# Energy Sources Overview

IB PHYSICS | ENERGY PRODUCTION

# What is Energy Used For?

## Residential/Commercial


## Industrial

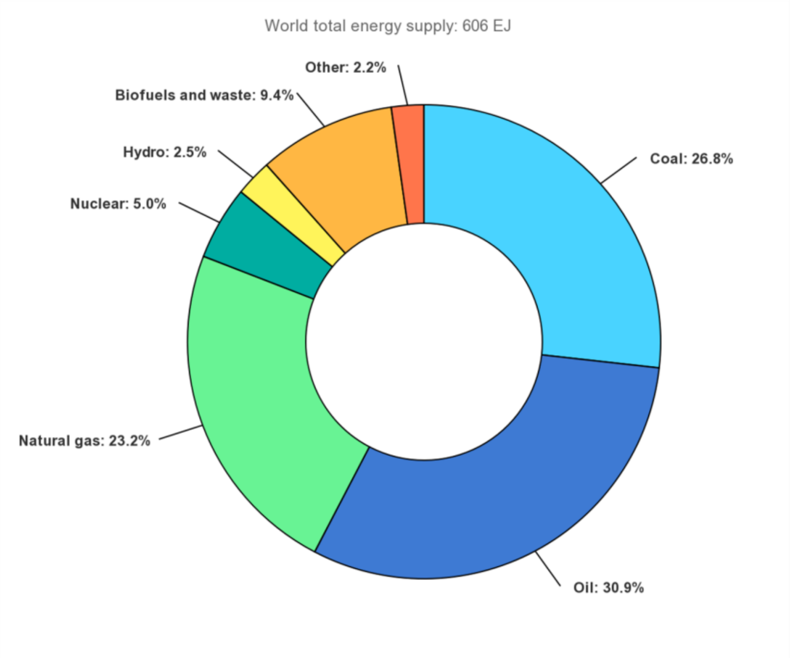
## Electric Power

## Transportation

# Where does our Energy Come From?

## World Sources

2019 Global Energy Supply

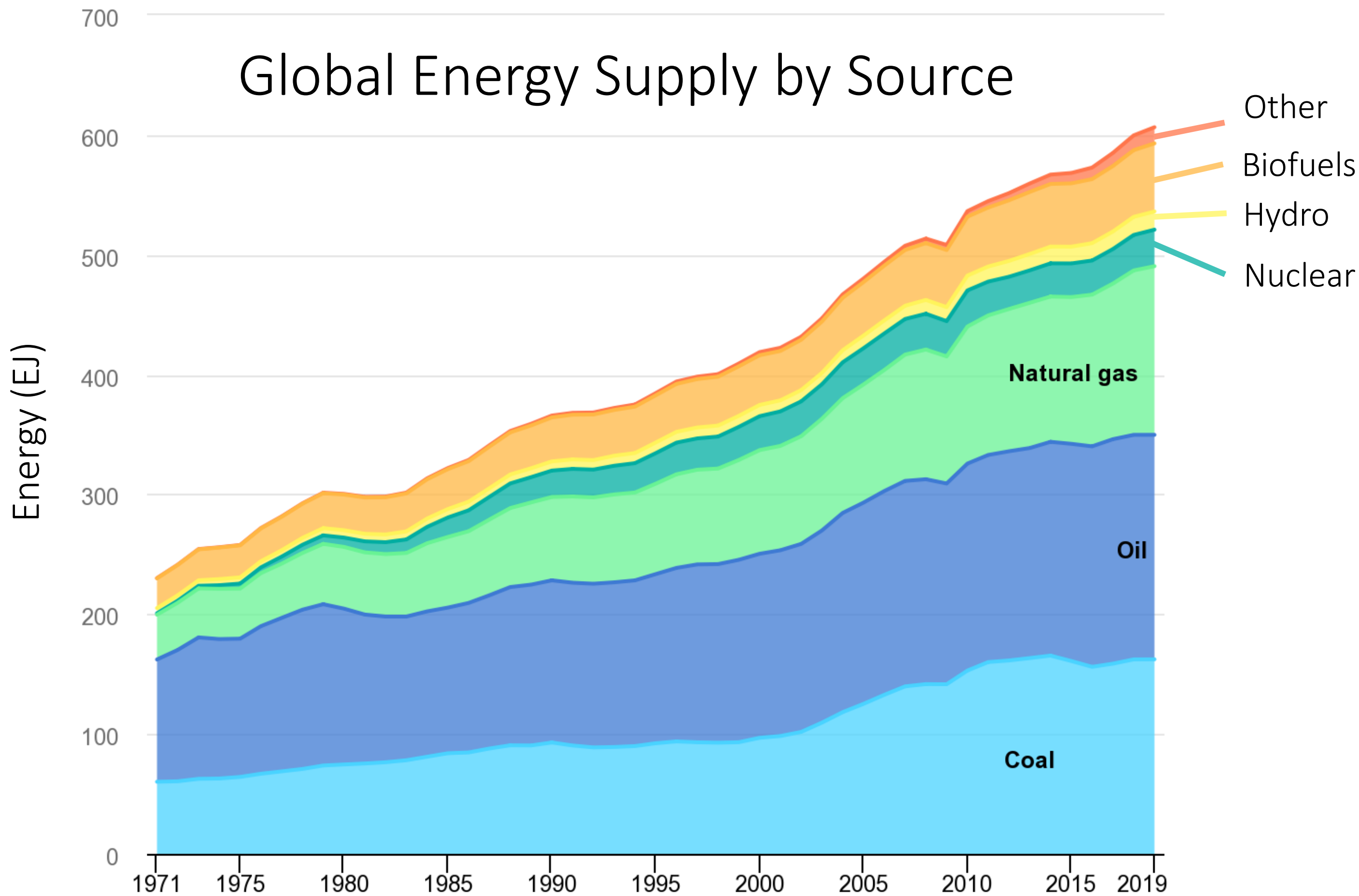



## List Sources in Order:

| | |
|---|---|
| **Oil** | ~31% |
| **Coal** | ~27% |
| **Natural Gas** | ~23% |
| **Biofuels** | ~9% |
| **Nuclear** | ~5% |
| **Hydropower** | ~2.5% |

