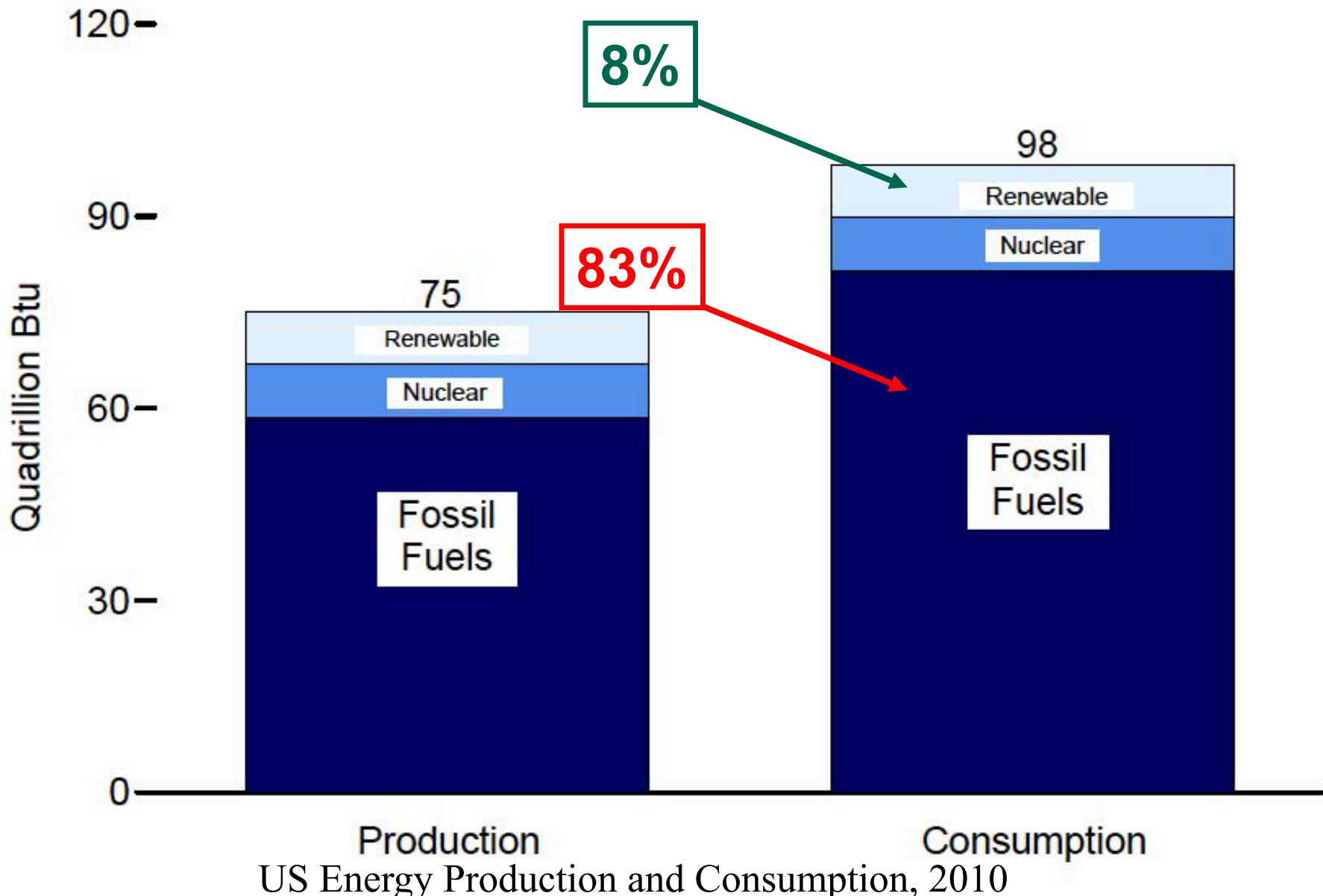


It's all about Energy!

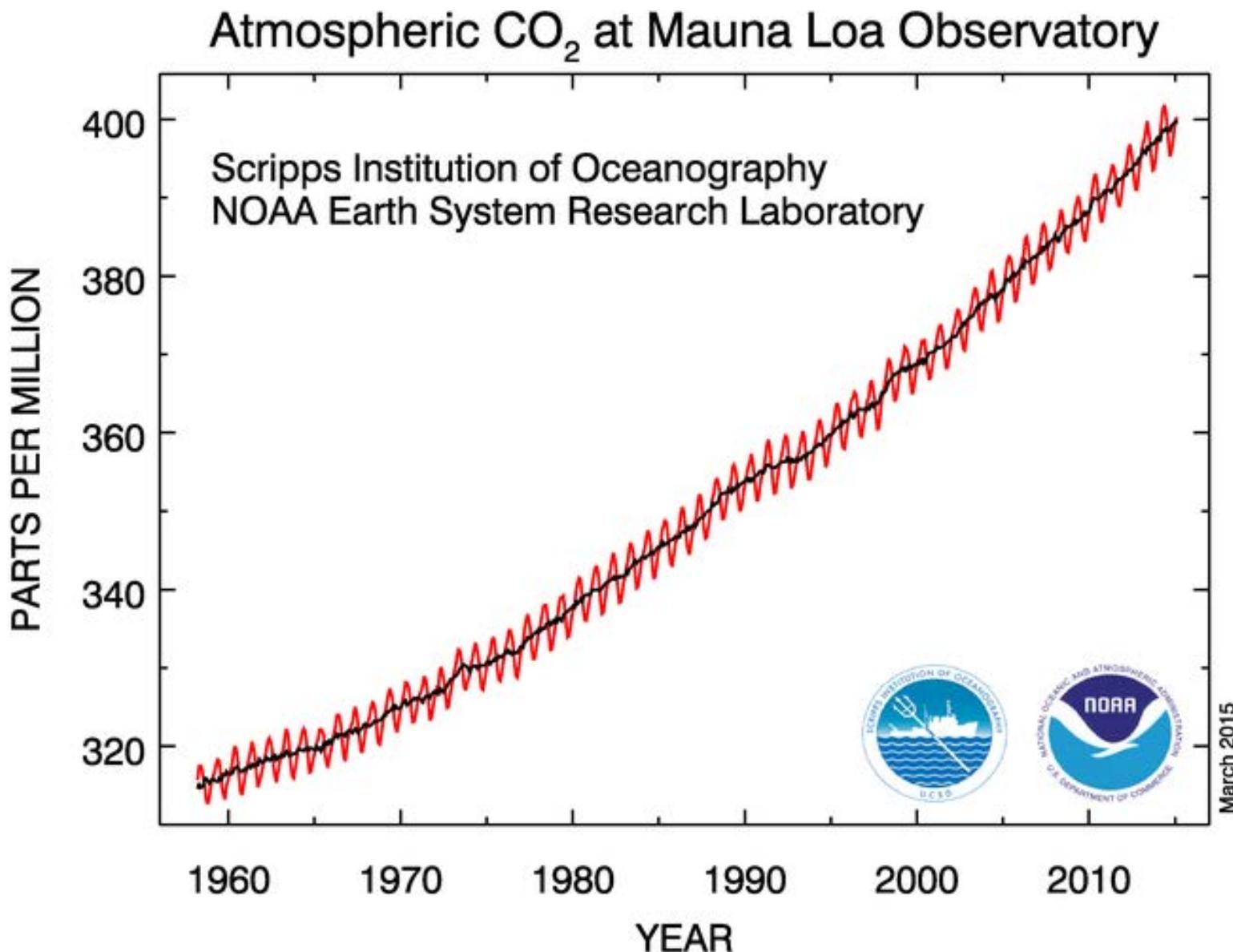


Steve Bertman
February 9, 2017

Where does US energy come from?



