The Florida Advanced Technological Education (FLATE) Center wishes to make available, for educational and non-commercial purposes only, materials relevant to the "EST1830 Introduction to Alternative/Renewable Energy" course comprised of images, texts, facilitator's notes, and other demonstration materials.

This instructional resource forms part of FLATE's outreach efforts to facilitate a connection between students and teachers throughout the State of Florida. We trust that these activities and materials will add value to your teaching and/or presentations.

FLATE
Hillsborough Community College - Brandon
10414 E Columbus Dr., Tampa, FL 33619
(813) 259-6575
www.fl-ate.org; www.madeinflorida.org; www.fesc.org

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Introduction to Alternative and Renewable Energy

EST1830

5. Economics and Policy

Policy

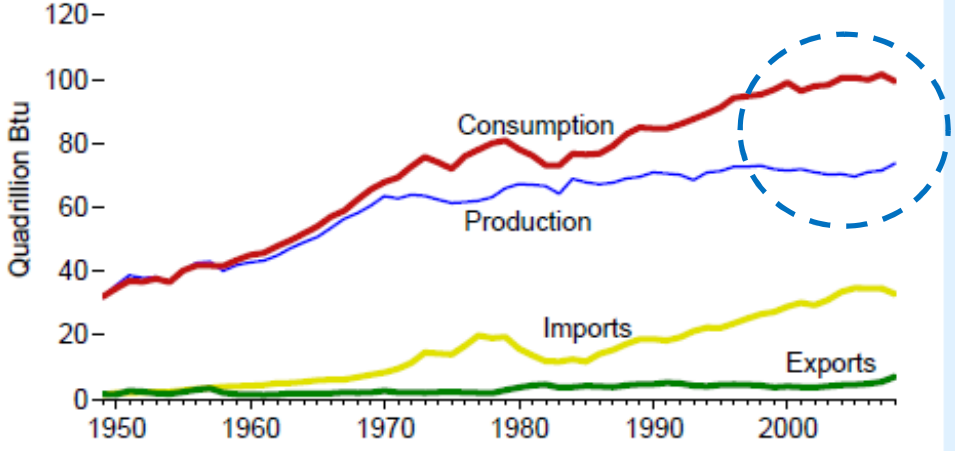
- When talking about policy, one must distinguish among the three levels of coverage and enforcement.
  - National Policy
  - State Policy
  - Local Level Policy:
    - County, Regional Governments, Cities, and Towns
    - Zoning Codes
    - Licensing Offices
    - Construction codes and standards such as National Electrical Code (NFPA-70)

Policy

- With regards to energy and the environment, National Policy, in its various forms of laws and regulations, aims to address issues within three major “buckets”:
  - Energy Consumption
  - Energy Production
  - Environmental Impact of our Energy Consumption and Production
- The next slide shows an extremely high level of reliance on energy imports to satisfy our demand.

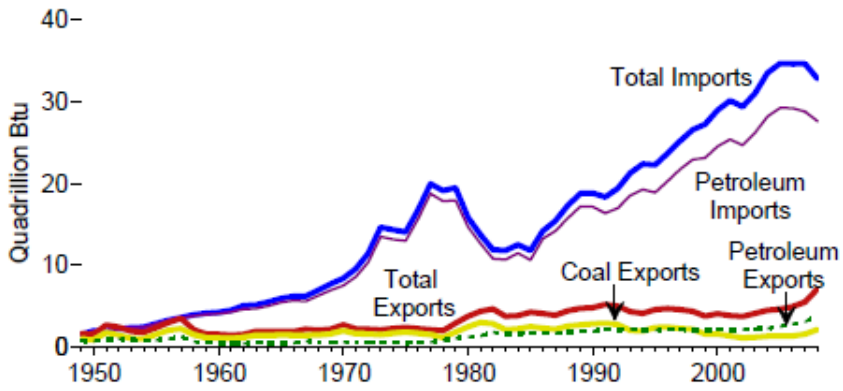
US Energy Consumption

Figure 1. Primary Energy Overview



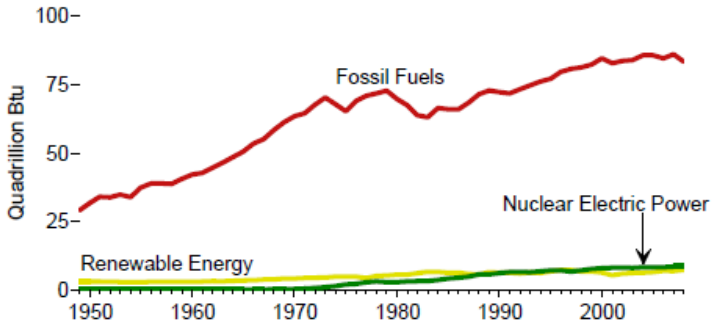
The United States was self-sufficient in energy until the late 1950s when energy consumption began to outpace domestic production. At that point, the Nation began to import more energy to fill the gap. In 2008, net imported energy accounted for 26 percent of all energy consumed.

Figure 13. Primary Energy Imports and Exports



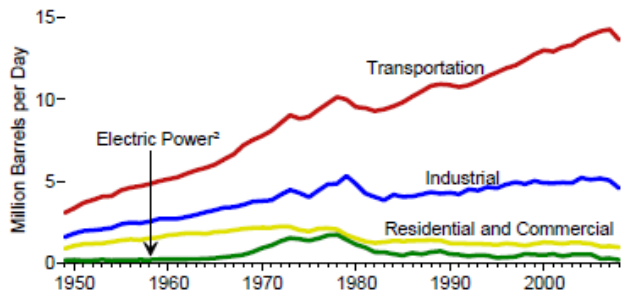
Since the mid-1950s, the Nation imported more energy than it exported. In 2008, the United States imported 33 quadrillion Btu of energy and exported 7 quadrillion Btu. Most imported energy was in the form of petroleum; since 1986, natural gas imports expanded rapidly as well. Through 1992, most exported energy was in the form of coal; after that, petroleum exports often exceeded coal exports.

Figure 4. Primary Energy Consumption by Source



Most energy consumed in the United States comes from fossil fuels. Renewable energy resources supply a relatively small but steady portion. In the late 1950s, nuclear fuel began to be used to generate electricity, and in most years since 1988, nuclear electric power surpassed renewable energy.

Figure 18. Petroleum Consumption[1] by Sector



[1] Petroleum products supplied is used as an approximation for consumption.
[2] Through 1988, electric utilities only; after 1988, also includes independent power producers.

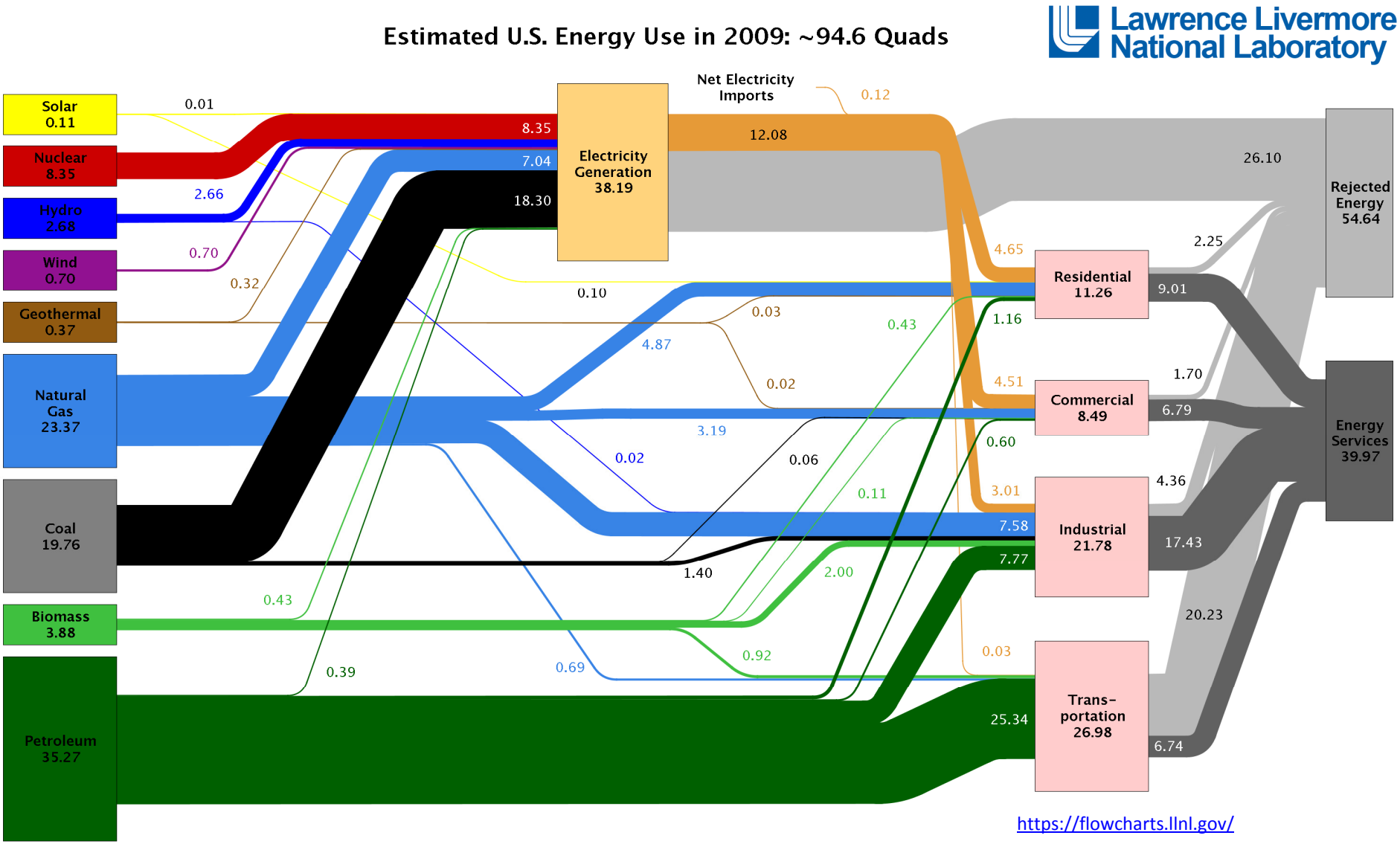
Transportation was the largest consuming sector of petroleum and the one showing the greatest expansion. In 2008, 13.7 million barrels per day of petroleum products were consumed for transportation purposes, accounting for 70 percent of all petroleum used.