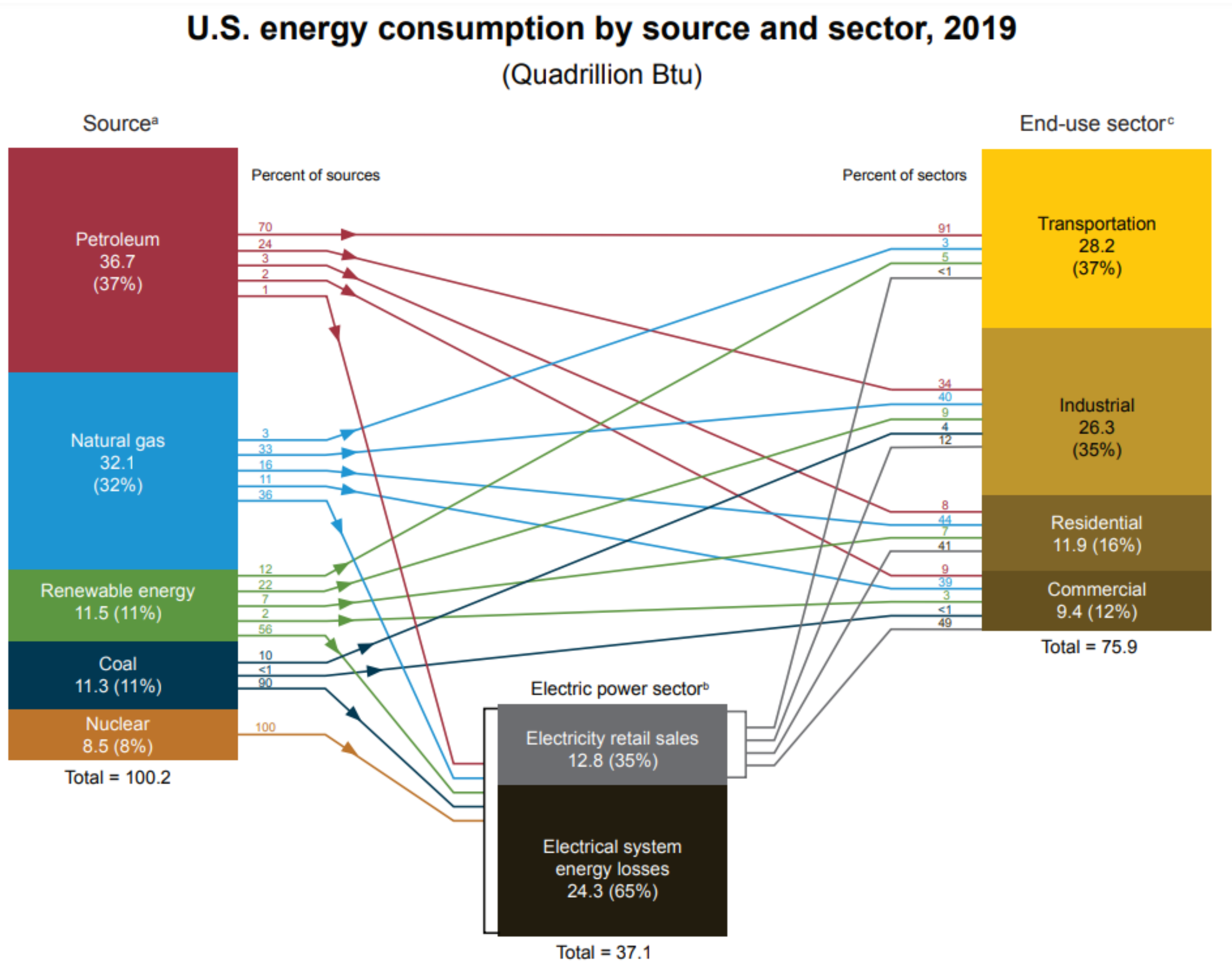
IEA, Global share of total energy supply by source, 2019, IEA, Paris
https://www.iea.org/data-and-statistics/charts/global-share-of-total-energy-supply-by-source-2019

# This changes over time




IEA, World total energy supply by source, 1971-2019, IEA, Paris
https://www.iea.org/data-and-statistics/charts/world-total-energy-supply-by-source-1971-2019

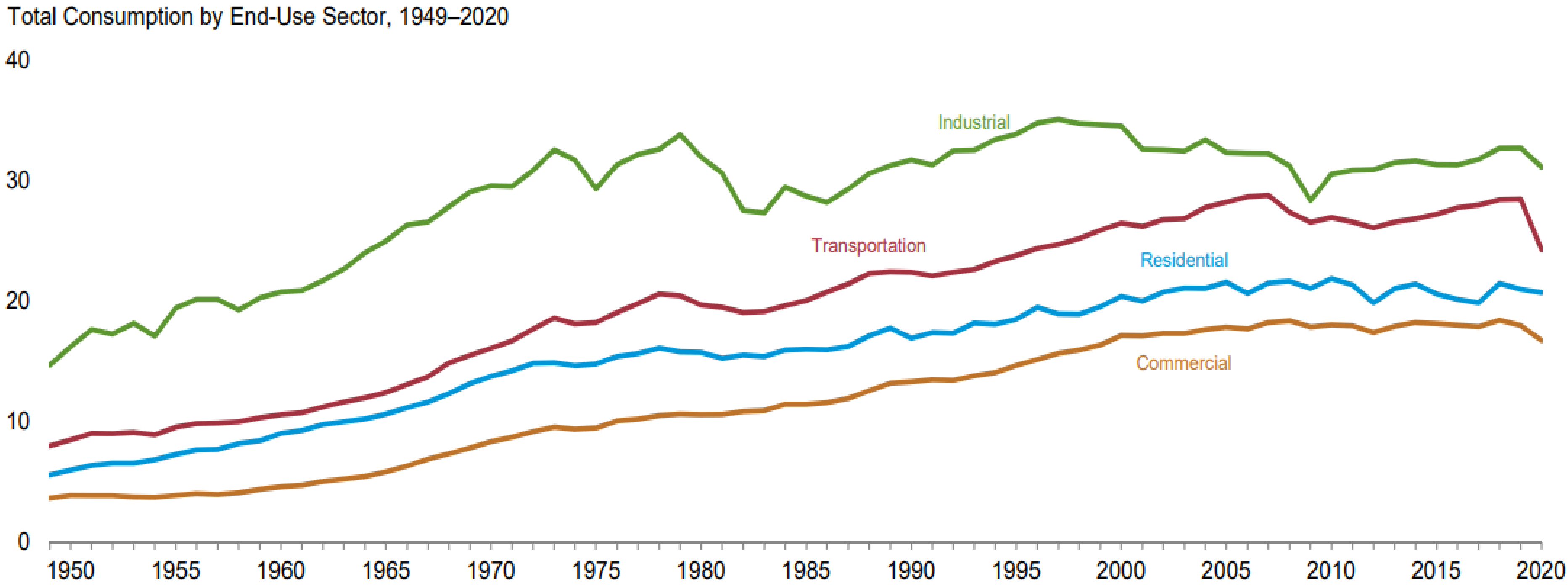
# Used in Many Ways…




https://www.eia.gov/totalenergy/data/monthly/pdf/flow/css_2019_energy.pdf

# Used in Many Ways…

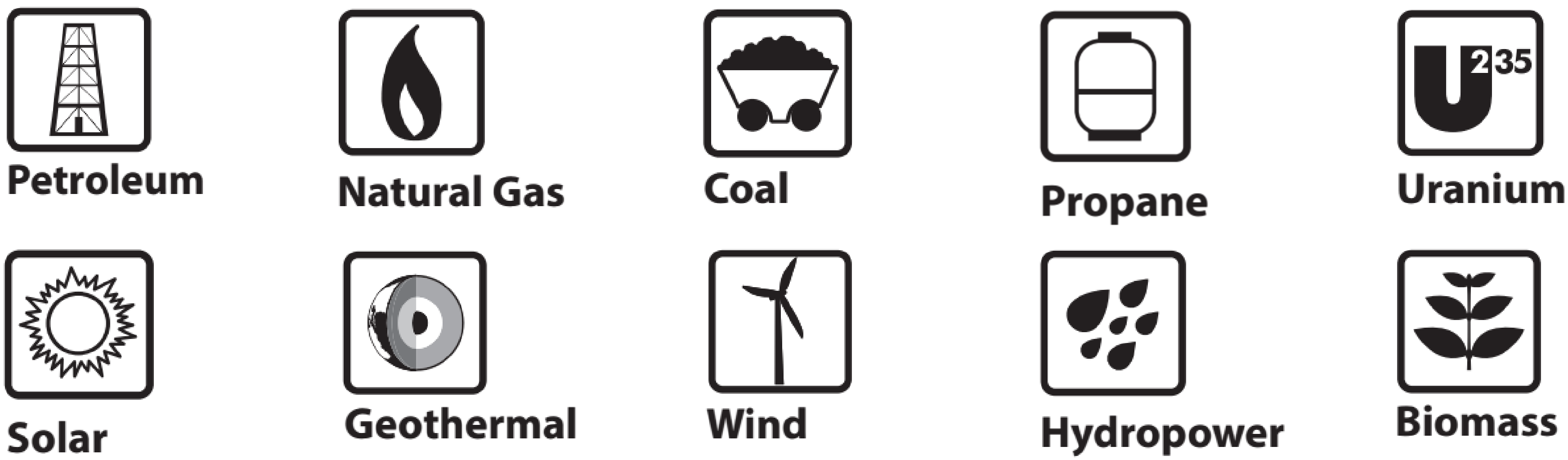
**Figure 2.1 Energy Consumption by Sector**
(Quadrillion Btu)




