Energy and the Built Environment
CRP 470.004 /570.004

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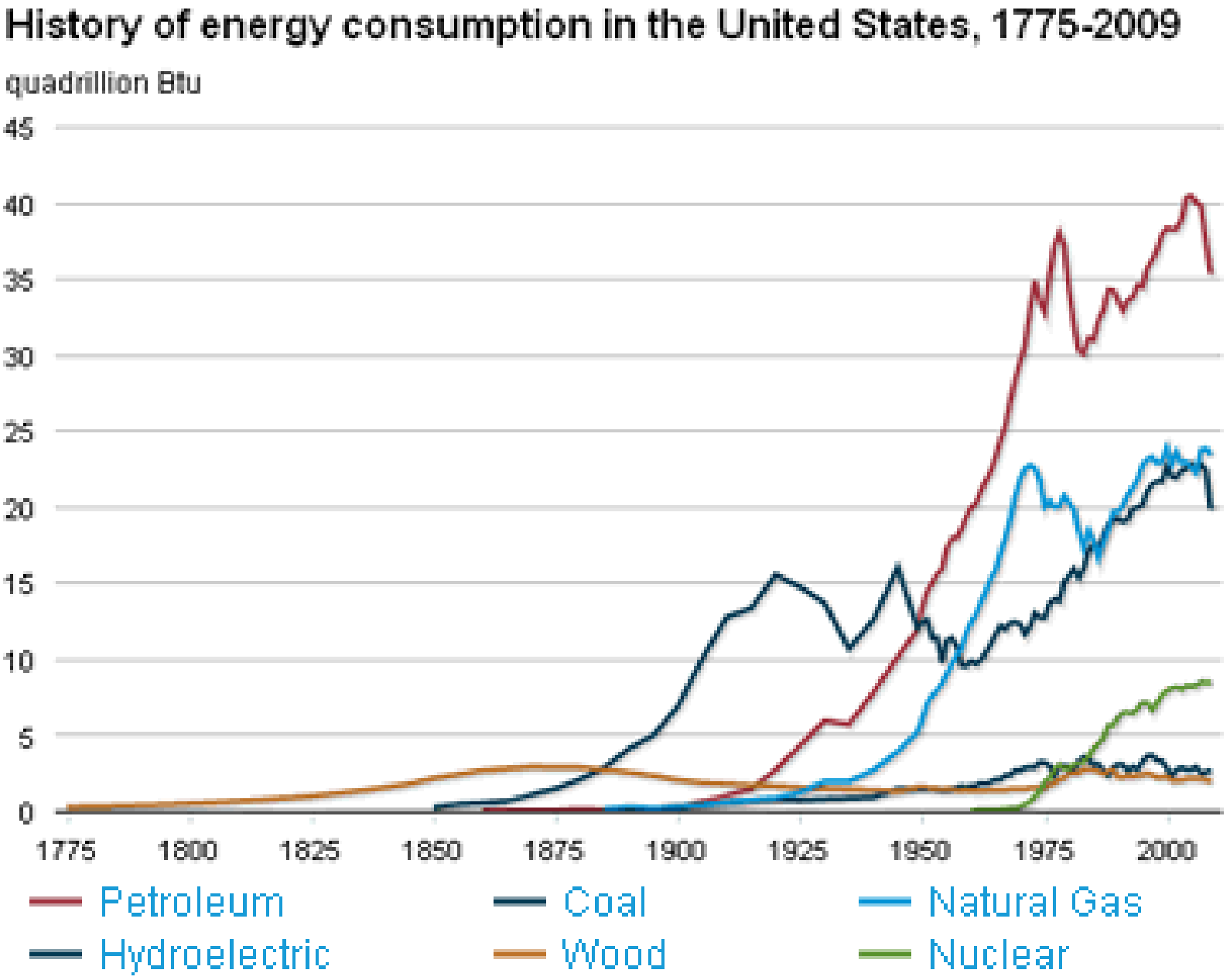
Lecture 2

US energy trends

Outline

- Discussion of readings
- Overview of US energy use
- Sample calculations
  - Unit conversions, significant digits