Source: Annual Energy Review 2008, http://www.eia.doe.gov/aer

Policy

- Unfortunately, a lot of our energy imports are “going up in smoke”, or actually wasted heat.
- The next slide shows wasted energy relative to consumed energy at a national level.
  - We can see that out of 94.61 Quads of Energy consumed, only 39.97 Quads go towards useful work, or 42%.
  - The rest of the energy consumed is wasted: 58%.
  - Electricity generation and transportation are the largest culprits with 27.6% and 21.4%, respectively.

US Energy Consumption

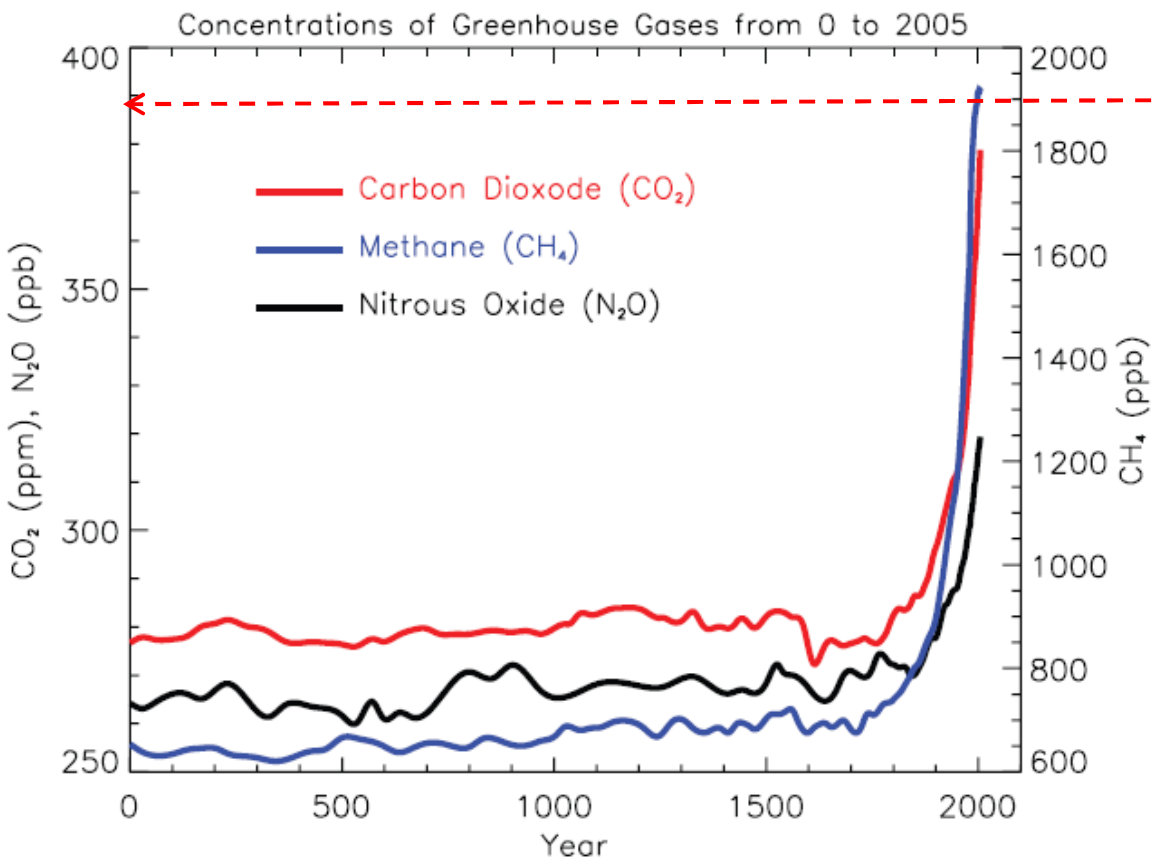


Source: LLNL 2010. Data is based on DOE/EIA-0384(2009), August 2010. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for non-thermal resources (i.e., hydro, wind and solar) in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

Policy

- Results of both our electricity generation and transportation activities, which utilize fossil fuels, re-introduce carbon byproducts that had been stored in the confines of the earth for millions of years back into our atmosphere.
- Coal, petroleum and natural gas are essentially carbon-containing matter that has formed and been stored deep in the earth's layers for millions of years.
- When coal, oil and gas are extracted from the earth, we are essentially re-introducing that stored carbon back into the atmosphere.
- This has been happening in a non-natural fashion since the industrial revolution. There is some natural seepage of carbon-containing matter.

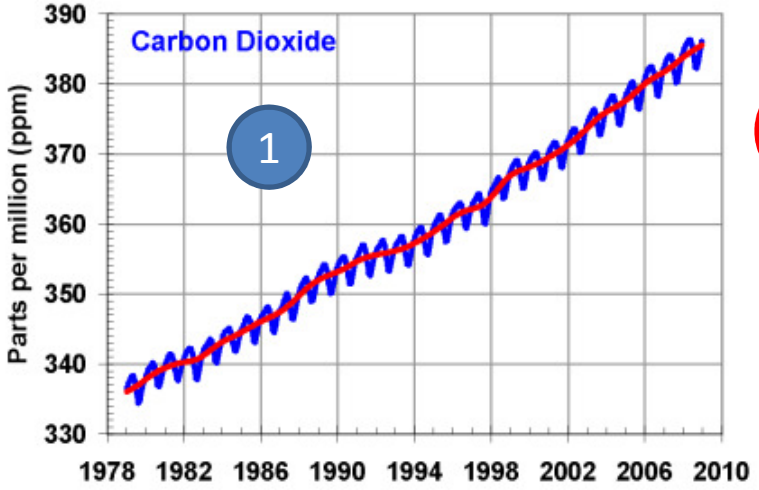
CO2, Methane, Nitrous Oxide

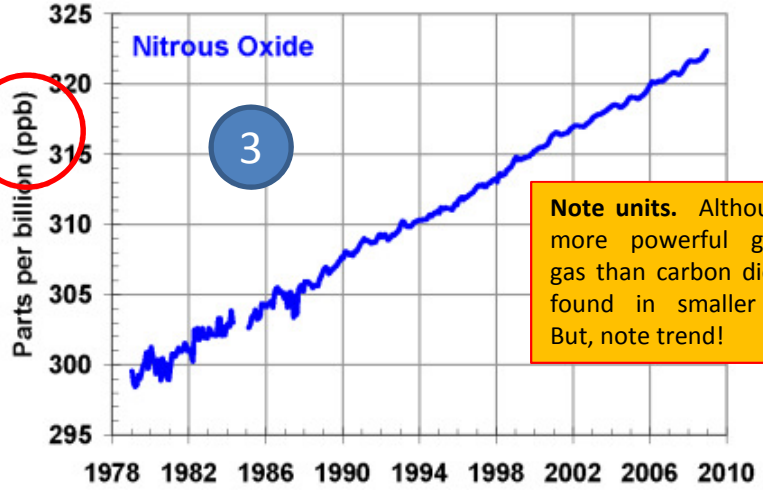


In 2009: 387ppm CO_2

http://www.ipcc-wg1.unibe.ch/publications/wg1-ar4/wg1-ar4.html

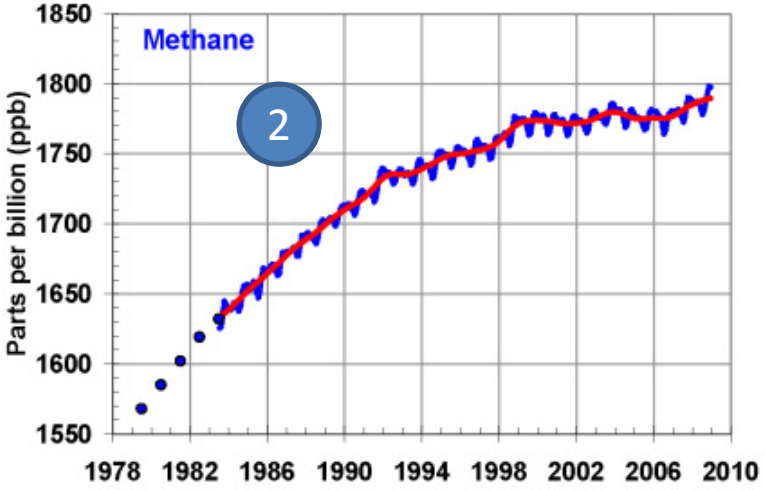
Annual Greenhouse Gas Index

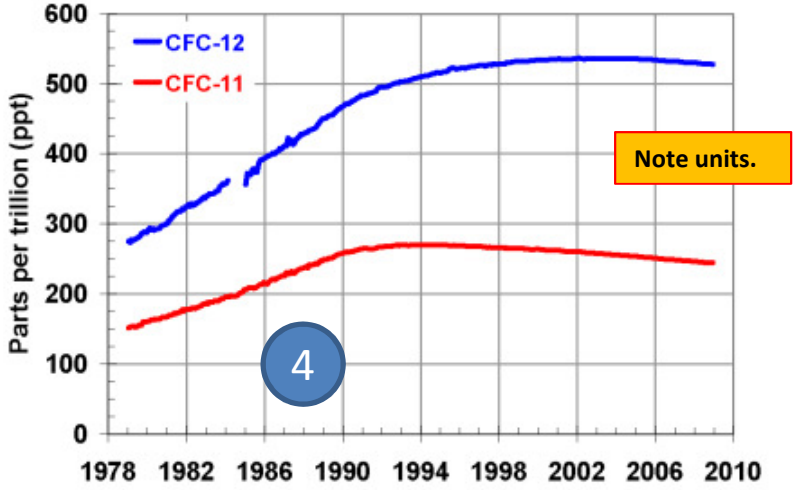




Note units. Although, it is a more powerful greenhouse gas than carbon dioxide, it is found in smaller amounts. But, note trend!

