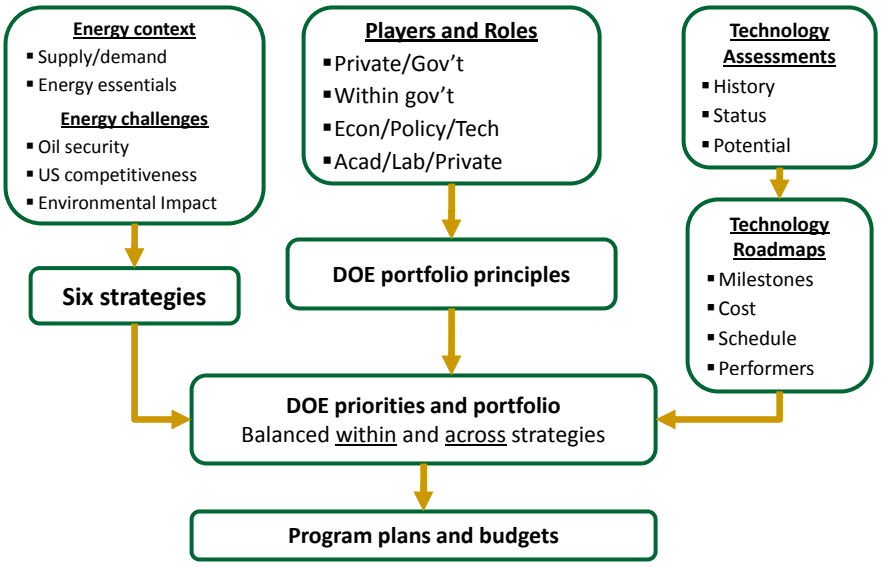
DOE Quadrennial Technology Review

Some Framing Facts on Energy

Washington, DC
13 July 2011

DOE-QTR Logic Flow



Six Strategies

	Supply		Demand
Stationary	Deploy Clean Electricity	Modernize the Grid	Increase Building and Industrial Efficiency
Transport	Deploy Alternative Hydrocarbon Fuels	Electrify the Fleet	Increase Vehicle Efficiency

www.energy.gov/QTR

U.S. DEPARTMENT OF ENERGY 3

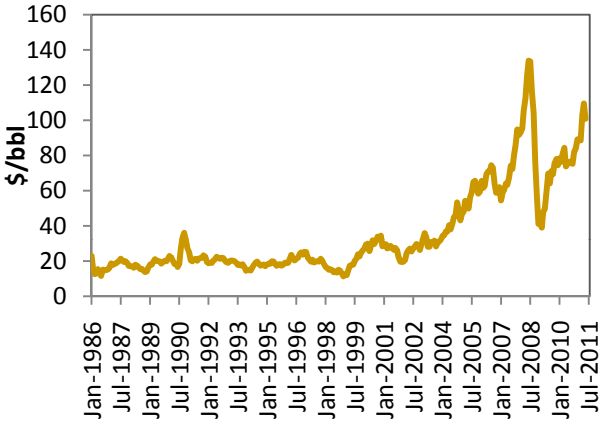
CONTEXT

U.S. DEPARTMENT OF ENERGY 4

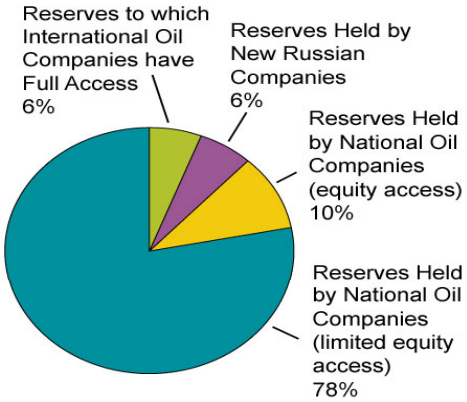
U.S. Energy Challenges

Energy Security

Monthly Spot Price OK WTI

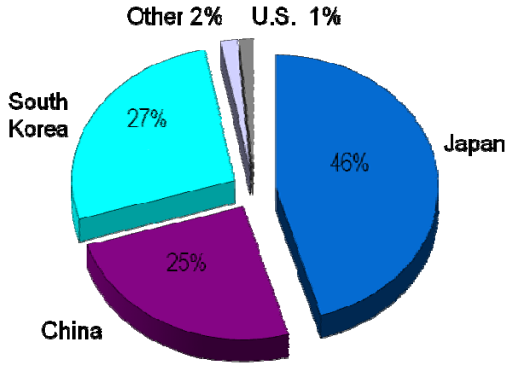


Share of Reserves Held by NOC/IOC

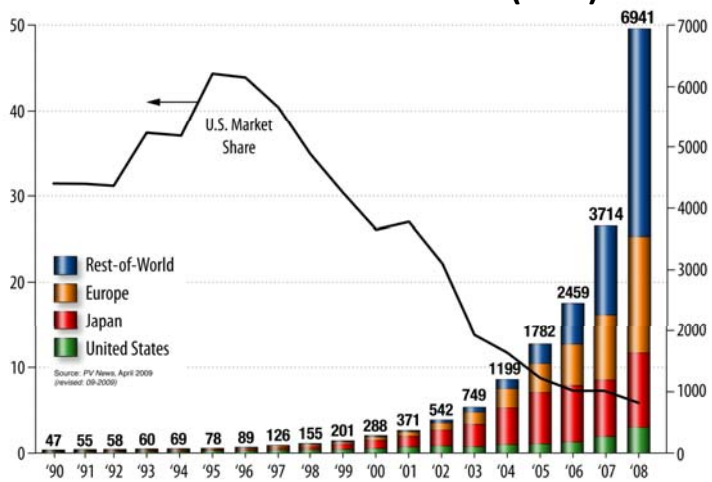


Competitiveness

Global Lithium-ion Battery Manufacturing (2009)

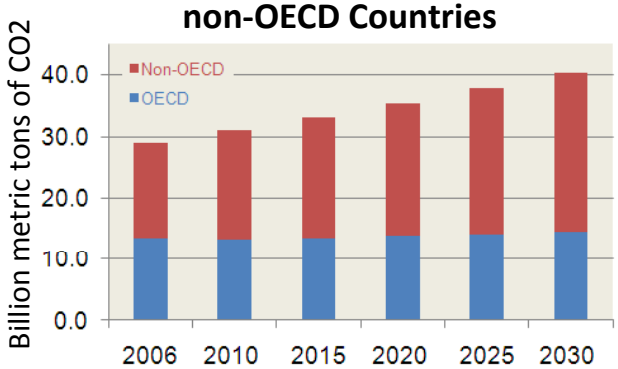


Worldwide Shipments of Solar Photovoltaics (MW)

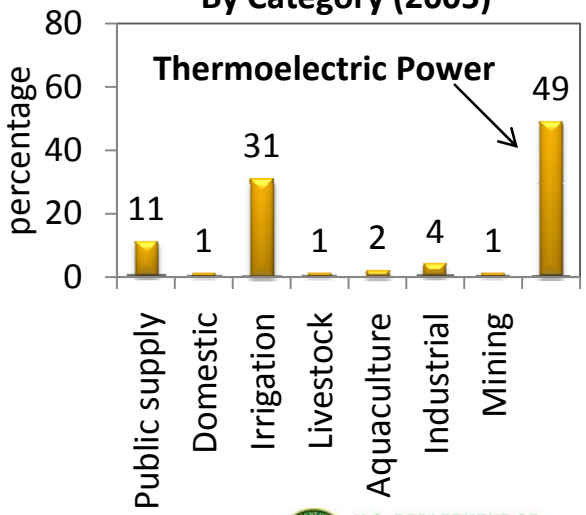


Environment

CO2 Emissions in OECD vs non-OECD Countries



Water Withdrawals in % By Category (2005)