Most imported energy is petroleum

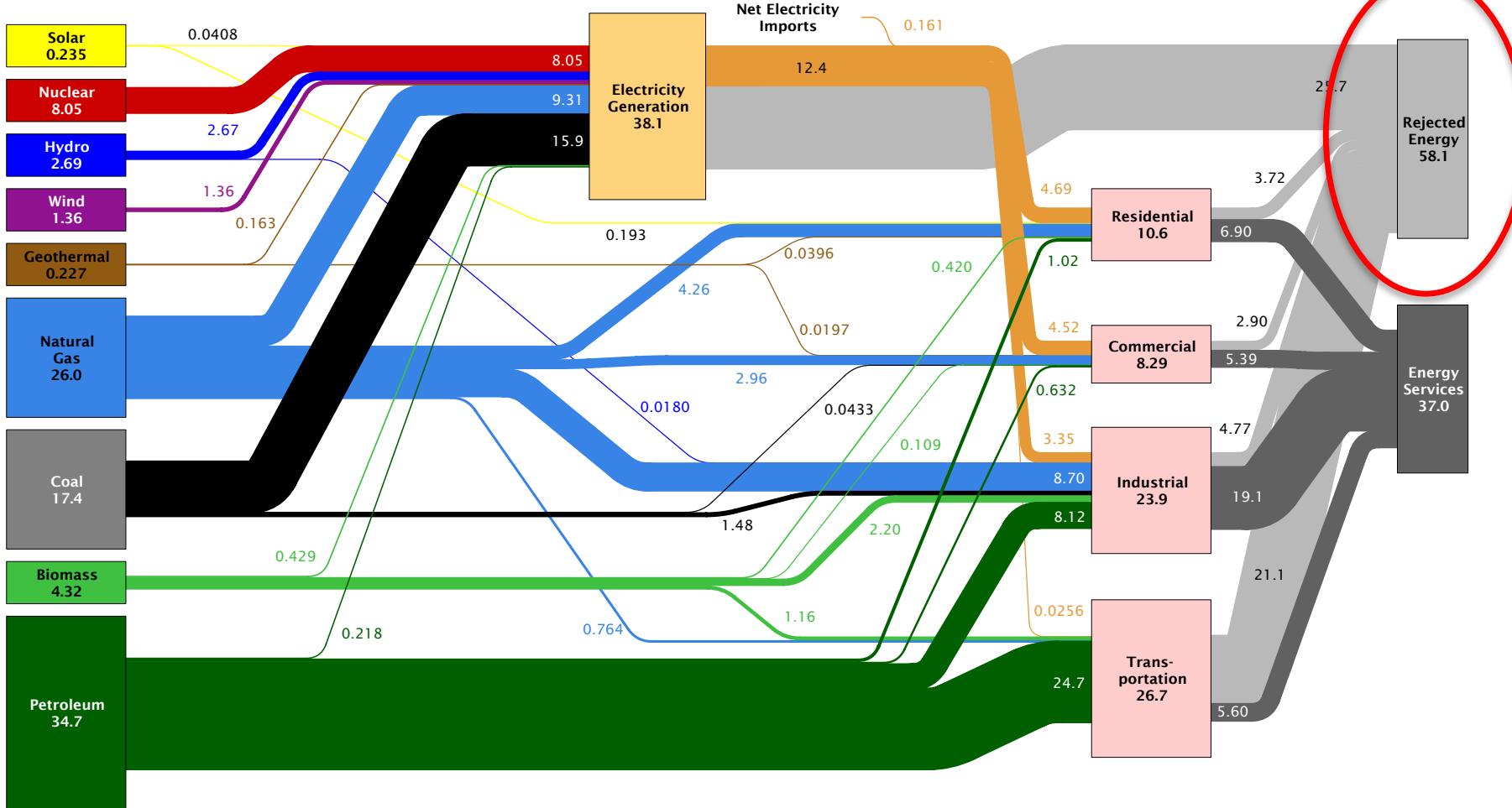


US Energy Flow (2012)

**“Rejected” Energy
(Waste)
58%**

 Lawrence Livermore
National Laboratory

Estimated U.S. Energy Use in 2012: ~95.1 Quads

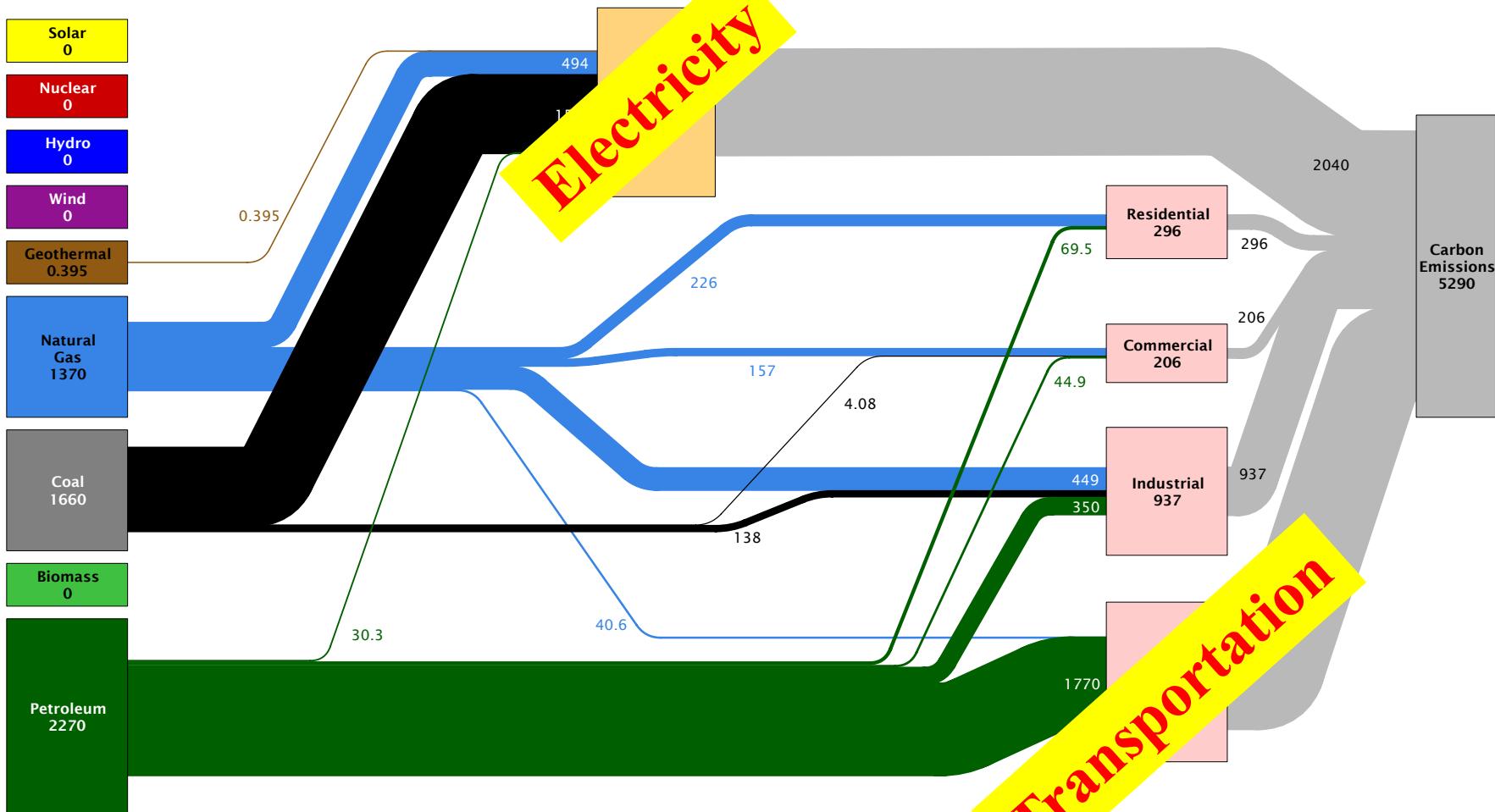


Source: LLNL 2013. Data is based on DOE/EIA-0035(2013-05), May, 2013. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity 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 65% for the residential and commercial sectors 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

US Energy Carbon Emission (2012)

Estimated U.S. Energy-Related
Carbon Dioxide Emissions in 2012: ~5,290 Million Metric Tons

