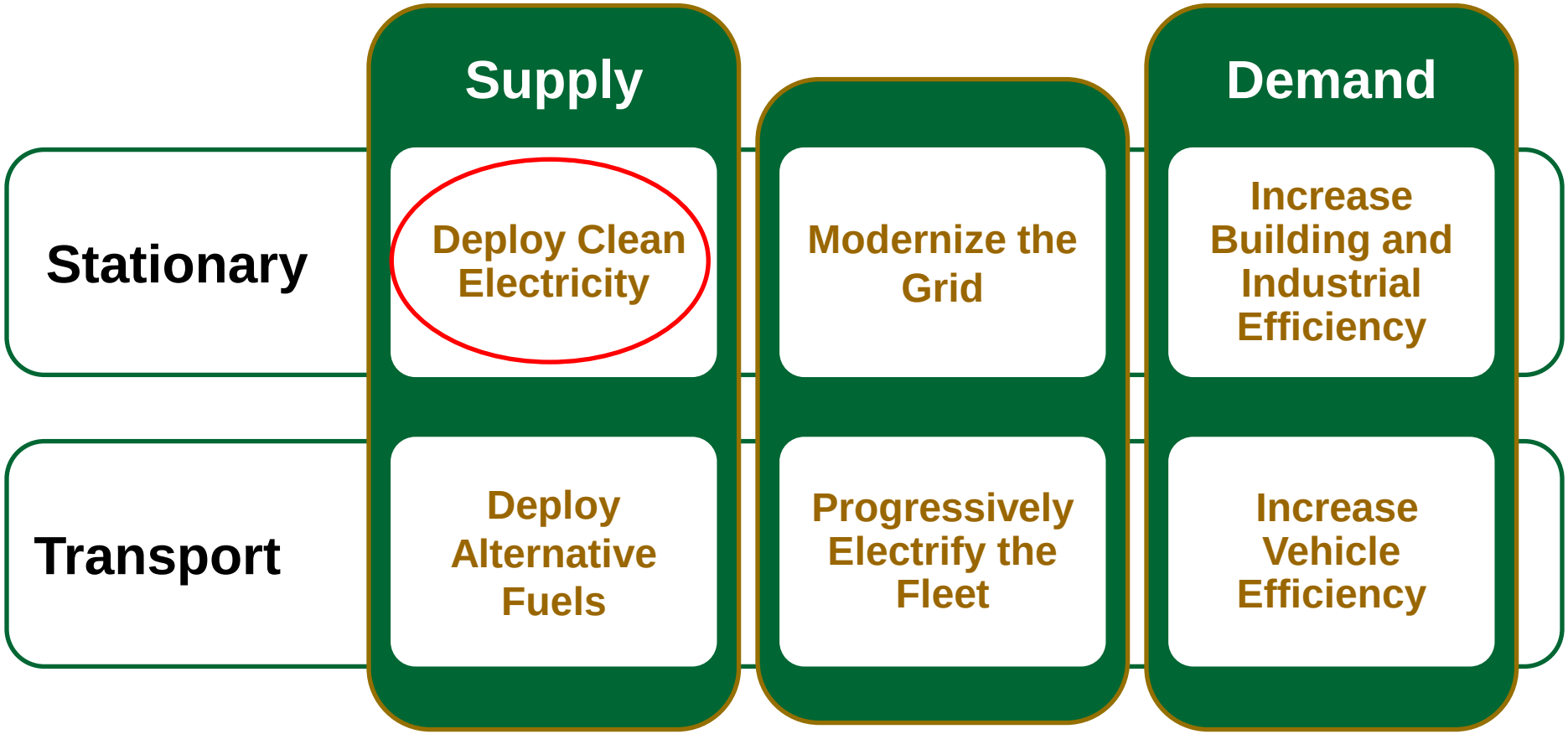

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Deploy Clean Electricity

Solar Photovoltaic (PV)