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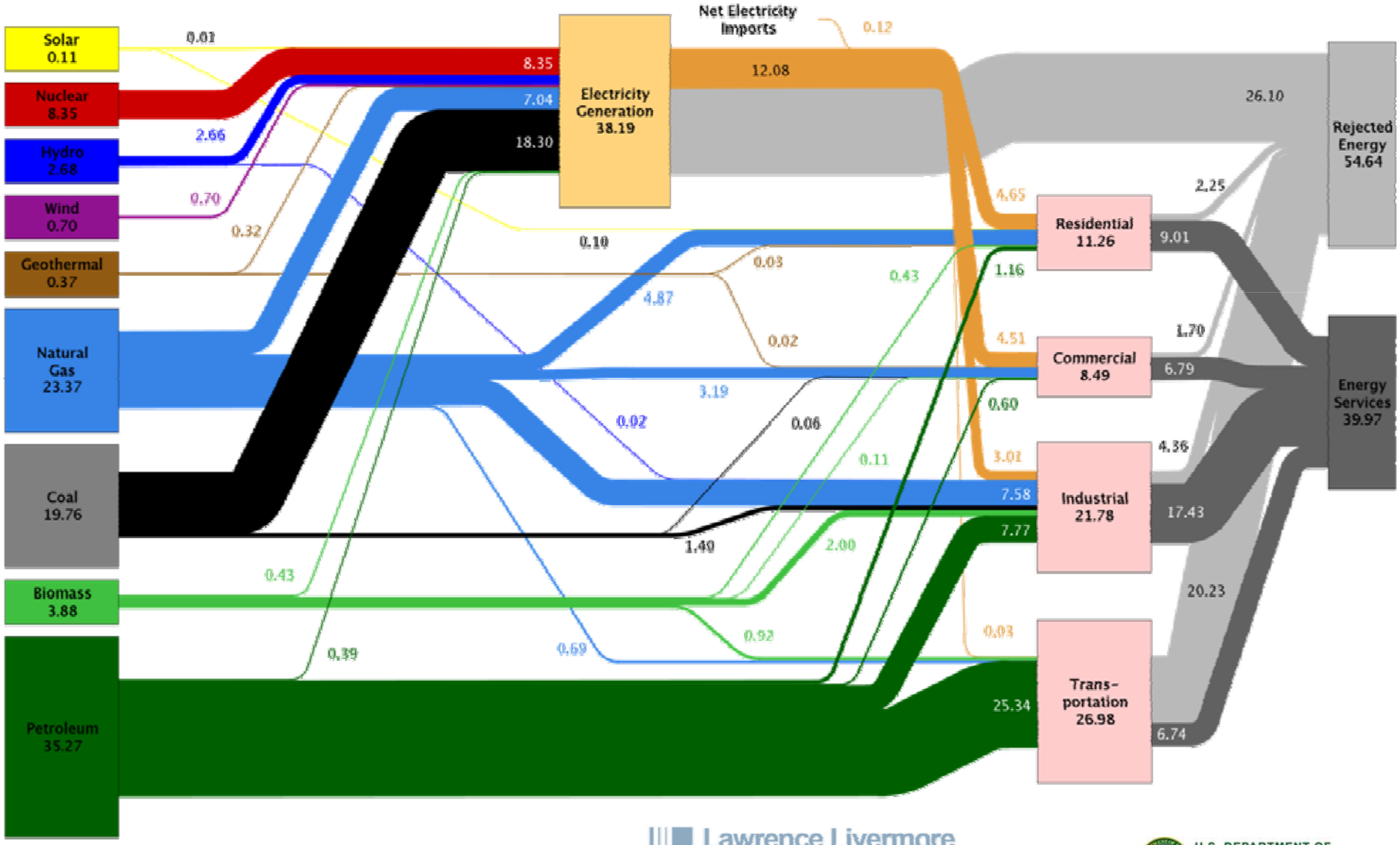
Estimated U.S. Energy Use in 2009: ~94.6 Quads



https://flowcharts.llnl.gov/

Lawrence Livermore National Laboratory

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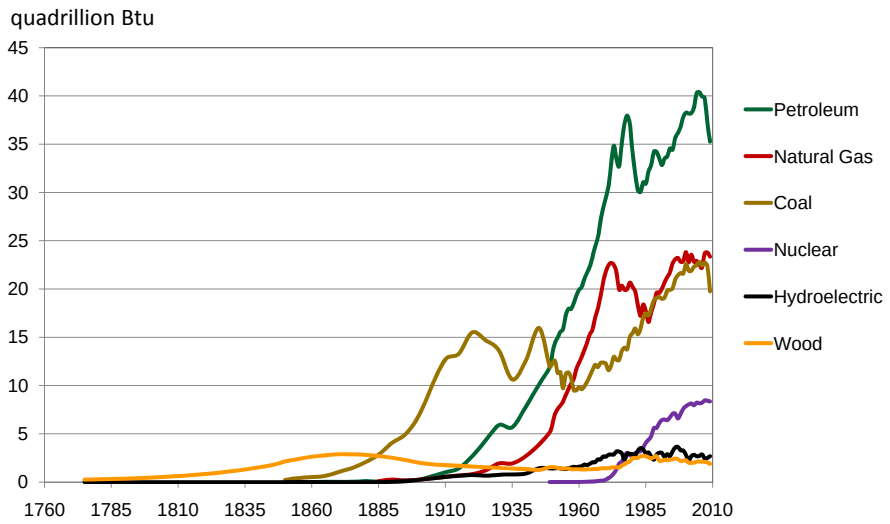
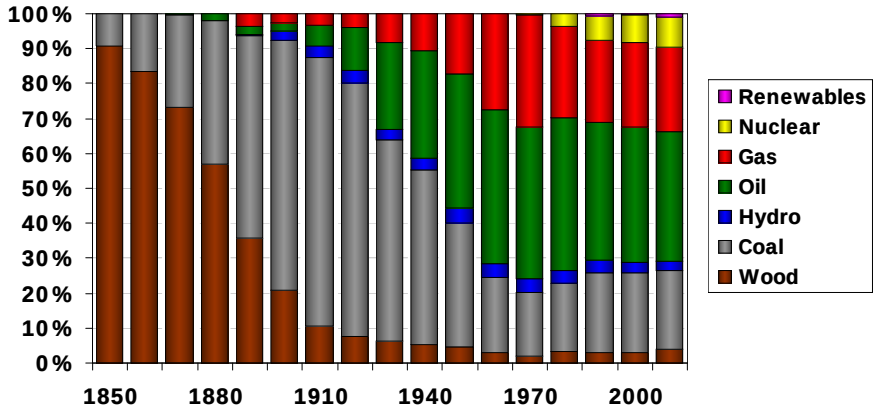
U.S. Primary Energy Sources (1775-2009)