http://www.esrl.noaa.gov/gmd/aggi/





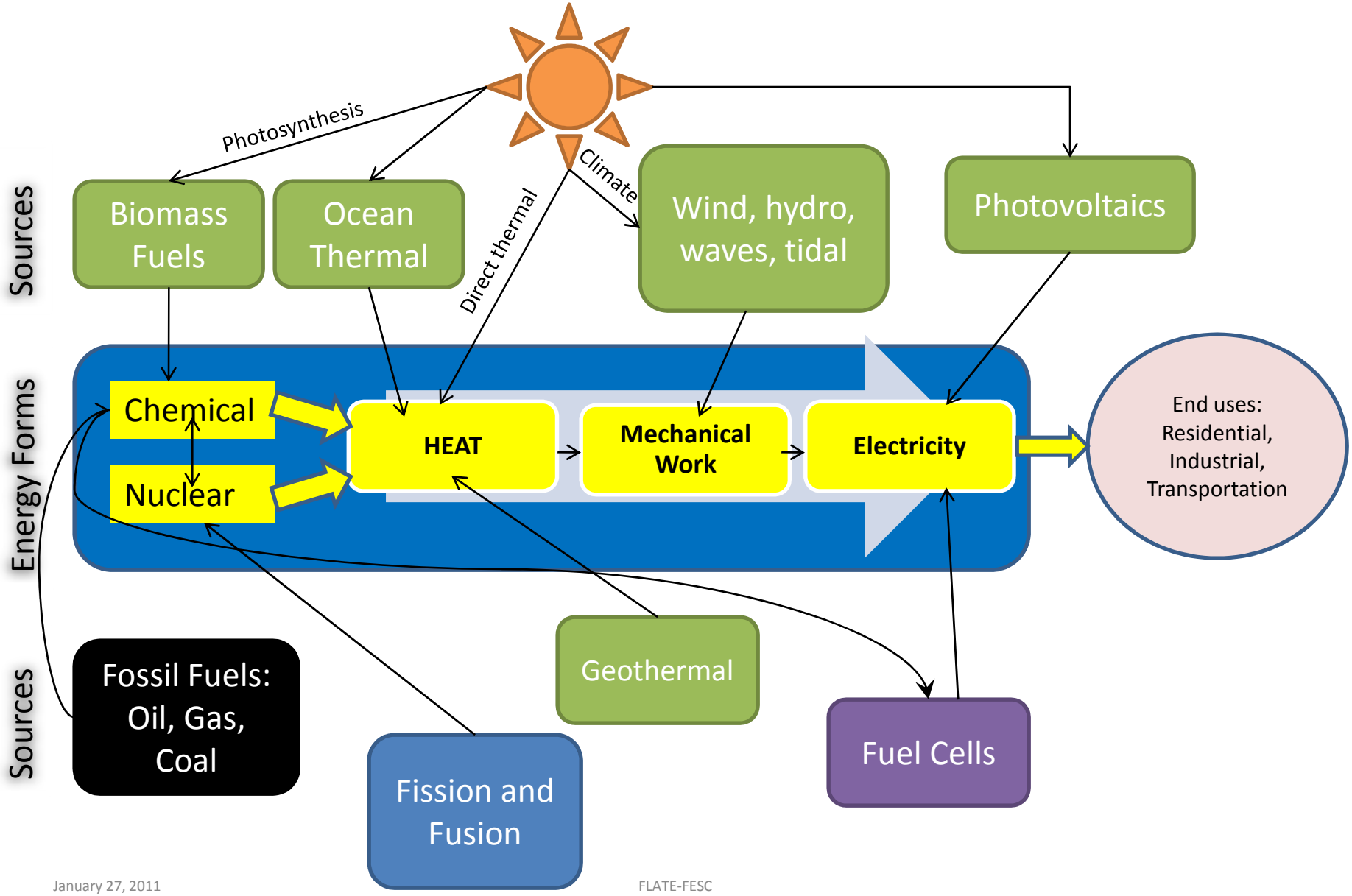
Note units.

Global averages of the concentrations of the major, well-mixed, long-lived greenhouse gases - carbon dioxide, methane, nitrous oxide, CFC-12 and CFC-11 from the NOAA global flask sampling network since the beginning of 1979. These gases account for about 96% of the direct radiative forcing by long-lived greenhouse gases since 1750. The remaining 4% is contributed by an assortment of 15 minor halogenated gases . Methane data prior to 1983 are annual averages from *Etheridge et al. (1998)*, adjusted to the NOAA calibration scale *[Dlugokencky et al., 2005]*.

Policy

- To address both the environmental and energy import dependencies, alternative energy seems a good option.
- However, costs, production capacities, regional natural resources and technological advancements must be weighed.
- The following slides review technology costs and regional natural resources.

Energy Sources and Conversion Processes



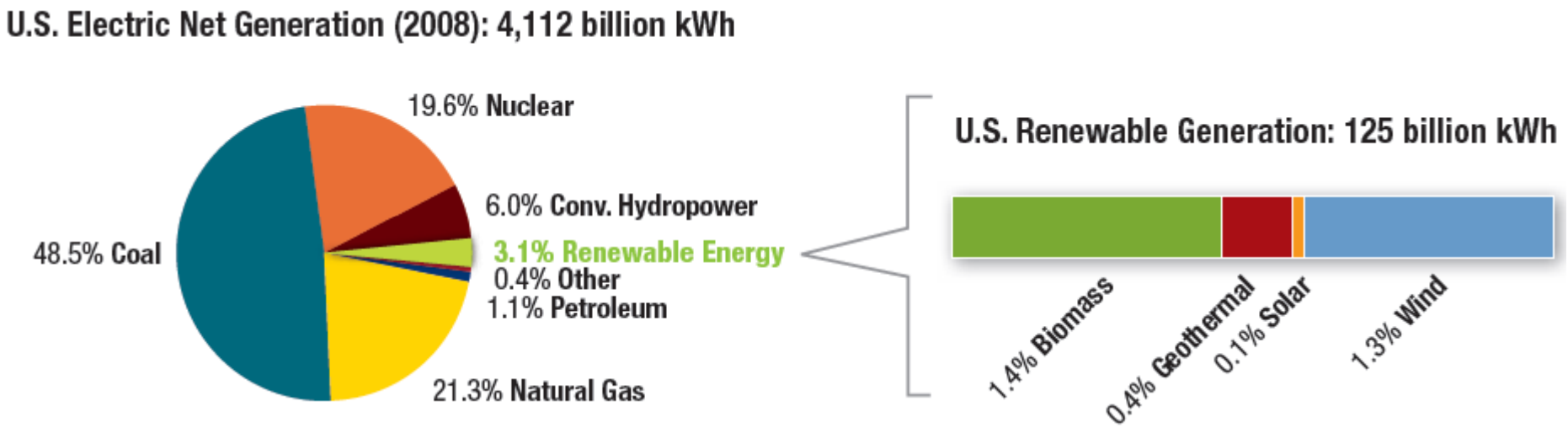
Source: Sustainable Energy: Choosing Among Options, J.W. Tester, et. al, MIT Press, 2005, adapted

Alternative and Renewable

	Non renewable	Renewable
Conventional	Coal Oil Gas	Wood Hydropower Human/Animal
Alternative	Oil Shale Tar Sands Nuclear Fission Geothermal	Wind Solar Biomass Wave/Tide Ocean Thermal