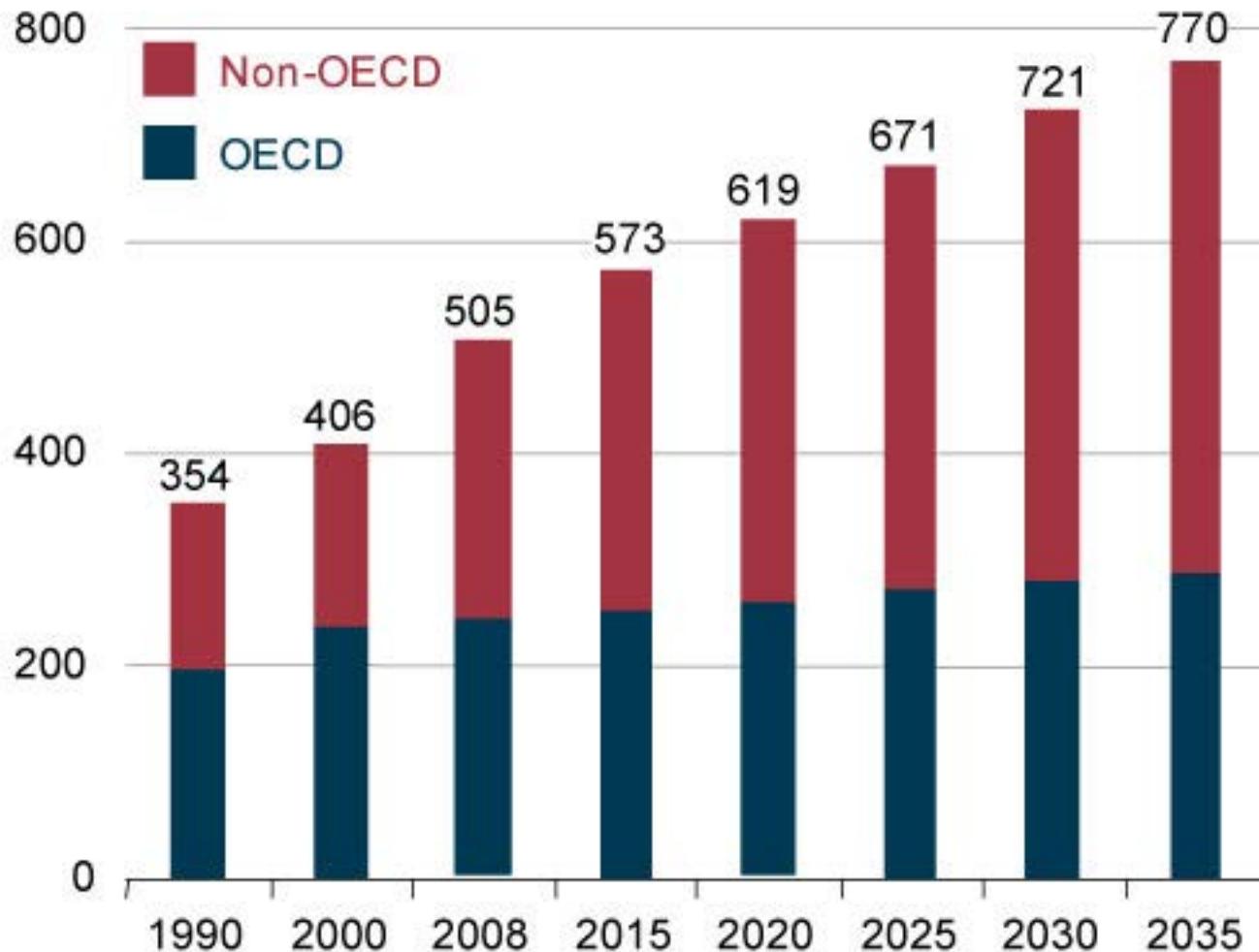
 Lawrence Livermore
National Laboratory



Source: LLNL 2013. Data is based on DOE/EIA-0035(2013-05), May, 2013. If this information or a reproduction of it is used, credit must be given to Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Carbon emissions are attributed to their physical source and are not allocated to end use for electricity consumption in the residential, commercial, industrial and transportation sectors. Petroleum consumption in the electric power sector includes the non-renewable portion of municipal solid waste. Combustion of biologically derived fuels is assumed to have zero net carbon emissions - the lifecycle emissions associated with producing biofuels are included in commercial and industrial emissions. Totals may not equal sum of components due to independent rounding errors. LLNL-MI-410527

World Energy Demand Drives GCC

INTERNATIONAL ENERGY OUTLOOK 2011



What is Renewable Energy?

Geothermal



Solar



Hydroelectric



Wind



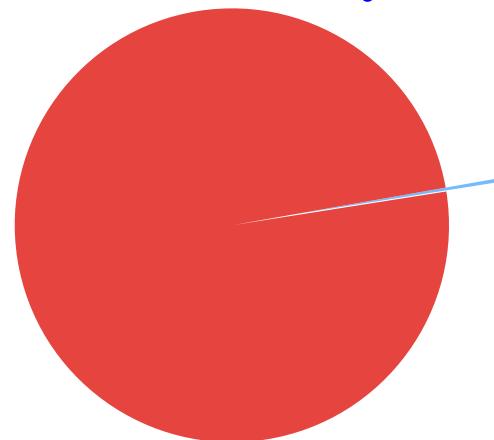
Biomass



Solar Technologies

More energy reaches earth from the sun in 1 hour than humans on the entire planet use in 1 year!

Annual solar energy flux
to continental US
(54,000 Quad)



Annual energy
use by USA
(0.2%)

Photovoltaics

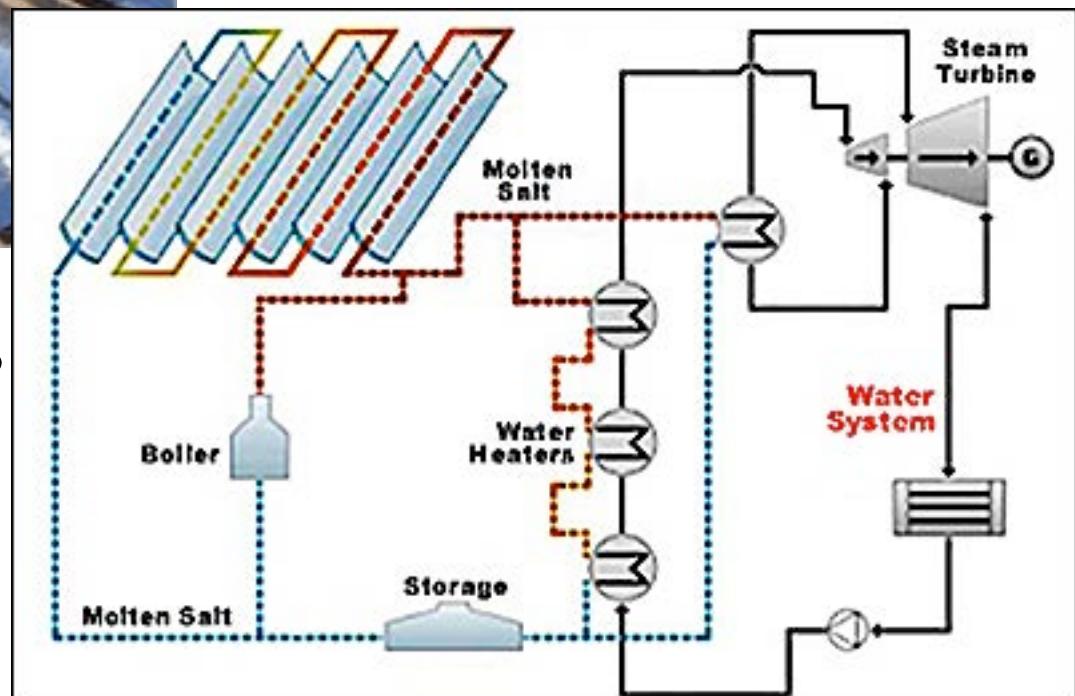


Several technologies available, such as polycrystalline or thin film.