Source: EIA

7

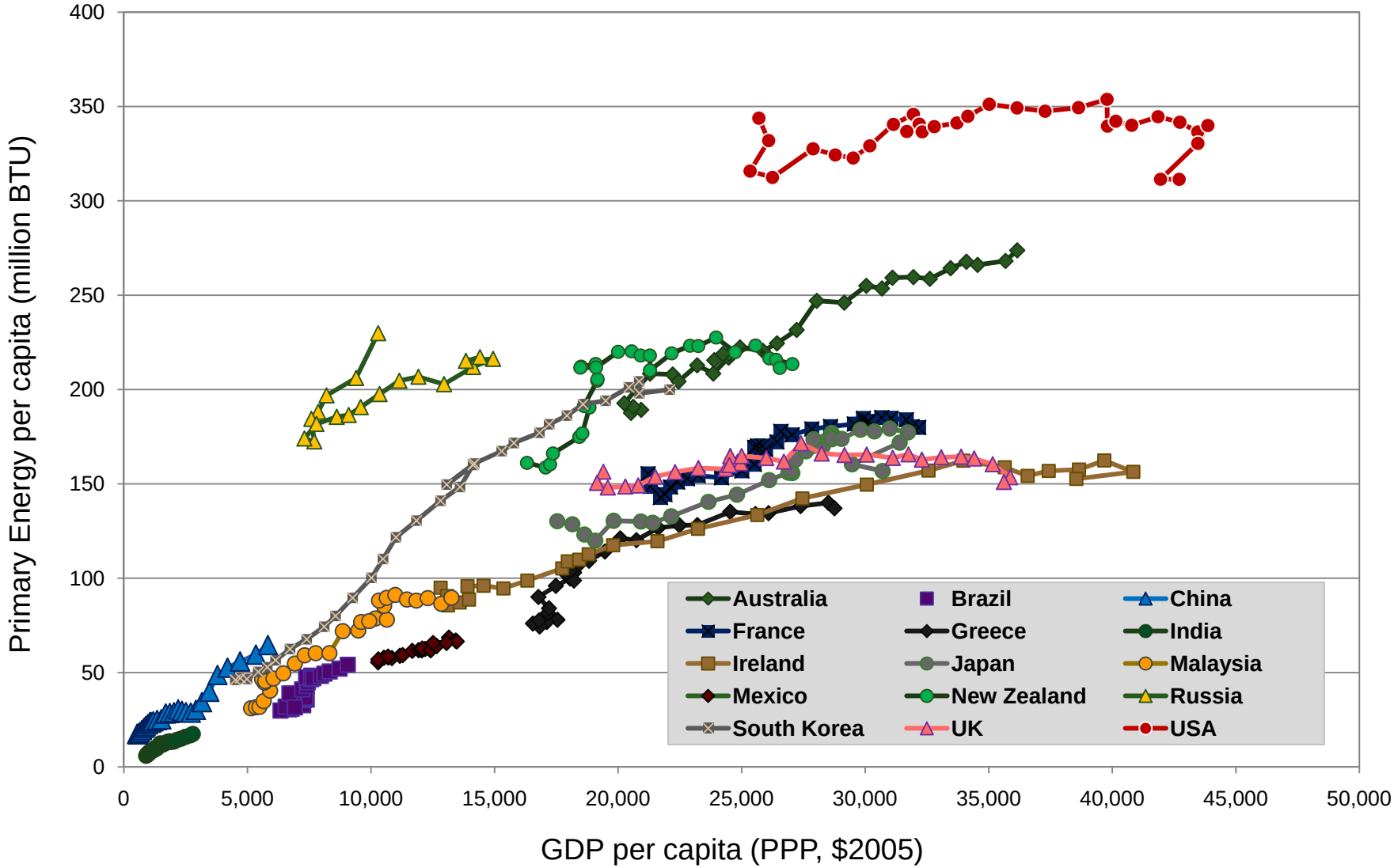
U.S. Energy Supply Since 1850



Source: EIA

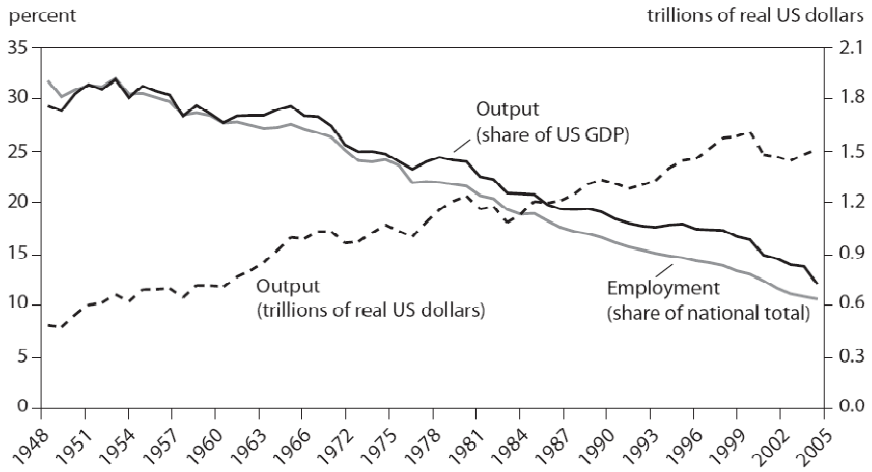
8

Energy Use vs. GDP, both per capita (1980-2010)



Source: EIA

Trends in U.S. Manufacturing

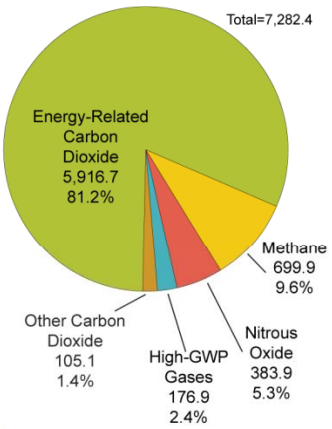


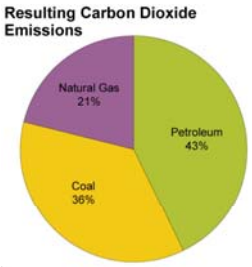
Sources: US Department of Commerce, Bureau of Economic Analysis, Industry Economic Accounts

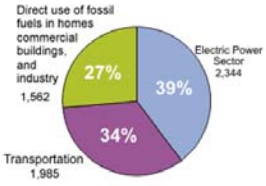
U.S. DEPARTMENT OF ENERGY 11

US anthropogenic GHG emissions are mostly energy-related

Over 80% of US greenhouse gas emissions in 2007 were energy-related







Source: EIA *Emissions of Greenhouse Gases in the United States 2007*

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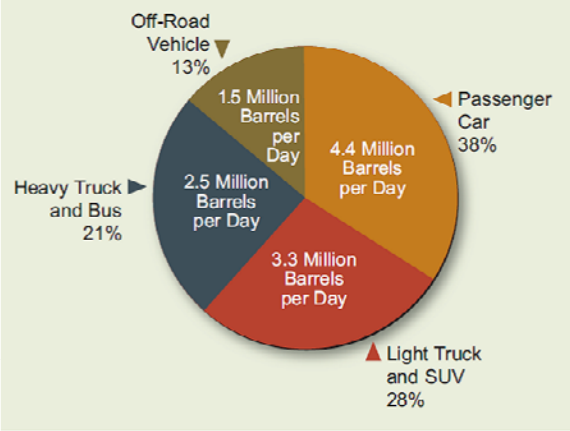
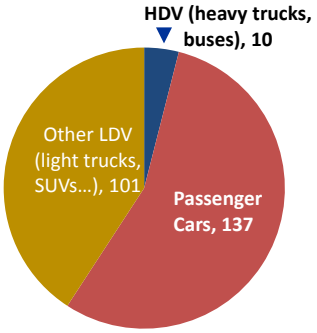
TRANSPORT

