Lecture 2
March 31, 2011

Problem:
Calculate the mass energy available in a single hydrogen atom expressed in Joules and MeV

- Solution.
- Idea: calculate the mass in kG of the Hydrogen atom and use Einstein;s eqn $E= MC^2$
- Mass= 1proton + 1 electron = 1 proton (electron is lighter by factor of 1000)= 1.67×10^{-27} kG
- $C= 3\ 10^8$ meters per second
- $E= 1.503\times10^{-6}$ Joule = 939 MeV

Similarly a single electron has mass energy =.5 MeV

In this way we can find the energy equivalent of any mass. In using this formula, we will usually first have to find the mass defect in some reaction, i.e. the difference in mass between LHS and RHS and then multiply by C^2 to get the energy.

Start thinking of energy content

Table 1.3: Energy Content of Fuels

Type of Fuel	Energy in joules/kg	Type of Fuel	Energy in joules/kg
Coal	2.9×10^7	Garbage and Trash	1.2×10^7
Crude Oil	4.3×10^7	Bread	1.0×10^7
Gasoline	4.4×10^7	Butter	3.3×10^7
Natural Gas	5.5×10^7	Nuclear fission with Uranium 235	8.0×10^{13} = $8{,}000{,}000 \times 10^7$
Wood	1.4×10^7		

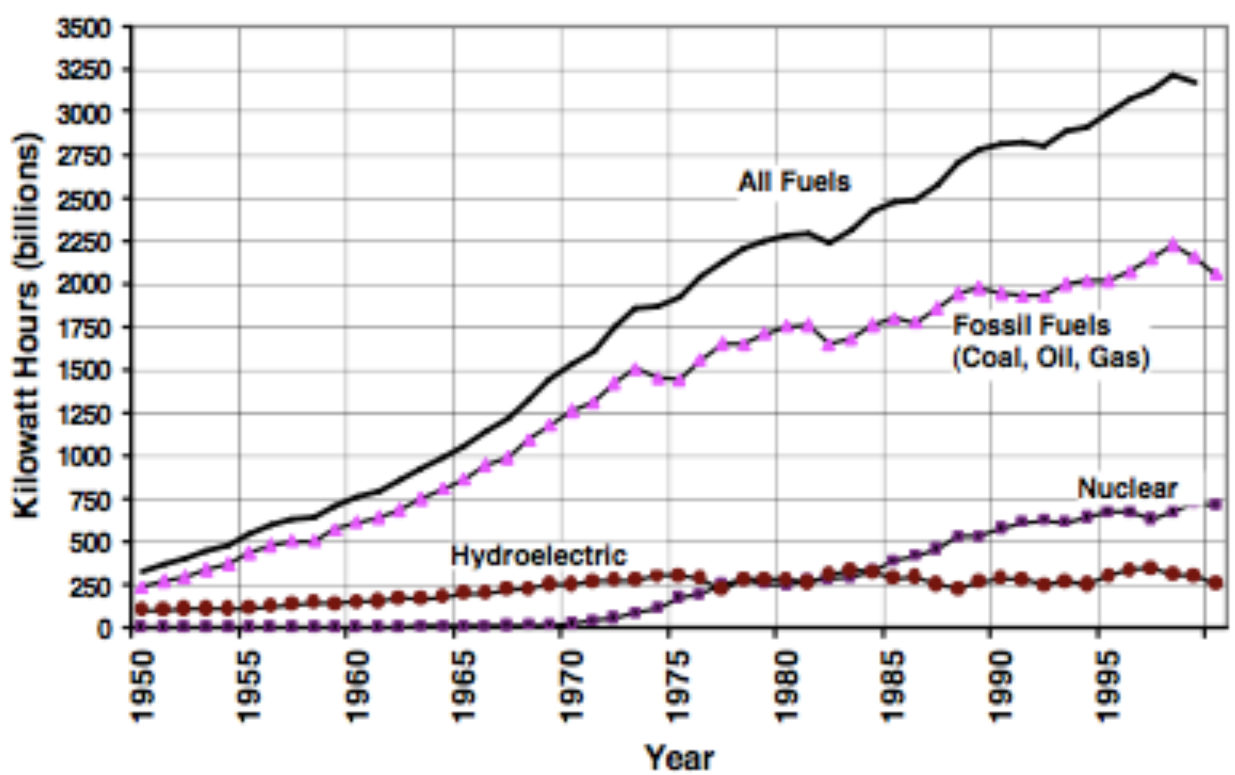
Most materials give us $\sim 10^7$ J/kg, not Uranium

From this table we see that Uranium has huge amount of energy:
as compared to converting garbage and trash.
1kg Uranium is appxly 6.7 Million kg of trash!!!

In practice the energy contained in nuclear reactions far exceeds any other source. However the risks involved are high, as seen in recent Fukushima incident and before that inChernobyl and the Three mile island.
We will discuss this aspect later.