Concentrating Solar Power



Parabolic concentrators



Source: www.solarcellcentral.com





U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis

Anthony Lopez, Billy Roberts, Donna Heimiller,
Nate Blair, and Gian Porro

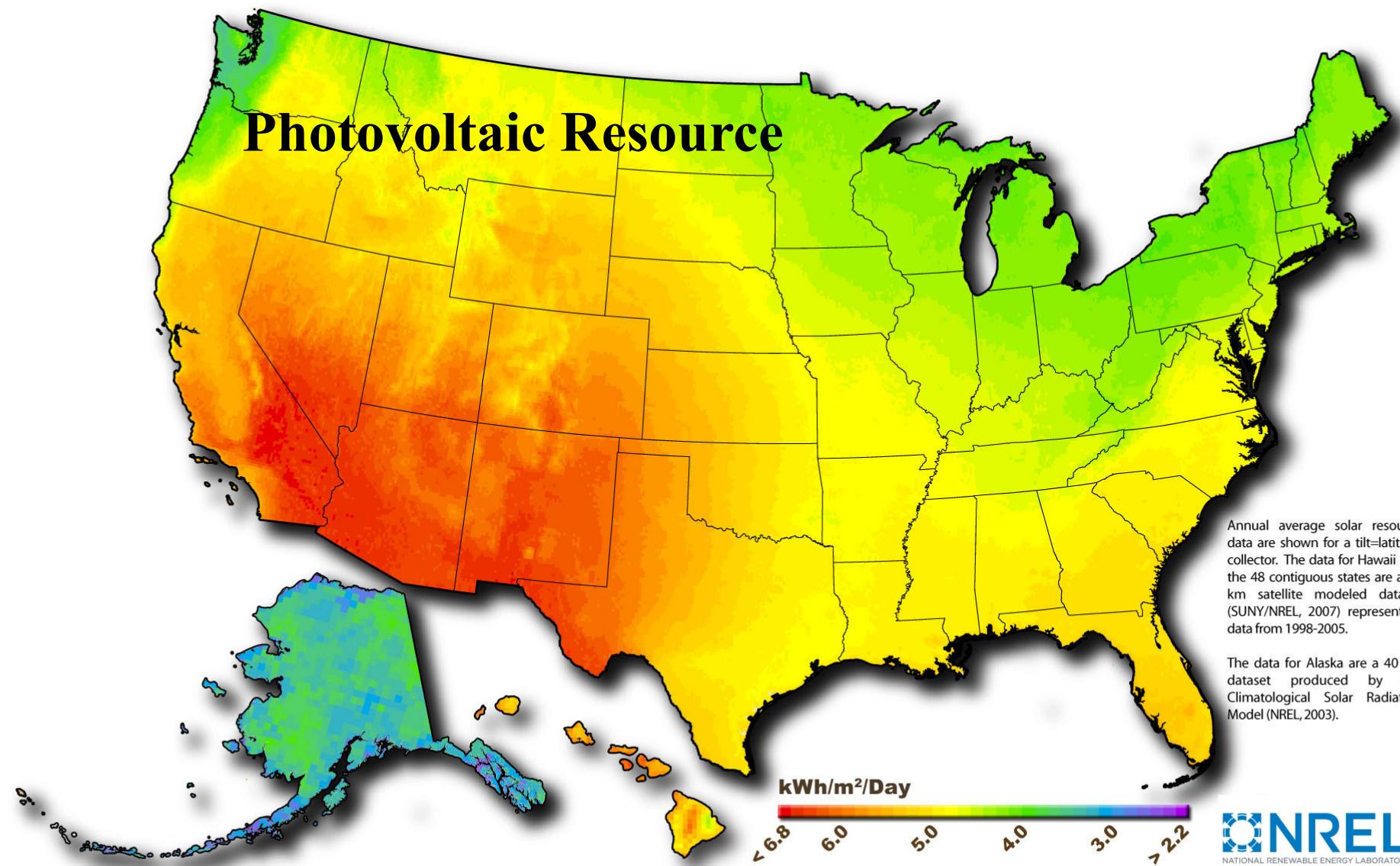
July 2012

U.S. Renewable Resources

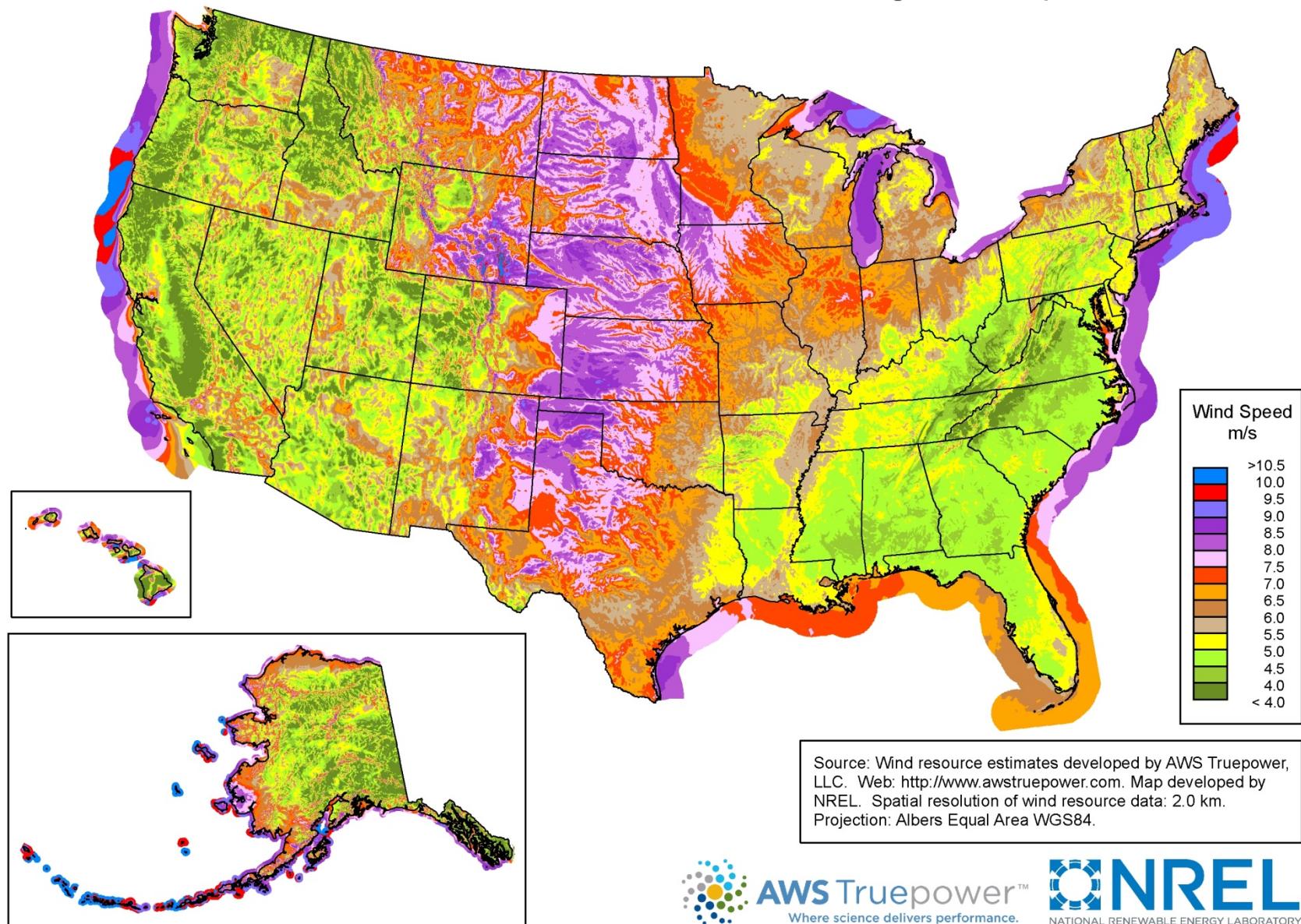
Resource	Solar PV/CSP)	Wind	Geothermal	Water Power	Biopower
Theoretical Potential	155,000 GW (PV) 38,000GW (CSP)	11,000 GW (onshore) 4,200 GW (offshore to 50 nm)	38 GW (conventional) 4,000 GW (EGS)	68 GW	62 GW

Meeting current US Energy demand requires approximately 3400 GW generation capacity

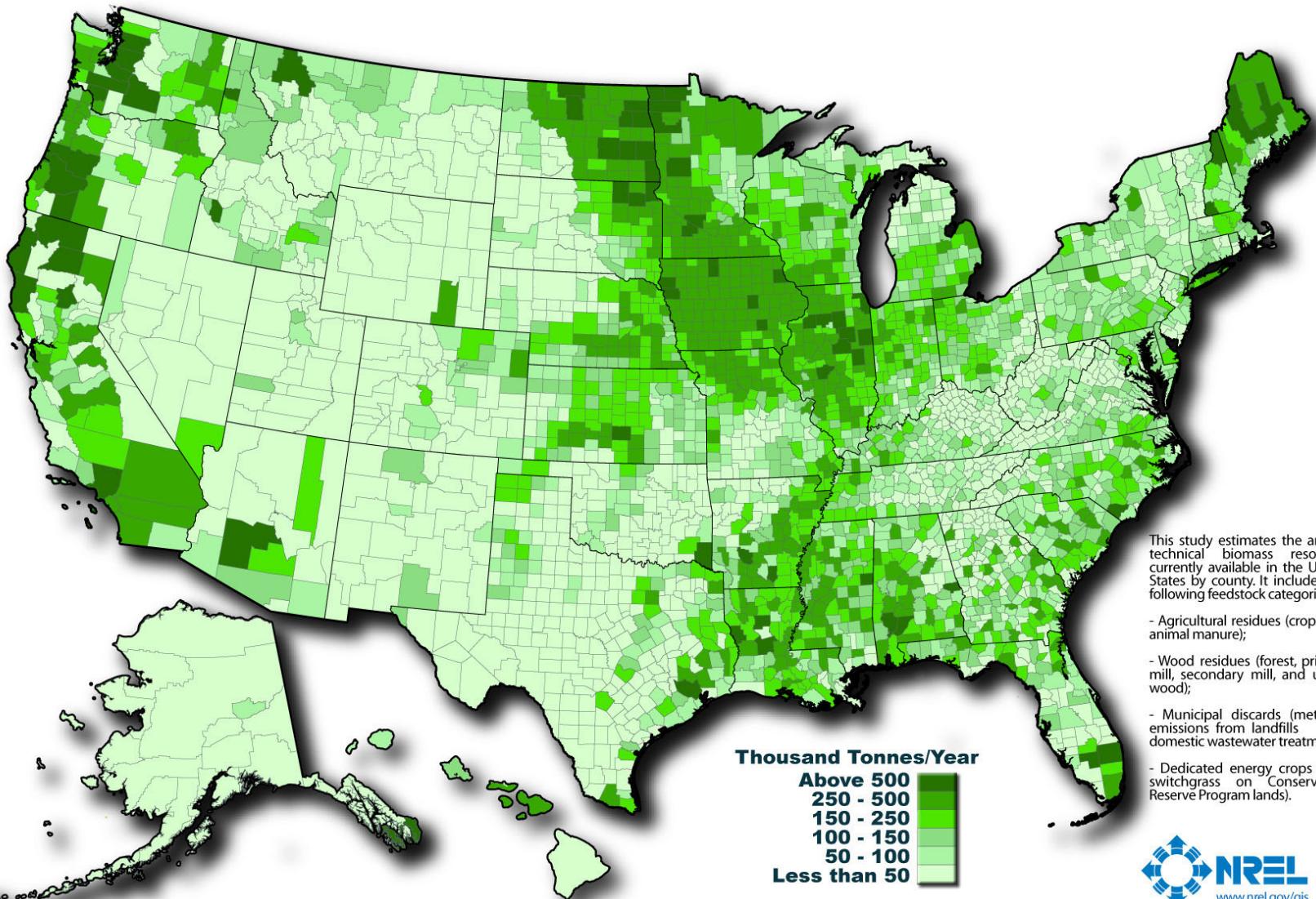
Solar resource not equally distributed



U.S. Wind Resource (80m)



