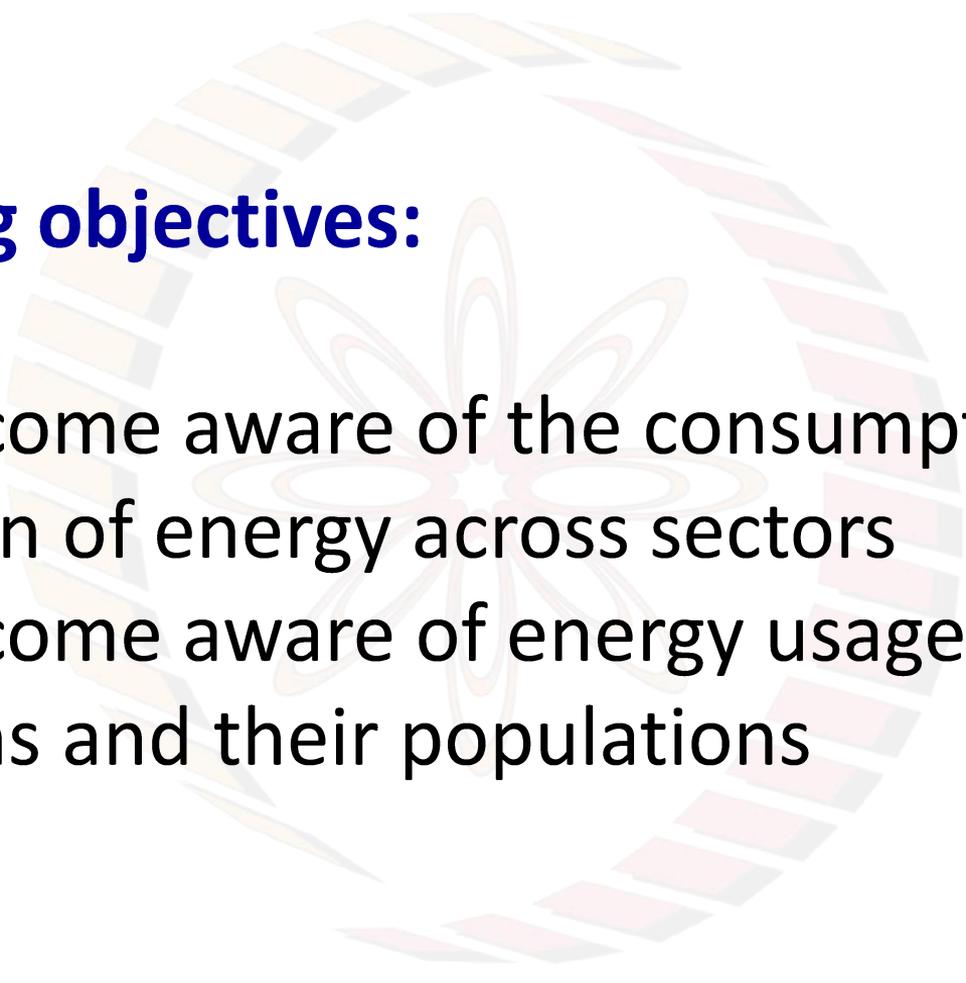




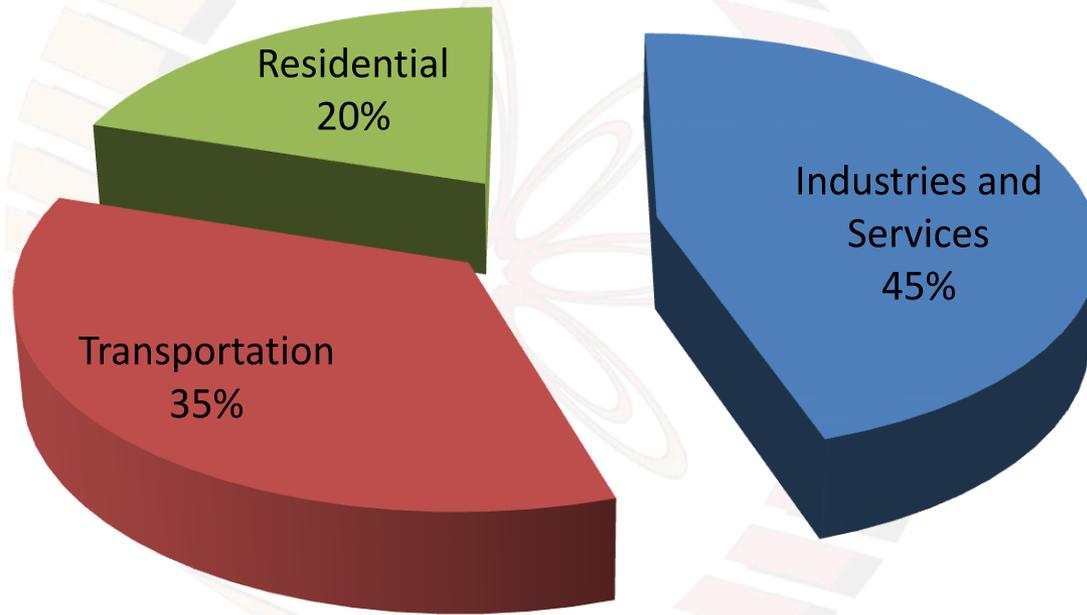
Energy Consumption



Learning objectives:

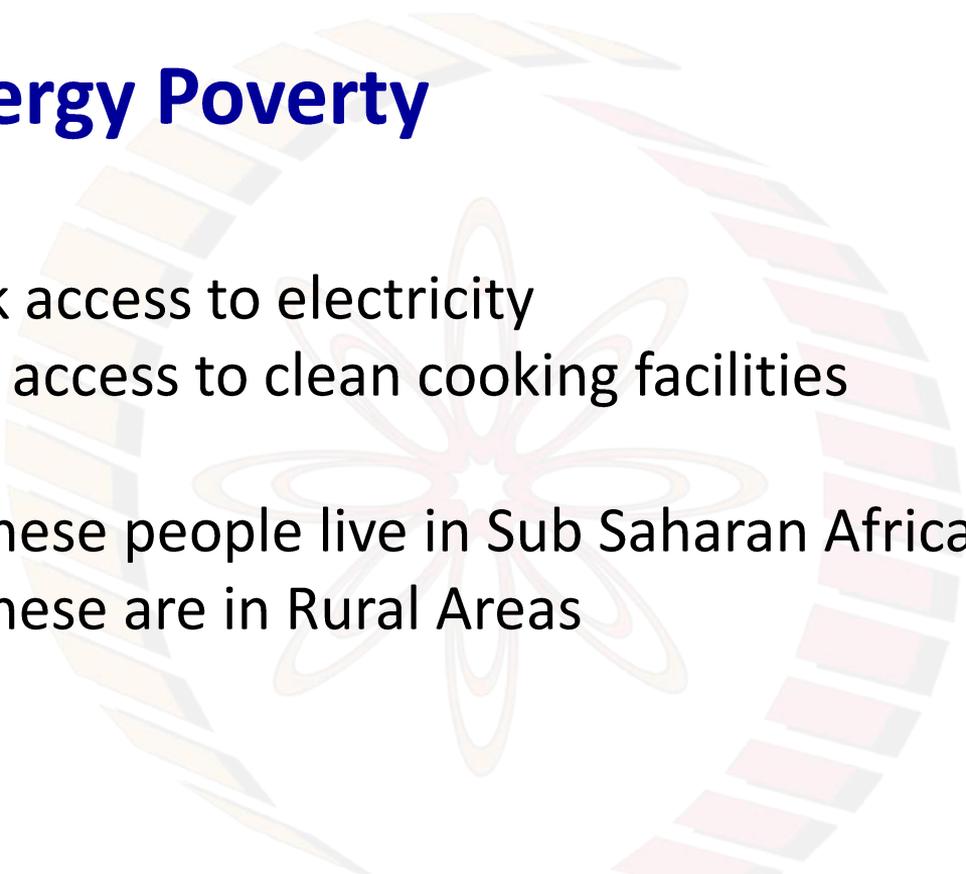
- 1) To become aware of the consumption pattern of energy across sectors
- 2) To become aware of energy usage across nations and their populations

Energy consumption by sector



Data Source: Key World Energy Statistics 2017; International Energy Agency (IEA)

Energy Poverty



17% Lack access to electricity

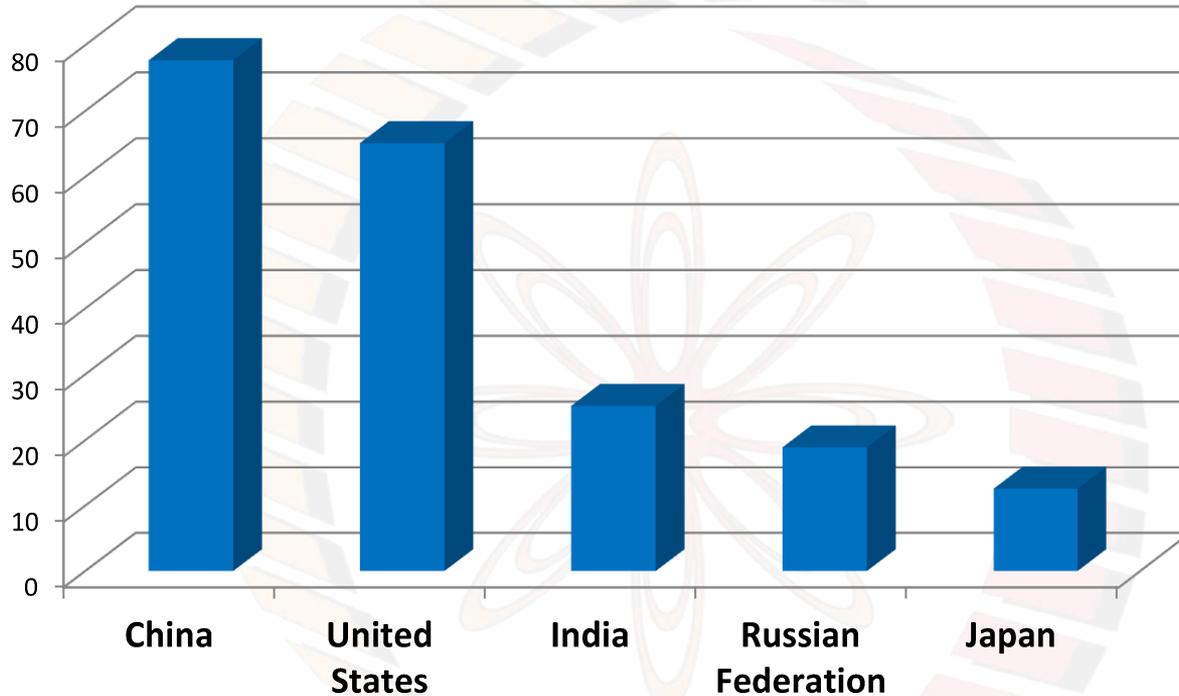
38% lack access to clean cooking facilities