Road Transport Fuels and Vehicles



Total U.S. highway and off-road vehicle fuel use in 2003 (diesel and gasoline only), in million barrels per day

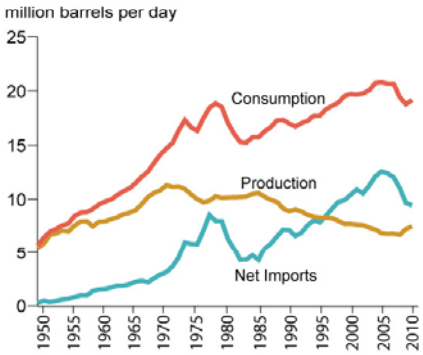
U.S. Road Vehicles in 2008 (in millions)



Sources: Transportation Energy Data Book, Edition 25 (Davis and Diegel, 2006); DOT/Bureau of Transportation Statistics

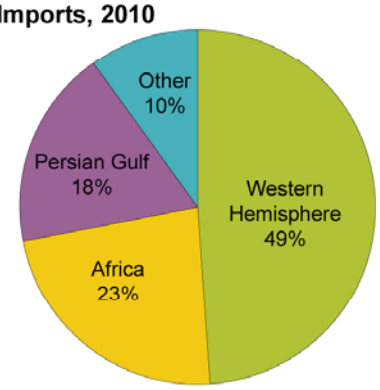
Petroleum Imports

Petroleum Consumption, Production, and Import Trends (1949-2010)



Source: U.S. Energy Information Administration, *Monthly Energy Review* (May 2011), preliminary data, and *Annual Energy Review 2009*, Table 5.1 (August 2010).

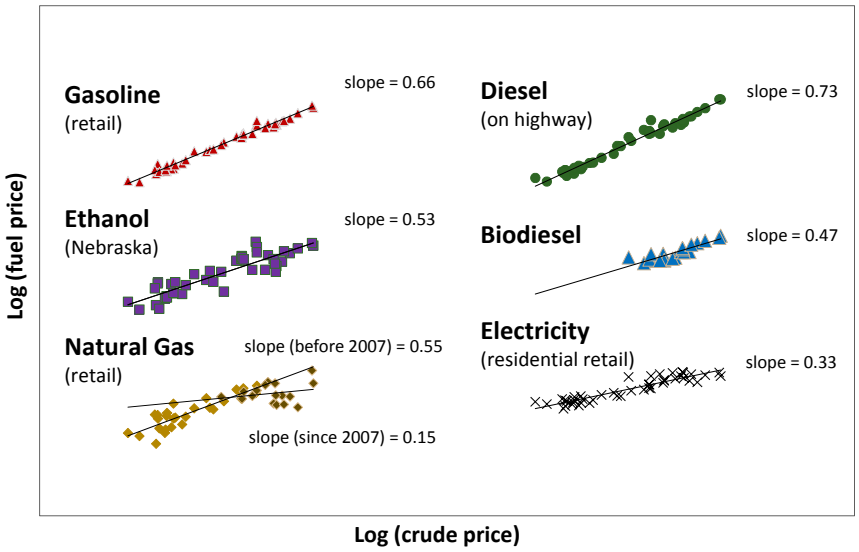
Sources of U.S. Net Petroleum Imports, 2010



Source: U.S. Energy Information Administration, *Petroleum Supply Monthly* (May 2011).

U.S. DEPARTMENT OF ENERGY 15

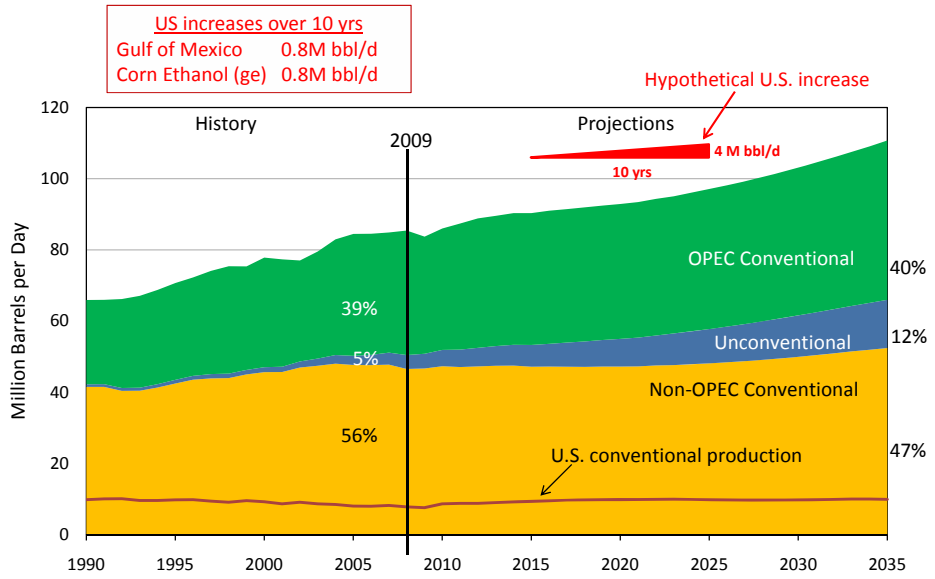
Correlation of Alternative Fuels with Crude (2000-2011)