U.S. Biomass Resource

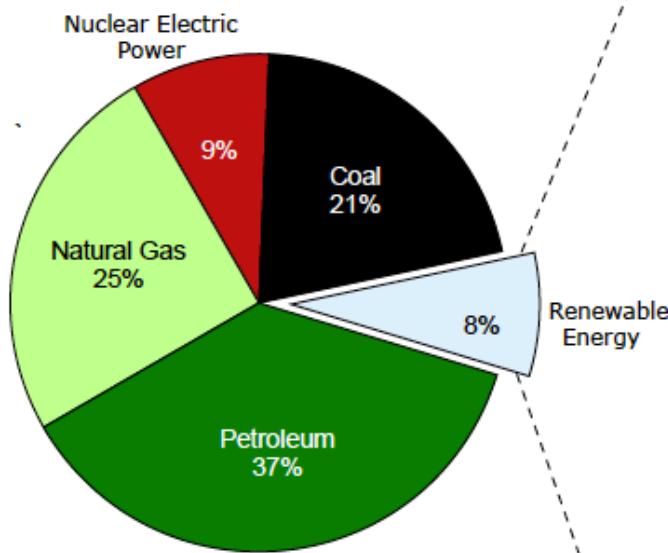


Author :Billy Roberts - October 20, 2008

This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.
See additional documentation for more information at <http://www.nrel.gov/docs/fy06osti/39181.pdf>



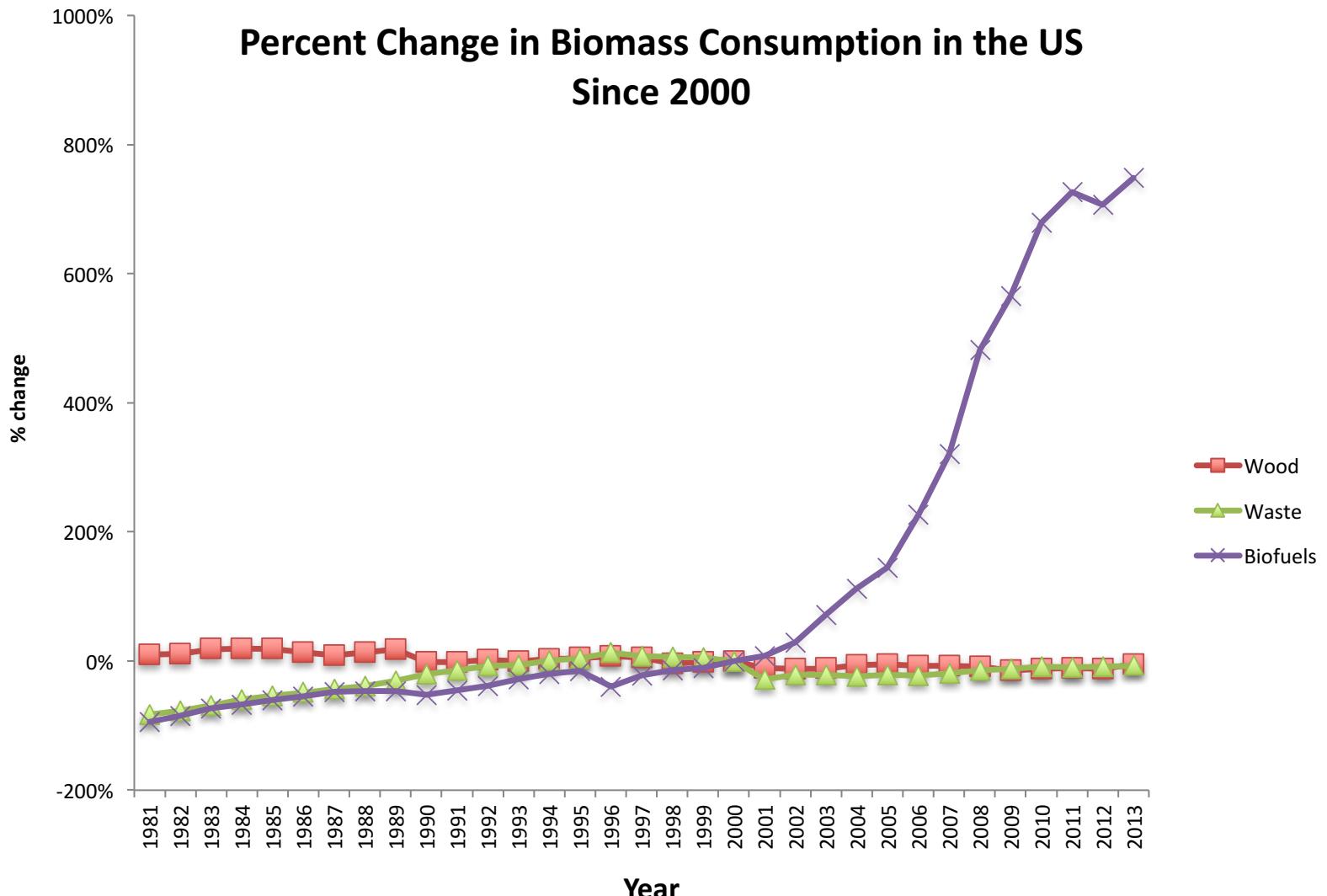
Biomass, one way to store solar energy, is now #1 renewable



Biofuels
+
Wood
+
Waste
=

54%

Biofuels “drive” biomass energy



Major Biomass-Derived Liquid Fuels

For gasoline engines:

Methanol, Ethanol, Butanol

For diesel engines:

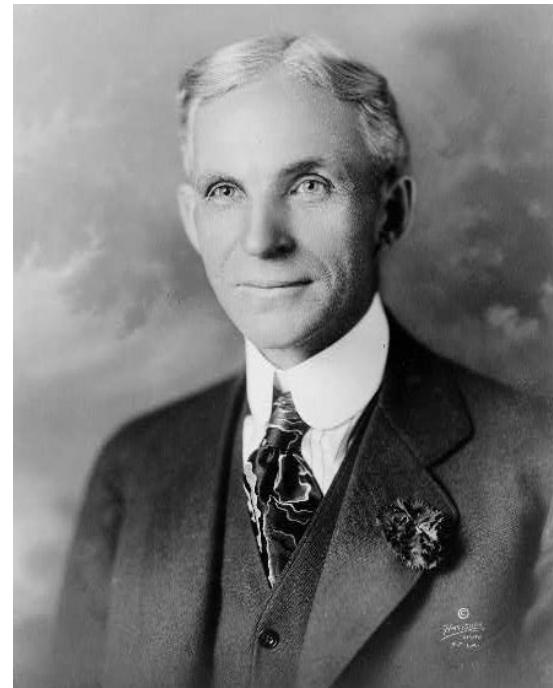
Biodiesel, “Synthetic” diesel

Biofuels are not new!