Wind

Nuclear Energy

Concentrating Solar Power

Carbon Capture and Storage

Other technologies

- Natural gas
- Hydro
- Solar thermal (parabolic troughs)
- Geothermal

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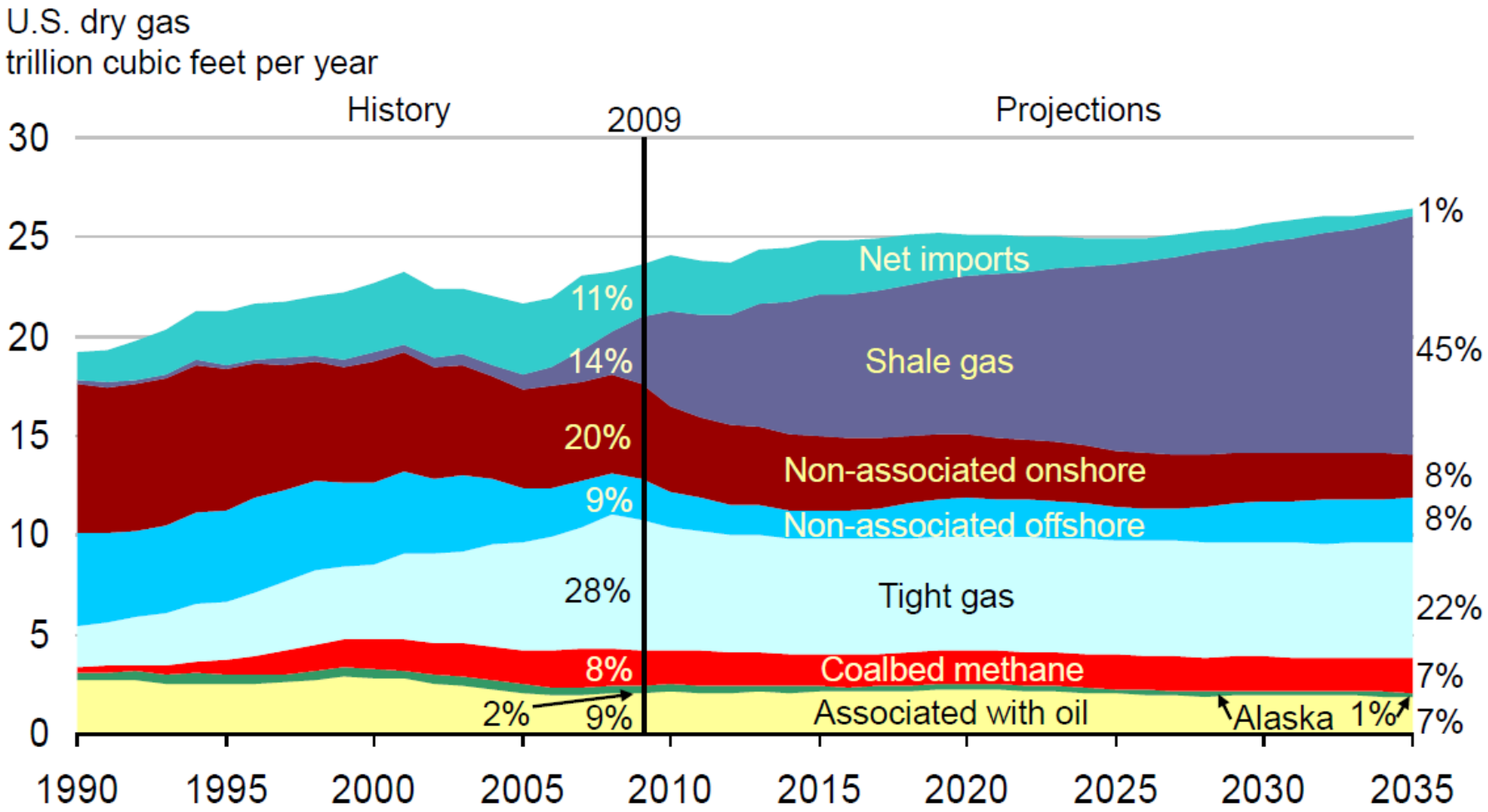
U.S. Gas Supply by Source