https://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf

# Primary vs. Secondary Sources

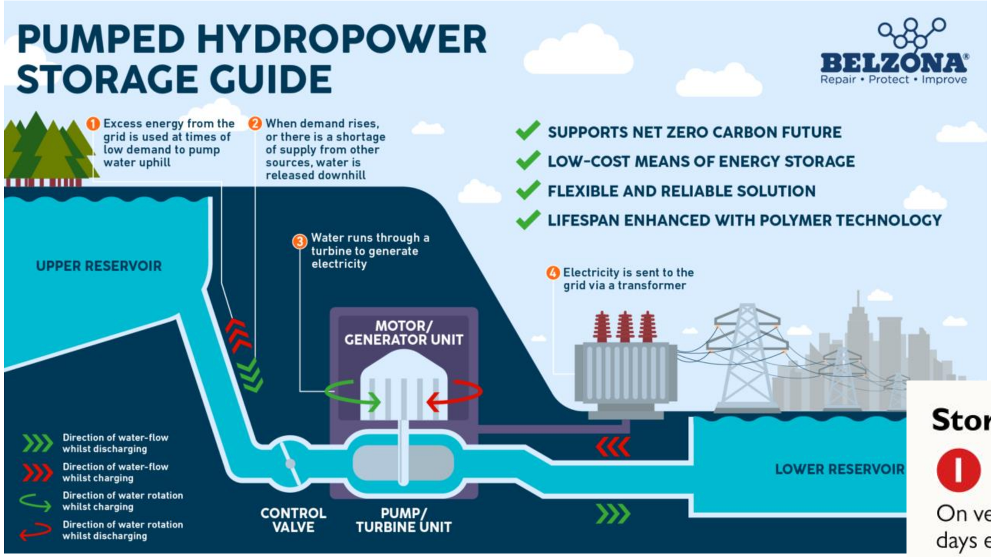
Primary energy sources are sources found in the natural environment

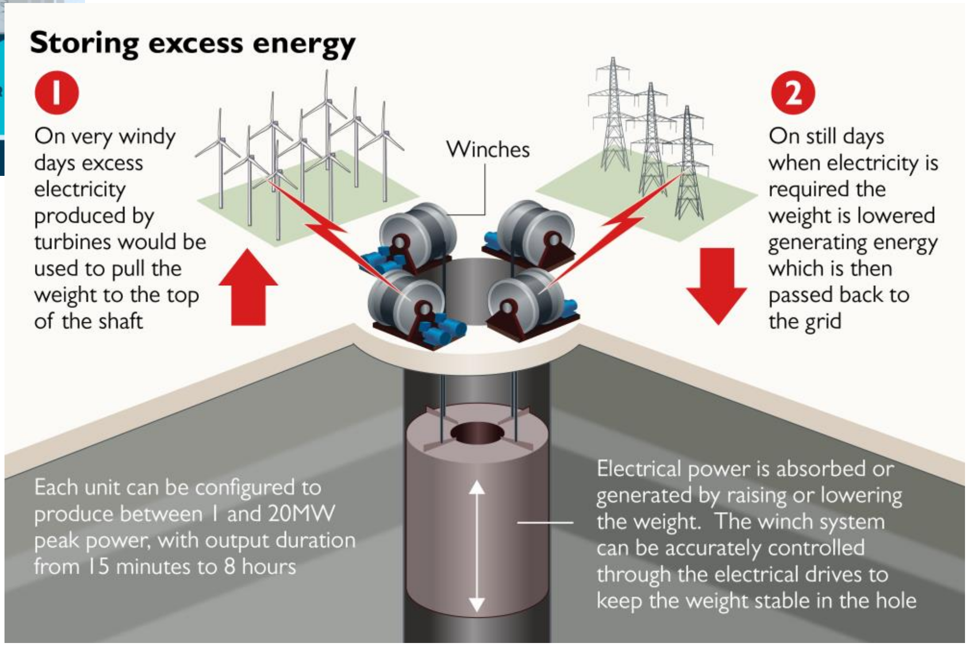



Secondary energy sources are useful transformations of the primary sources. (typically used to **store** energy)

Electricity – Batteries, Stored Hydropower

# Other Secondary Sources…



# What is the Ultimate Primary Source?

**The Sun**

# Which one is the best?

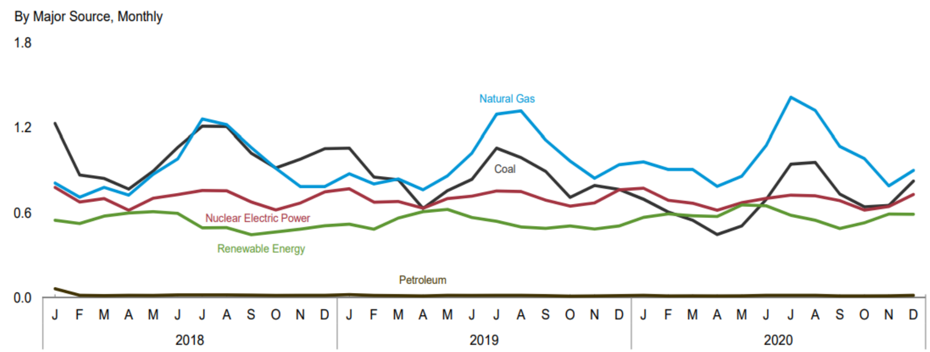
That’s a hard question and depends on many factors

Some of the big ones are:

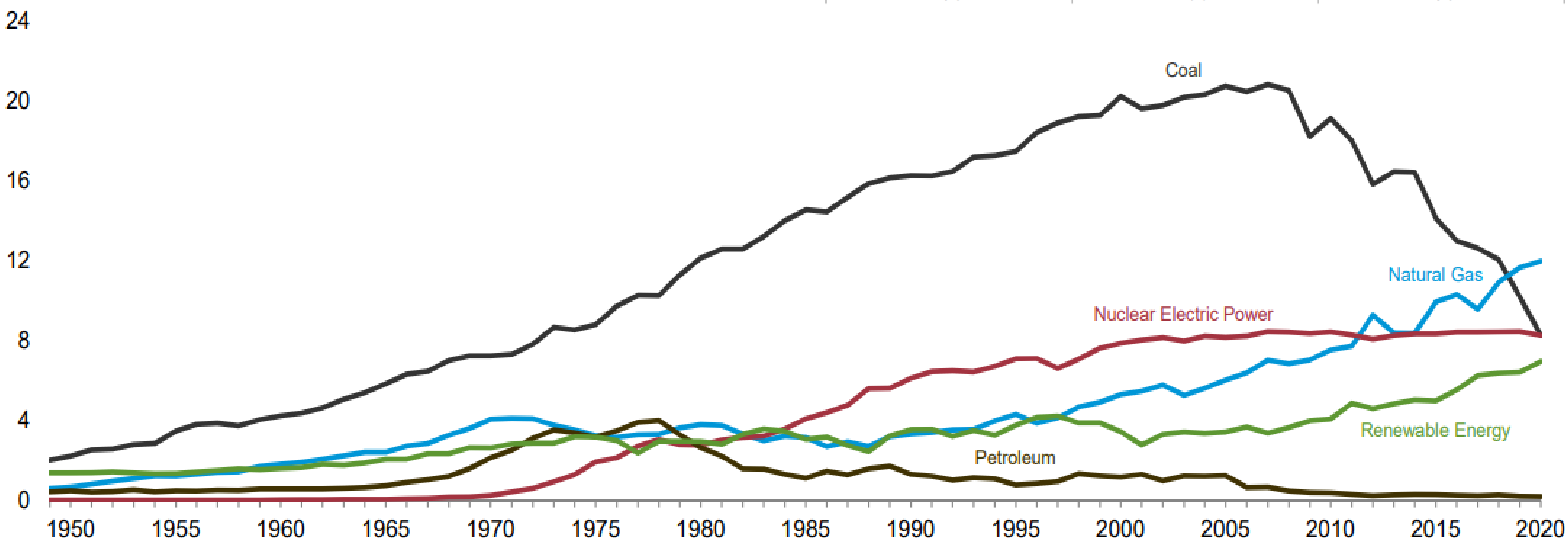
- Energy Density
- Cost
- Availability and Location
- Politics
- Safety
- Environmental