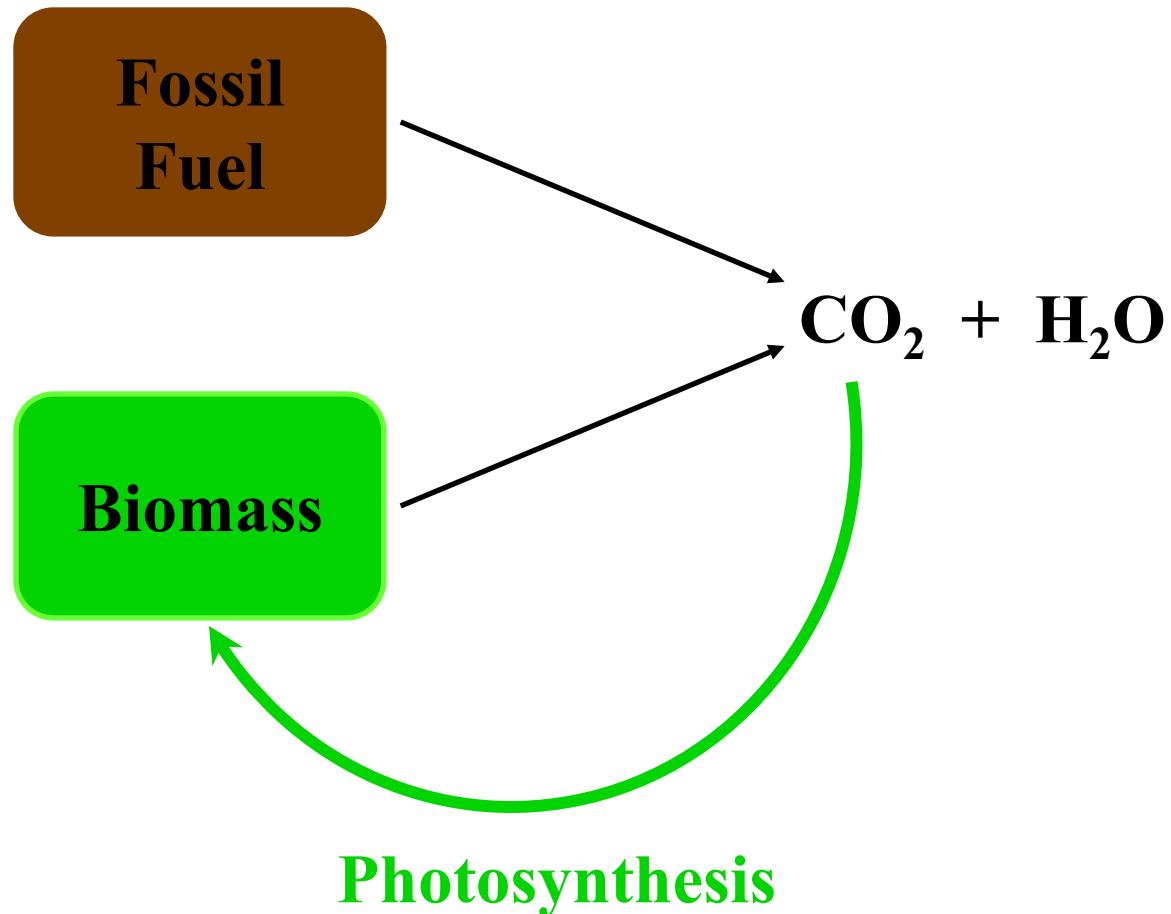


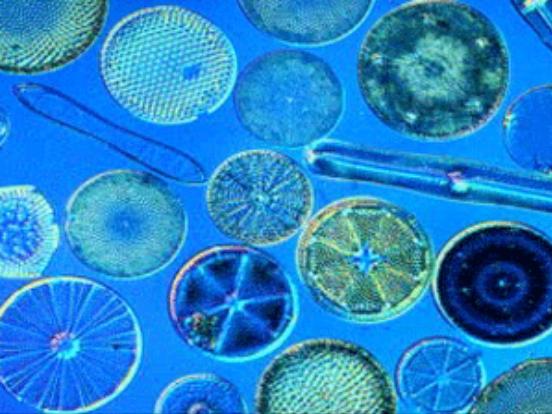
Rudolph Diesel ran his engine in the 1911 World's Fair in Paris on peanut oil.

Henry Ford designed his automobiles, beginning with the 1908 Model T, to use ethanol.



Is biomass better than fossil fuels?





Biofuels have several advantages for transportation:

- 
- Good energy density
 - Similar fuel economy and horsepower to petroleum
 - Use existing infrastructure
 - Renewable
 - Cleaner burning
 - Lower carbon burden
- 

How do we make biofuels?