Source: FIT, Renewable Energy course, spring 2010

Renewable Energy's Share of Electricity Generation

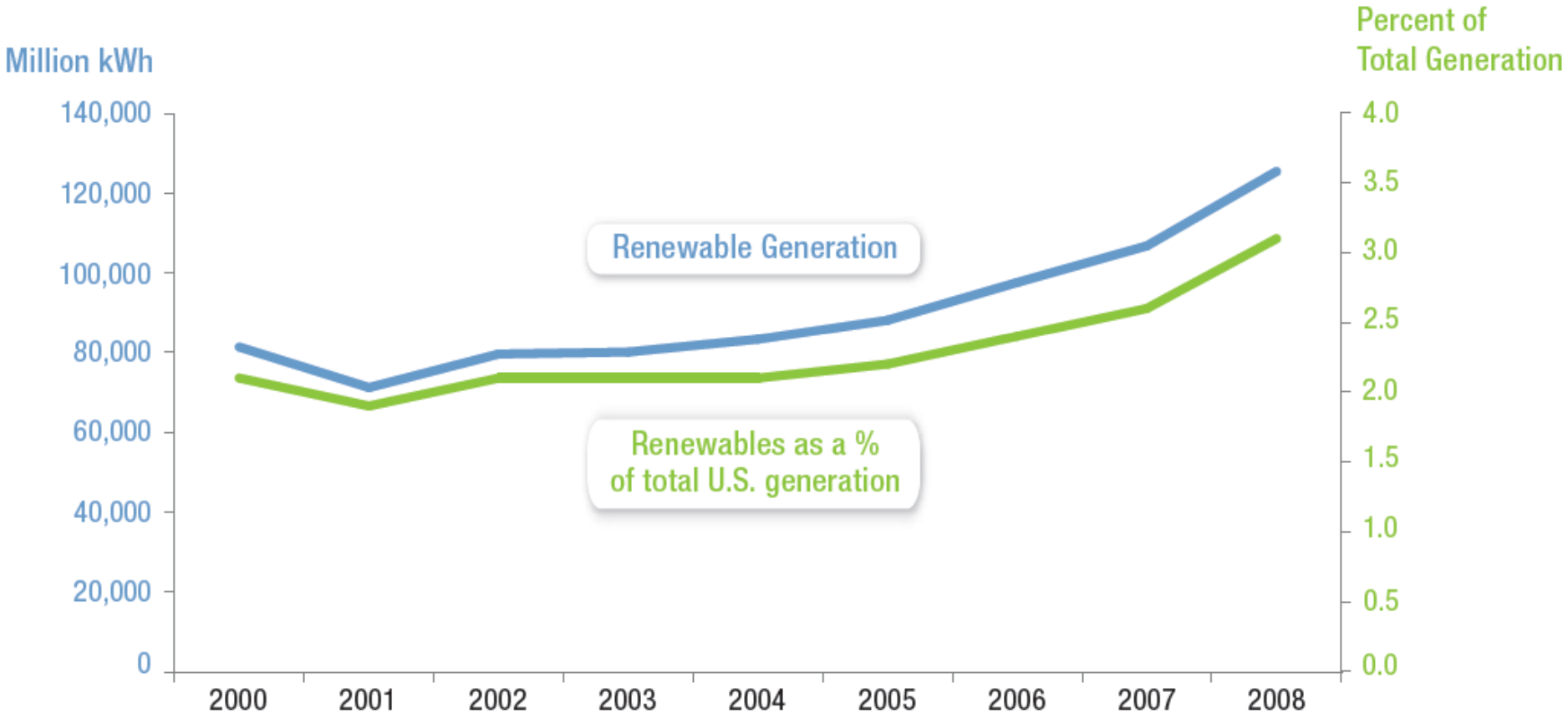


For all the hype, solar made up only 0.1% of US electricity generation and wind 1.3% in 2008.

Source: EERE, 2008 Renewable Energy Data Book, July 2009.

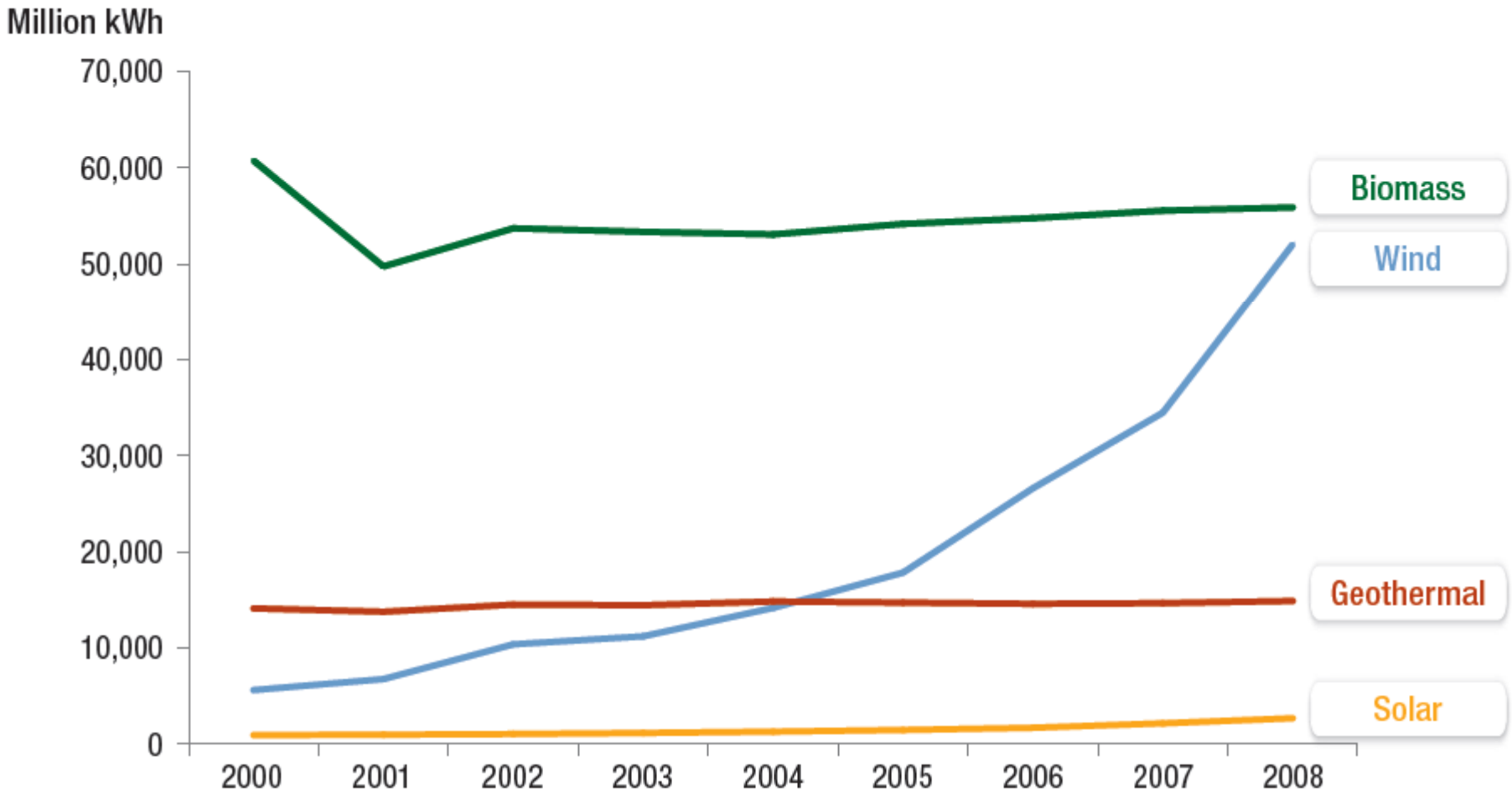
US Renewable Electricity Generation

(Excluding hydropower)



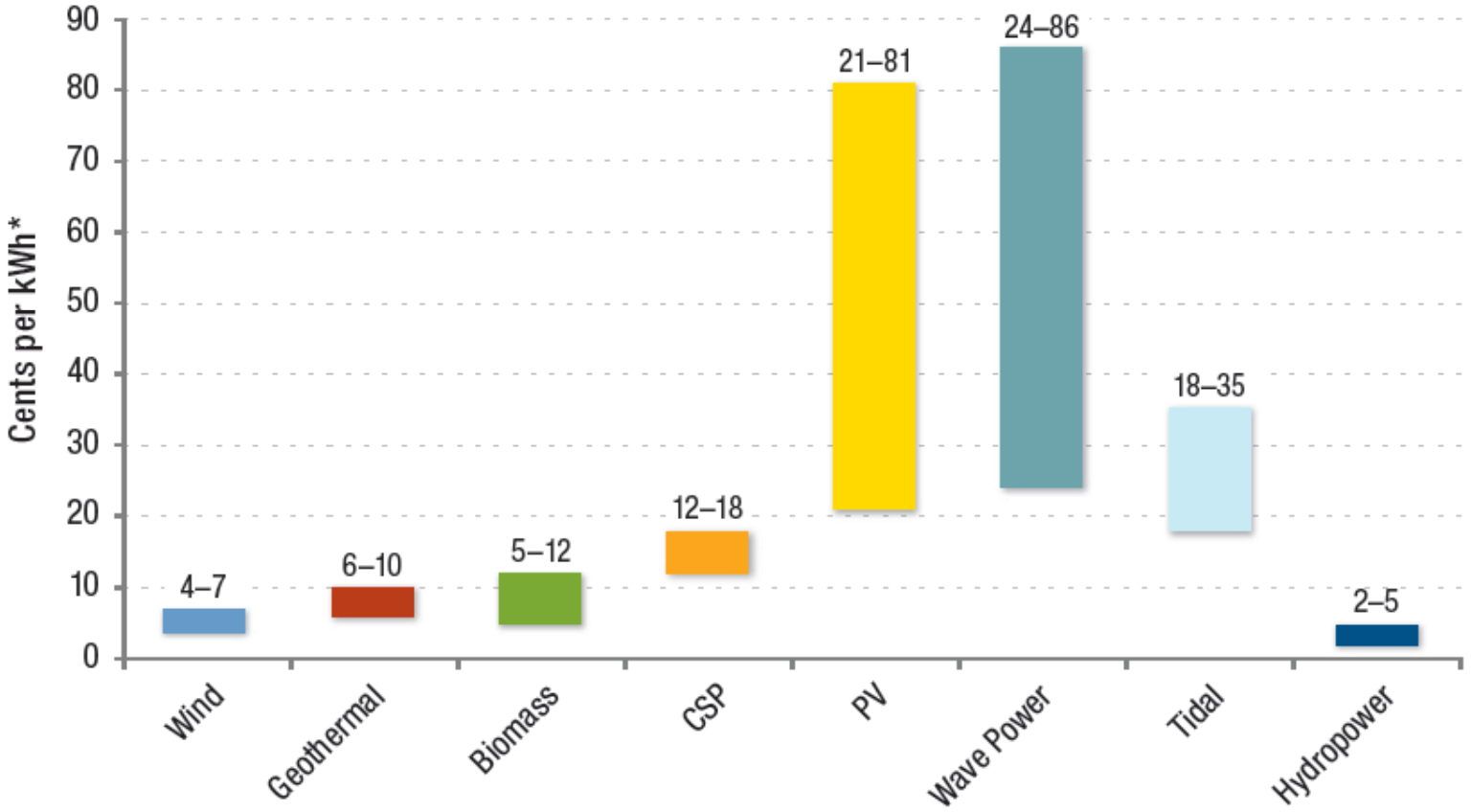
Source: EERE, 2008 Renewable Energy Data Book, July 2009.