# U.S. Electricity Generation

**Figure 2.6 Electric Power Sector Energy Consumption**
(Quadrillion Btu)

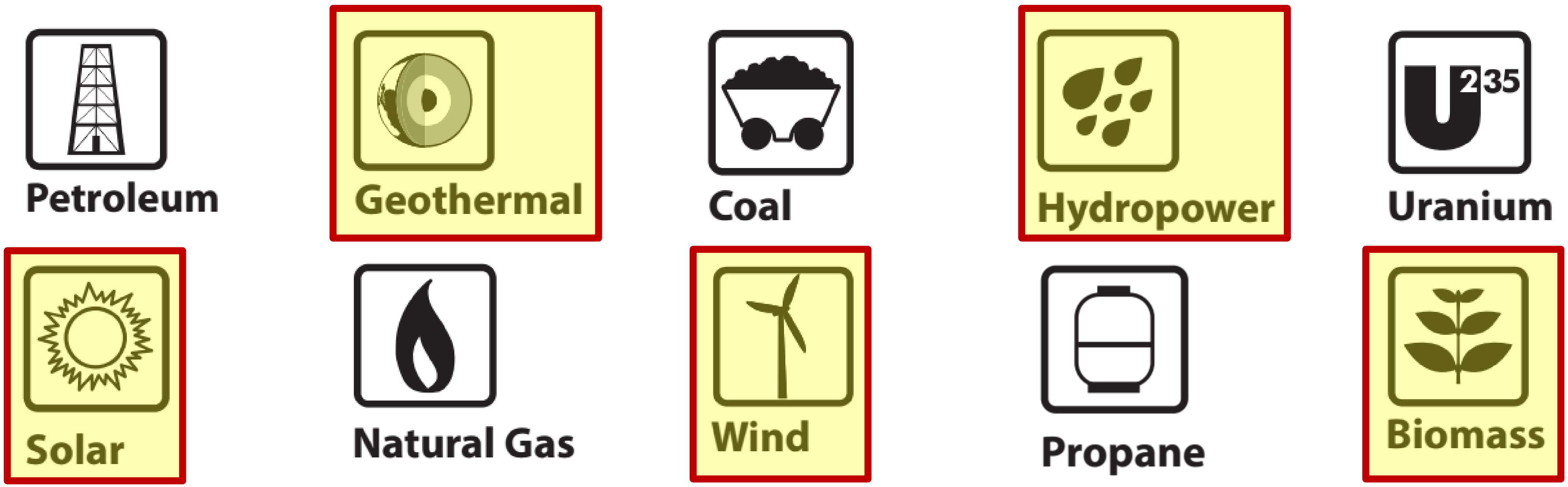



By Major Source, 1949–2020



# Renewable vs. Non Renewable

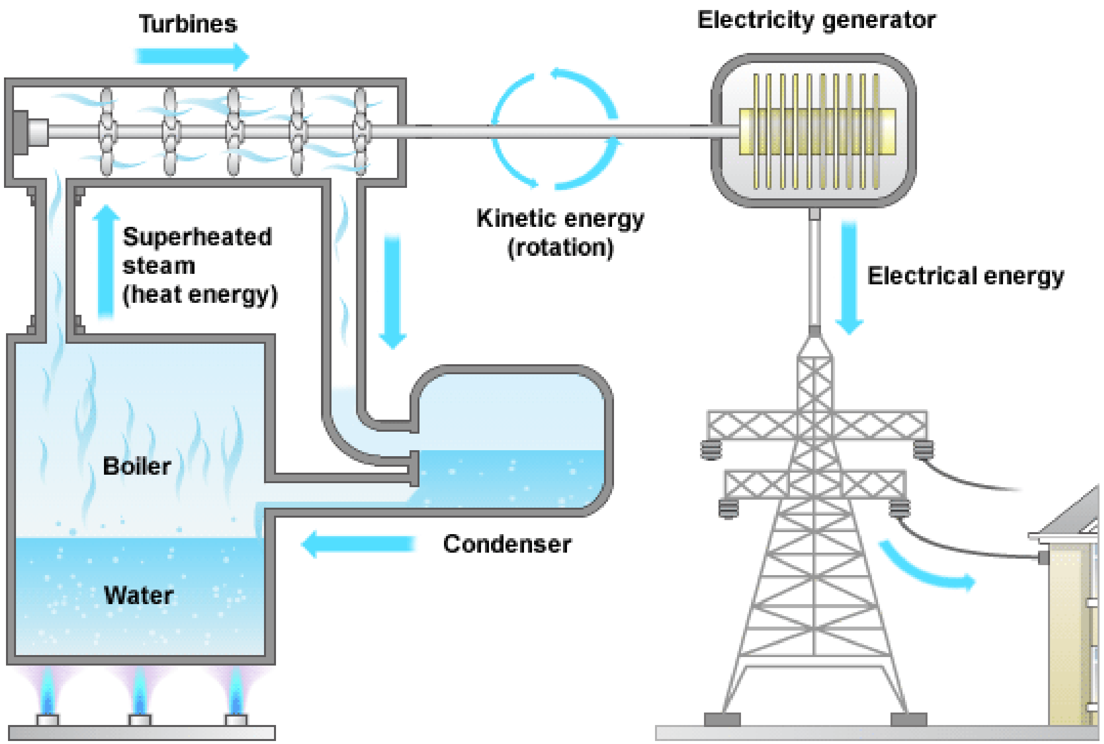
Highlight the primary energy sources that are considered renewable




*Note: this doesn’t mean that it cannot **ever** be replaced, just that it won’t happen in any sort of useful time frame…

# Efficiency

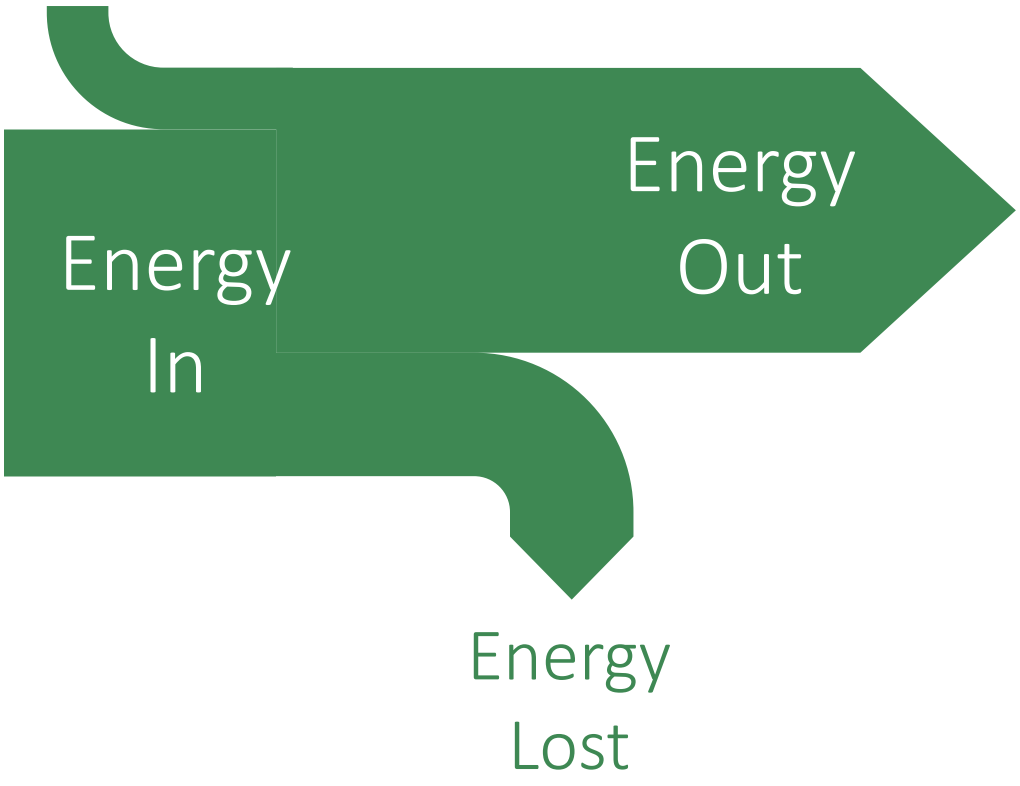
Almost every energy source has the same general path