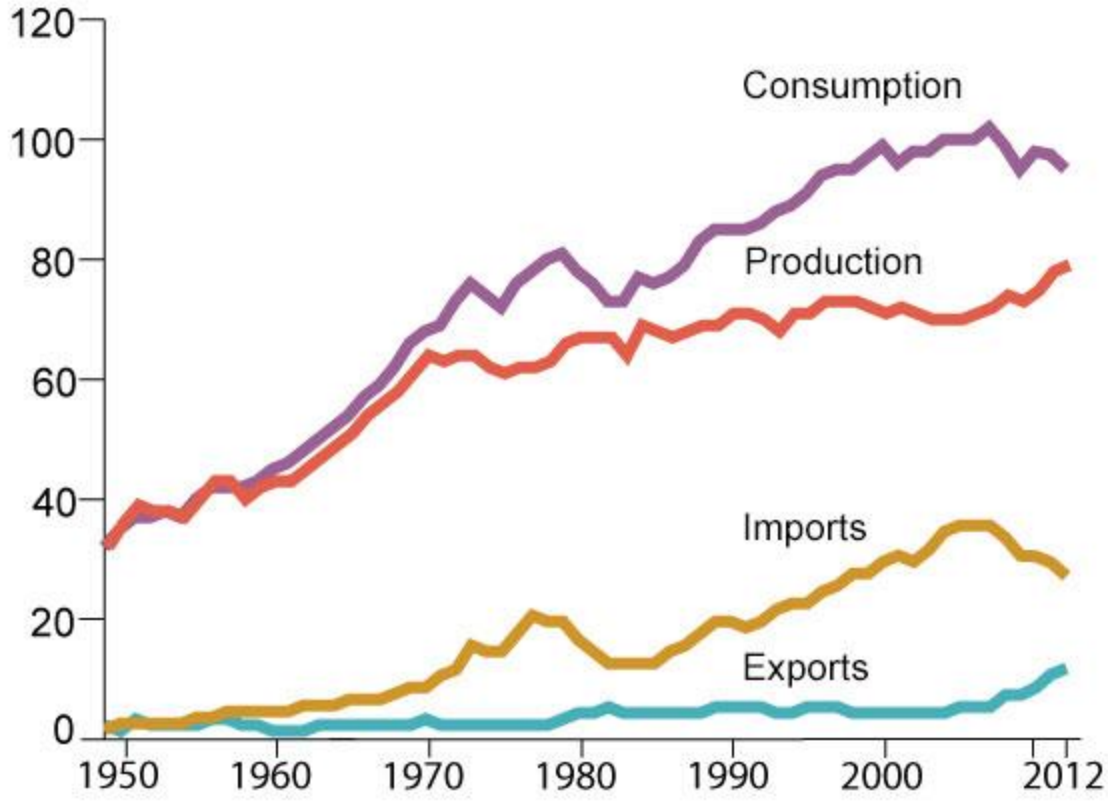

History of energy consumption in the United States, 1775-2009
quadrillion Btu
45
40
35
30
25
20
15
10
5
0
1775
1800
1825
1850
1875
1900
1925
1950
1975
2000
Petroleum
Coal
Natural Gas
Hydroelectric
Wood
Nuclear
Source: U.S. Energy Information Administration - Annual Energy Review 2009

Consumption versus Production

Domestic energy supply met 84% demand in 2013

U.S. primary energy overview

quadrillion Btu

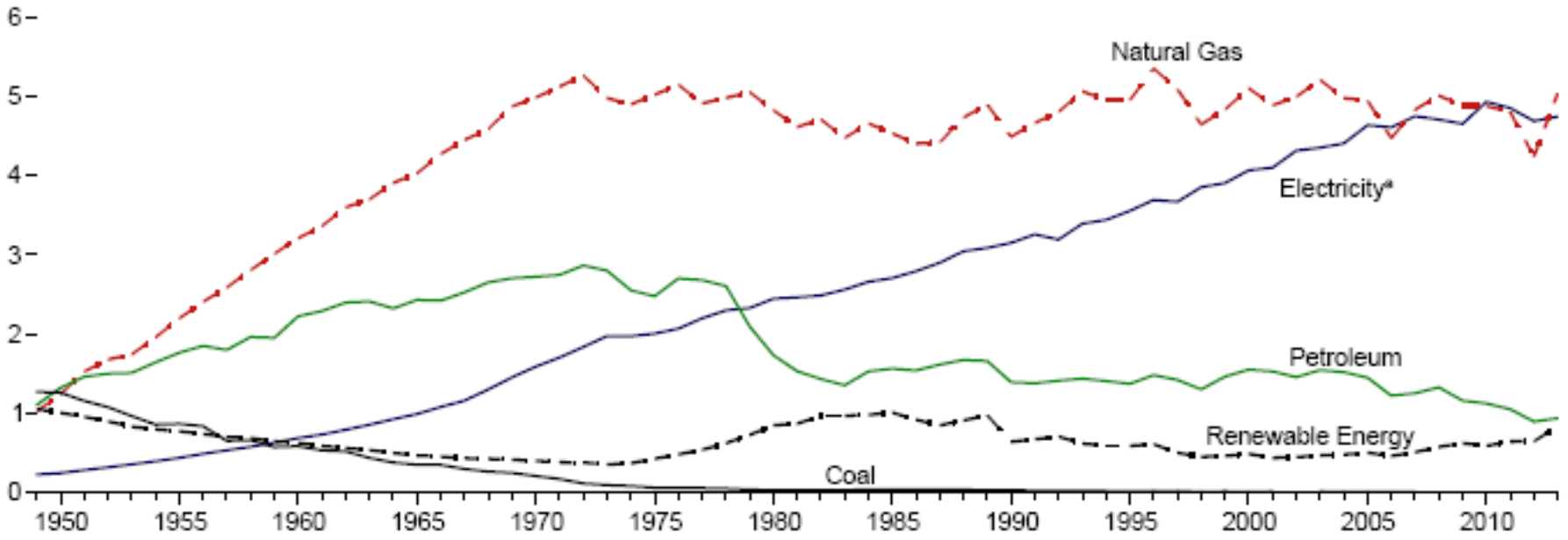


Source: U.S. Energy Information Administration, *Monthly Energy Review,* Table 1.1 (April 2013), preliminary 2012 data

70% of total imported energy was crude oil (EIA, 2013)

Figure 2.2 Residential Sector Energy Consumption
(Quadrillion Btu)

By Major Source, 1949–2013



Example: conversions

- Many of the EIA's plots are in units of quadrillion BTUs, also known as a Quad.
- Convert 1 quadrillion BTU's to 1 GWh
- Hint:
  - 1 quadrillion is 1 thousand million million (1e15)
  - 1 BTU = 1055 J
  - 3.6e6J = 1 kWh

Example: conversions

- Convert 1 quadrillion BTU's to 1 GWh
- Hint:
  - 1 quadrillion is 1e15
  - 1 BTU = 1055 J
  - 3.6e6J = 1 kWh (exact)