95% of these people live in Sub Saharan Africa, or Asia

80% of these are in Rural Areas

<http://www.iea.org/topics/energypoverty/>

Top 5 Nations based on Total Energy Consumption (Annual)



Humans use 500 Exa Joules of energy annually
1 Exa Joule = 10^{18} Joules

Data Source: Key World Energy Statistics 2017; International Energy Agency (IEA)

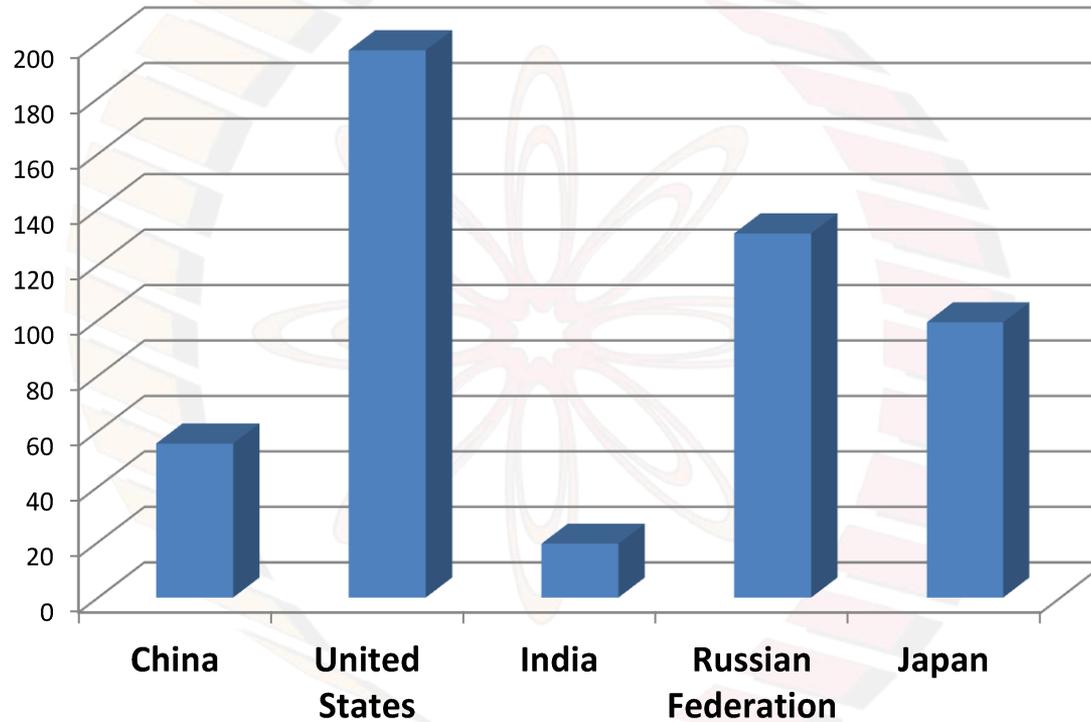
10^{18}



World energy usage per year : 500 exa joules

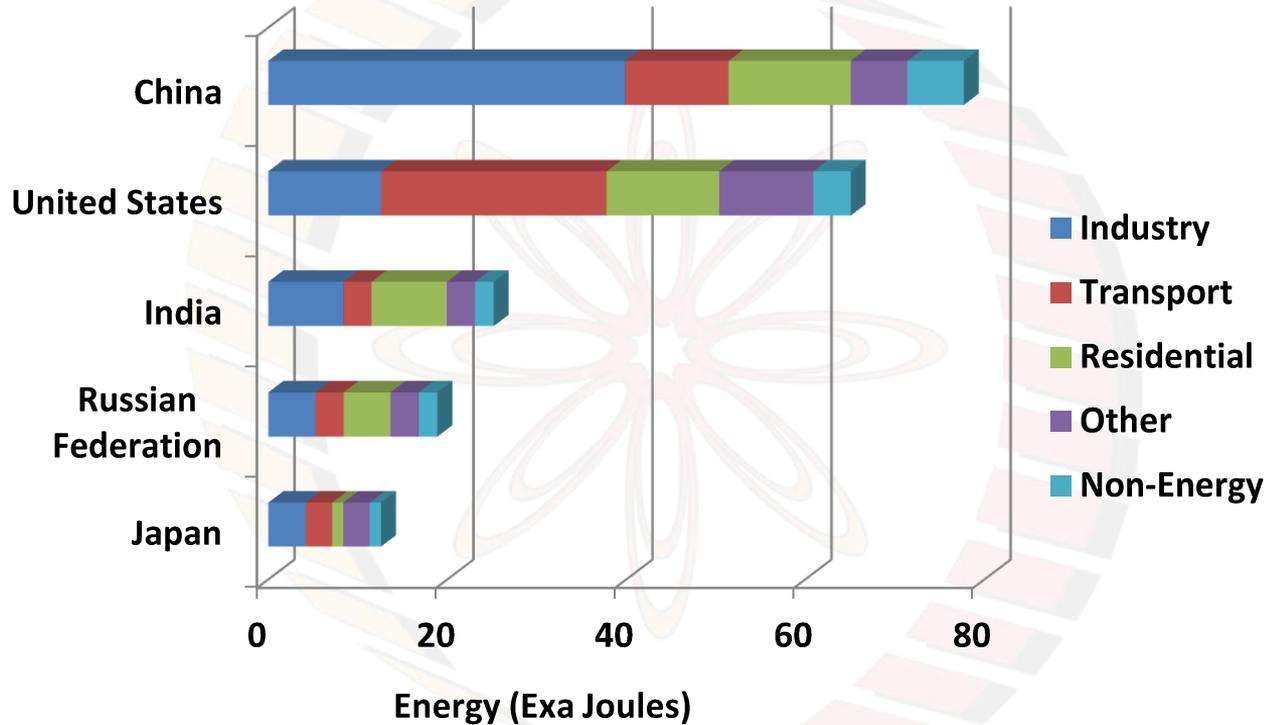
Image Credit NASA

Per Capita Energy Consumption (Annual)