Source: EIA, Annual Energy Outlook 2011 Early Release

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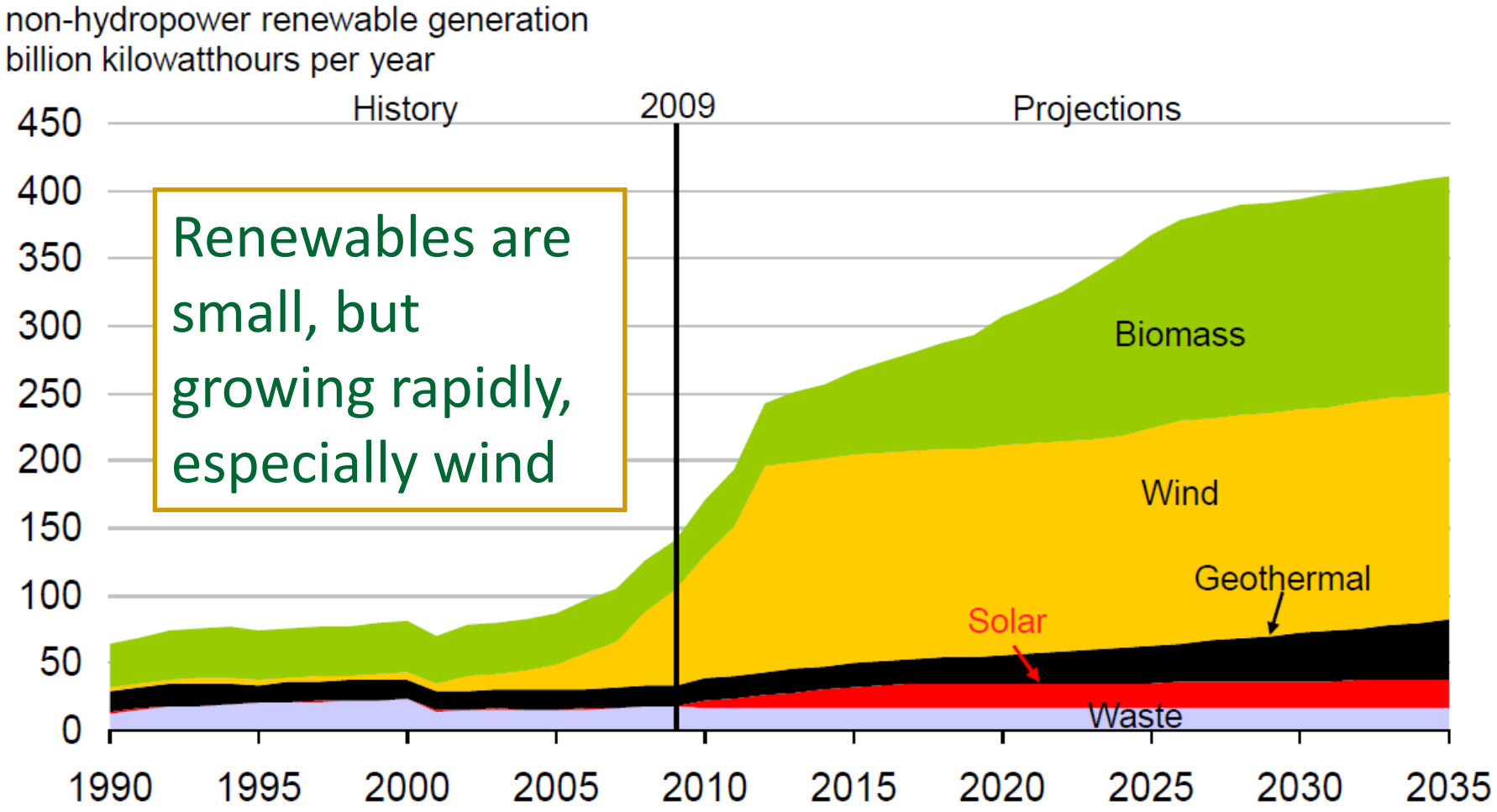
US Renewable Generation (GWh)