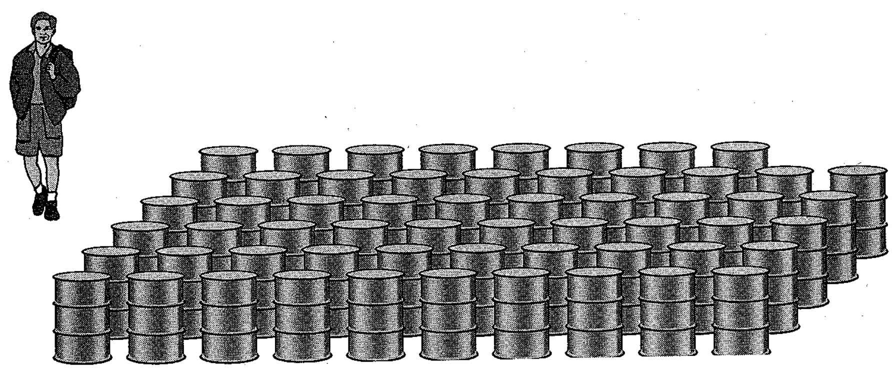
	Numbers useful on a bigger scale					
	Total energy consumption in USA					
	(1 QBtu ~ referred to as a Quad)			1 Quad=172.4	Million Barrels	
	1 Quad = 293 TWh		1000TWh=3.41	Quad		
2003	98.3 Quad		2.88×10^{16}	watt hours	28800 TWh	
2007	101.6 Quad		2.97×10^{16} watt hours		29700 TWh	
	Annual electricity production in USA in 2010					
	3992 TWh		(China 3715 TWh)			
	Energy Consumption per capita in US = 101.6x 172.4 Mill/290 Mill =				60.4 barrels per person	

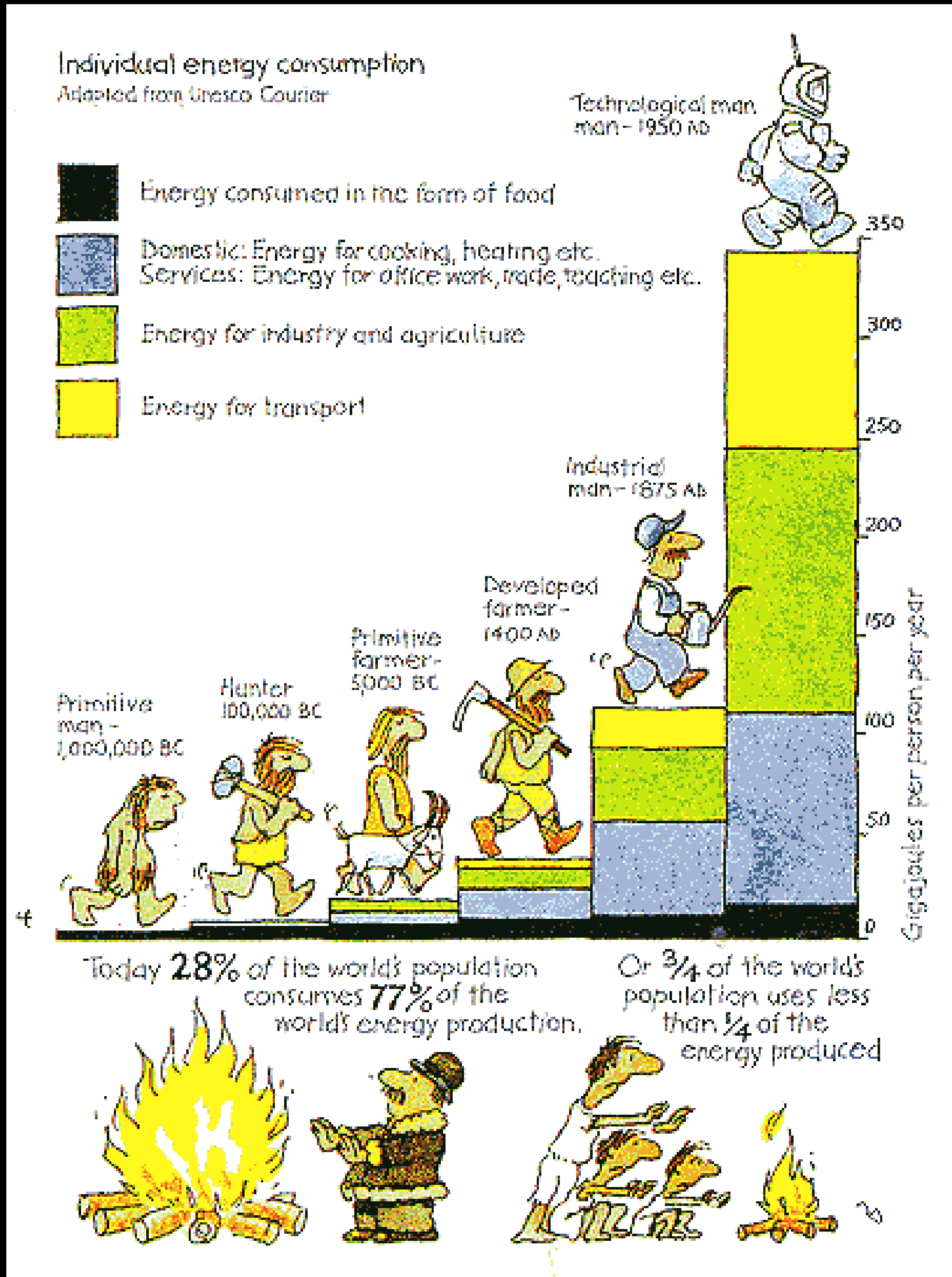
Fig. 1.1: Annual Electricity Production in the U.S. by Type of Fuel