US Renewable Generation by Technology (Excluding hydropower)



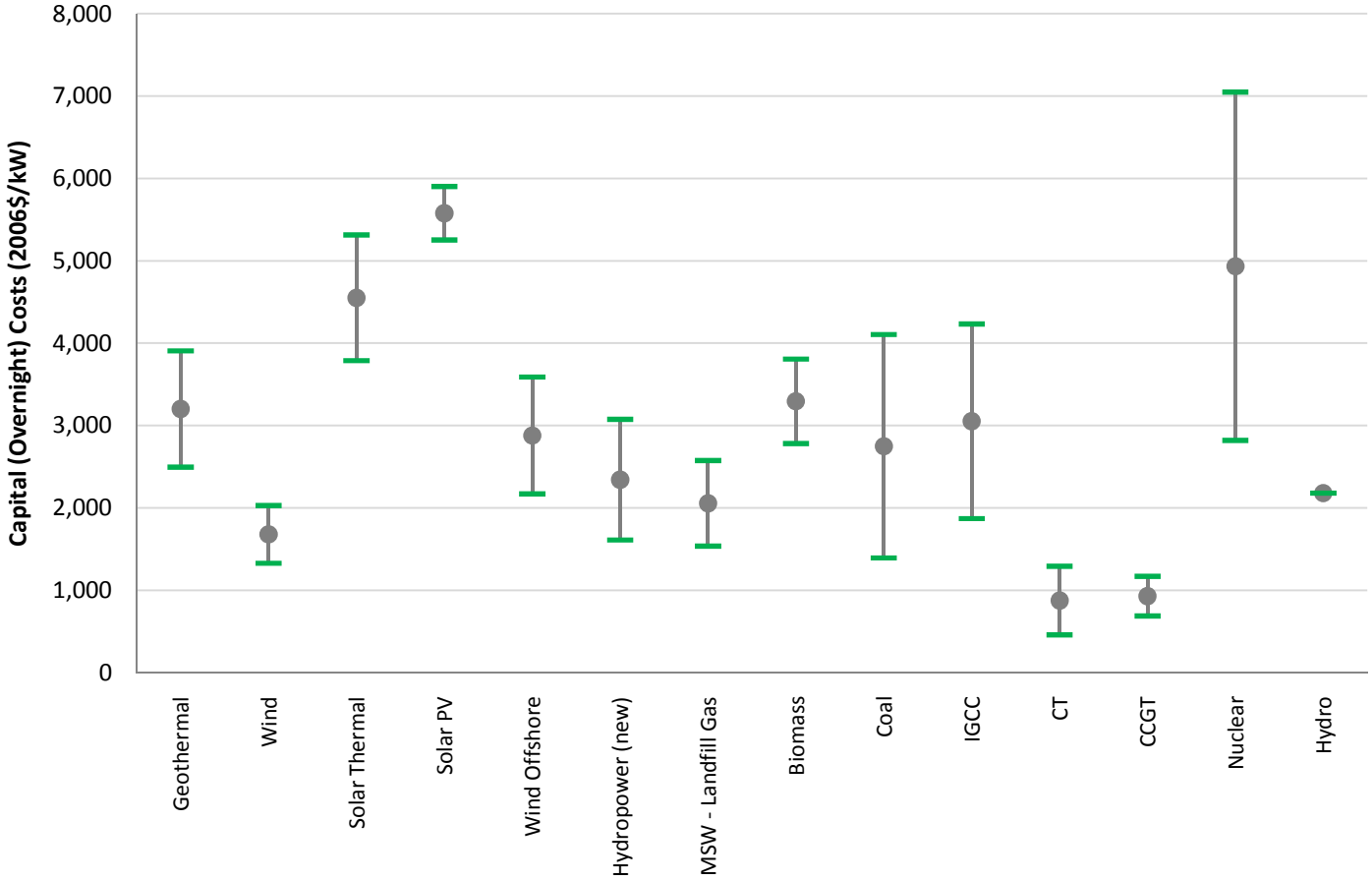
Source: EERE, 2008 Renewable Energy Data Book, July 2009.

Price range of renewable electricity by technology



Source: EERE, 2008 Renewable Energy Data Book, July 2009.

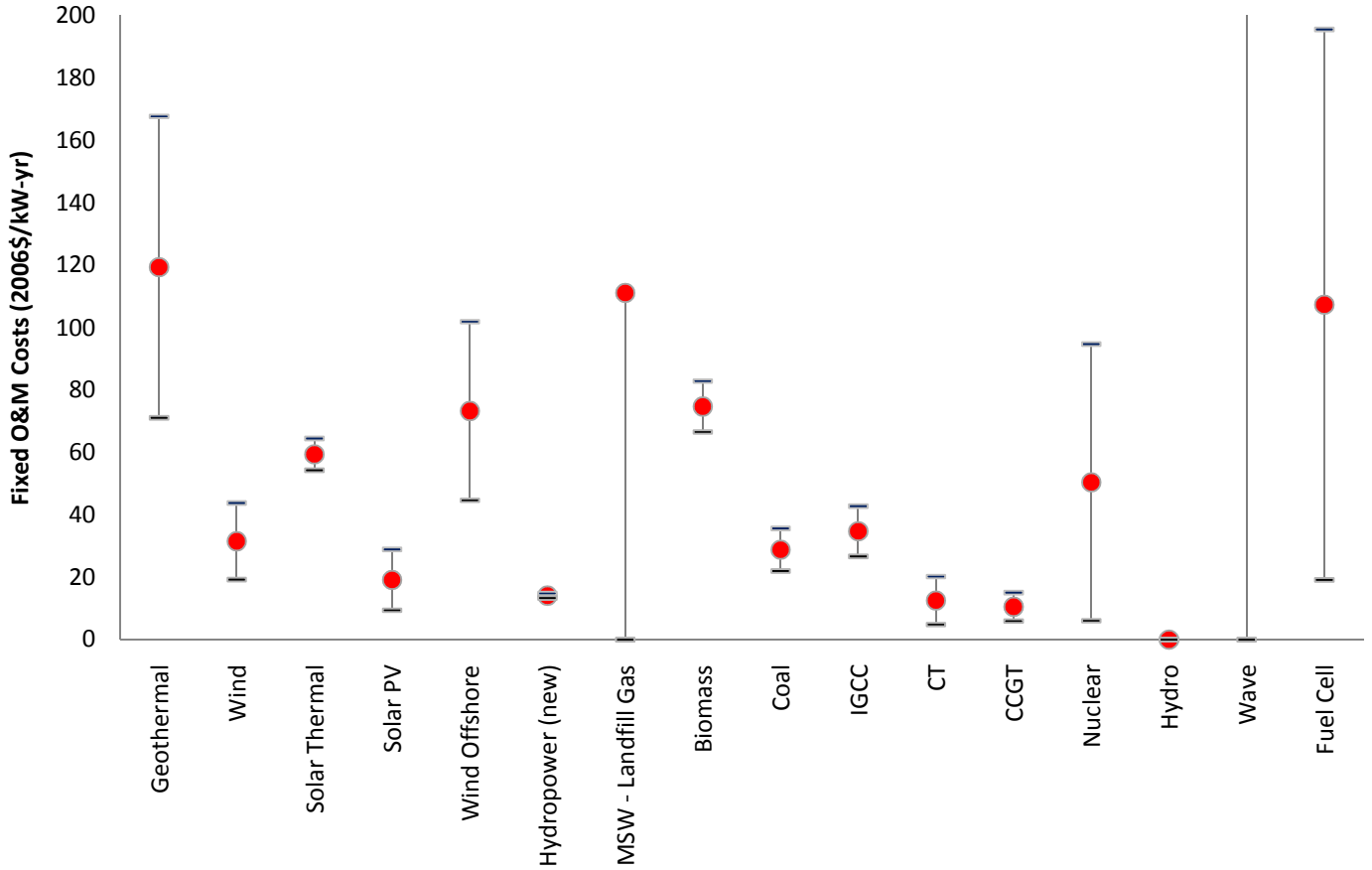
Total “Overnight” Costs in 2007-2008



Overnight cost is the cost of a construction project if no interest was incurred during construction, as if the project was completed "overnight."