# Sankey Diagram

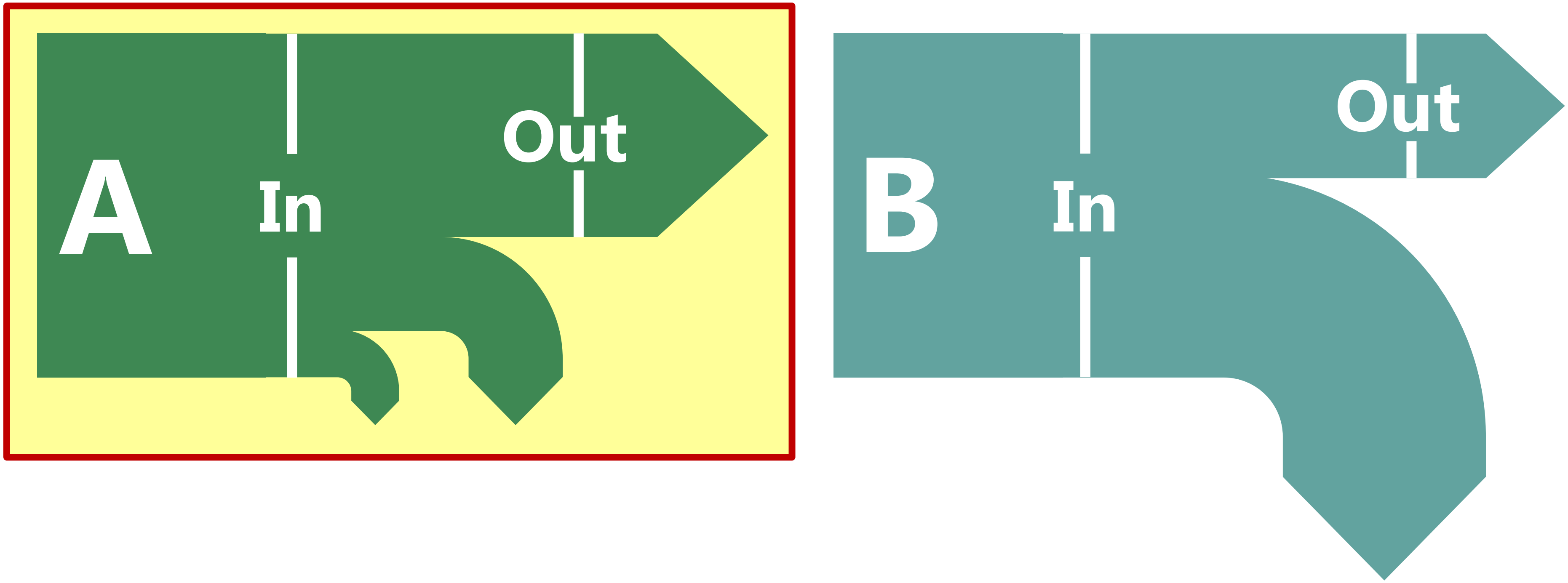
Sometimes it's easiest to represent energy flow in a picture.

In these diagrams the width of the arrow represents the amount of energy

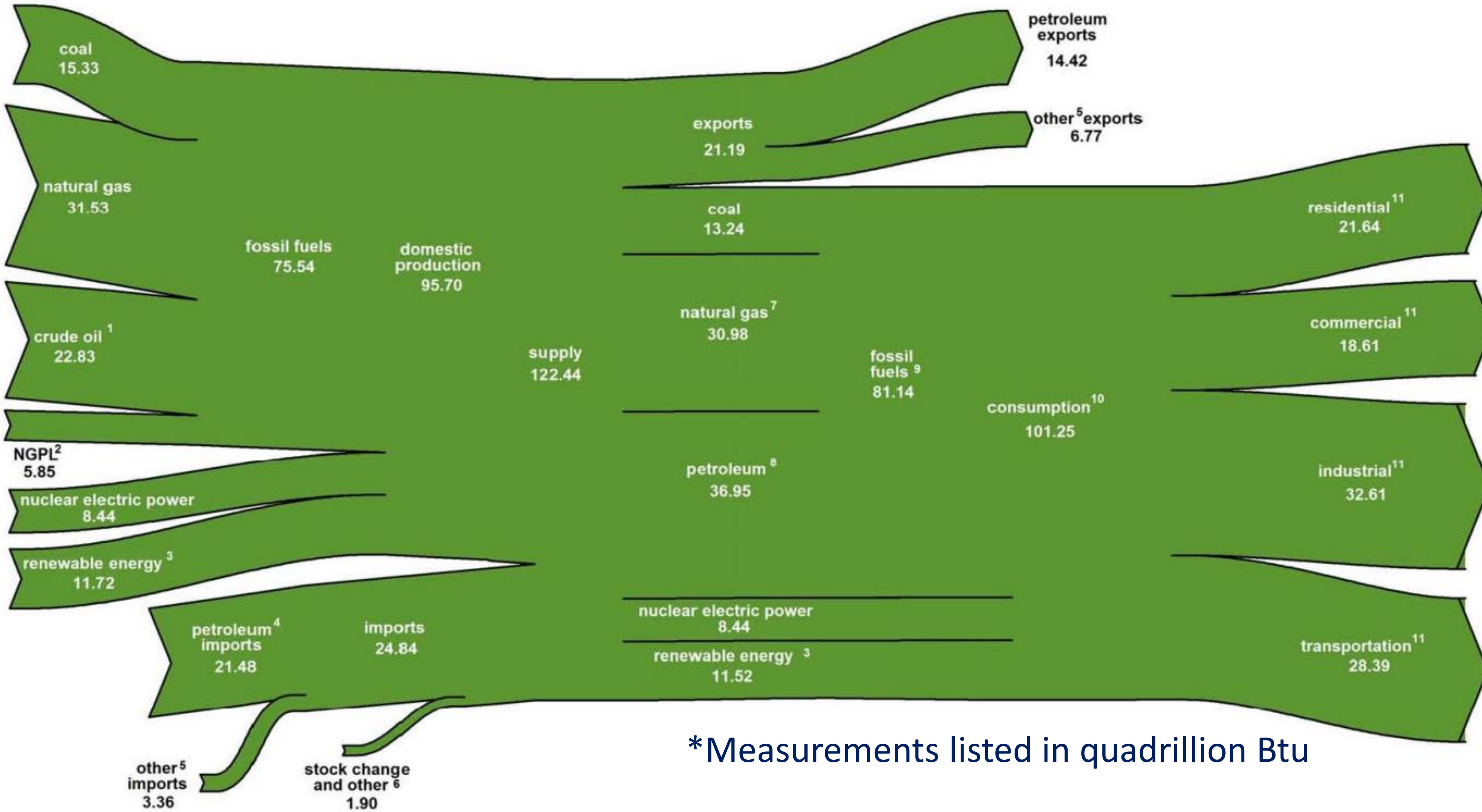


# Sankey Diagrams

Which process is more efficient?