	Total energy consumption in USA			
	(1 QBtu ~ referred to as a Quad)		1 Quad=172.4 Million Barrels	
	1 Quad = 293 TWh	1000TWh=3.41 Quad		
2003	98.3 Quad	2.88×10^{16}	watt hours	28800 TWh
2007	101.6 Quad	2.97×10^{16} watt hours		29700 TWh

Energy Consumption per capita in US = 101.6x 172.4 Mill/290 Mill =
60.4 barrels per person





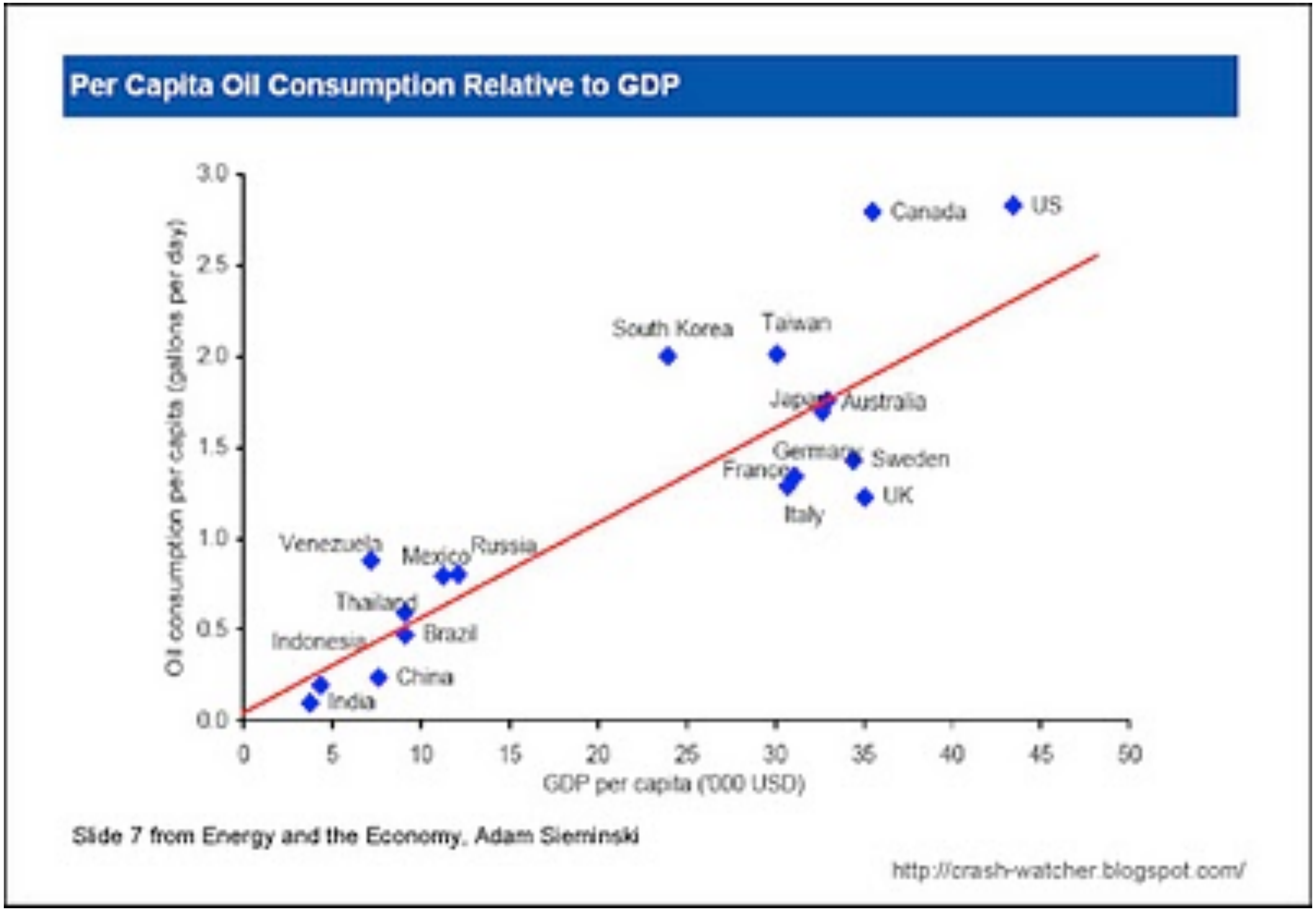
Individual Energy Consumption across the Ages

Today, a man uses **100 times** the Energy his primitive ancestors used to consume!