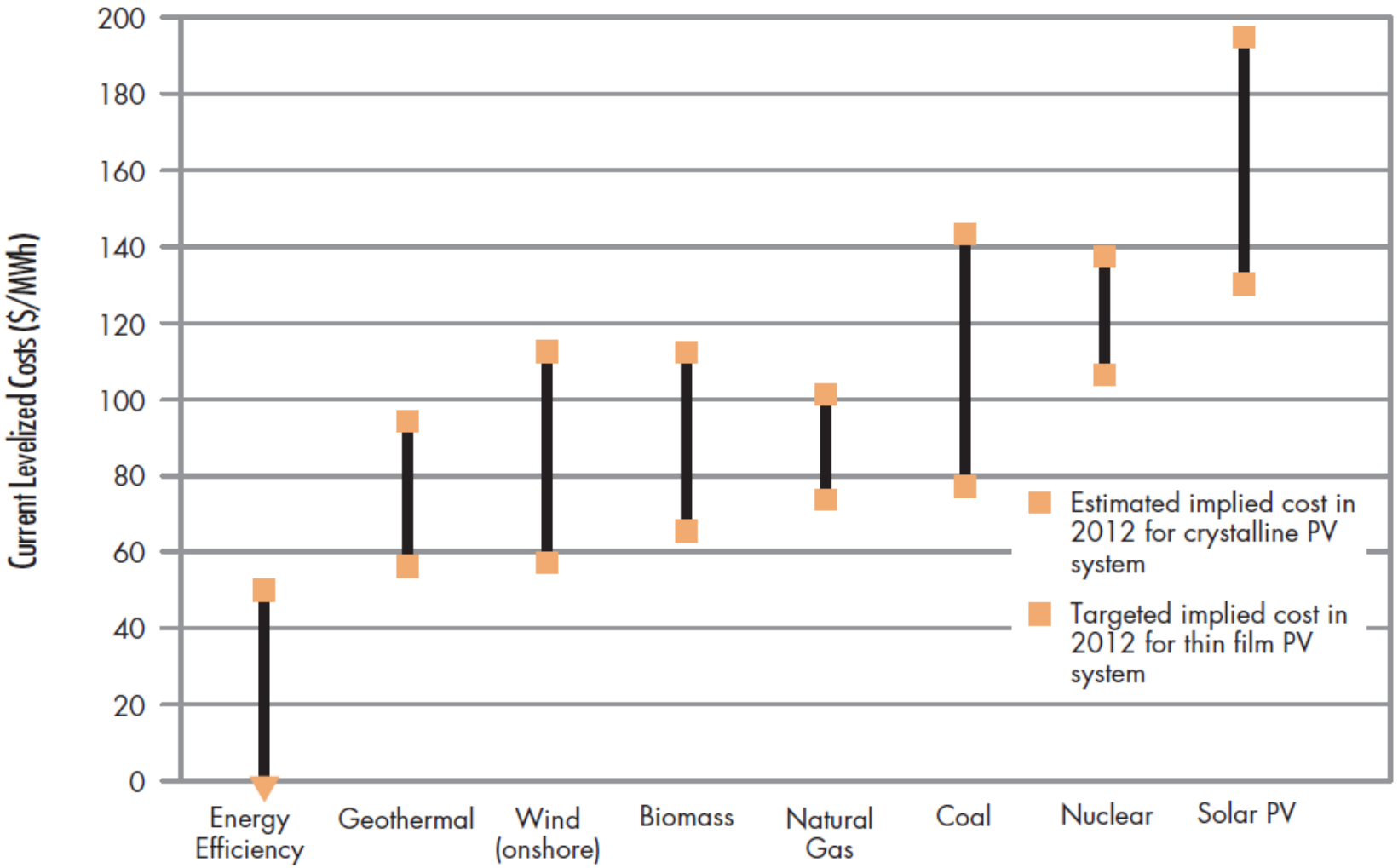
http://vibe.nrel.gov/files/datasets/1692/re_costs_20090806.xls

Fixed Operating & Maintenance Costs in 2007-2008



http://vibe.nrel.gov/files/datasets/1692/re_costs_20090806.xls

Figure 2. Levelized cost of new power generation technologies in 2008

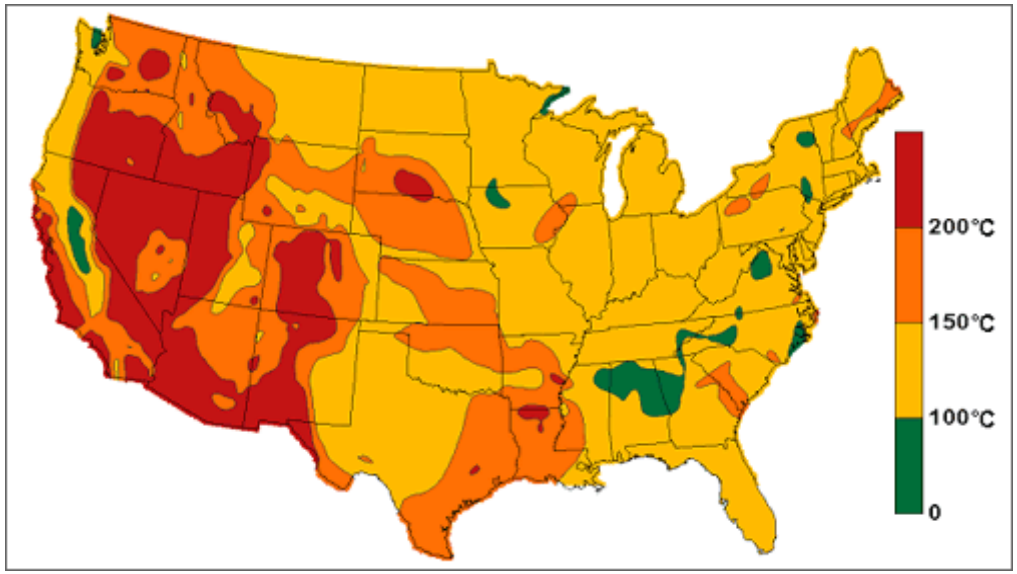


Note: Costs have been levelized over the lifetime of the technology and include construction, fuel, and operation and maintenance costs. The bars represent typical cost ranges at average capacity factors for each technology.

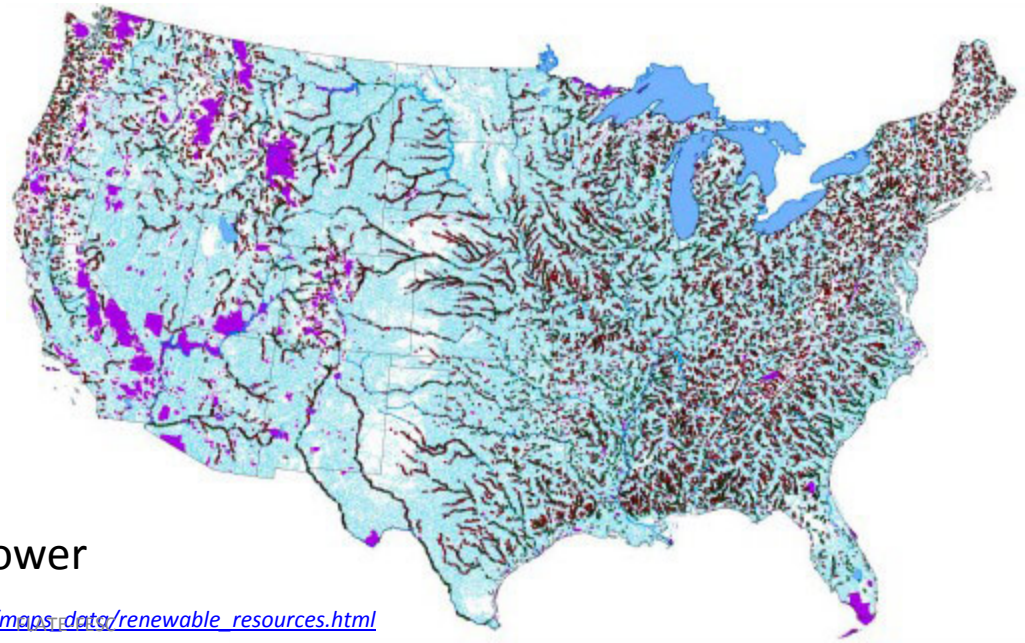
Source: Lazard. February 2009. Levelized Cost of Energy Analysis, Version 3.0.

<blog.cleanenergy.org/files/2009/04/lazard2009_levelizedcostofenergy.pdf> .