Quarterly prices in constant dollars;
Data from EIA, EERE, USDA

U.S. DEPARTMENT OF ENERGY 16

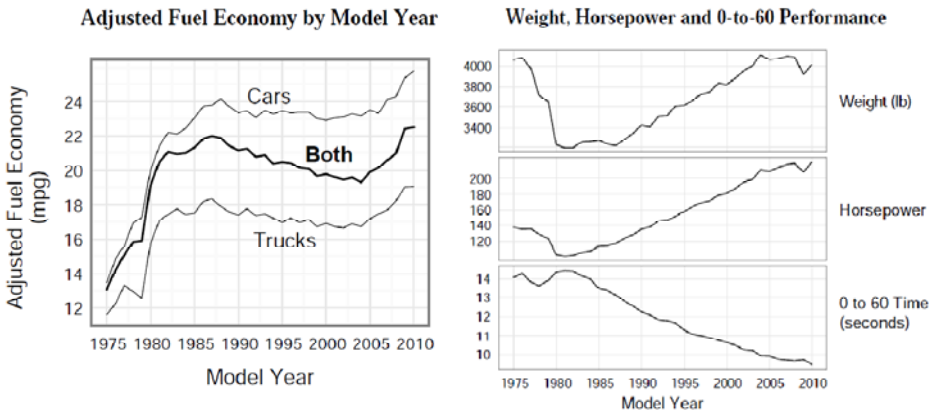
Impact of Domestic Liquids Production



Global Liquids Production Data from EIA

17

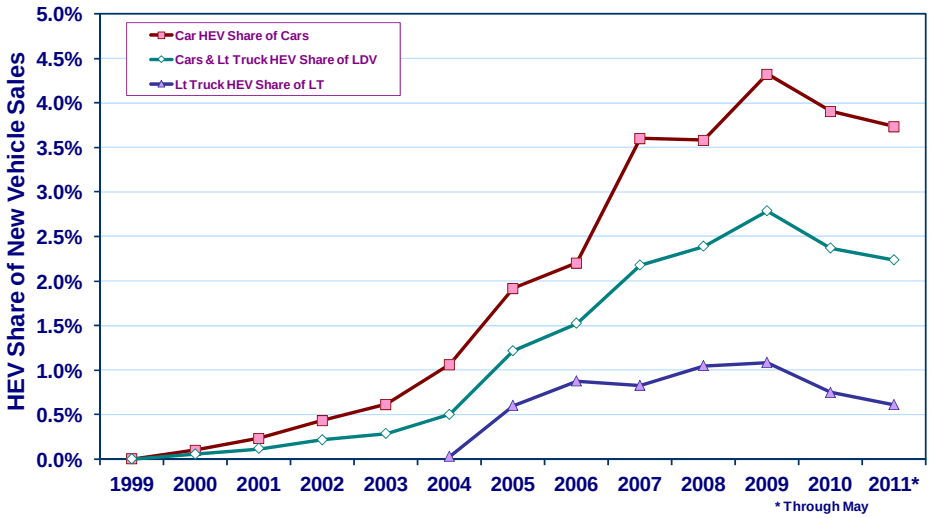
Trends for New LDVs (1975 – 2010)



Source: EPA2010 (http://www.epa.gov/otaq/cert/mpg/fetrends/420r10023.pdf)

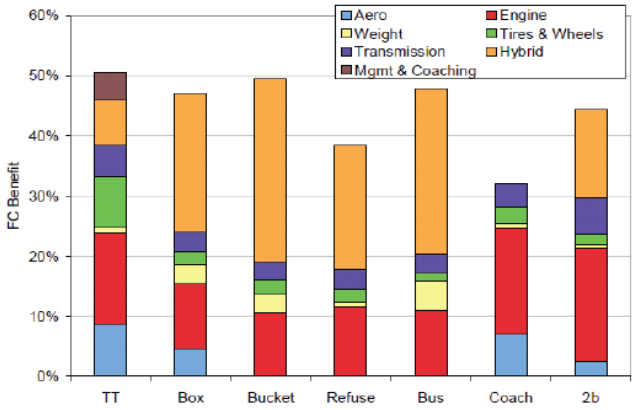
18

Hybrid Electric Vehicles Share of U.S. Sales (1999-2011)



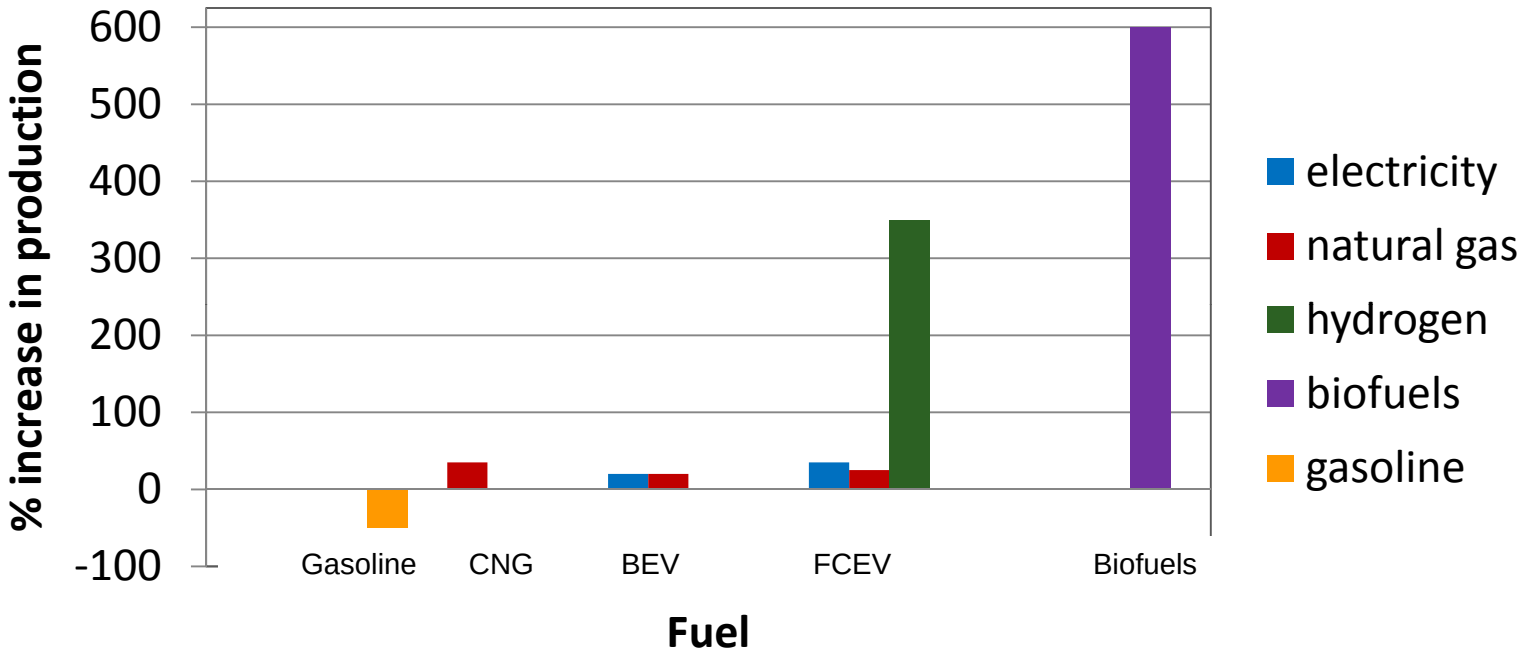
Source: ANL based on JD Power sales data

Routes to HDV Efficiency



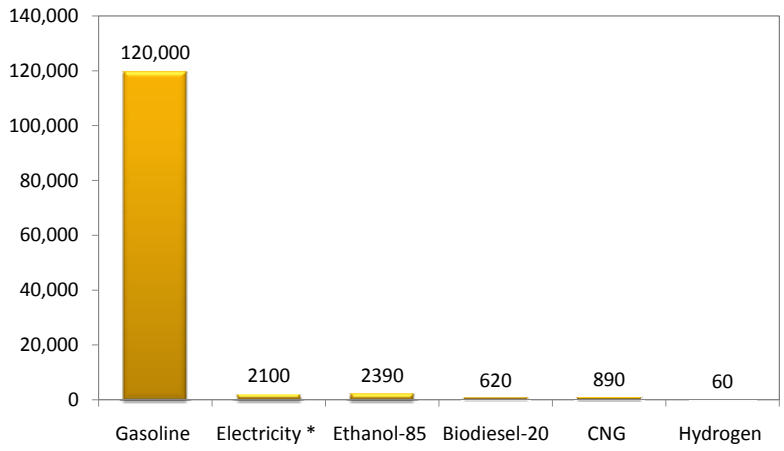
Comparison of 2015-2020 new-vehicle potential fuel-saving technologies for seven vehicle types: tractor trailer (TT), Class 3-6 box (box), Class 3-6 bucket (bucket), Class 8 refuse (refuse), transit bus (bus), motor coach (coach), and Class 2b pickups and vans (2b). Potential fuel reductions are not additive. Adapted from Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles (NRC, 2009)