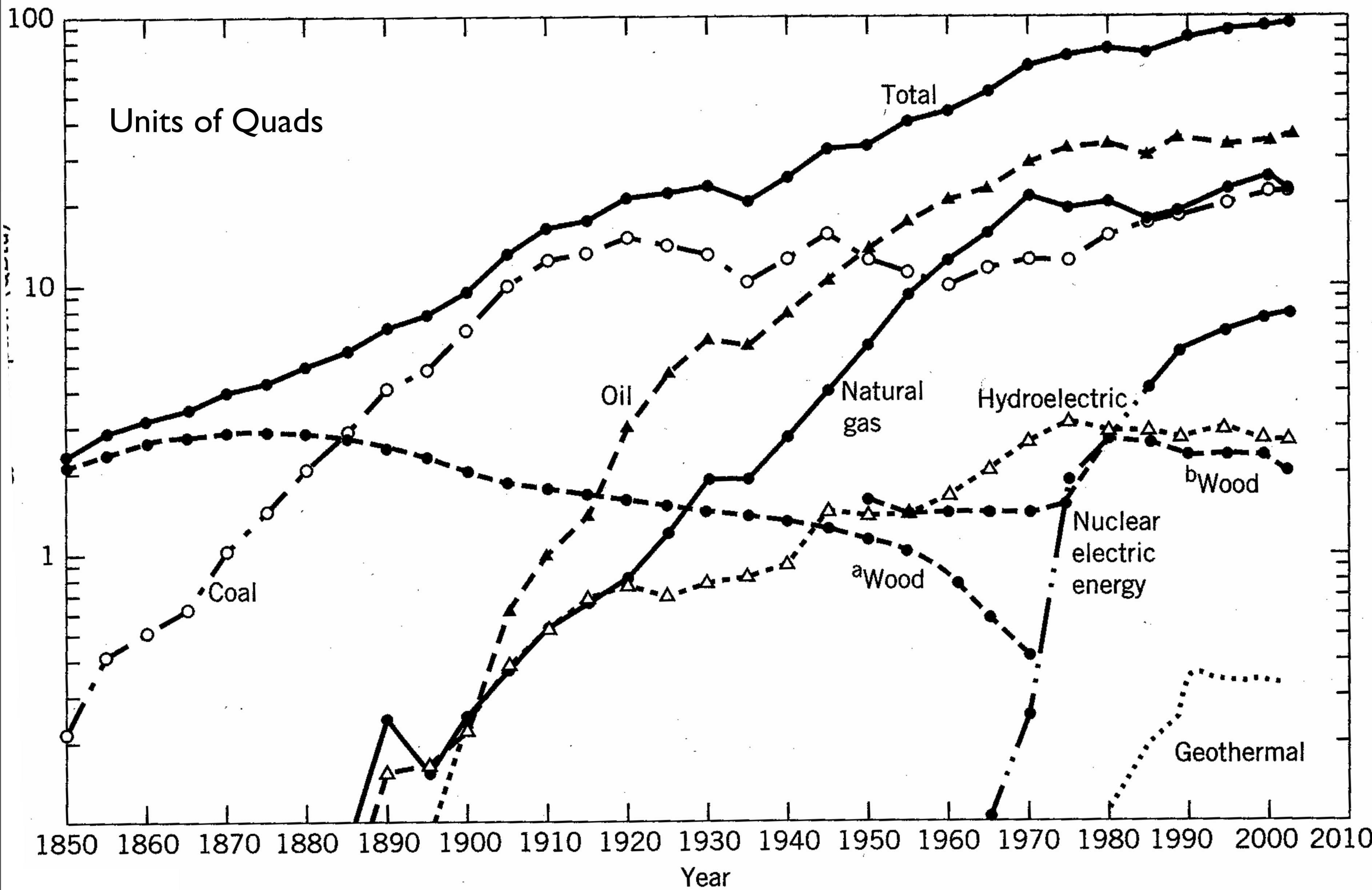
1 GigaJoule= 10^9J
6.12 GigaJoule= 1 Barrel
350 GigaJoule =57 Barrels

- Why do we use so much energy?
- Poor efficiency in part
- Habits of affluent civilizations
- Poor or exuberantly optimistic planning