Renewable Energy Resources: Geothermal and Hydropower



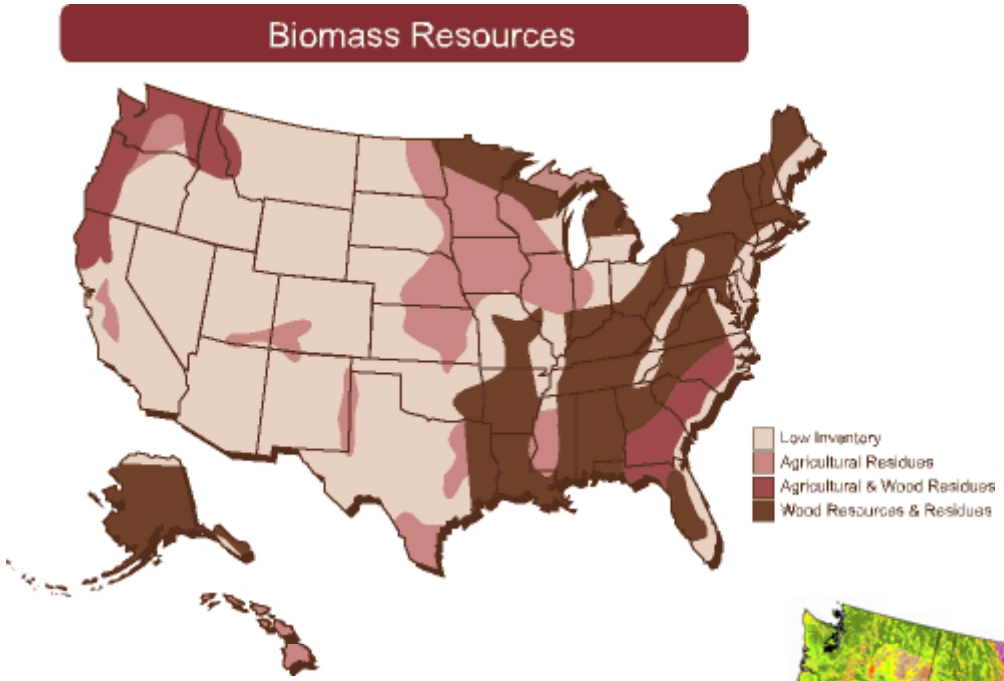
Geothermal

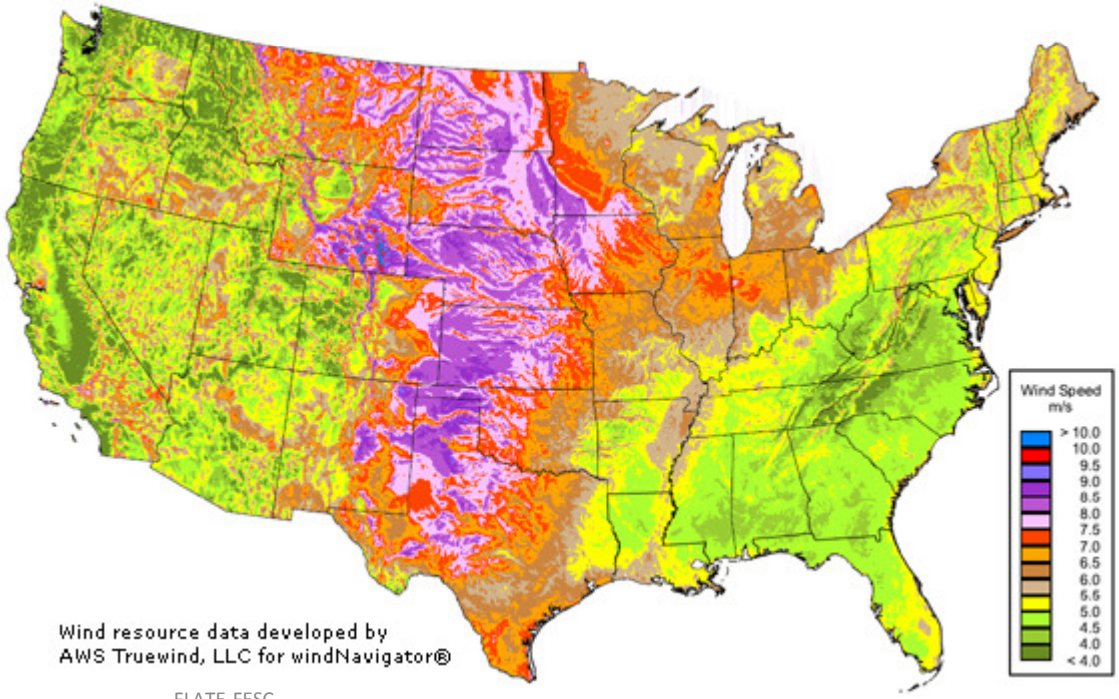


Hydropower

Source: http://www1.eere.energy.gov/maps_data/renewable_resources.html

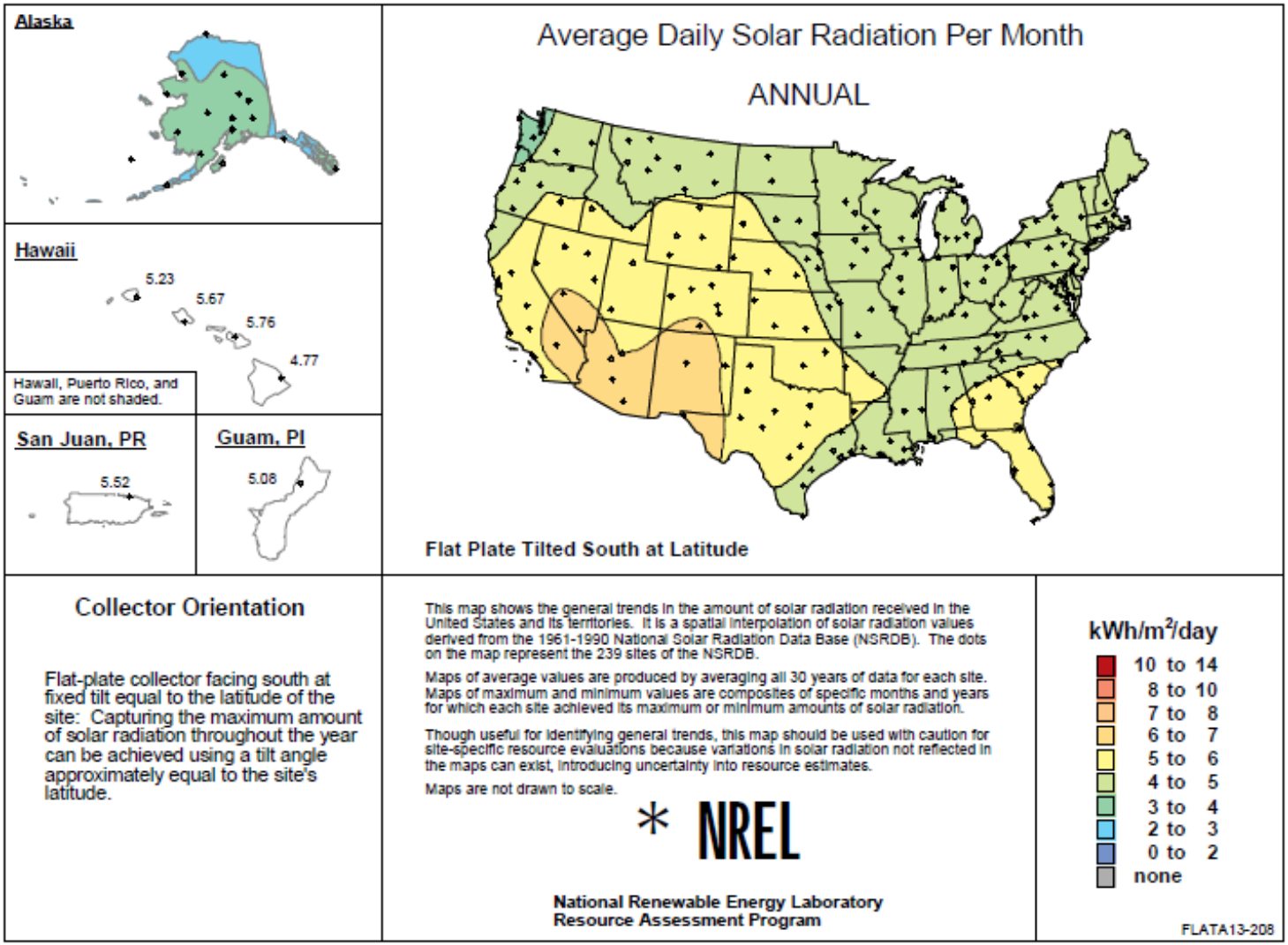
Renewable Energy Resources: Biomass and Wind





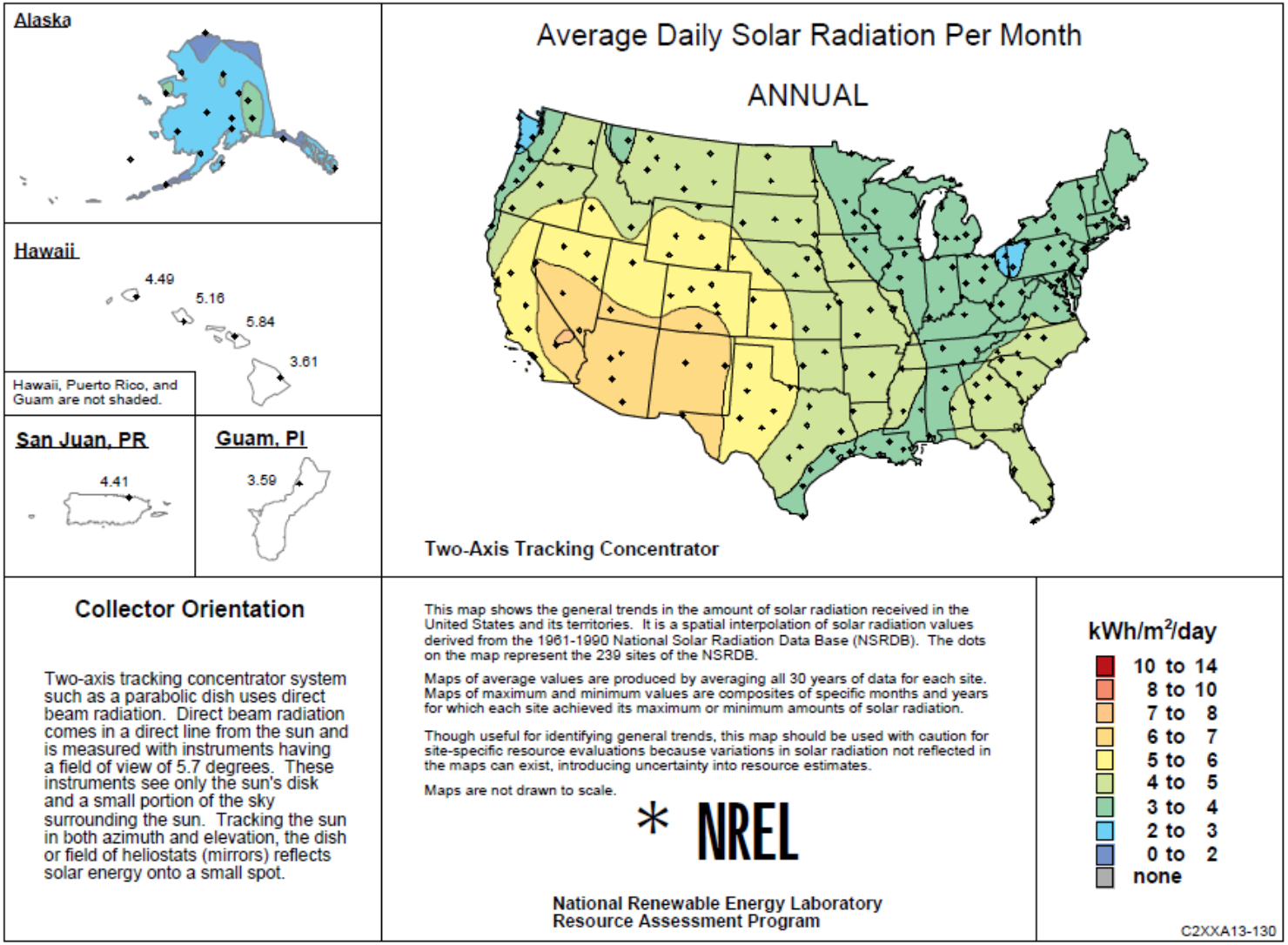
Source: http://www1.eere.energy.gov/maps_data/renewable_resources.html