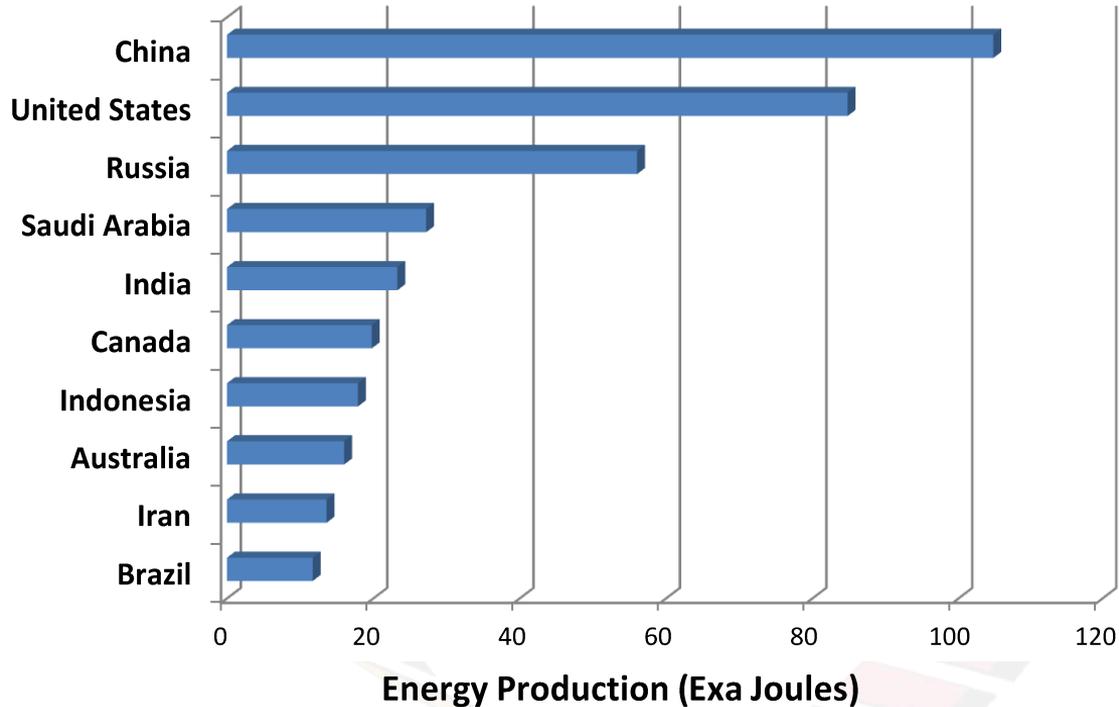
Data Source: Key World Energy Statistics 2017; International Energy Agency (IEA)

Top 5 Nations based on Total Energy Consumption (Annual) Sector wise distribution