Global trends



Different forms of energy in the US

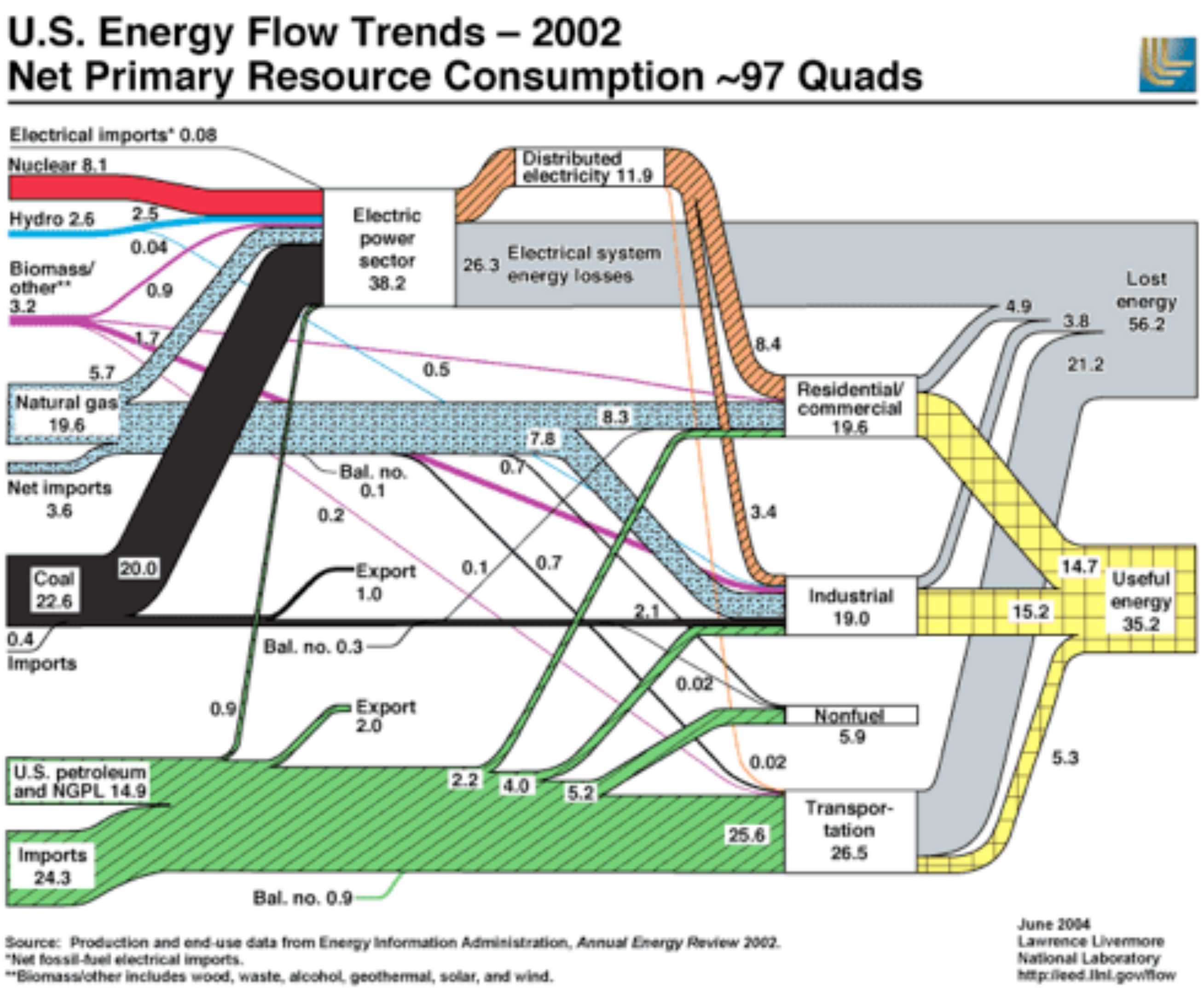


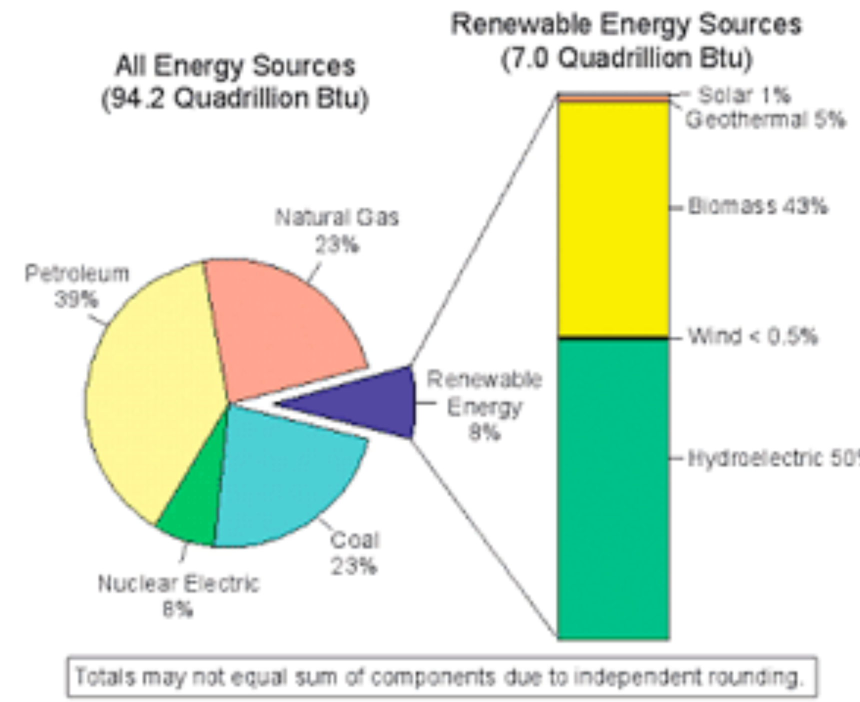
Various forms of energy consumed in the United States since 1850. This