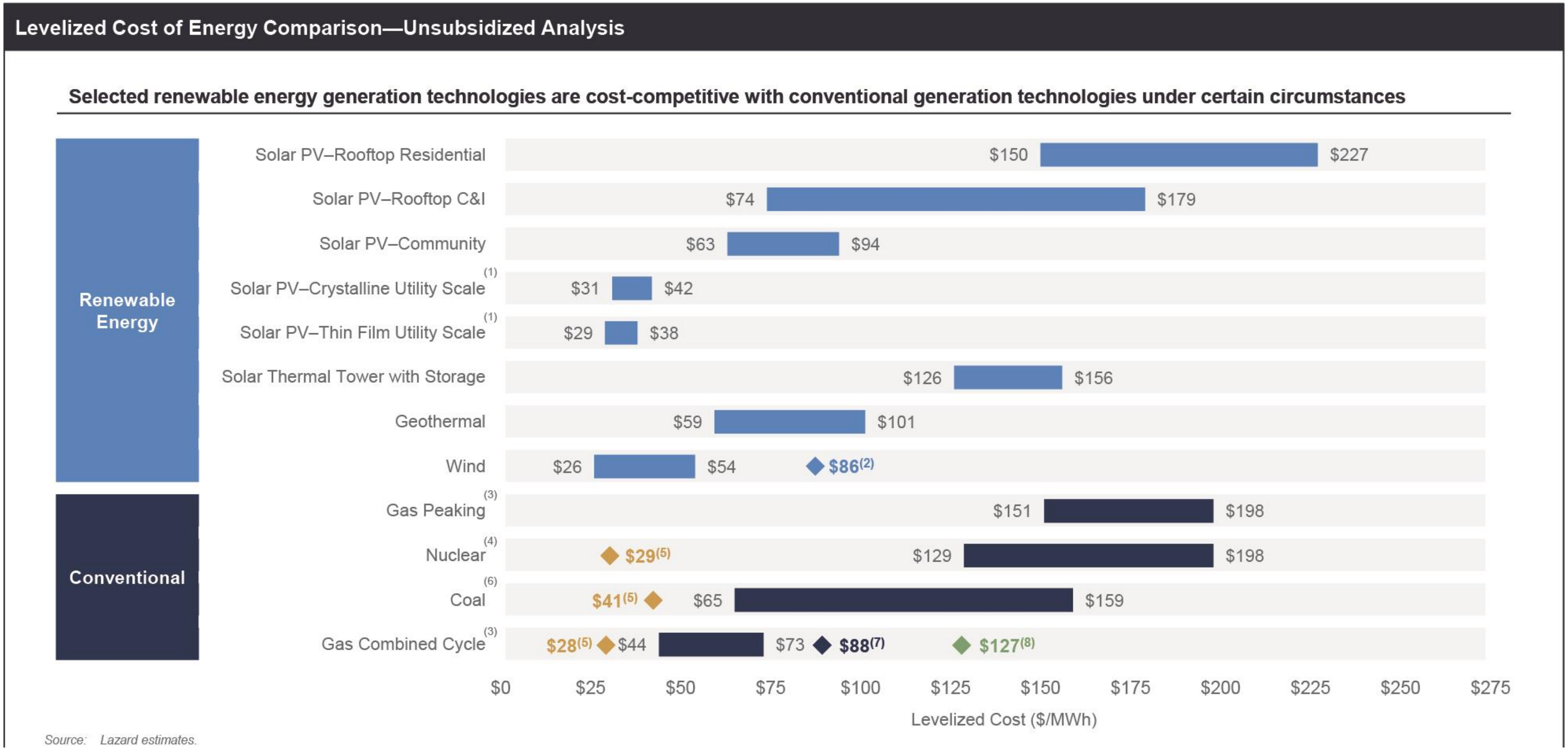
# U.S. Energy Flow 2018




*Measurements listed in quadrillion Btu

https://www.eia.gov/totalenergy/data/monthly/pdf/flow/total_energy.pdf

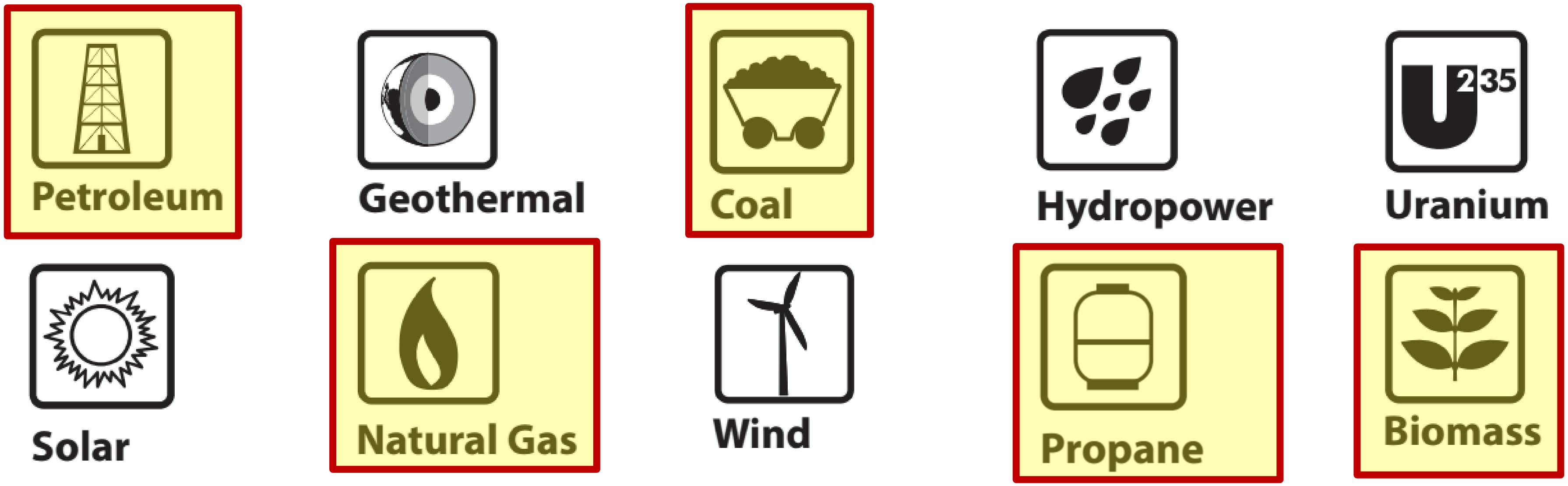
# Cost




https://www.lazard.com/perspective/lcoe2020

# $CO_2$ Emissions

Highlight the primary energy sources that are produce Carbon Dioxide