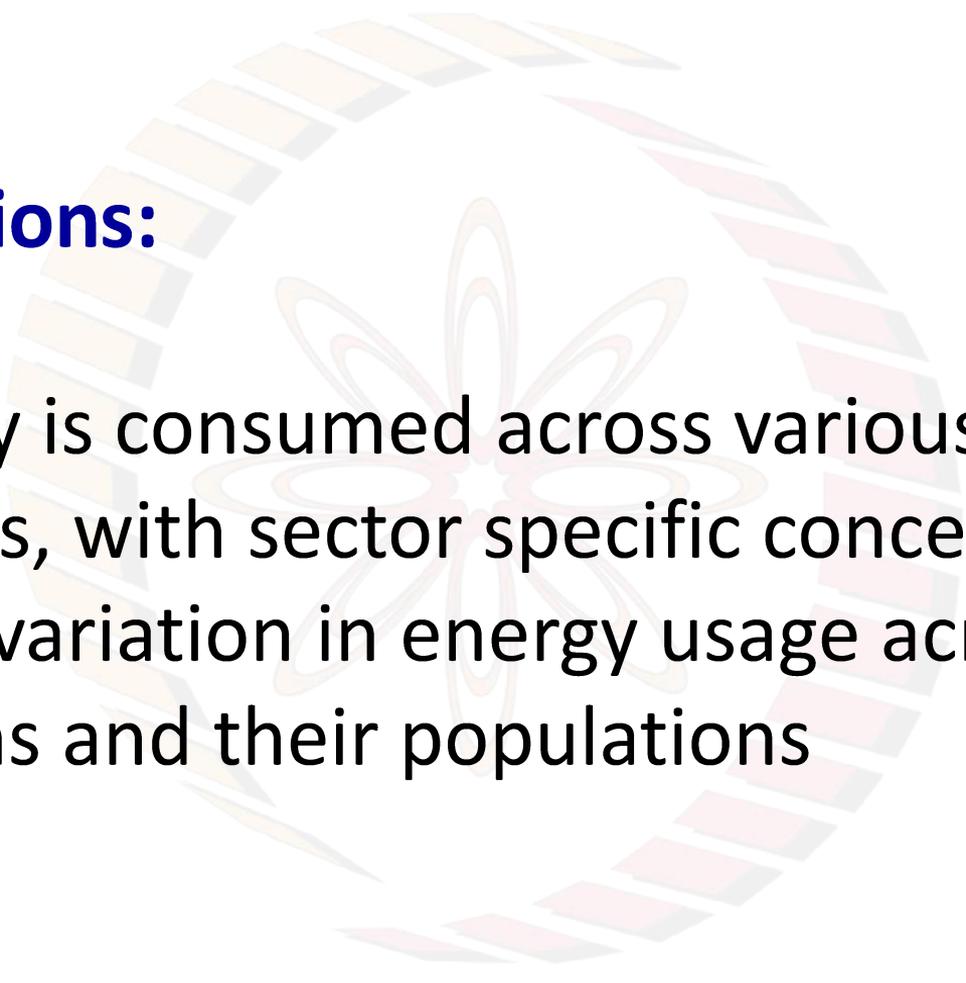


Data Source: Key World Energy Statistics 2017; International Energy Agency (IEA)

Top 10 Nations based on Total Energy Production (Annual)



<https://www.iea.org/statistics/statisticssearch/>
2015 data



Conclusions:

- 1) Energy is consumed across various sectors, with sector specific concerns
- 2) Wide variation in energy usage across nations and their populations



Split up of Energy usage

Industrial sector:

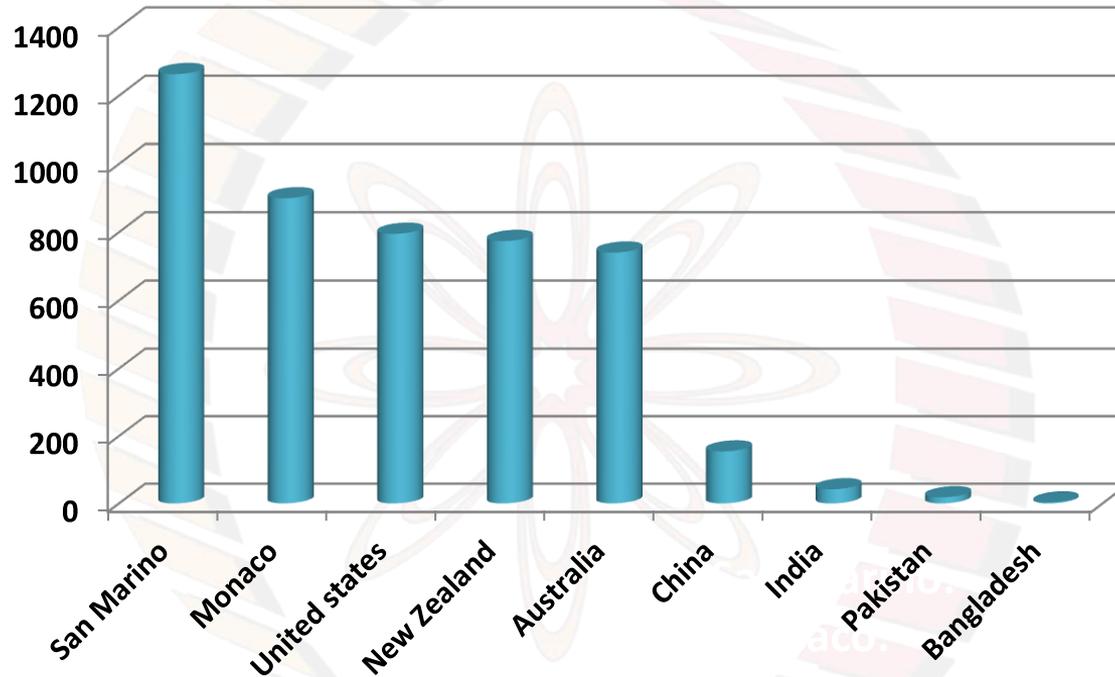
(Oil refining, Metallurgical processes, Glass manufacture)

- 1) **Process heating:** Raising temperature of components during manufacturing
- 2) **Refining Crude oil:** Separation of products
- 3) **Boiler heating:** To generate steam