fermentation



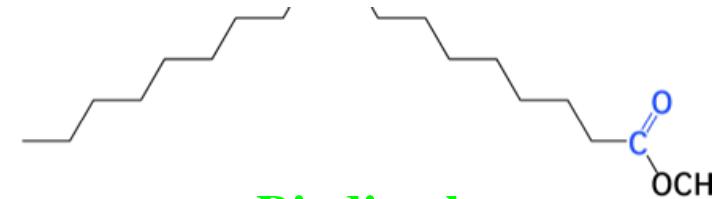
Ethanol



esterification

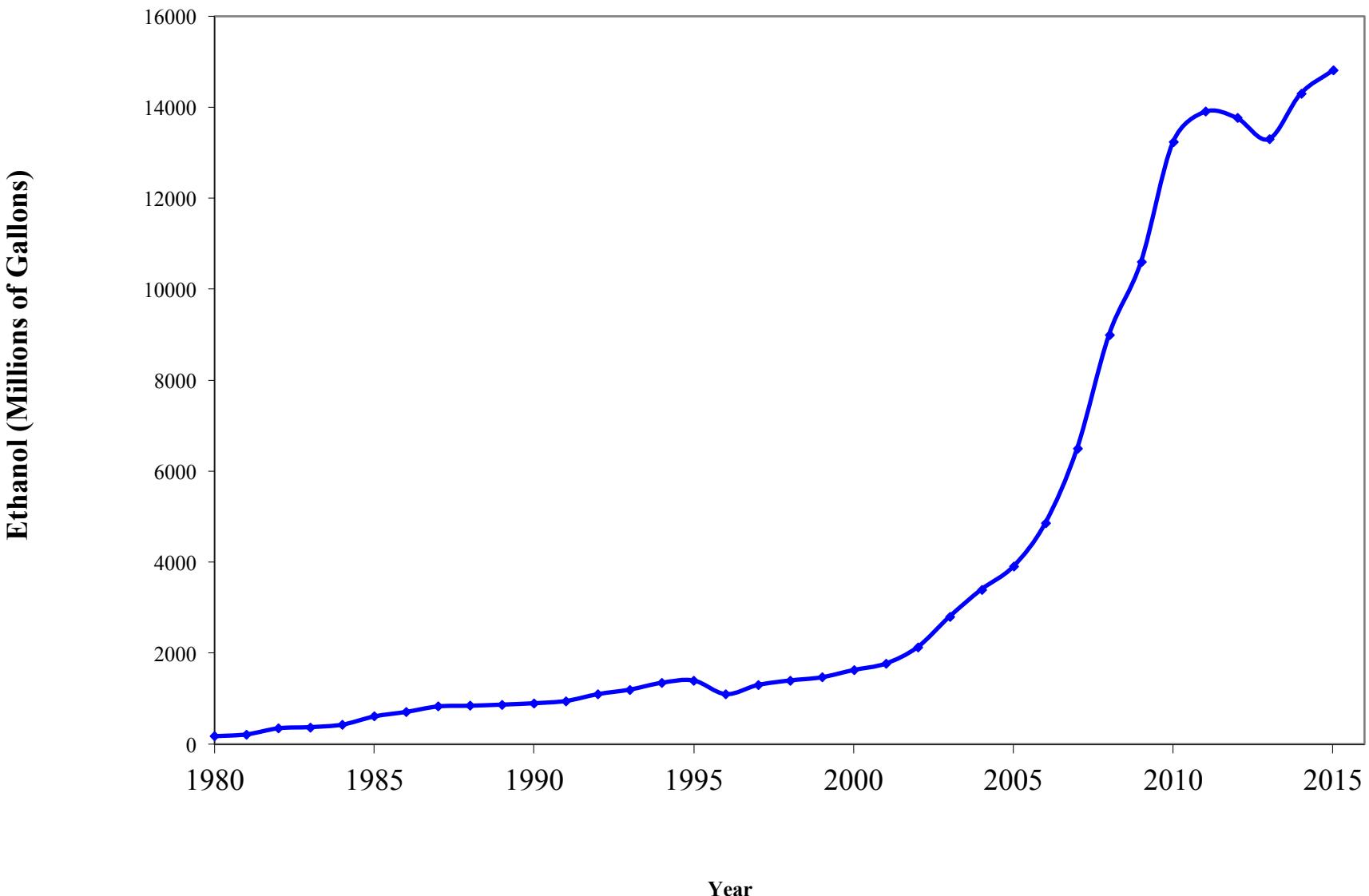


Biodiesel

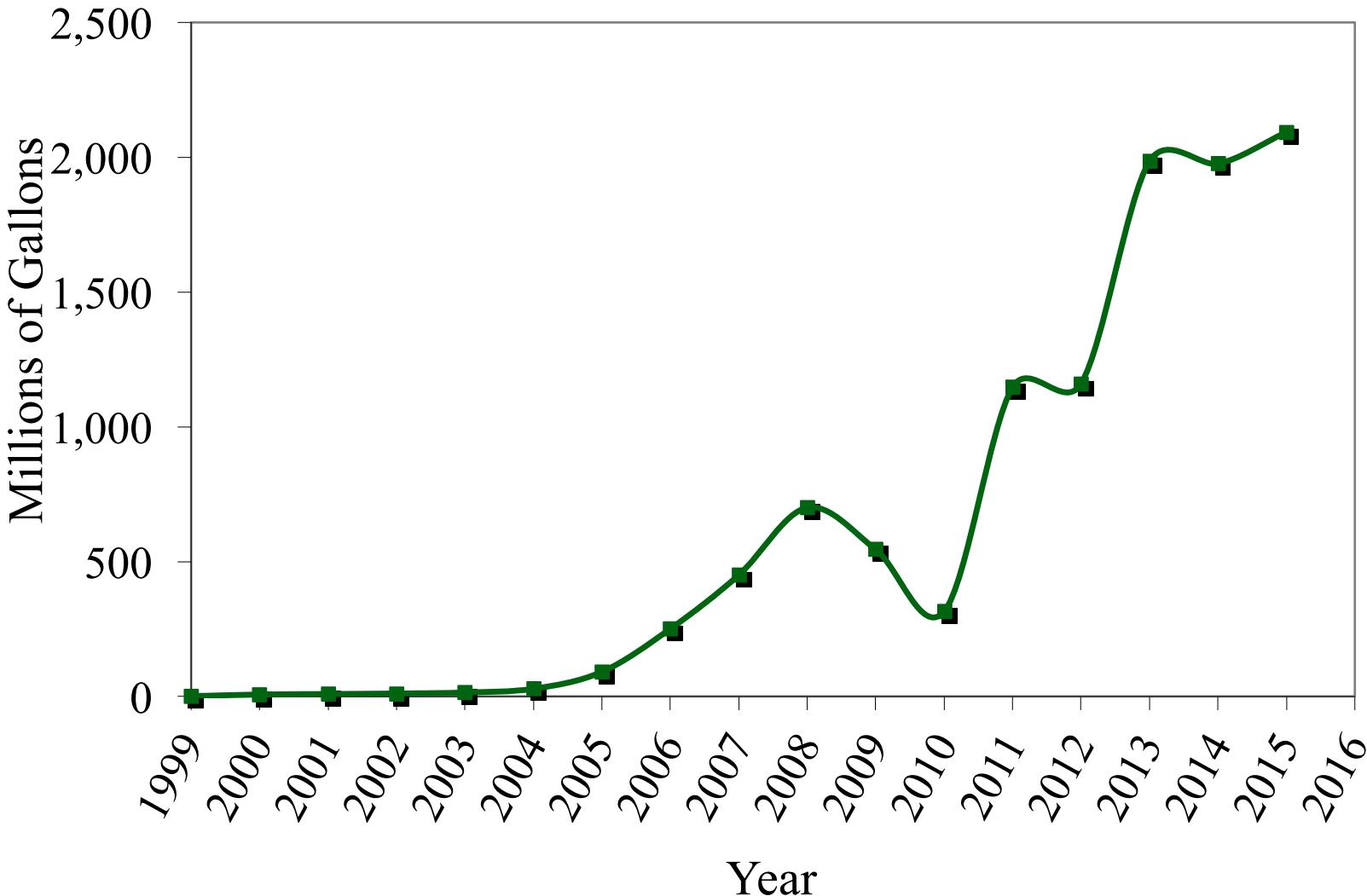




US Ethanol Production (millions of gallons)



Estimated Biodiesel Consumption in US



Represents about 8% of our current liquid fuel use.



Can we grow enough biomass?

Current agricultural use:

450 million acres crops

580 million acres grassland

Current fuel use:

60 Billion Gallons Petro-Diesel: 900 Million acres (soy)

140 Billion Gallons Gasoline: 600 Million acres (corn)

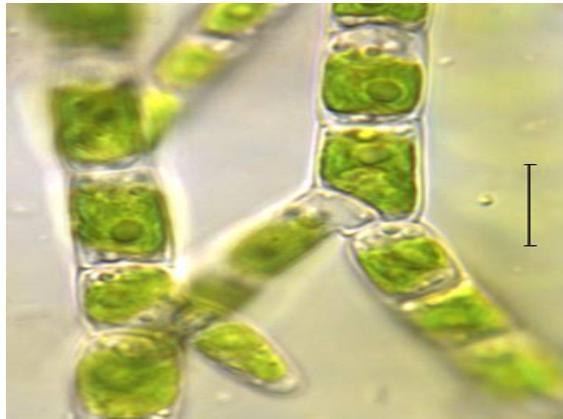
Non-Traditional Feedstocks



fermentation



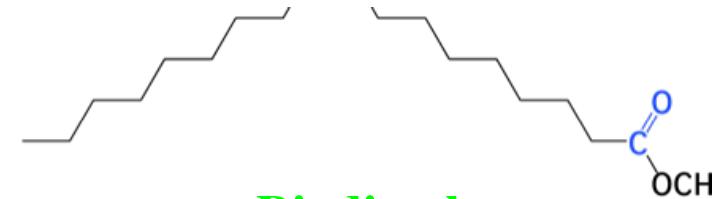
Ethanol



esterification



Biodiesel



New feedstocks offer improvements in carbon emissions and energy balance

Ethanol (corn): 13% lower emissions per unit energy of fuel

Ethanol (cellulose): 80+% lower

Biodiesel (soy): 78% lower

Biodiesel (algae): 80+% lower?

Farrell et al., Science, 311, 506 (2006)

USDA/DOE, (1998)

Tilman et al., Science, 314, 1598 (2006)

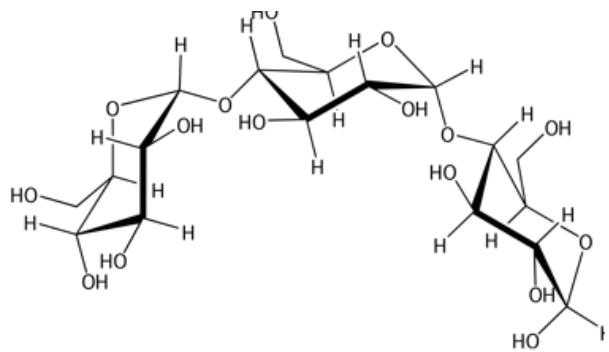
Worldwatch Institute, (2006)

Shapouri, et al. (2004)