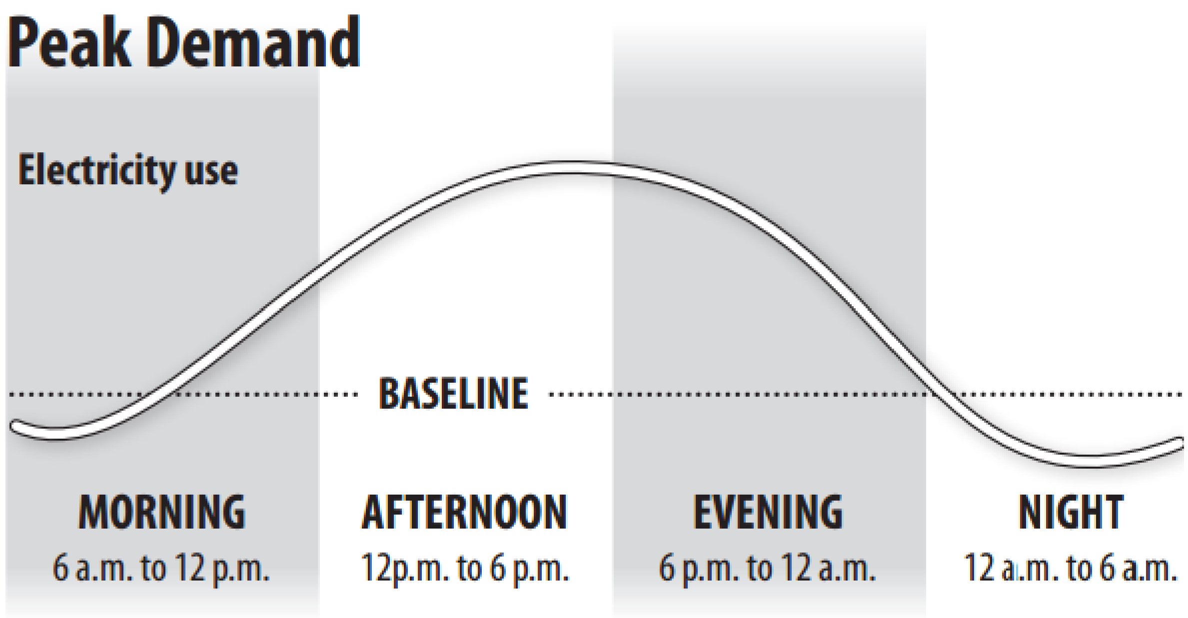



*Note: this is just one of several greenhouse gases. We'll discuss this.

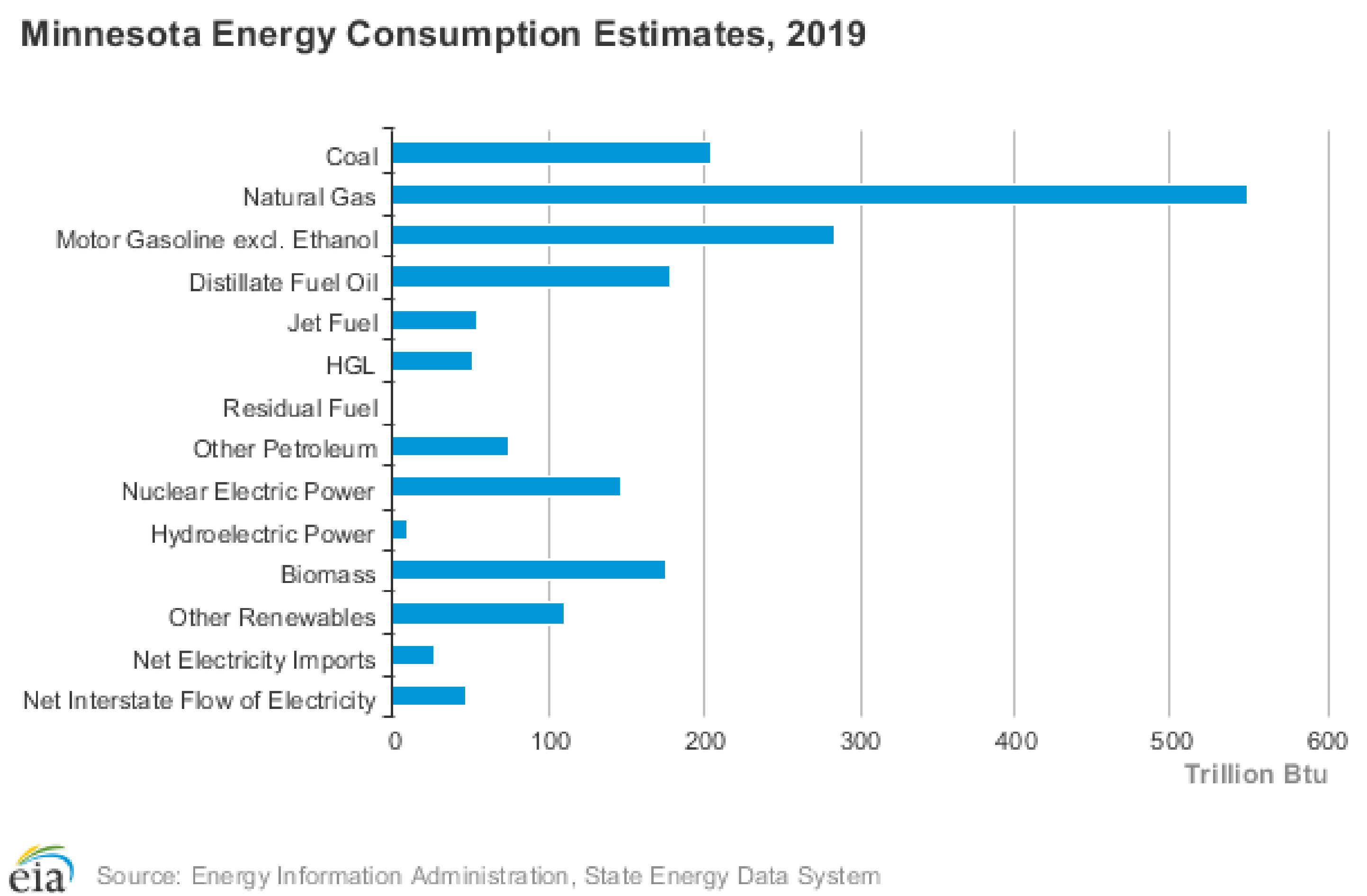
# Location Dependency and Politics

# Energy Load Requirements

Energy needs to be available when electricity is most needed but should also be available other times as well.

