Energy on this world and elsewhere

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Course web site available at www.phys.virginia.edu, click on classes and find Physics 1110.
or at http://people.virginia.edu/~gdc4k/phys111/fall11

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Announcements

• Brief (~20 minute) multiple-choice quiz on Tuesday, September 6. The quiz will cover:
  – Lectures 1-4 (although no calculations will be required),
  – Chapters 1 and 2 of the class notes,
  – Chapters 1 and 2 of Energy Environment and Climate by Wolfson,
  – and Chapter 3 of Feynman’s “The Character of Physical Law”.

• Problem session/office hours Thursday, Sept. 1, 3:30-5PM, room 120, first floor of this building.

• Problem session/office hours Monday, Sept. 5, 3:30-5PM, room 120, first floor of this building.
Primary Energy Sources
The sources from which we extract the energy we use

- Oil
- Coal
- Natural gas
- Nuclear
- Biomass
- Hydroelectric
- Wind
- Geothermal
- Solar
While I find the term “energy servant” a little silly, there is an interesting, even a sobering point here.
Getting a concrete sense of energy output

A person burns energy at the rate of about 100 Watts

\[
\text{Power} = \frac{\text{Energy}}{\text{Unit time}} = \frac{\text{Joules}}{\text{second}} = \text{Watts}
\]

A person burns energy at the rate of about 100 Watts

Athletes can maybe go to a few hundred watts output
The power we generate
The power we consume

A person burns energy at the rate of about 100 Watts

American’s per capita energy consumption is 100x100 Watts = 10 kilowatts

- The standard of living is closely coupled to per capita energy use.
- It is not unreasonable to interpret the forces behind slavery as, in part, a way of harnessing greater power output at a time when there were no John Deere Tractors, energy grids, etc.
The correlation between GDP and energy consumption
Energy intensity tends to improve with time.

Energy intensity is the average power consumed per unit of GDP.
End uses for energy

There is no one unique way to enumerate end uses.

- Residential
- Commercial
- Industrial
- Transportation
- Electricity Grid
- Natural gas grid
- Centralized distribution of liquid fuels for transportation
- other

It will become clear in a moment why I include the list on the left. I prefer thinking about things with categorizations more along the lines of the list on the right.
An important resource for this class

I will put a copy of this in the resources folder on UVa Collab.
Figure 1.0 Energy Flow, 2009
(Quadrillion Btu)

1 Includes lease condensate.
2 Natural gas plant liquids.
3 Conventional hydroelectric power, biomass, geothermal, solar/photovoltaic, and wind.
4 Crude oil and petroleum products. Includes imports into the Strategic Petroleum Reserve.
5 Natural gas, coal, coal coke, biofuels, and electricity.
6 Adjustments, losses, and unaccounted for.
7 Coal, natural gas, coal coke, electricity, and biofuels.
8 Natural gas only; excludes supplemental gaseous fuels.
9 Petroleum products, including natural gas plant liquids, and crude oil burned as fuel.
10 Includes 0.02 quadrillion Btu of coal coke net exports.
11 Includes 0.12 quadrillion Btu of electricity net imports.
12 Total energy consumption, which is the sum of primary energy consumption, electricity retail sales, and electrical system energy losses. Losses are allocated to the end-use sectors in proportion to each sector's share of total electricity retail sales. See Note, "Electrical Systems Energy Losses," at end of Section 2.

Notes: • Data are preliminary. • Values are derived from source data prior to rounding for publication. • Totals may not equal sum of components due to independent rounding.

Sources: Tables 1.1, 1.2, 1.3, 1.4, and 2.1a.
The Electric Grid
Looking at these pie charts, we can see how shifting energy consumption to the electric grid facilitates using many different primary energy sources. Note wind has quadrupled in fractional contribution in five years.
Infrastructure

- Railroads
- Mining operations
- Power plants
- Oil fields
- Pipelines
- Electrical power-line grids
- Natural-gas-line grids
- Vehicle fleet (cars, trucks, etc.
- and much much much more

Some authors estimate 50 years will be necessary to truly change our energy infrastructure.
Railroads

From postcard dated September 20, 1910. In 1840's, was the western-most station in Virginia. Today the station is gone, but the tracks still carry CSX trains carrying coal that also go through Charlottesville.
Coal-fired power plants in excess of 60 years old

Dominion Power’s Bremo coal-fired power plant

- First two units (now retired) went into operation in 1931.
- Units 3 and 4 went into operation in 1950 and 1958 respectively.
- Have been retrofitted with electrostatic precipitators to trap fly ash.
- Also uses burners that minimize the emission of "NOx's"
- Produces 220 Megawatts using 2500 tons of coal daily (25 hoppers).
Transportation fleet

- Over 150,000,000 vehicles domestically.
- Typically less than 10% replaced per year.
- No more than a few percent are hybrids.
- Replacement time with new technology should be measured in decades.
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An American Physical Society study suggest that 65% of the energy for transportation could come from the electric grid by moving heavily toward plug-in hybrids and electric cars. Such a move, however, would take multiple decades.
Energy flow
(from Wolfson's book)
Homework

• Read Chapters 1 and 2 of the class notes.
• Read Chapters 1 and 2 from Energy Environment and Climate.
• Read Chapter 3 of Feynman’s “The Character of Physical Law”.