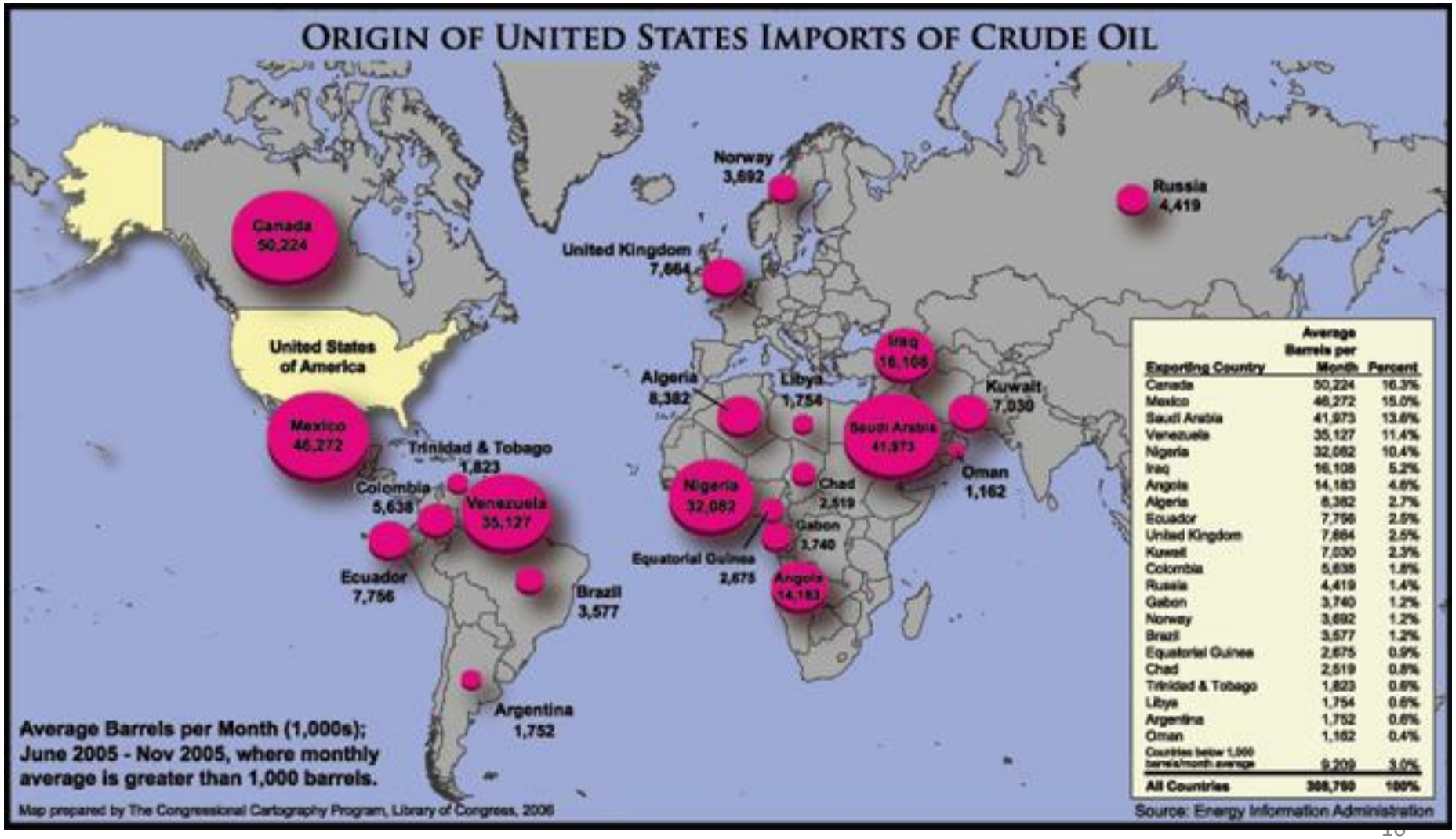
$$\frac{1e15BTU}{1} x \frac{1055J}{1BTU} x \frac{1kWh}{3.6e6J} x \frac{1TWh}{1e9kWh} = 293.1TWh$$

The US's energy challenge

- 25% of primary energy consumed in the US in 2013 was imported
- 70% of these energy imports were crude oil.
  - 71% of crude oil is used in transportation sector
  - 25% is used in industry
  - This is a huge energy security (and climate) challenge!
- US electricity (39 % of all energy use) is primarily from coal.
  - This is a huge climate challenge!

Source: US EIA

Where does our oil come from?

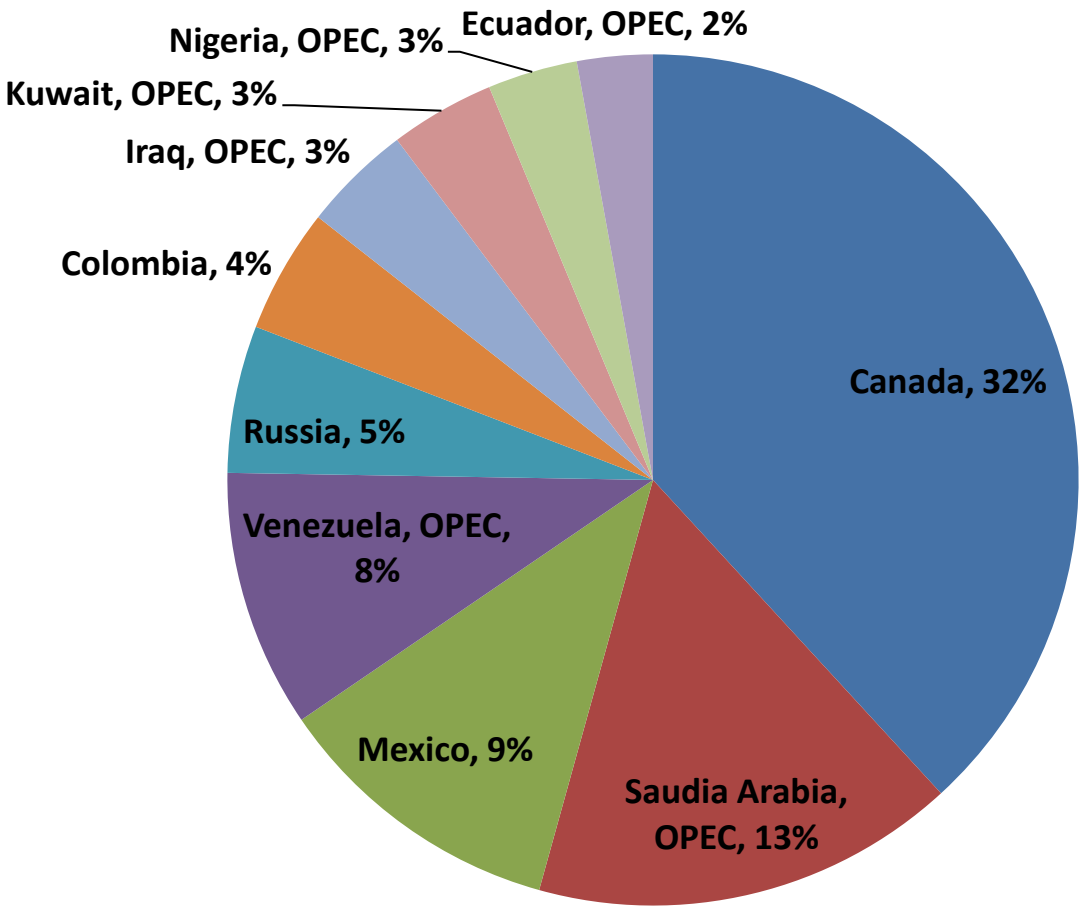


Exporting Country	Average Barrels per Month	Percent
Canada	50,224	16.3%
Mexico	46,272	15.0%
Saudi Arabia	41,973	13.6%
Venezuela	35,127	11.4%
Nigeria	32,082	10.4%
Iraq	16,108	5.2%
Angola	14,183	4.6%
Algeria	8,382	2.7%
Ecuador	7,756	2.5%
United Kingdom	7,664	2.5%
Kuwait	7,030	2.3%
Colombia	5,638	1.8%
Russia	4,419	1.4%
Gabon	3,740	1.2%
Norway	3,692	1.2%
Brazil	3,577	1.2%
Equatorial Guinea	2,675	0.9%
Chad	2,519	0.8%
Trinidad & Tobago	1,823	0.6%
Libya	1,754	0.6%
Argentina	1,752	0.6%
Oman	1,162	0.4%
Countries below 1,000 barrels/month average	9,209	3.0%
All Countries	308,760	100%