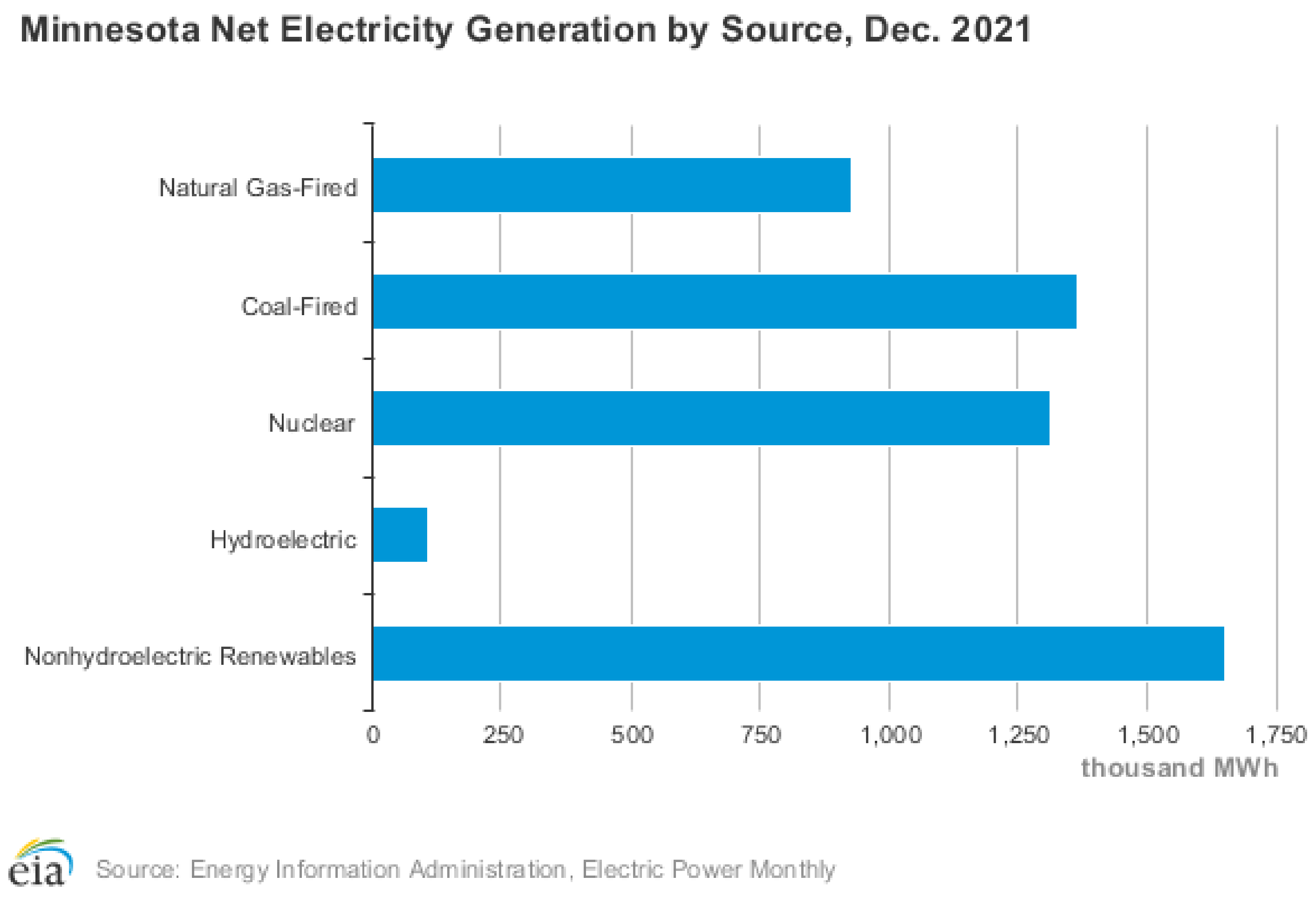


# Where does our Energy Come From?




From the U.S. Energy Information Administration | https://www.eia.gov/state/?sid=MN

# Where does our Energy Come From?



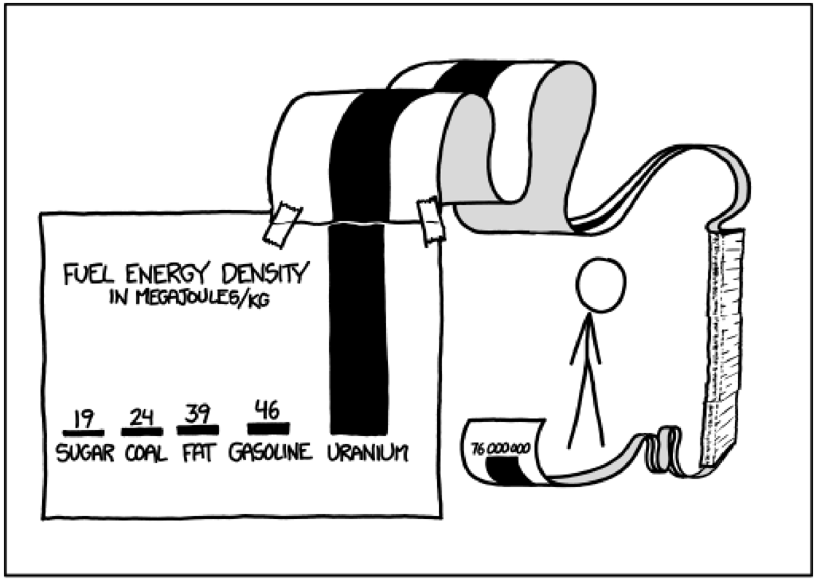
# Energy Density

Specific Energy = Energy per Unit Mass [J kg$^{-1}$]

Energy Density = Energy per Unit Volume [J m$^{-3}$]

$$E_S = \frac{E}{m}$$

$$E_D = \frac{E}{V}$$




SCIENCE TIP: LOG SCALES ARE FOR QUITTERS WHO CAN'T FIND ENOUGH PAPER TO MAKE THEIR POINT *PROPERLY*.

# Energy Density

| Material | Specific Energy / MJ $kg^{-1}$ | Energy Density / MJ $m^{-3}$ |
|---|---|---|
| Uranium – (Nuclear Fission) | 83,000,000 | 15,000,000,000,000 |
| Natural Gas (Methane) | 54 | 37 |
| Gasoline/Petrol | 46 | 34,000 |
| Crude Oil | 42 | 36,500 |
| Coal | 32 | 23,000 |
| Ethanol | 30 | 21,000 |
| Wood | 17 | Varies |
| Average Food | 17 | Varies |

Why are **Specific Energy** and **Energy Density** important?

Higher energy density lowers transportation and storage costs

# Power and Energy

| Energy | Power |
|---|---|
| Joules [J] | Watts [W] |

How are these quantities related?

$$1\,\mathrm{W} = 1\,\frac{\mathrm{J}}{\mathrm{s}}$$

# Energy Density

How much coal must be supplied per day to run a 500 MW power plant at 30% efficiency? (Specific Energy of coal is 32 MJ $kg^{-1}$)

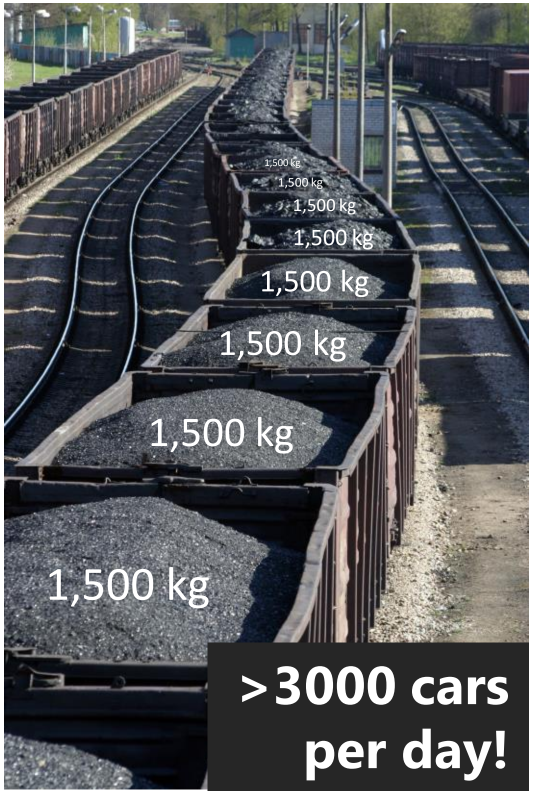
30% efficient

$$E_{in} \times 0.3 = 500\,\frac{\text{MJ}}{\text{s}}$$

$$E_{in} = 1{,}700\,\frac{\text{MJ}}{\text{s}}$$

$$\frac{1{,}700\text{ MJ}}{1\text{ s}} \times \frac{1\text{ kg}}{32\text{ MJ}} = 53.1\,\frac{\text{kg}}{\text{s}}$$

$$\sim 4{,}600{,}000\,\frac{\text{kg}}{\text{day}}$$




How many train cars per day?

# Energy Density

If a nuclear power plant powered by uranium-235 (83,000,000 MJ $kg^{-1}$) has the same output (500 MW) and the same efficiency (30%) as the coal-fired plant of the previous example, how many kg of nuclear fuel will it burn per day? Per year?

30% efficient

$$E_{in} \times 0.3 = 500\,\frac{\text{MJ}}{\text{s}}$$

$$E_{in} = 1{,}700\,\frac{\text{MJ}}{\text{s}}$$

$$\frac{1{,}700\text{ MJ}}{1\text{ s}} \times \frac{1\text{ kg}}{83{,}000{,}000\text{ MJ}} = 0.00002\,\frac{\text{kg}}{\text{s}}$$

$$\sim 1.77\,\frac{\textbf{kg}}{\textbf{day}}$$

$$\sim 646\,\frac{\textbf{kg}}{\textbf{year}}$$