Source: EIA, Annual Energy Outlook 2011 Early Release

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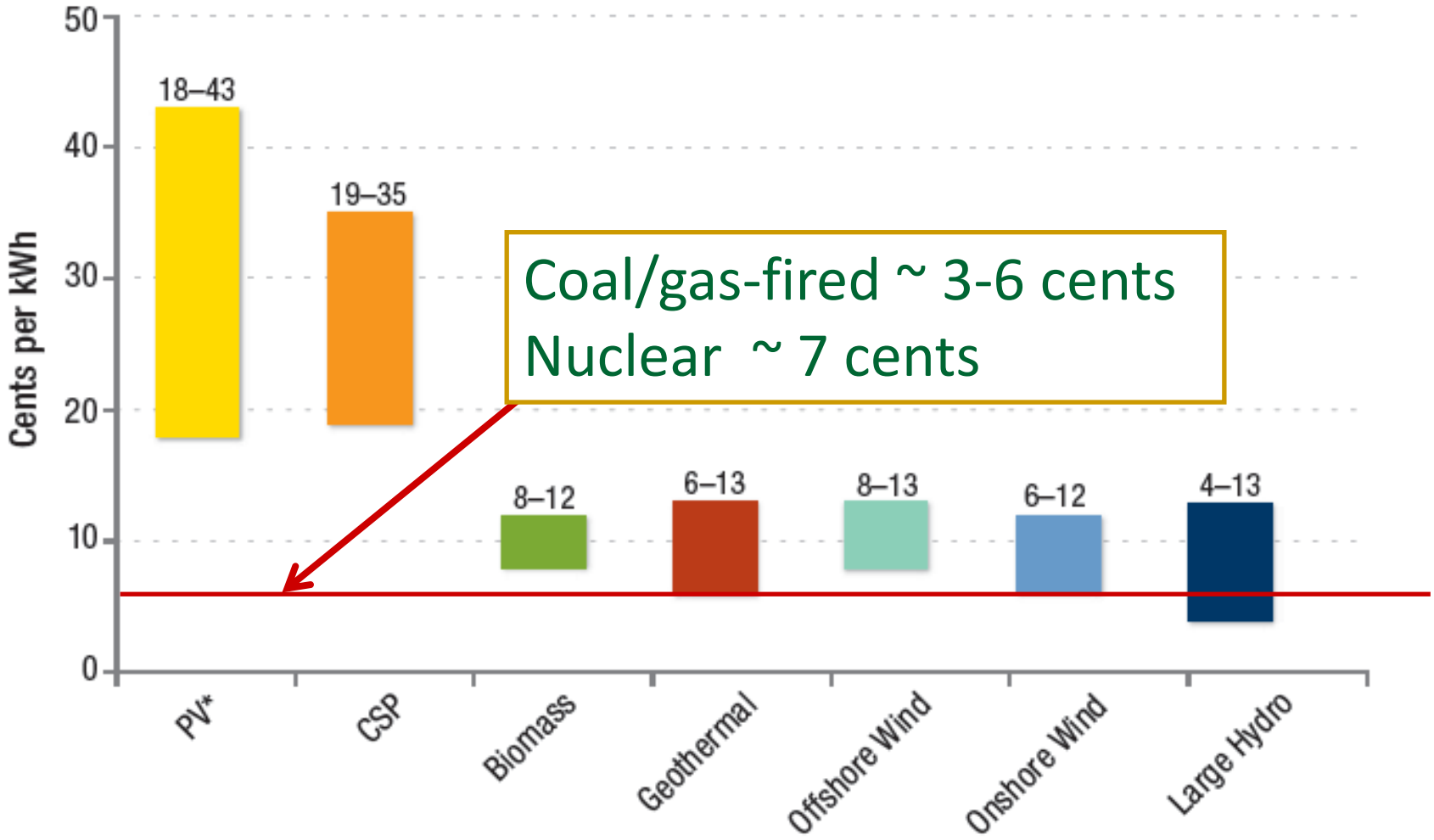
Renewable Electricity Costs (2009)



Source: 2009 Renewable Energy Data Book (EERE)