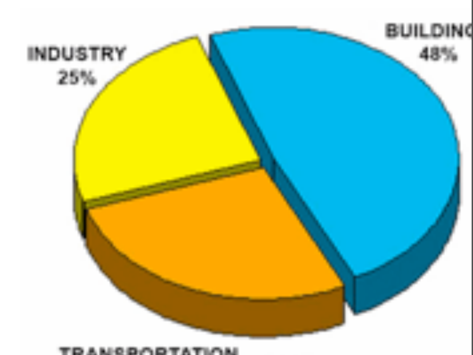
Fossil fuel is a single time usage affair and is far from being inexhaustible.
M King Hubbert's realization on next slide

Today we distinguish between Renewable and non renewable fuel. Renewable implies that nature replenishes the resource over time.
Non renewable is clearly everything else.

- **Renewable energy**
  - ✦Biofuel
  - ✦**Biomass**
  - ✦Hydroelectricity
  - ✦Solar energy
  - ✦Tidal power
  - ✦Wave power
  - ✦Wind power


U.S. Energy Flow Trends – 2002
Net Primary Resource Consumption ~97 Quads
Electrical imports* 0.08
Nuclear 8.1
Hydro 2.6
Biomass/ other** 3.2
Natural gas 19.6
Net imports 3.6
Coal 22.6
0.4 Imports
U.S. petroleum and NGPL 14.9
Imports 24.3
Electric power sector 38.2
Distributed electricity 11.9
Electrical system energy losses
Residential/ commercial 19.6
Industrial 19.0
Nonfuel 5.9
Transportation 26.5
Lost energy 56.2
Useful energy 35.2
Export 1.0
Export 2.0
Bal. no. 0.1
Bal. no. 0.3
Bal. no. 0.9
Source: Production and end-use data from Energy Information Administration, Annual Energy Review 2002.
*Net fossil-fuel electrical imports.
**Biomass/other includes wood, waste, alcohol, geothermal, solar, and wind.
June 2004
Lawrence Livermore National Laboratory
http://eed.llnl.gov/flow


All Energy Sources (94.2 Quadrillion Btu)
Renewable Energy Sources (7.0 Quadrillion Btu)
Petroleum 39%
Natural Gas 23%
Coal 23%
Nuclear Electric 8%
Renewable Energy 8%
Solar 1%
Geothermal 5%
Biomass 43%
Wind < 0.5%
Hydroelectric 50%
Totals may not equal sum of components due to independent rounding.