Estimated supply impacts of meeting 50% of today's LDV demand by various alternative fuels



Current annual LDV demand is 16 Q, so 8 Q of gasoline need to be replaced. That would require a 6x increase in **biofuel** supply. Since ICE efficiency is about the same for **CNG** and gasoline, the CNG option would need 8 Q of gas, or 1/3 of current annual demand. A **BEV** is 4X more energy-efficient than an ICE, so 2Q of electricity would be needed, or 1/6 of current generation. If this were produced from natural gas, assuming a 50% efficiency in generation, 4 Q, would be needed, or 1/6 of current gas demand. For the **H2** option, an FCV is 2X more energy efficient than an ICE, so 4 Q of H2 would be needed, or 3.5x of current H2 supply. If this were produced all from NG, assuming a 75% energy efficiency in H2 production, than 5.3Q of gas are required, or ¼ of current demand. If all the H2 were instead produced from electricity with 75% efficiency, then 5.3Q of electricity would be required, or about 1/3 of current generation.

Current Number of Fueling Stations in the U.S.

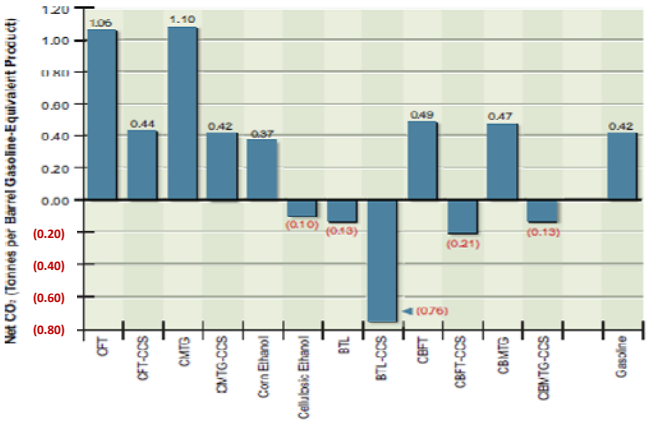


*Does not include residential charging. There are about 60 million single-family homes with garages in the US.

Source: DOE/EERE

U.S. DEPARTMENT OF ENERGY 21

Well-to-wheels lifecycle carbon emissions for transportation fuels



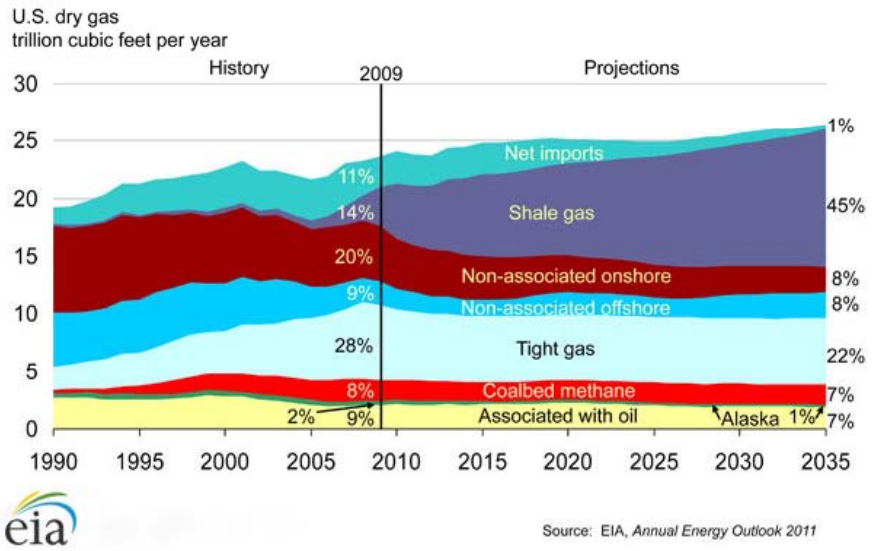
CFT—coal to liquid fuels via Fischer Tropsch.
CFT/CCS—Coal to liquid fuels via Fischer Tropsch with carbon capture and storage.
CMTG—coal to liquid fuels via methanol to gasoline.
CMTG/CCS—Coal to liquid fuels via methanol to gasoline with carbon capture and storage.
Corn ethanol—Ethanol produced from corn grain via biochemical conversion.
Cell ethanol—Ethanol produced from cellulosic biomass via biochemical conversion.
BTL—Cellulosic biomass to liquid fuels via Fischer Tropsch.
BTL/CCS—Cellulosic biomass to liquid fuels via Fischer Tropsch with carbon capture and storage.
CBFT—Coal and biomass to liquid fuels via Fischer Tropsch.
CBFT/CCS—Coal and biomass to liquid fuels via Fischer Tropsch with carbon capture and storage.
CBMTG—Coal and biomass to liquid fuels via methanol to gasoline.
CBMTG/CCS—Coal and biomass to liquid fuels via methanol to gasoline with carbon capture and storage.

Source: America's Energy Future Panel on Alternative Liquid Transportation Fuels; National Research Council (2009)

U.S. DEPARTMENT OF ENERGY 22

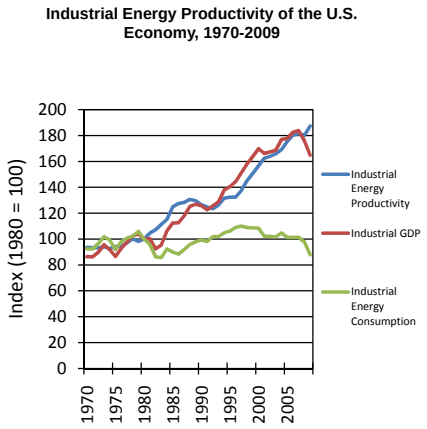
STATIONARY

Natural Gas Supply (1990-2035)

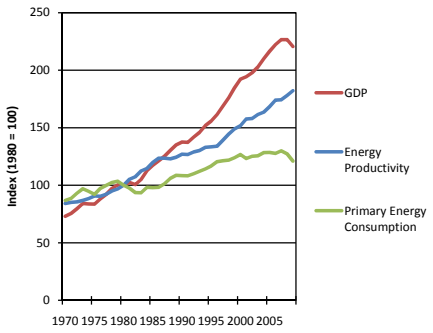


Source: EIA, Annual Energy Outlook 2011

U.S. Energy Intensity Trends



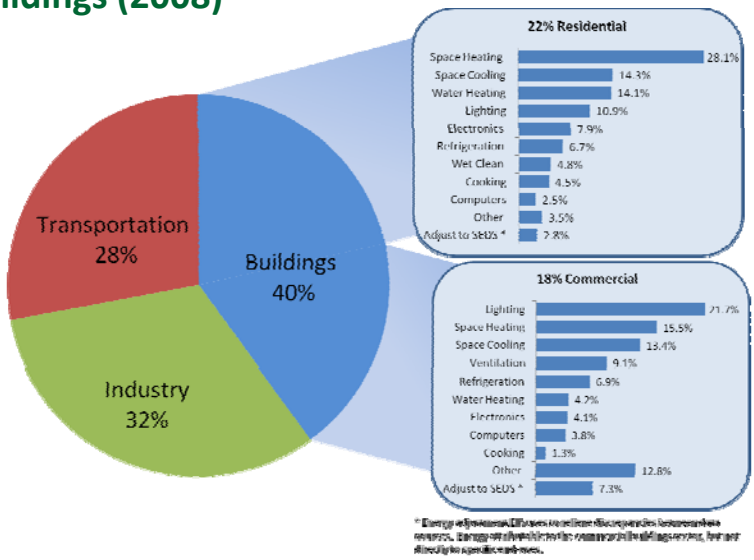
Sources: EIA, Dept of Commerce; based on primary energy use