Where does our oil come from?

About 50% of our demand is supplied domestically

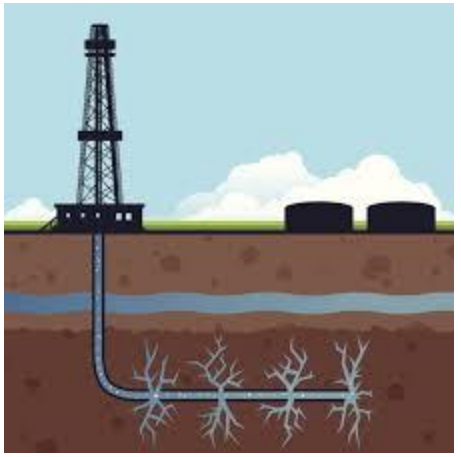
Top 10 Sources of Oil Imports to the US, 2013



Accounting for 84% of imported oil. Data source: EIA, Dec, 2014

Views of energy security

The proposed Keystone XL Pipeline (Phase IV, green), duplicates the Phase I pipeline between Hardisty and Steele City with a shorter route and a larger-diameter pipe.



Became “spill, baby, spill” after Deepwater Horizon in 2010

Keystone Pipeline calculation

- The phase 1 can deliver up to 590,000 bbl of oil per day to mid-western refineries.
  - What is the energy equivalent of this, in TWh?
- Annual energy consumption of oil in 2013 was 35 Quads.
  - What was the daily average consumption?
  - What percent of daily use of oil is delivered in the Keystone pipeline to the midwest?

Keystone Pipeline calculation

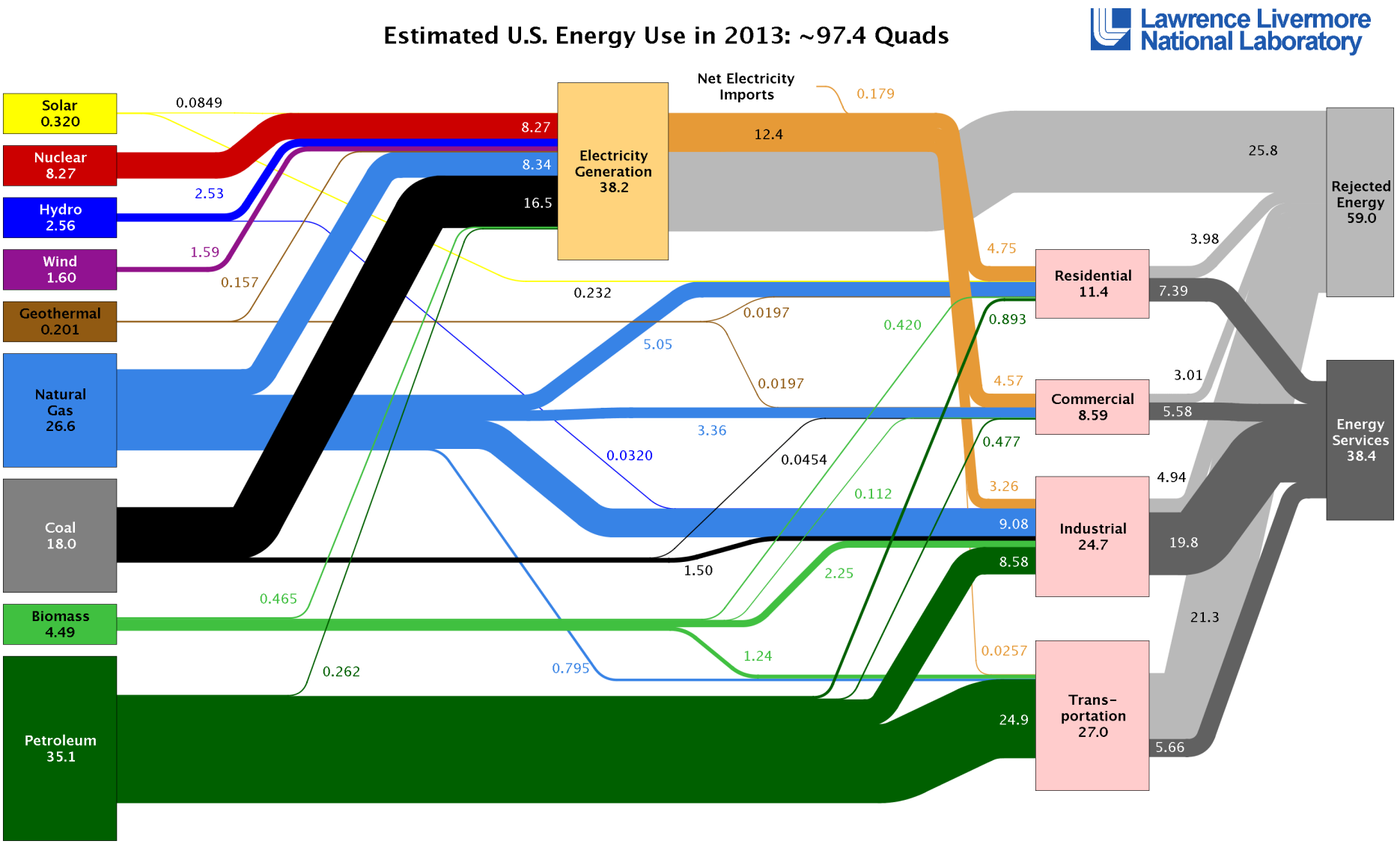
$$\frac{590000bbl}{day} x \frac{5.8e6BTU}{1bbl} x \frac{1kWh}{3412BTU} x \frac{1TWh}{1e9kWh} = 1.0TWh/day$$

$$\frac{35Quads}{year} x \frac{293.1TWh}{1quad} x \frac{1yr}{365days} = 28TWh/day$$