Renewable Energy Resources: Solar Photovoltaic



Source: http://www1.eere.energy.gov/maps_data/renewable_resources.html

Renewable Energy Resources: Solar Thermal



Source: http://www1.eere.energy.gov/maps_data/renewable_resources.html

US Policy History

US Policy History

- Growth in demand for electrical services began in earnest during the early part of the 20th century soon after the first few power stations opened up in 1882 in the US and UK.

- The Federal Power Commission (FPC) was originally founded in 1920 to coordinate federal hydropower development, but later evolved to regulate the nascent electrical power industry, including natural gas.

- As demand for energy grew and more power plants came online, pollution became apparent. The US National Environmental Policy Act of 1969 established the US Environmental Protection Agency to protect public health and the environment.

Source: Sustainable Energy: Choosing Among Options, J.W. Tester, et. al, MIT Press, 2005, adapted

US Policy History

- Starting in 1973-1974 the US suffered through what is known as the 1973 Oil Crisis (or oil embargo). OPEC plus Egypt, Syria and Tunisia proclaimed an oil embargo in response to the US decision to re-supply the Israeli military during the Yom Kippur war.

- After the oil crisis, the Department of Energy (DOE) was formed through legislation signed by President Jimmy Carter called the Department of Energy Organization Act of 1977.

- In the same year, the FPC was renamed and taken into DOE as the Federal Energy Regulatory Commission (FERC), with its independent agency status intact.

Source: Sustainable Energy: Choosing Among Options, J.W. Tester, et. al, MIT Press, 2005, adapted

US Policy History

- US Congress followed up with enactment the National Energy Act of 1978.
  - The NEA 1978 entailed passage of the Public Utility Regulatory Policy Act (PURPA).
  - PURPA
    - Goals of PURPA were to:
      (1.) Reduce dependence on foreign oil
      (2.) Promote Alternative energy sources and energy efficiency
      (3.) Diversify the electric power industry
    - Though it was difficult to unbundle the utility infrastructure, the regulatory strategy was to allow entry of new power generators into the a competitive power market.
    - Provisions for PURPA allowed small generators to sell power back to the local utility at a pre-assigned price.

Automobile Standards

Corporate Average Fuel Economy (CAFE)

- Regulations first enacted by US Congress in 1975, and intended to improve the average fuel economy of cars and light trucks (trucks, vans and sport utility vehicles) sold in the US in the wake of the 1973 Arab Oil Embargo.
- **The standard is expressed in miles per gallon (mpg).**
- In late 2007, CAFE standards received their first overhaul in more than 30 years. It requires automakers to boost fleet-wide gas mileage to 35 mpg by the year 2020. This requirement applies to all passenger automobiles, including "light trucks."

http://www.nhtsa.gov/fuel-economy

CAFE STANDARDS

MODEL YEAR	PASSENGER CARS	LIGHT TRUCKS		
		COMBINED	2WD	4WD
1978	18.0			
1979	19.0		17.2	15.8
1980	20.0		16.0	14.0
1981	22.0		16.7	15.0
1982	24.0	17.5	18.0	16.0
1983	26.0	19.0	19.5	17.5
1984	27.0	20.0	20.3	18.5
1985	27.5	19.5	19.7	18.9
1986	26.0	20.0	20.5	19.5
1987	26.0	20.5	21.0	19.5
1988	26.0	20.5	21.0	19.5
1989	26.5	20.5	21.5	19.0
1990	27.5	20.0	20.5	19.0
1991	27.5	20.2	20.7	19.1
1992	27.5	20.2		
1993	27.5	20.4		
1994	27.5	20.5		
1995	27.5	20.6		
1996	27.5	20.7		
1997	27.5	20.7		
1998	27.5	20.7		
1999	27.5	20.7		
2000	27.5	20.7		
2001	27.5	20.7		
2002	27.5	20.7		
2003	27.5	20.7		
2004	27.5	20.7		
2005	27.5	21.0		
2006	27.5	21.6		
2007	27.5	22.2		
2008	27.5	22.5*		
2009	27.5	23.1*		
2010	27.5	23.5*		

US Policy History

- The Energy Policy Act of 1992 was enacted by the 102nd congress.
  - The law mandated that the FERC open up the national electricity transmission system to wholesale suppliers on a case-by-case basis.
  - These provisions eliminated a major barrier power producers who wanted to compete to build new non-rate-based power plants.
  - Most of these plants were expected to be gas turbines because of the lower upfront capital costs compared with those of large coal-fired plants.
  - The Act also encouraged investment in energy efficiency by electric utilities and provided efficiency grants to state regulatory agencies.
  - It also encouraged
    - Residential and Building efficiency and use of alternative fueled vehicles by Federal Vehicle Fleets.
    - Demonstration and use of electric vehicles.
    - Mandated government R&D, demonstration and commercialization of clean coal technologies.

US Policy History

- The Energy Policy Act of 2005 was enacted by the 109th congress
- Major Points
  - Provides revised ANNUAL energy reduction goals (2% per year beginning in FY 2006) for federal government.
  - Provides revised renewable energy purchase goals.
  - Reauthorizes Energy Savings Performance Contracts (ESPCs) until October 1, 2016.
  - Requires federal procurement of ENERGY STAR® or FEMP-designated products.
  - Updates federal green building standards with emphasis on energy efficiency and sustainable design principles(TBD).
  - Mandates a variety of research and demonstration activities to stimulate the market for fuel cell vehicles and hydrogen energy systems (TBD) .
  - Moved the start and end of Daylight Savings Time, previously set in 1966.

Florida Policy

- 2006 Florida Energy Act
  - Signed by Governor Jeb Bush
  - This four-year plan provided rebates, grants and tax incentives to create an diversified energy portfolio by increasing Florida's investment in renewable energy sources such as solar, hydrogen and biofuels.
  - Encourages diversity in new electric generation capacity by allowing the Public Service Commission to consider fuel diversity and fuel reliability, instead of cost alone, when reviewing electric generation permits.
  - Set aside $5M to fund rebates in two programs
    - The Energy Efficient Appliance Rebate Program providing consumer rebates for purchases of energy efficient ENERGY STAR appliances.
    - The Solar Energy Equipment Rebate Program reduced the initial costs for installations of photovoltaic and solar thermal technology on residential and commercial buildings.

Florida Policy

The 2008 Florida legislature passed HB1735: Among other things it created the Florida Energy Systems Consortium (FESC)

Florida Energy Systems Consortium

Created by Florida Statute to share energy related expertise and promote collaboration among the energy experts at its 11 public universities.

Goal

Uniting Florida's Universities to become a leader in energy research, education, technology, and energy systems analysis.

Vision

Florida Universities innovating for sustainable energy generation, distribution, and usage systems.

FESC
Florida Energy Systems Consortium

Policy Activity

- There have been several policies enacted that in effect address issues within the three “buckets” previously mentioned.
  - Energy Consumption : Efficiency policies.
  - Energy Production: PURPA, among others.
  - Environmental Impact of our Energy Consumption and Production: CAFE standards and other Environmental Laws and Regulations.
- Cap & Trade (or emission trading) is also being discussed as means of pollution abatement.

Cap & Trade

- Cap & Trade is a market-based approach used to control pollution by providing economic incentives for achieving reductions in the emissions of pollutants.
- In this scheme, a governing body sets a limit to the amount of a pollutant that can be emitted.
- The limit (or cap) is allocated or sold to firms in the form of emissions permits which represent the right to emit or discharge a specific volume of the specified pollutant.
- Firms are required to hold a number of permits (or *carbon credits*) equivalent to their emissions. The total number of permits cannot exceed the cap, limiting total emissions to that level.
- Firms that need to increase their emission permits must buy permits from those who require fewer permits. The transfer of permits is referred to as a trade.
- In effect, the buyer is paying a charge for polluting, while the seller is being rewarded for having reduced emissions.
- Thus, in theory, those who can reduce emissions most cheaply will do so, achieving the pollution reduction at the lowest cost to society.

Standby for additional policies aimed at addressing energy and environmental issues……

New technologies will be critical in addressing those issues facing us today…