INDUSTRY 25%
BUILDINGS 48%
TRANSPORTATION

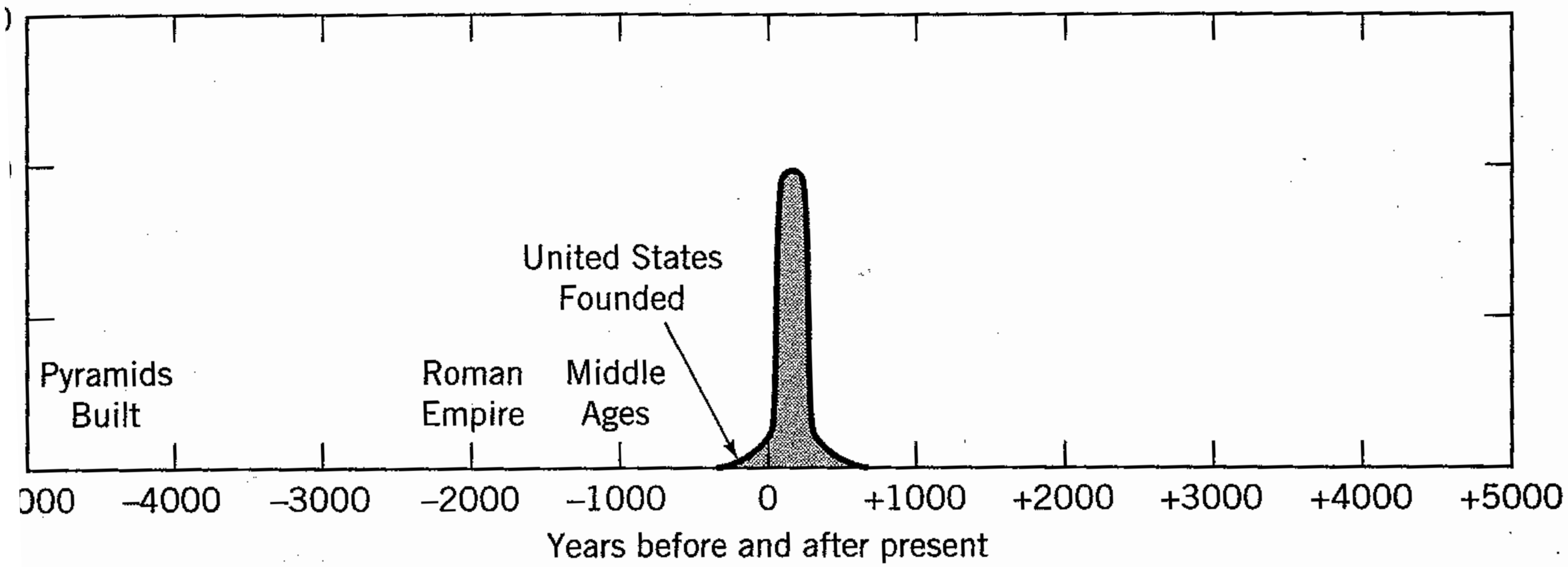
Renewable energy is energy which comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable (naturally replenished). In 2008, about 19% of global final energy consumption came from renewables,

The share of renewables in electricity generation is around 18%, with 15% of global electricity coming from hydroelectricity and 3% from new renewables.

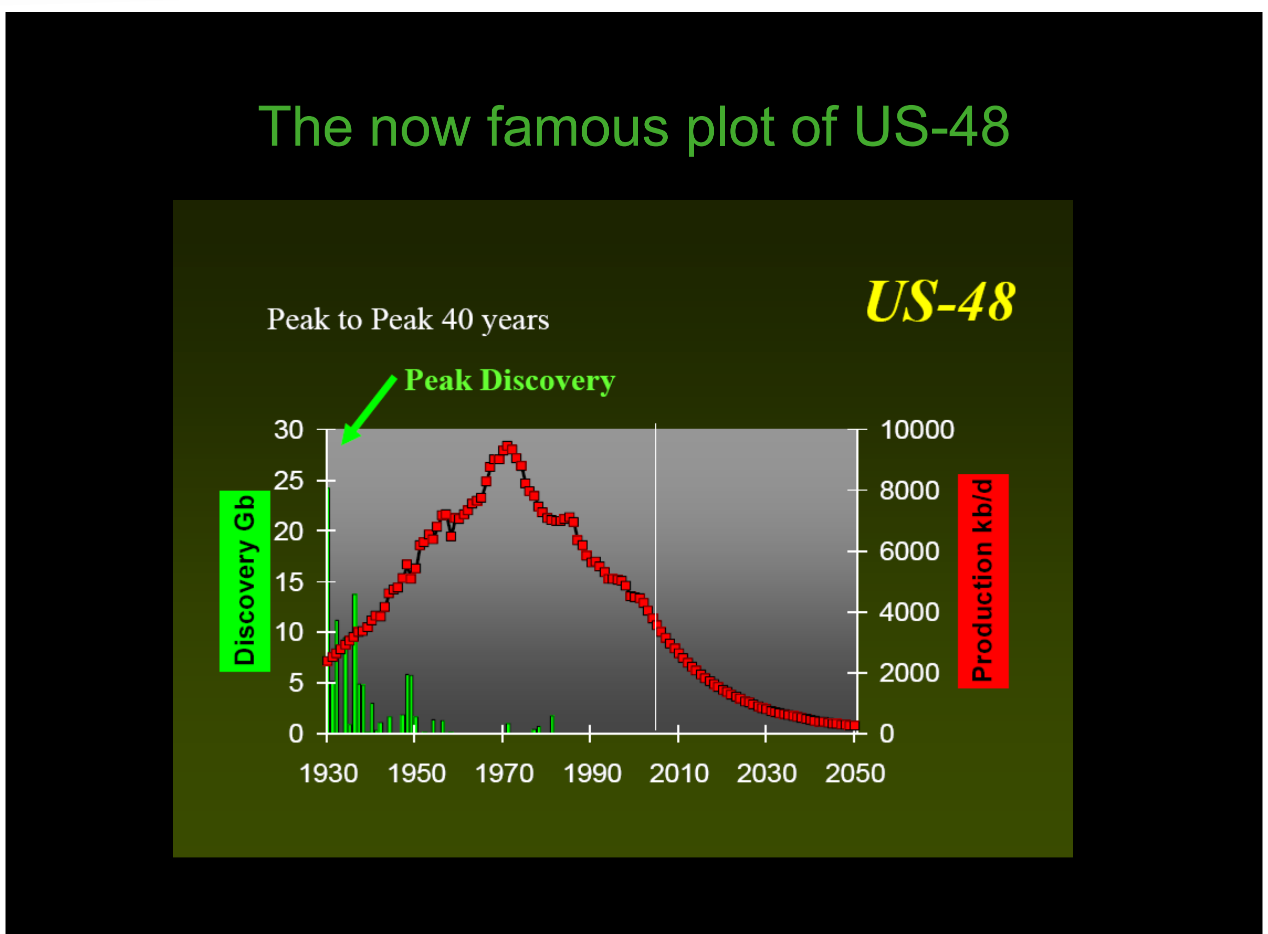
Wind power is growing at the rate of 30% annually, with a worldwide installed capacity of 158 gigawatts (GW) in 2009, and is widely used in Europe, Asia, and the United States. At the end of 2009, cumulative global photovoltaic (PV) installations surpassed 21 GW and PV power stations are popular in Germany and Spain. Solar thermal power stations operate in the USA and Spain, and the largest of these is the 354 megawatt (MW) SEGS power plant in the Mojave Desert. The world's largest geothermal power installation is The Geysers in California, with a rated capacity of 750 MW. Brazil has one of the largest renewable energy programs in the world, involving production of ethanol fuel from sugar cane, and ethanol now provides 18% of the country's automotive fuel. Ethanol fuel is also widely available in the USA.