Comparison of Ethanol Feedstocks

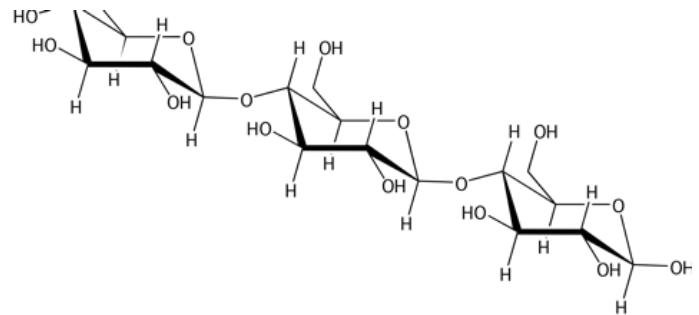


starch



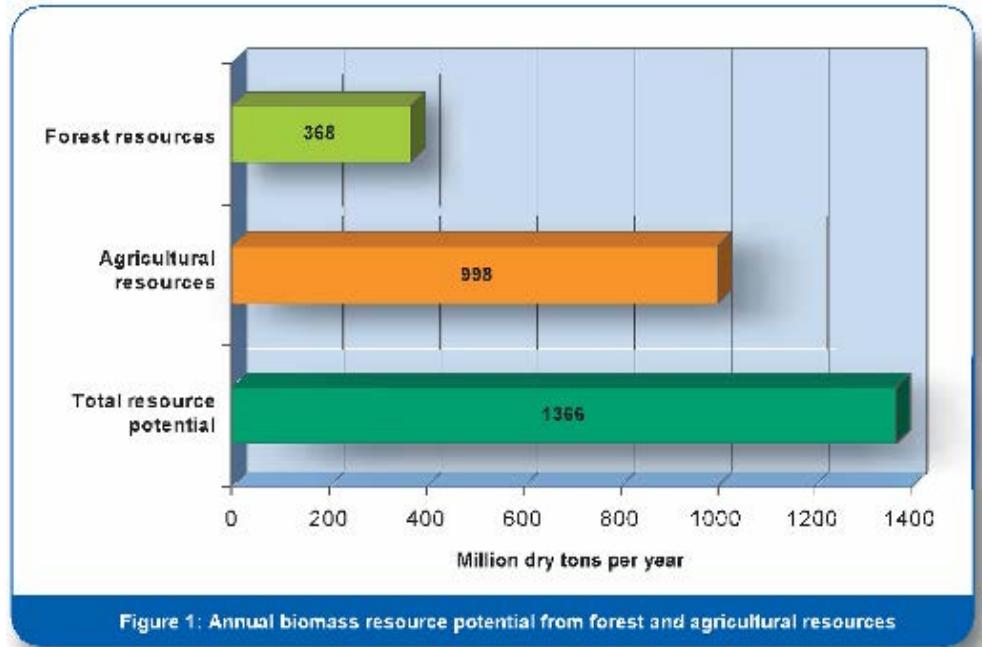
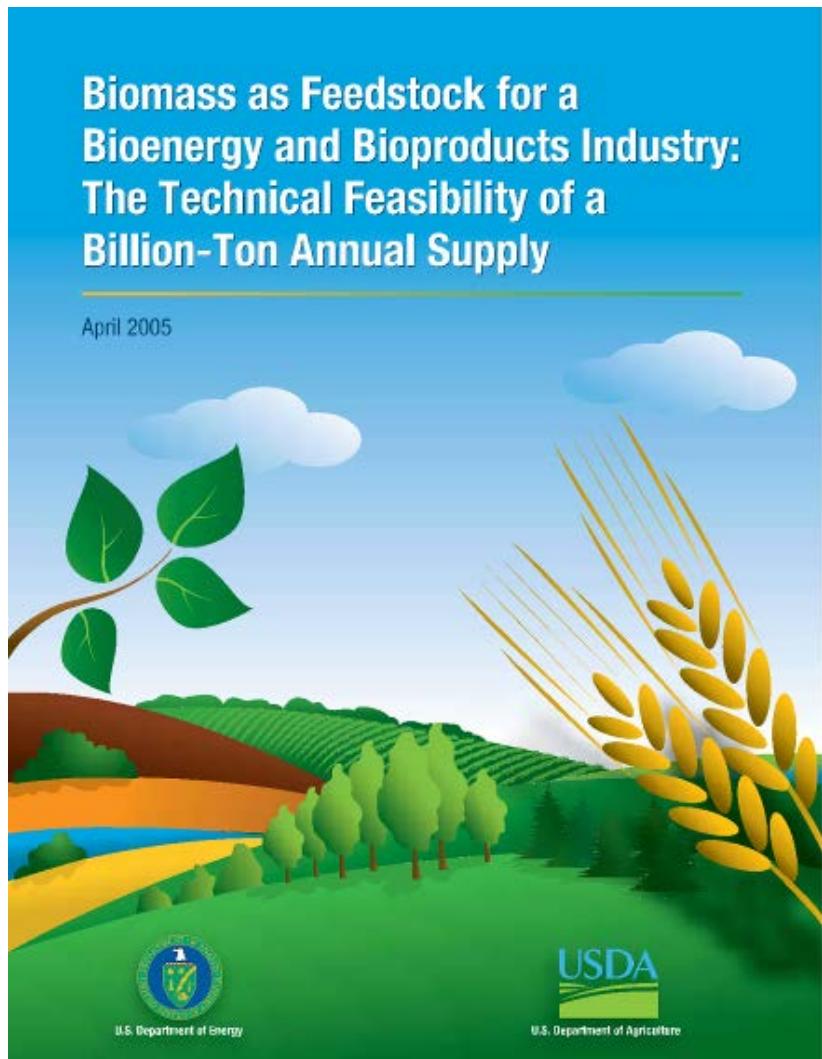
-glucose-glucose-glucose-

cellulose



-glucose-glucose-glucose-

Biomass (Cellulose) Could Provide 15% of U.S. Energy Demand by 2030



Will require lots of work!

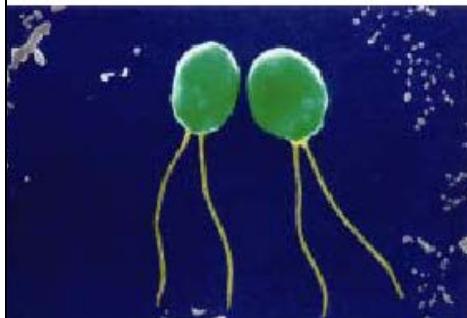
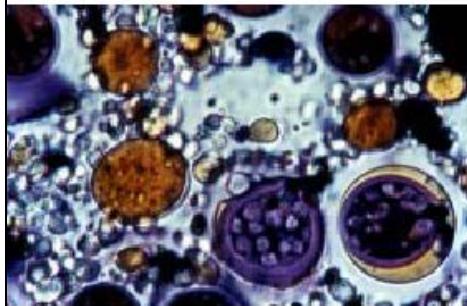
Cellulose is not oil

National Renewable Energy Laboratory

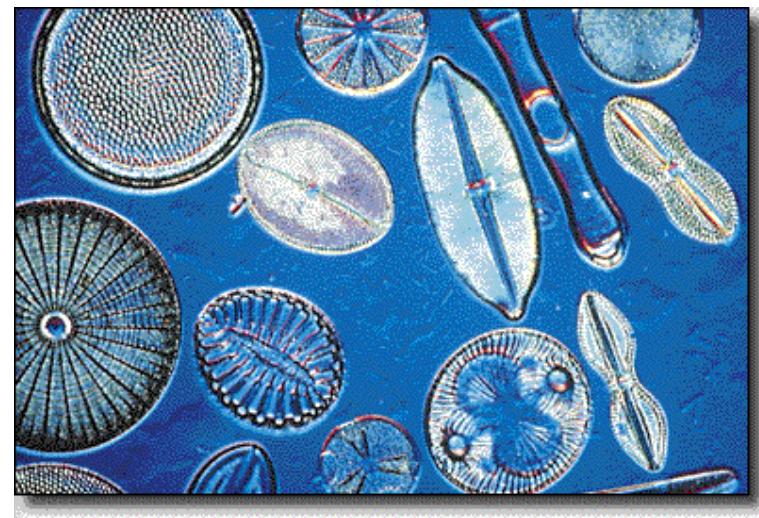


NREL/TP-580-24190

A Look Back at the U.S. Department of Energy's Aquatic Species Program: Biodiesel from Algae

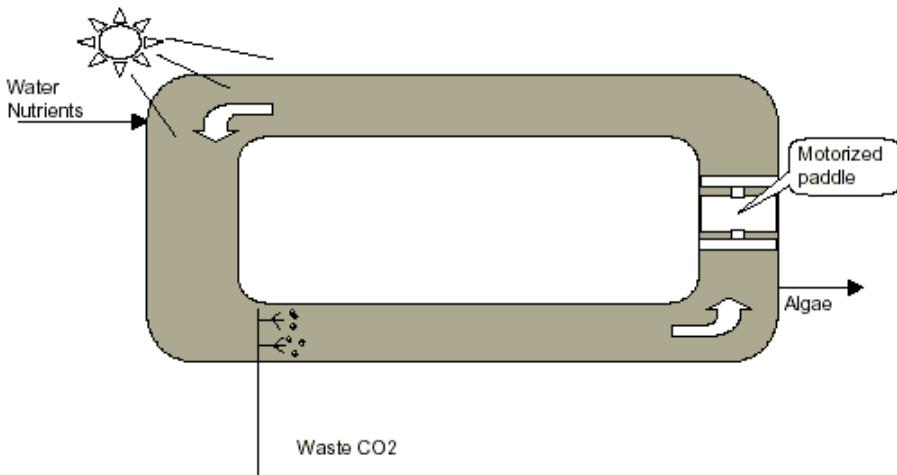


Some diatoms are composed of 60% triglycerides by mass and grow in 3 days



DOE:

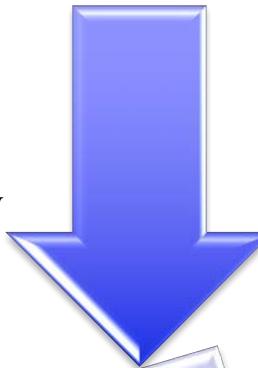
In open raceway ponds,
enough biodiesel to replace
ALL petroleum transportation
fuels (**gas & diesel**) could be
grown in about 10 million
acres, equivalent to 12.5% of
the area of the Sonora desert.



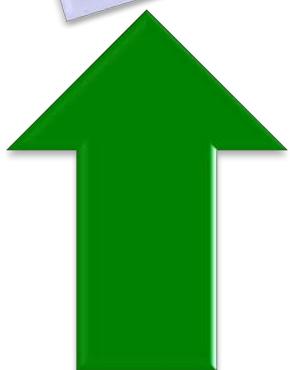
Strategy for Energy Independence

Decrease demand

Efficiency
Regulation & Tax policy
Conservation
Waste Reduction



Increase supply



New technologies
New fuels
Distribution
Cost Reduction
Improve supply chain management

WMIJ



Couple waste cleanup with energy recovery



Biofuels are not a panacea

- Biofuels will play a role in our future energy “mosaic”
- Can contribute to urban sustainability
- Tremendous opportunities for future economic growth and **JOBS**
- Need to make smart decisions



Questions?