1 TWh/day / 28 TWh/day = 1/28

= 0.036 or 3.6 %

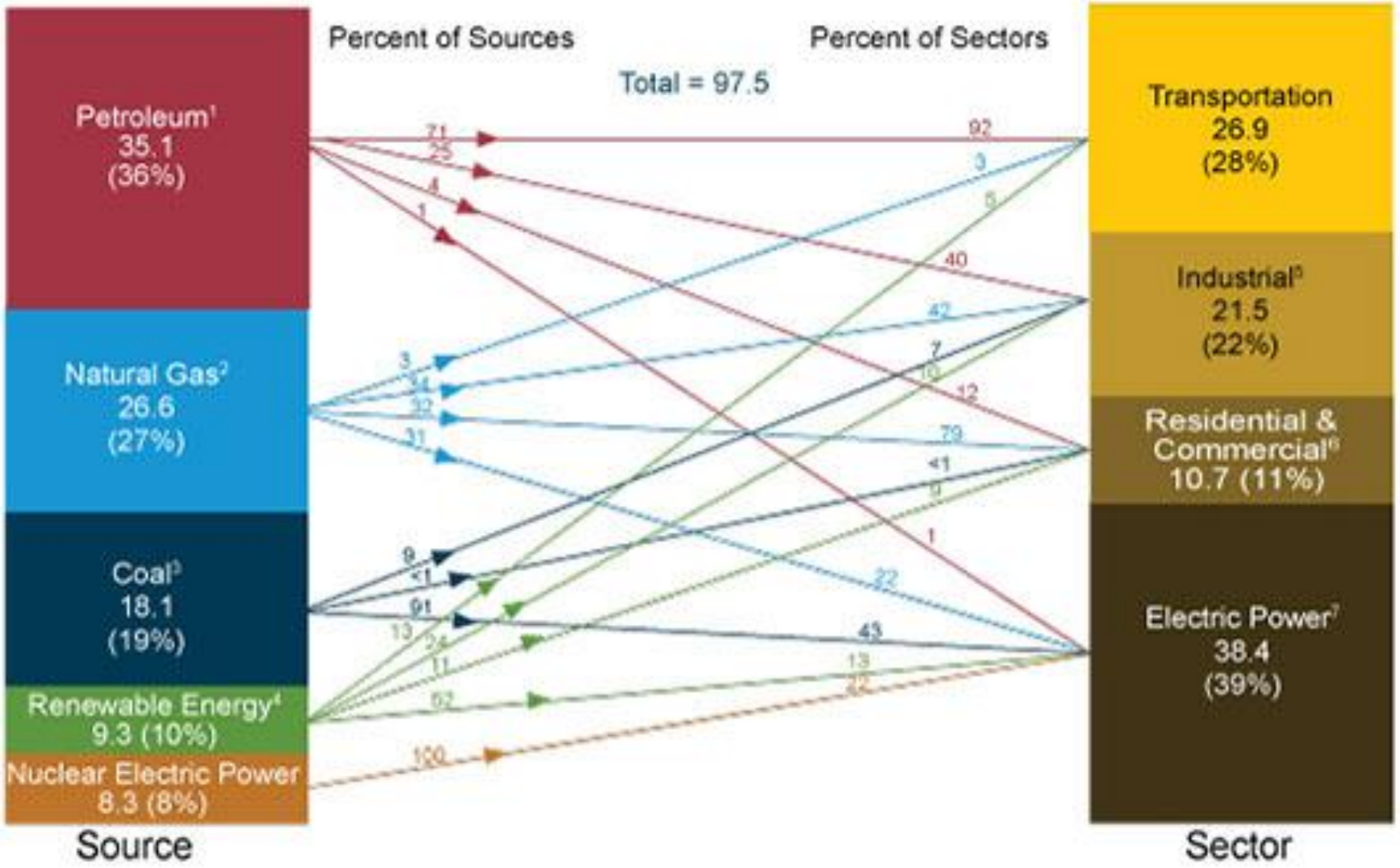
Sankey Diagram of US energy use



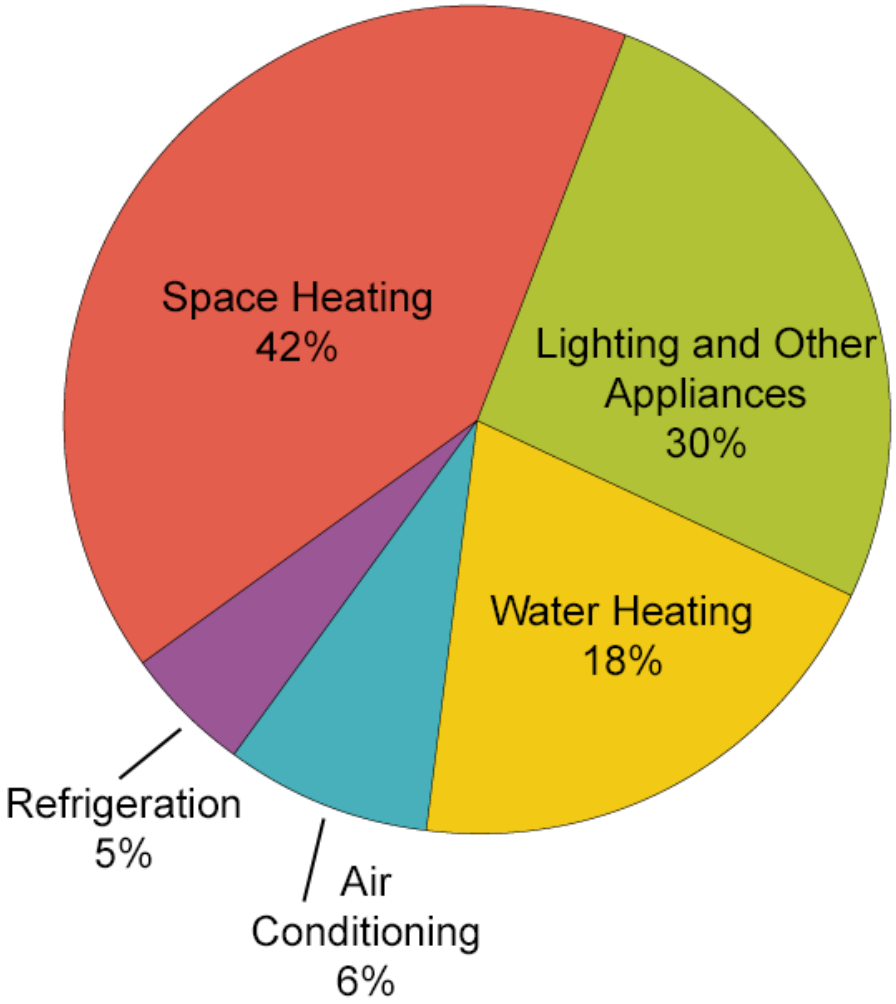
Source: LLNL 2014. Data is based on DOE/EIA-0035(2014-03), March, 2014. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents 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