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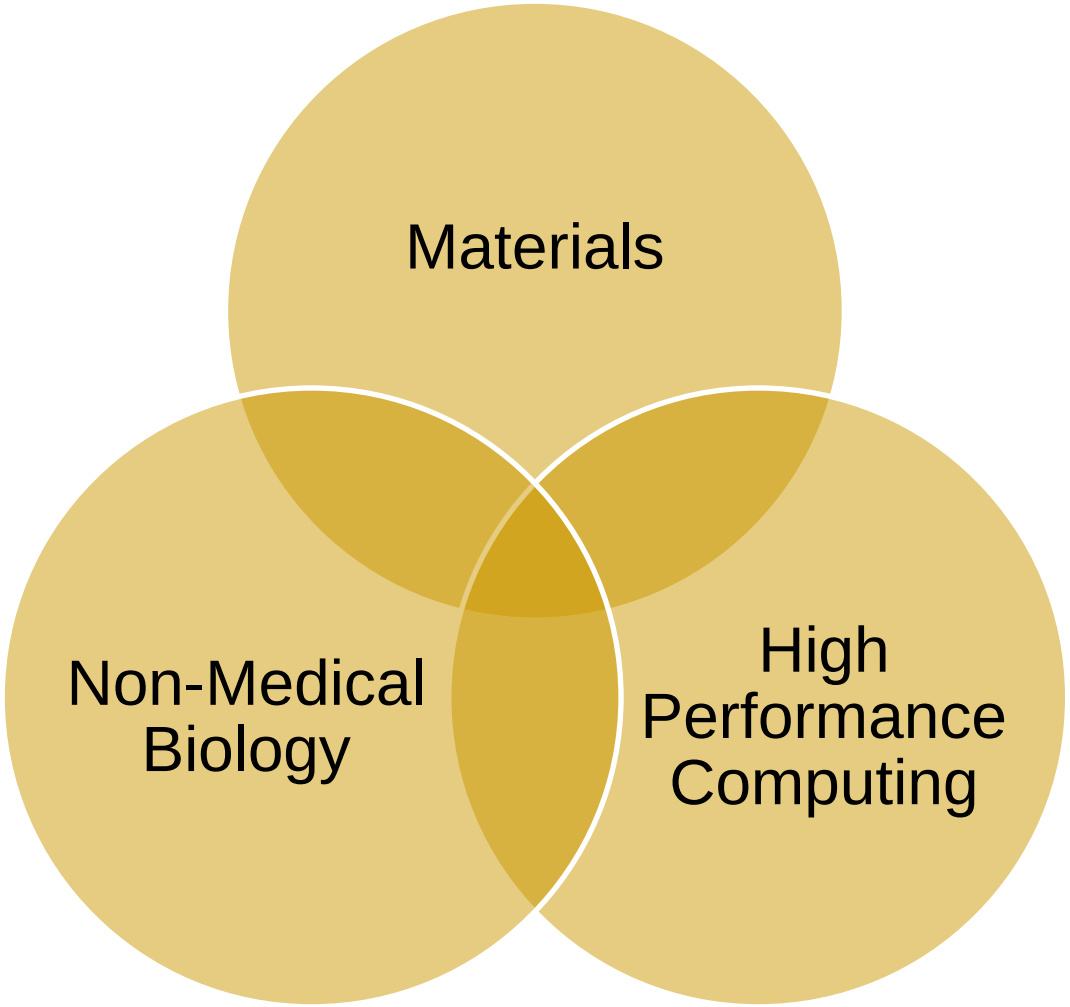
Areas of DOE Research Focus



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We must integrate diverse players with diverse roles

- Universities
  - Knowledge, people, education, credible voices
- National labs
  - Large facilities and programs, multidisciplinary RD&D
- Government
  - Consistent policies, precompetitive R&D
- For-profit sector
  - High-risk innovation, take technology to scale
  - Optimize under economics and regulation

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Technology transfer from the DOE labs

Intellectual property licensing, technology assistance, funding, partnerships, initiatives & more

One vision, 17 labs, aligned missions

- World class laboratories
- Top-notch scientists
- One-of-a-kind

  User Facilities
- Driving innovation
- Wide range of contractual vehicles

The DOE national labs are open for business and ready to help!