Primary: Natural gas and oil

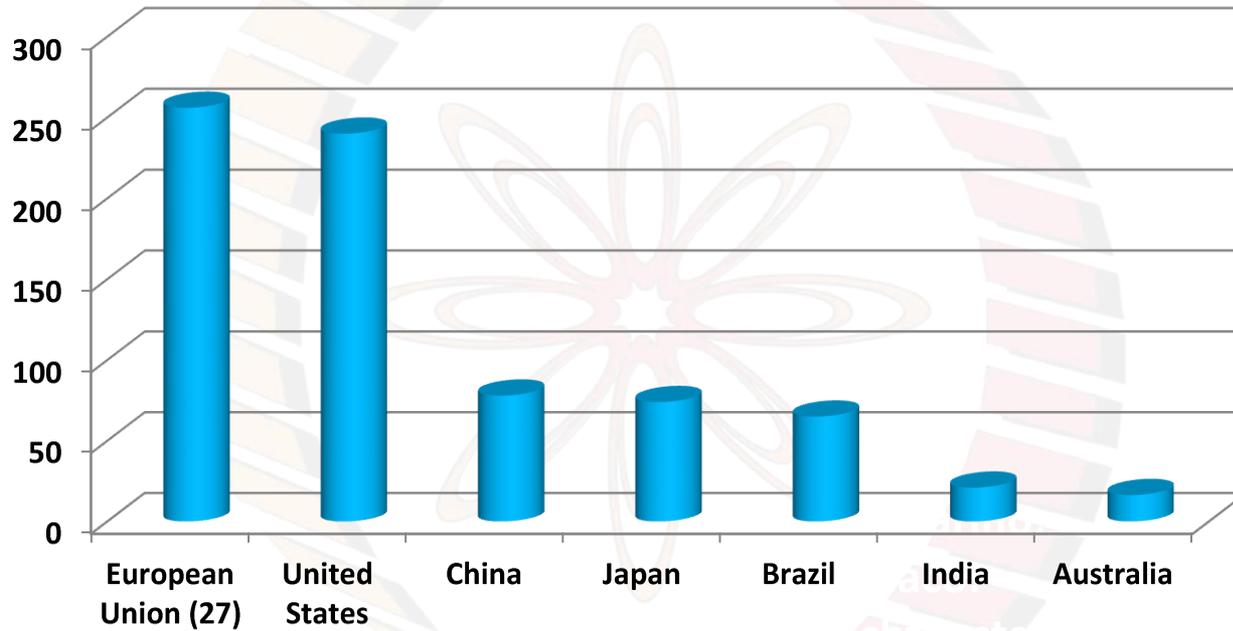
Secondary: Electricity

Vehicles per 1000 people



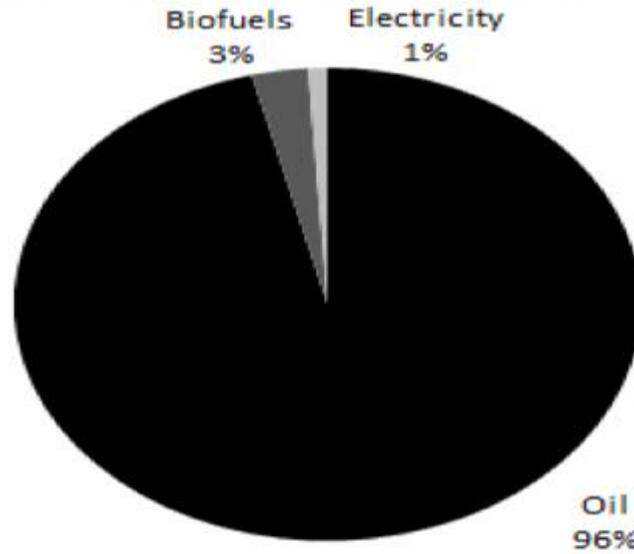
https://en.wikipedia.org/wiki/List_of_countries_by_vehicles_per_capita
2014 - 2016 data

Vehicle population



https://en.wikipedia.org/wiki/Motor_vehicle
2010 - 2011 data

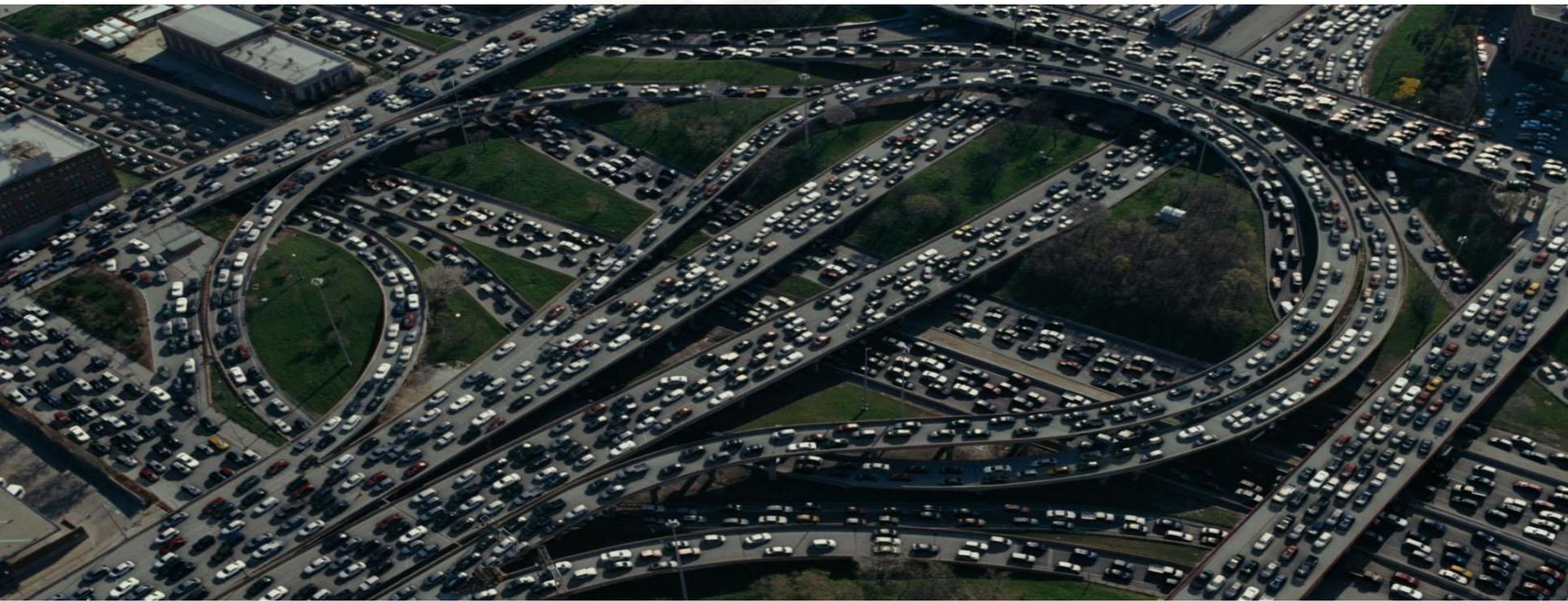
Global Transportation Consumption



Amount = 88 mbd

Energy sources for transportation (mbd= millions of barrels a day).