Sources: EIA Annual Energy Review (consumption); BEA National Economic Accounts (GDP)

U.S. DEPARTMENT OF ENERGY 25

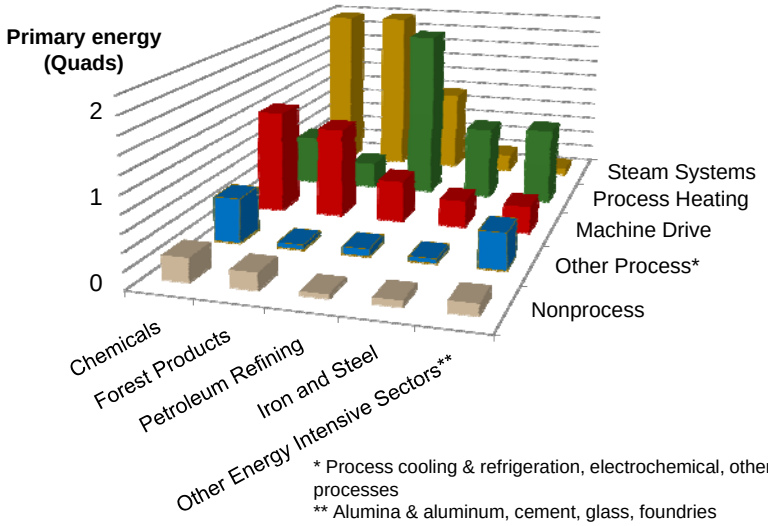
Energy Use in Residential and Commercial Buildings (2008)



Source: DOE EERE/Buildings Energy Data Book

U.S. DEPARTMENT OF ENERGY 26

Energy Use by Industrial System by Industry Subsector

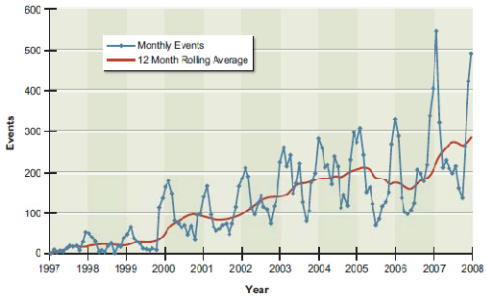


* Process cooling & refrigeration, electrochemical, other processes
** Alumina & aluminum, cement, glass, foundries

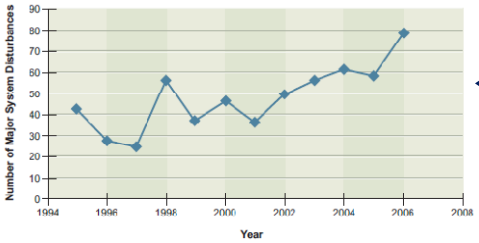
Source: Based on Energy Information Administration, 2006 Manufacturing Energy Consumption Survey

U.S. DEPARTMENT OF ENERGY 27

Grid stress is increasing



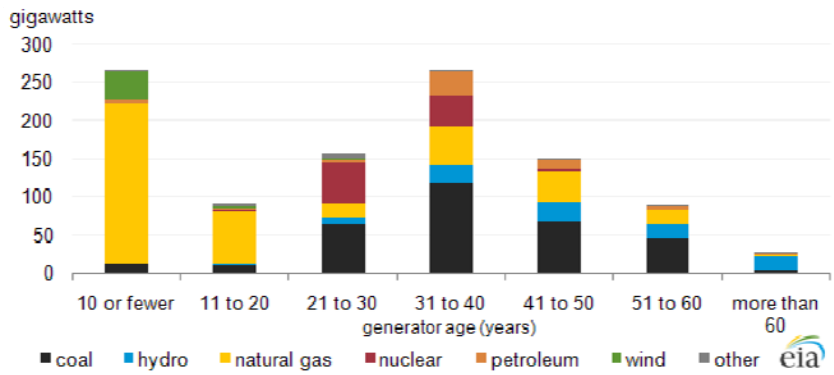
Transmission offload events, which are a measure of increasing system congestion.



Major transmission system disturbances reported to NERC; these disturbances can affect the reliability of the bulk (generation and transmission) energy system, but do not necessarily reflect outages.

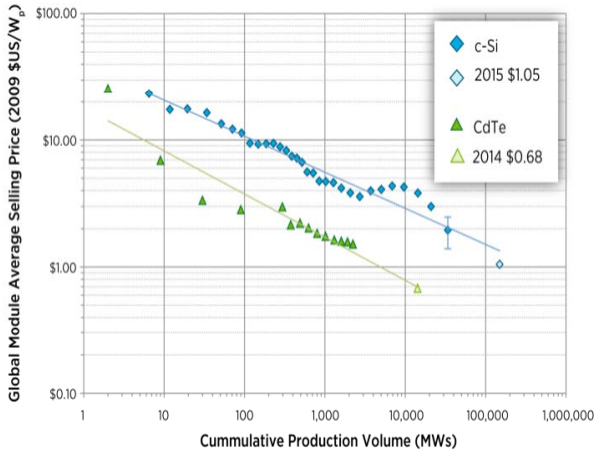
U.S. DEPARTMENT OF ENERGY 28

Age and capacity of existing electric generators by fuel type, as of year-end 2010



Source: EIA

Solar PV Experience Curves: historical solar production costs



Technologies: Crystalline Silicon (c-Si), Cadmium Telluride (CdTe)

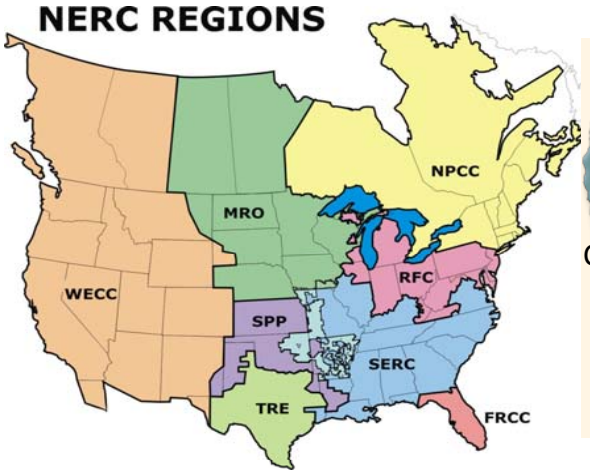
Sources: (CdTe) First Solar Earnings Presentation, SEC Filings; (c-Si) Navigant, Bloomberg NEF, NREL internal cost models