Primary energy consumption by source and sector, 2013

quadrillion Btu



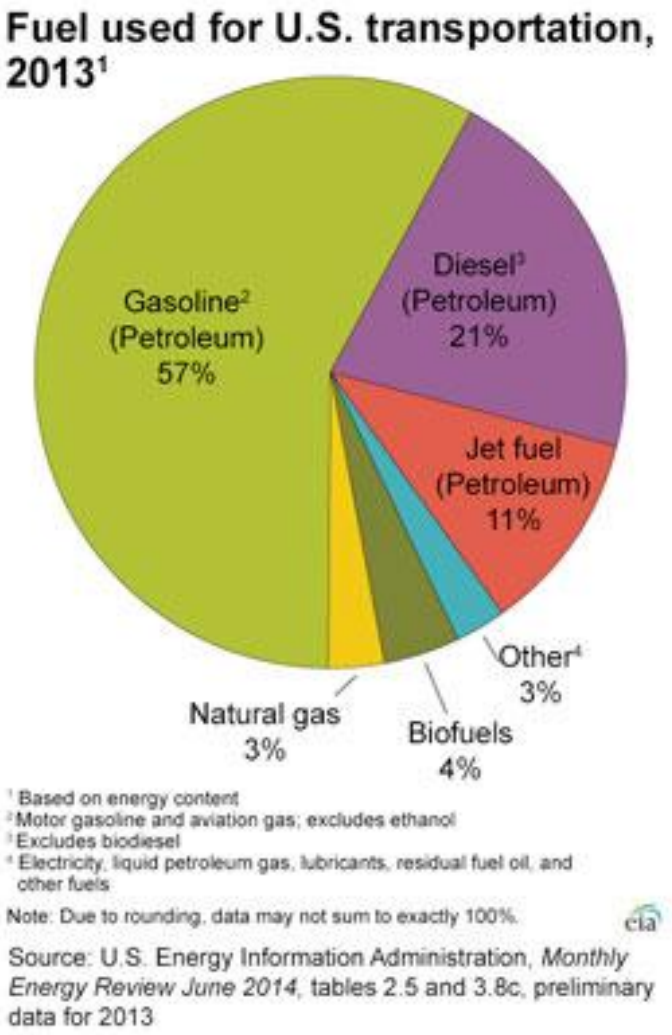
How Energy Is Used in Homes (2009)*



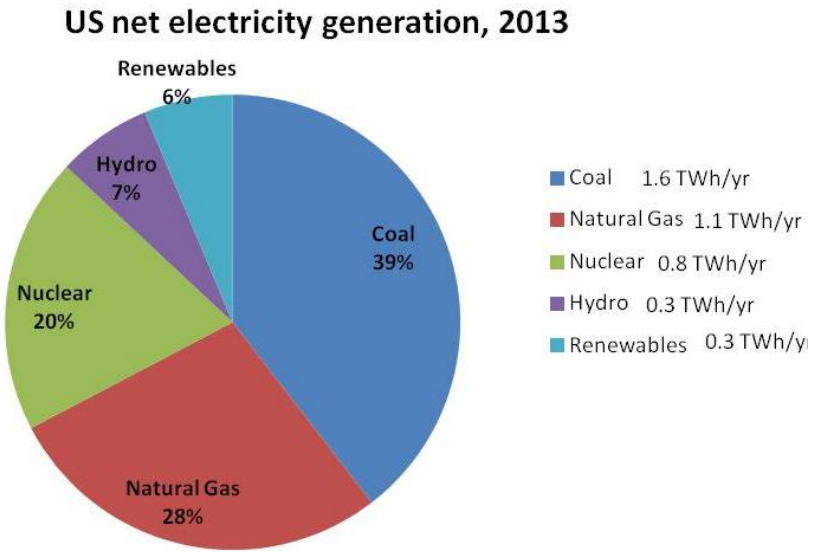
* 2009 is the most recent year for which data are available.

Source: U.S. Energy Information Administration, *Residential Energy Consumption Survey (RECS) 2009*.

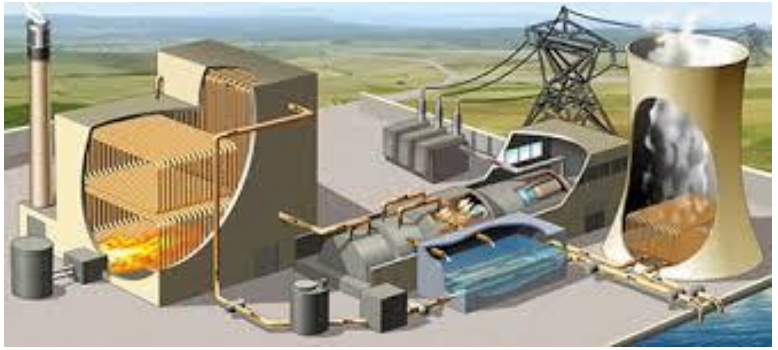
28% of energy use for transportation in the US



