PHYS-310: Energy, Society, and the Environment

Also, PSC-320 "Area-F" has many spaces tell your friends!!!

Pete:
1) Name, Major, Relationship with Energy / Favorite Energy Tech
2) Website, Syllabus, Homework, etc.
3) How are we going to learn all this stuff? / Group Discussion

DH:
3) Exponential Growth

What did you find Compelling, Scary, Boring, Confusing in the videos? … In the reading?

Fracking – Fracture Hydraulic Drilling
Methane Hydrate – water + methane crystal
CAFE Corporate Average Fuel Economy
Price of Gas in Europe ~ twice that of the USA
Quad – 10^{15} BTU ~ EJ = 10^{18} J
US Annual Consumption ~ 10^{20} J
GW_e – GigaWatt of electricity
Capacity Factor ~ % of time running
Yucca Mountain Nuclear Waste Depository
TCF – Trillion cubic foot
Combined Cycle, Demand Elasticity,
Gbbl – Billion Barrels (of Oil)

Heat is work and work is heat,
That's the *First Law of Thermodynamics*
The *Second Law of Thermodynamics*,
Heat cannot go by itself from one body to a hotter body,
The Universe is going to cool down,
Then there will be no more work,
That's *Entropy* Man.

[M. Flanders and D. Swann, *The Laws of Thermodynamics*, Angel Records]

Petroleum Turn-around

- FIGURE 10.1. Net Import share of US liquids supply in two cases, 1970-–2040 (millions of barrels per day). U.S. could be net exporter of liquid fuels under certain favorable conditions, such as doubled CAFE standards, favorable oil and gas production from hydraulic fracking, and some electric cars. [*Annual Energy Outlook,* Energy Information Administration (EIA), 2013]

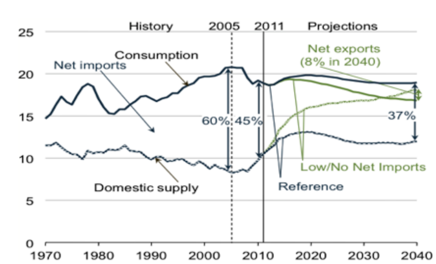
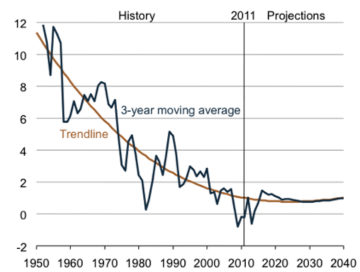


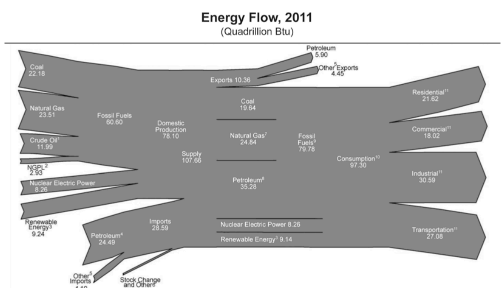
TABLE 10.1. US energy consumption for 2011 and 2040, growth rates and cost. [EIA, 2013]

Fuel	2011 energy quads/year	2040 energy quads/year	growth %/year
liquid fuels	37.0	36.1	–0.1
natural gas	24.9	29.8	0.6
coal	19.7	20.4	0.1
nuclear	8.3	9.4	0.5
hydropower	3.2	2.9	–0.3
biomass	2.7	4.9	2.0
other renewable	1.9	4.1	3.1
TOTAL	97.7	107.6	0.3

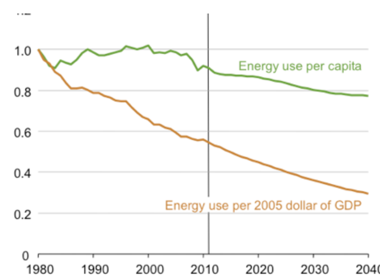
Electricity, less but significant



100 quads/y = 45 Mbbl/d



efficiency and mode change



Renewables, can be 25% grid for now

TABLE 10.2. US renewable energy production. Rows 1–3 in quads/year, row 4 is *average* electrical in GW_e. [EIA, 2013]

	hydro	geoth	wind	solar	biom.	renewables	energy total
1973	2.9	0.04	0	0	2.3	5.2	76.6 quads
2000	2.8	0.3	0.05	0.01	2.9	6.1	99.3 quads
2011	3.2	0.2	1.2	0.02	4.1	10.0	97.7 quads
2011 elec.	36.8	1.9	13.6	0.7	8.0	57	467 avg. GW_e

Energy, 25% of you per day

- (46 Mbbl/d)(0.84 fossil)(42 gal/bbl)(3.5 kg/gal)/(312 M persons) = 18 kg/day, (10.1)

kWh and cheap

A 100-watt bulb left on overnight for 10 hours consumes 1 kWh, corresponding to a work equivalent of

$$W = 1\ \text{kWh} = (1000\ \text{J/s})(3600\ \text{s}) = 3.6 \times 10^6\ \text{J}. \qquad (10.2)$$

The work done by 10 cents worth of electricity can raise an 80-kg body halfway up Mt. Everest at 90% efficiency η, as calculated here:

$$h = \eta E/mg = 0.9(3.6 \times 10^6\ \text{J})/(80 \times 9.8\ \text{J/m}) = 4\ \text{km}. \qquad (10.3)$$

The modern age depends on electricity made with modest fuel (1 kWh from 0.6 pound of coal) at cheap prices.

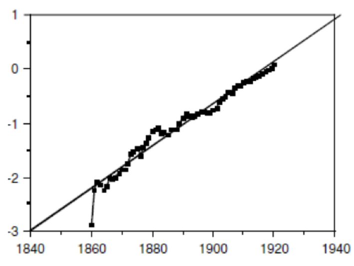
2-3 clothes drier heat power

Coal and nuclear power plants operate at 30–40% efficiency, but new combined-cycle gas turbines (CCGT) using natural gas operate at 60%. At 33% efficiency, it takes 4.5 thermal kilowatts (kW_t) to produce the per capita average electrical power of 1.5 kW_e. It took 39.4 quads to generate US electricity in 2011, which was 40% of US total energy use. Combining these factors gives an average *per capita thermal power*

$$P_{avg/capita} = (4.5\ kW_t)/(40\%\ \text{electrical}) = 11.3\ kW_t. \qquad (10.5)$$

This is the heat power of 2–3 clothes dryers, operating full time over the entire year.

9%/year over 60 years



King Hubbert, but ???