Image Credit: Benjamin Sovacool.



Traffic jam in San Francisco



Traffic jam in China



Traffic jam in Chennai

(US data)

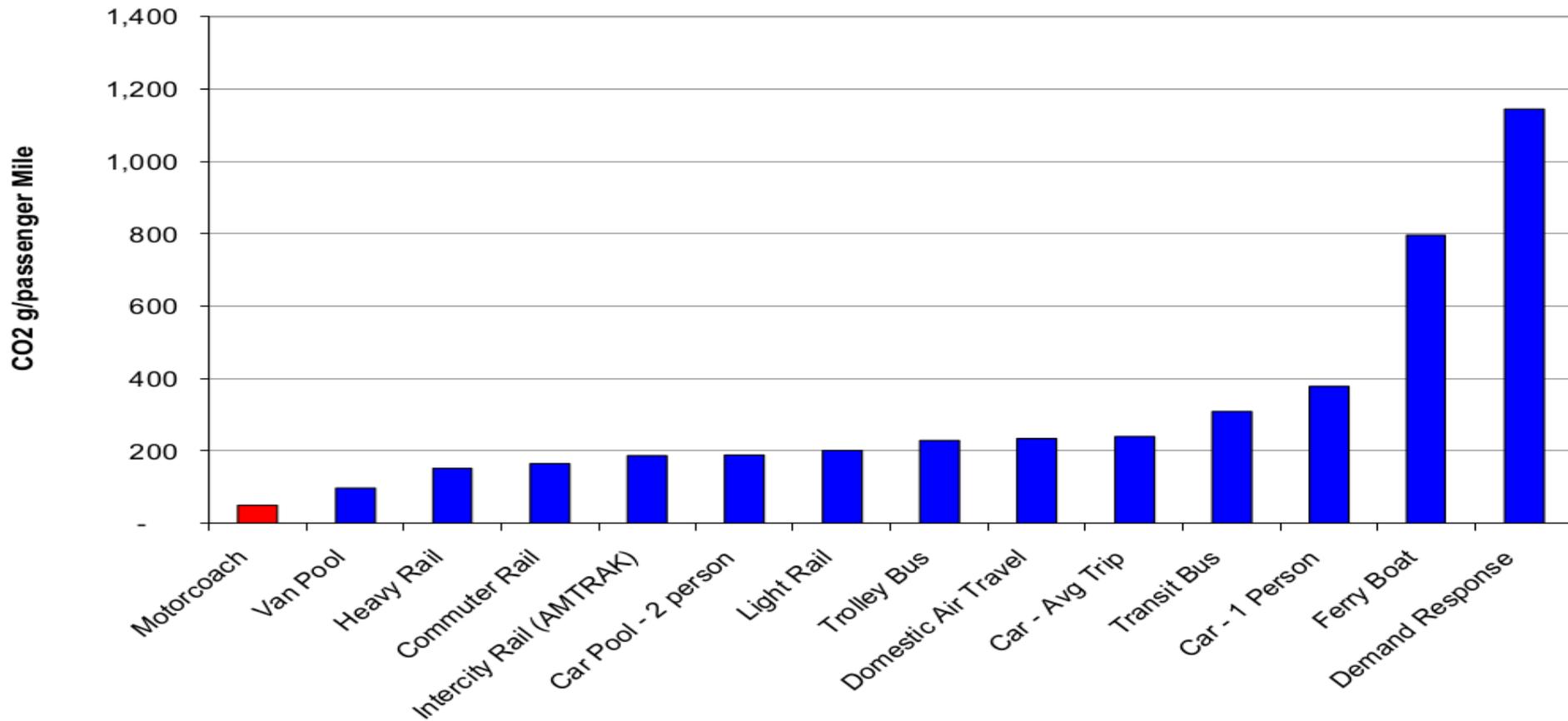
Traffic congestion wasted 1.9 billion gallons of fuel in 2010 and is “severely threatening the potential oil-saving benefits associated with more efficient vehicles and alternative fuels.”

Just as significant are the valuable wasted hours of people and goods stuck in traffic. The annual cost of wasted fuel and time together comes to about \$100 billion, the report estimates.

In the San Francisco Bay Area alone, those costs exceeded \$1 billion in 2010 and idling drivers wasted 54 million gallons of fuel
Congestion in America: A Growing Challenge to U.S. Energy Security. by FedEx CEO Fred Smith and retired Marine Corps Commandant, Gen. P.