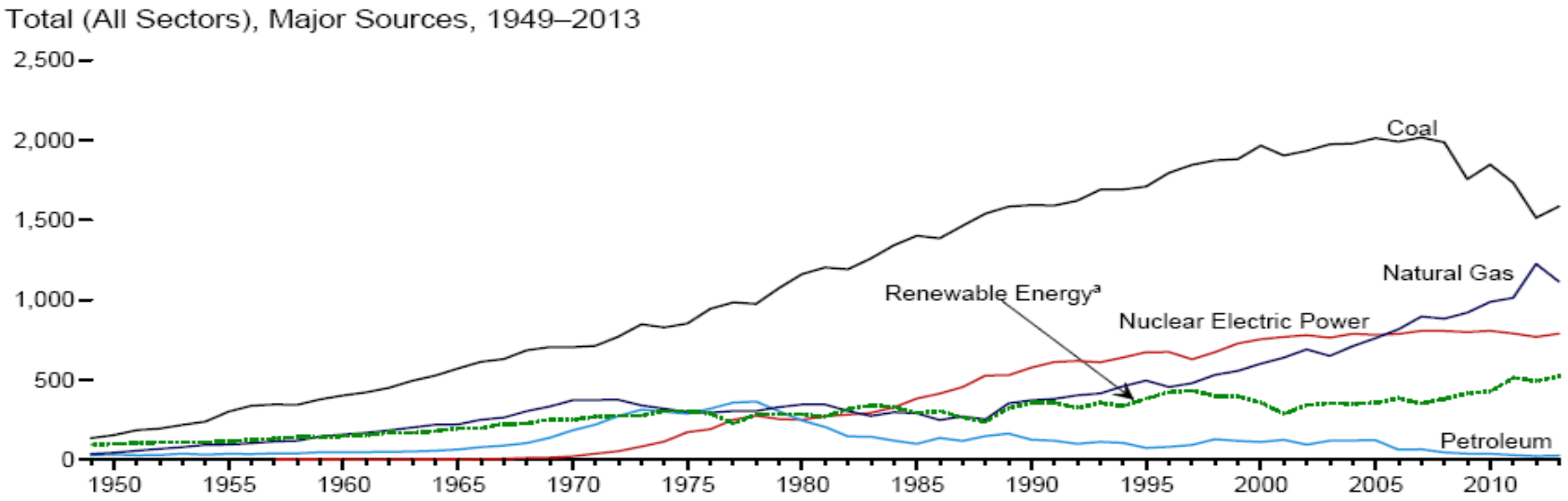
Net electricity generation in US (billion kWh)



Source: EIA, 2014



Net electricity generation in US (billion kWh)



Source: EIA, 2014

Electrical Production by Renewables in the US in 2012

Power Source	Plants	Summer Capacity (GW)	Capacity Factor	Annual Energy (billion kWh)	% of annual production
Hydro	4023	78.7	0.40	276.24	6.75
Wind	947	59	0.272	140.82	3.44
Wood	351	7.5	0.575	37.8	0.92
Biomass	1766	4.8	0.471	19.82	0.48
GeoThermal	197	2.6	0.683	15.56	0.38
Solar	553	3.2	0.154	4.33	0.11
Total	7837	155.8	0.362	494.57	12.08

Supplemental

Examples

1. A light bulb has a rating of 50 W. If the light is turned on for 3 hours, how much energy was changed from electricity into____and ____?
2. How many hours will it take for a 100 W light bulb to consume 1 kWh of electricity?
3. A solar panel has a rating of 50W under direct sunlight. If it receives direct sunlight for 3 hours, how much electricity will it generate? How many hours would this be able to power 4 LED light bulbs, of 3W each?

Examples

1. A light bulb has a rating of 50 W. If the light is turned on for 3 hours, how much energy was changed from electricity into power and heat?
   - 3 hrs x 50 w = 350 Wh = 0.350 kWh = 0.35x10^1 kWh
2. How many hours will it take for a 100 W light bulb to consume 1 kWh of electricity?
   - Time = energy/power = 1kWh/0.1kW = 10 hrs
3. A solar panel has a rating of 50W under direct sunlight. If it receives direct sunlight for 3 hours, how much electricity will it generate? How many hours would this be able to power 4 LED light bulbs, of 3W each?
   - 50W x 3 hrs = 150 Wh
   - 150Wh/12W = 12.5 h = 13 h