There are many grid stakeholders

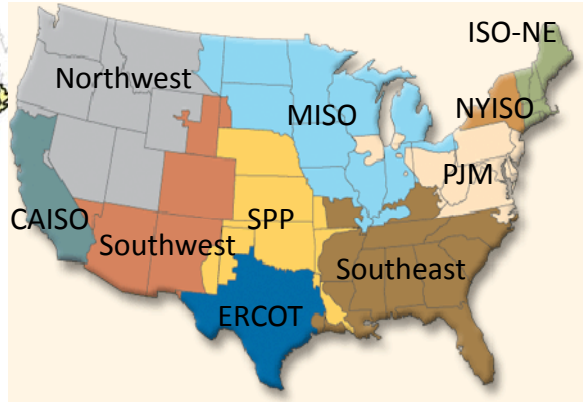
Regional | **Sub-Regional** | **State & Local**

Oversight

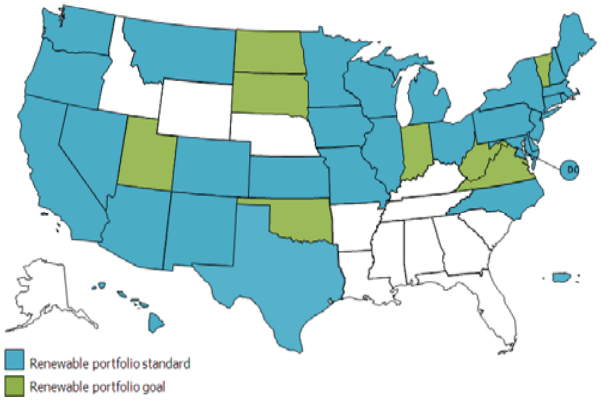
NERC REGIONS



FERC Electric Power Markets

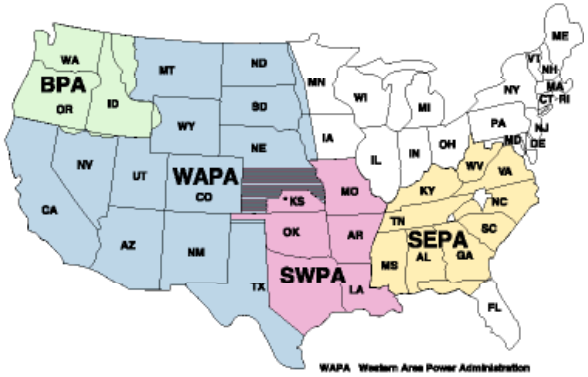


RPS Policies

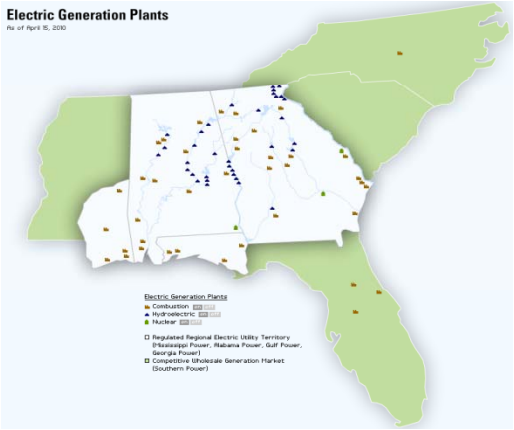


Operation

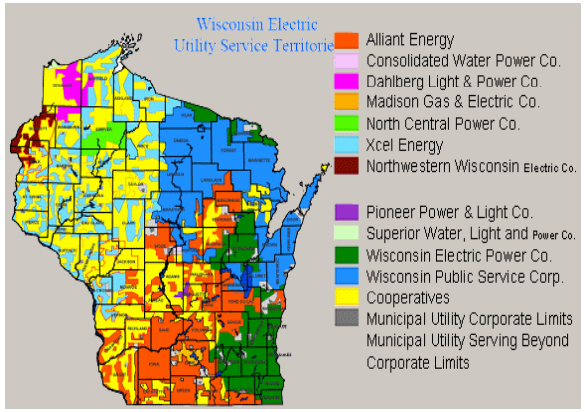
Federal Power Marketing Administrations



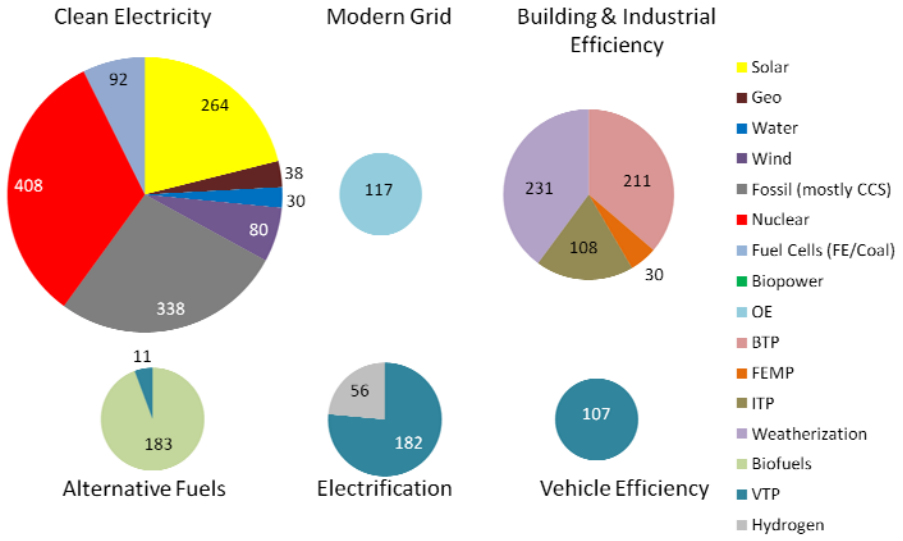
Southern Company Service Territory



Wisc. Electric Utility Service Territories



FY11 Enacted DOE Budget Breakdown as Function of Strategy ($million)



U.S. DEPARTMENT OF ENERGY 33

Recovery Act

The 2009 Recovery Act gave the Department's energy programs $24.7 billion dollars (FY11 enacted budget for the same programs is $3.36 billion). This allowed the Department to make investments in demonstration and deployment projects otherwise outside of its reach. For example (in millions):

- **Advanced Battery Manufacturing** 48 new advanced battery and electric drive projects, selected through a highly competitive process, to accelerate the development of U.S. manufacturing capacity for batteries and electric drive components as well as the deployment of electric drive vehicles: $1,990
- **Energy Efficiency and Conservation Block Grants** Used for energy efficiency and conservation programs and projects communitywide, as well as renewable energy installations on government buildings: $3,200
- **Energy Efficient Appliance Rebate** Available to states and territories to promote the purchase of ENERGY STAR® qualified appliances: $300
- **Smart Grid Investment Program** Competitive, merit-based matching grant program that covers up to 50% of investments planned by electric utilities and other entities for the deployment of Smart Grid technology : $3,500
- **Grid Workforce Development** Develop a well-trained, highly skilled electric power sector workforce, which is vital to implementing and maintaining the Smart Grid: $100

U.S. DEPARTMENT OF ENERGY 34

Questions/Comments?

Project Website

http://www.energy.gov/qtr

Public Comments

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U.S. DEPARTMENT OF ENERGY 35