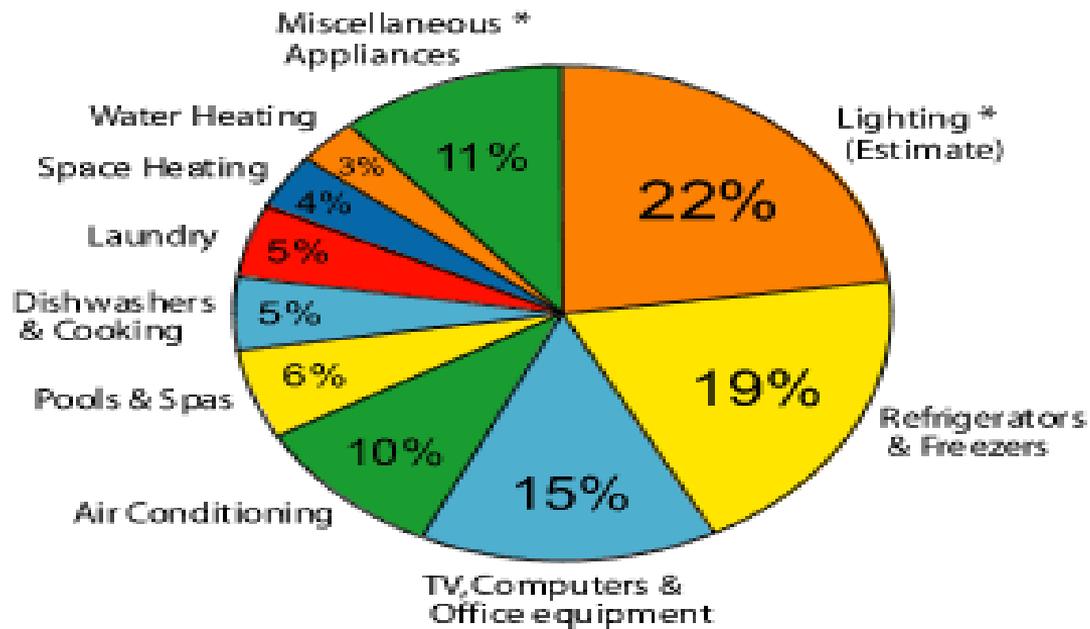
Total Annual energy usage (US) $25000 \text{ TWh} = 2.5 \times 10^3 \times 3.6 \times 10^3 \times 10^{12} = 9 \times 10^{18} \text{ J}$

$(1.9 \times 10^9 / 42) \times 6.1 \times 10^9 = 0.28 \times 10^{18} \text{ J} \sim 10\% \text{ of energy usage in transportation}$

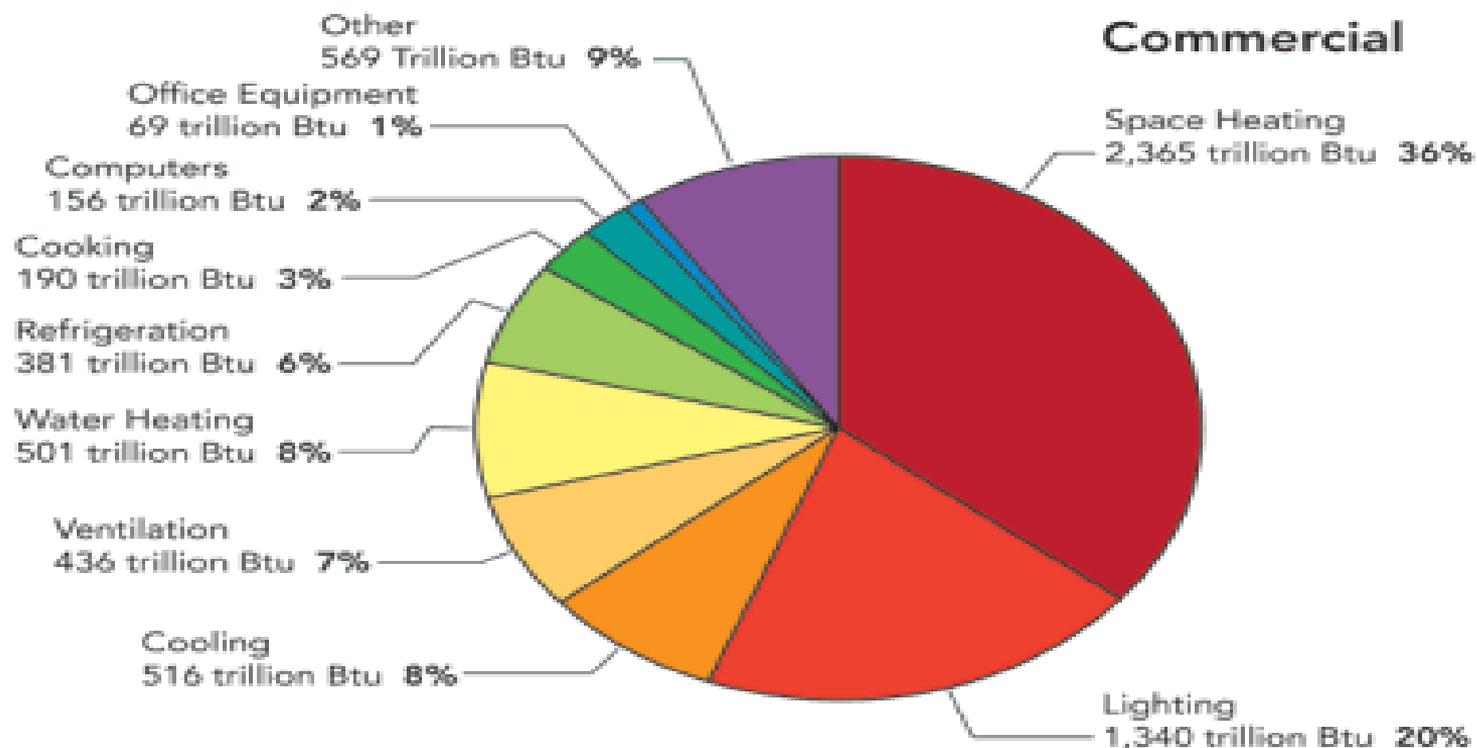


Average carbon dioxide emissions (grams) per passenger mile (USA). Based on 'Updated Comparison of Energy Use & CO 2 Emissions From Different Transportation Modes, October 2008' (Manchester, NH: M.J. Bradley & Associates, 2008), p. 4, table 1.1





Energy consumption in a typical California home



Percentage of energy use for commercial facilities (EIA)