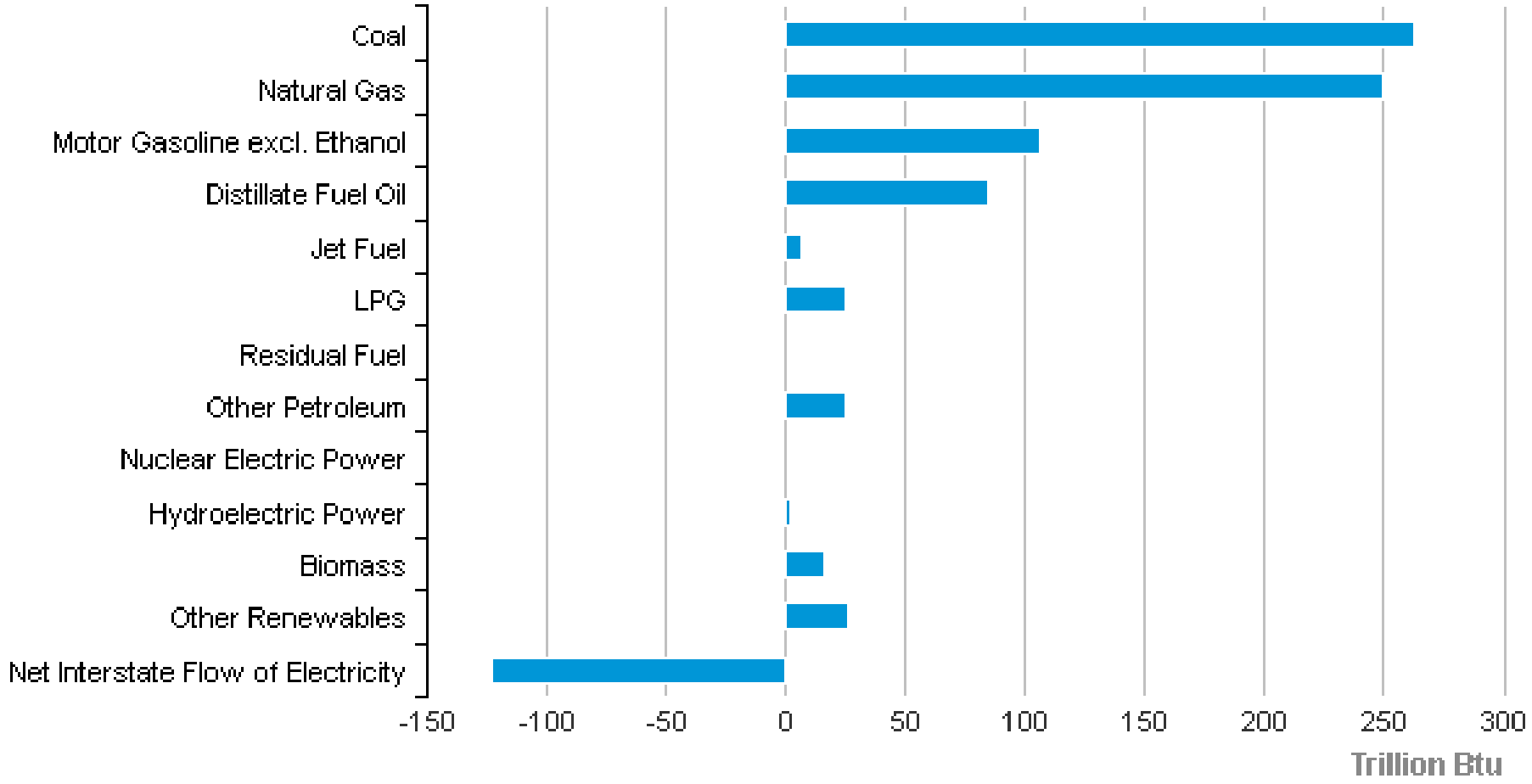
Example

- How many Joules are in a kWh of energy?
  - Hint: 1 kWh = 1000 Wh, and 1 W = 1 J/s

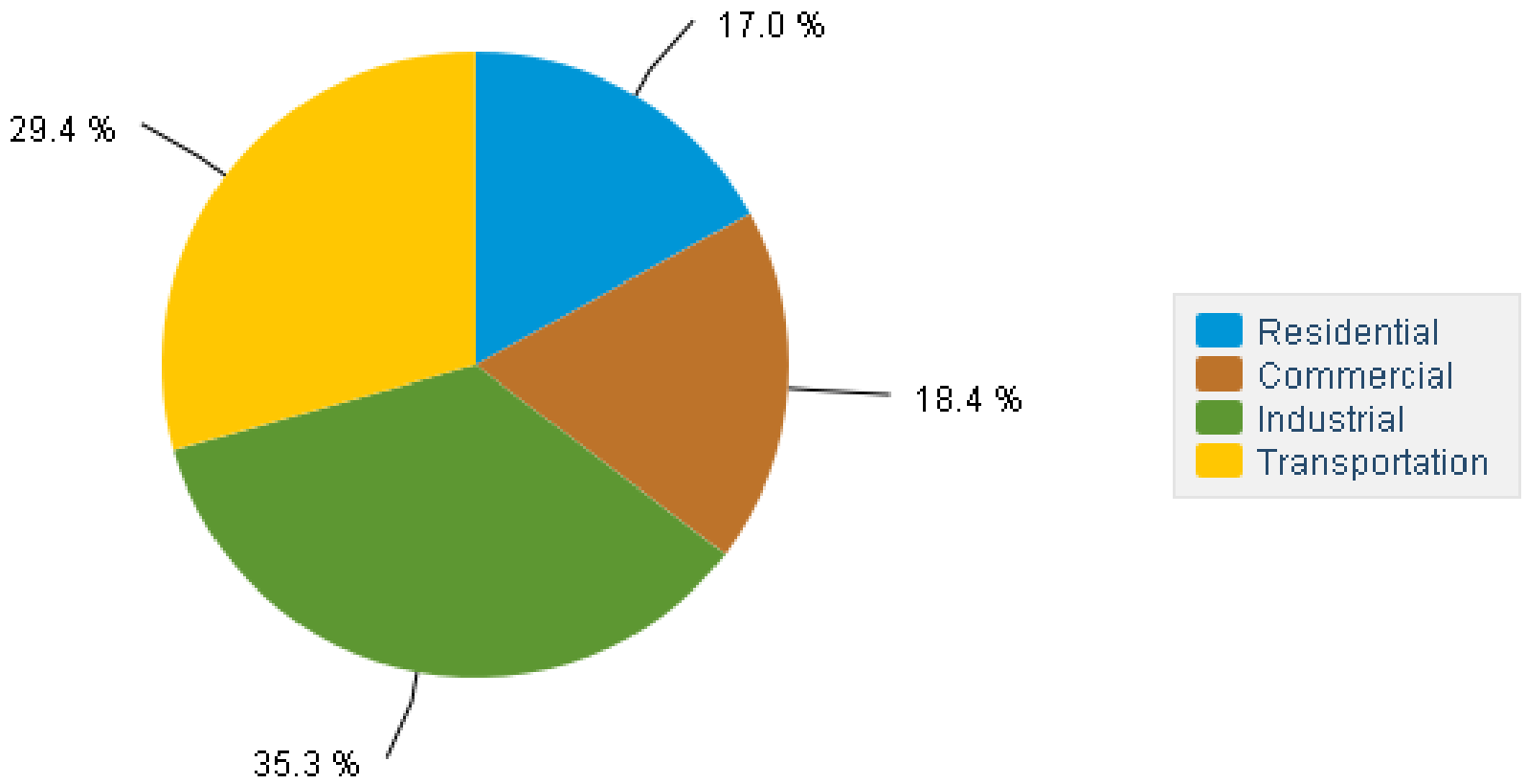
Example

- How many Joules are in a kWh of energy?
  - Hint: 1 kWh = 1000 Wh, and 1 W = 1 J/s
  - 1 kWh = 1000 Wh = 1000 J/s x h
  - 1000 J/s x 1 h x 60 min/ 1 h x 60 sec / 1 min
  - 3600000 J = 3.6 x 10^6 J

New Mexico Energy Consumption Estimates, 2012



NM Energy consumption by end-use, 2012



Source: Energy Information Administration, State Energy Data System