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Contractual Vehicles

- CRADA (Cooperative Research and Development Agreement)
- WFO (Work For Others)
- User Facilities (Proprietary vs. Non-Proprietary)
- Grants http://www.grants.gov
- SBIR/STTR http://www.sbir.gov
- Sub-Contracts (from Labs)
- Licensing
- Federal Business Opportunities https://www.fbo.gov

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Technology Licensing

All DOE National Laboratories and Some Facilities

- How it works:
  - Businesses, entrepreneurs, and others locate licensable technologies via lab websites, DOE sites, referrals, etc.
  - Contact laboratories for more information; NDA; negotiate terms
  - Programs at each lab are similar, but are not exactly alike
- How it's helped:
  - Thousands of technologies are licensed to companies each year, providing a basis for U.S. competitiveness and creating new jobs

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http://techtransfer.energy.gov/

DOE's "America's Next Top Energy Innovator" Start-Up Initiative

- Seeks to attract entrepreneurs and small businesses to consider Laboratories' current patent portfolios and new technologies
  - 17 National Laboratories hold 15,000+ patents and patent applications
- Start-up companies can option groundbreaking technologies developed by the National Laboratories for $1,000
- Seeks to reduce transaction costs associated with acquiring an Option, such as upfront fees, patent reimbursement cost and the time to negotiate an agreement.

Technology Assistance Program

- How it works:
  - Business requests assistance
  - Provides several days of technology assistance at no charge (a business is eligible once per fiscal year)
  - Cannot compete with private sector offerings
- How it's helped:
  - Provides support that is otherwise unattainable for most small businesses

SBIR/STTR Alerting Service

Pacific Northwest National Laboratory

- Automatic free alerts sent every other week, includes solicitations, training, conferences, tips, and contact information with web addresses
- Covers all 11 agencies, not just DOE

http://www.pnl.gov/edo/opportunities/sbir.stm

Research Parks / Incubators

- How it works:
  - Reduce commercialization risk (helps established and startup companies retain and create jobs)
  - Provides access to Lab technical expertise and know how
  - Nurtures entrepreneurial environment
  - Networking, Education, Market Intelligence, Coaching, Linking Community Contacts

- How it helps:
  - Provides basic infrastructure to start-up and creates jobs!

Sandia National Laboratories

Los Alamos NATIONAL LABORATORY EST. 1943

Lawrence Livermore National Laboratory

OAK RIDGE National Laboratory

Pacific Northwest NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

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Licensing Success Stories

High-Powered Battery for Hybrid Electric Vehicles (HEVs)

BERKELEY LAB

Argonne NATIONAL LABORATORY

Ultrathin Film Solar Technology using Nanocrystal Semiconductors

Millimeter Wave Holographic Body Scanner

Pacific Northwest NATIONAL LABORATORY

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Web Portals and Other Support

- EERE Portal & Tech Comm Fund (techportal.eere.energy.gov)
- DOE Patent Site (osti.gov/doepatents)
- DOE Tech Transfer Site (techtransfer.energy.gov)

- How they help:
  - Connects business with emerging technologies and laboratories developing them, as well as grant opportunities

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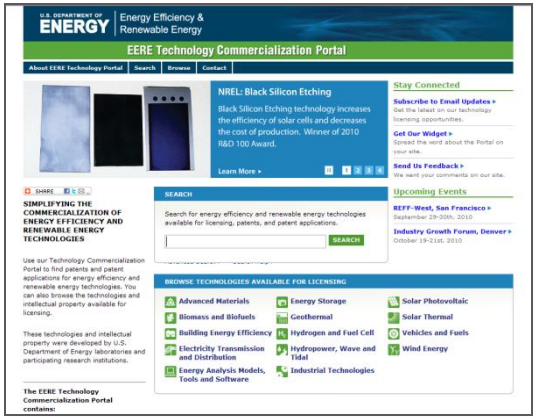
NREL National Renewable Energy Laboratory
Innovation for Our Energy Future



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Upcoming Events

12th Annual DOE Small Business Conference & Expo

May 10-12, Kansas City, MO

http://smallbusinessconference.energy.gov

NBIA's 25th International Conference on Business Incubation

Apr 10-13, San Jose, CA

http://www.nbia.org/events/conf2011/index.php

CSU Clean Energy Supercluster & Cenergy Expo 2011

April 20, Fort Collins, CO

http://energy.colostate.edu/CenergyExpo.html

U.S. Small Business Administration - Jobs Act Tour

March-April 2011, cities around the US.

www.sba.gov/jobsacttour

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QUESTIONS?/COMMENTS?

http://science.energy.gov/s-4

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