The **DeSoto Next Generation Solar Energy Center** is a photovoltaic solar power facility in Arcadia, DeSoto County, Florida owned by Florida Power & Light (FPL)

Goodbye Fossil Fuels!



1.2 The complete exploitation of the world's fossil fuels will span only a rela-
rief time in the 10,000 year period shown centered around the present. (*Source*:
ted with permission from M. K. Hubbert, *Resources and Man*, Washington,
National Academy of Sciences, 1969. Historical events added.)



M King Hubbert predicted in a famous report written in 1956 (available on the resource page) that the peak of discovery of oil fields in 1932 followed by a drop off, would be mirrored in the oil production curve with a time lag caused by the development activity.

Some problems relating to conversions
HW1 some highlights and hints

3. If you push a cart along a horizontal surface with a force of 10 pounds, and the cart moves 10 feet, how much work have you done in ft·lbs? In joules?

Hint: (1) Identify the formula needed (2) Plug in the numbers.

7. How many tons of coal would be needed each year to provide for the entire energy needs for the average person in the United States?

Hint: This problem requires us to find out the energy content in coal by looking up a table, finding out how much energy is needed per person in USA from another table and combining the two.

10. Solar energy is incident on a black parking lot with an intensity of 1000 Watts/m^2 and 90% of it is absorbed. What is this in Btu/hr per square meter? m2 What happens to the other 10%?

Hint: This problem is much simpler than it looks at first sight. We can take 1 square meter as the relevant area, and then we just need to convert from watts to BTU/hour

11. A windmill produces 1400 watts of electric power that is used to heat water. The efficiency is 100%. How long will it take to raise the temperature of 40 gallons of water by 50 degrees F?

This is a slightly complex problem consisting of two parts: supply and usage. Assume the time to be t seconds and work out how much power is produced in this time interval. From the thermal side, find out the energy needed to raise 40 gallons of water by 50 degrees Farenheit. Recall the definition of BTu as the energy needed to raise one pound of water by 1 deg F. Then find out how many pounds of water are present in 40 gallons by looking up the density of water in lb/ft^3 , and number of cubic feet per gallon given on the front page of the RK book. (Scan of the first two pages available on the website)

(3)

Power= rate of doing work

$$[P] = [W]/[T] = \frac{[M][L]^2}{[T]^3}$$

Watt = Joule/sec

Horsepower (Old units)

1 horsepower = 745.699872 watts

(4) Therefore Energy can be given in two possible ways.

Energy = Force x distance
= Joule or FP

Energy = Power x time
=kWH

	Energy equivalents			
	Conversion table			
		J	kWh	Btu
1 Joule		1	2.78×10^{-7}	9.49×10^{-4}
1 kWh Kilowatt Hour		3.60×10^{6}	1	3413
1 calorie		4.184	1.16×10^{-6}	3.97×10^{-3}
1 British Thermal Unit BTU		1055	2.93×10^{-4}	1
1 ft pound (ft-lb)		1.36	3.78×10^{-7}	1.29×10^{-3}
1 electron volt (eV)		1.60×10^{-19}	4.45×10^{-26}	1.52×10^{-22}
1 Barrel petroleum		6.12×10^{9}	1700	5.8×10^{6}
(42 US Gallon)				