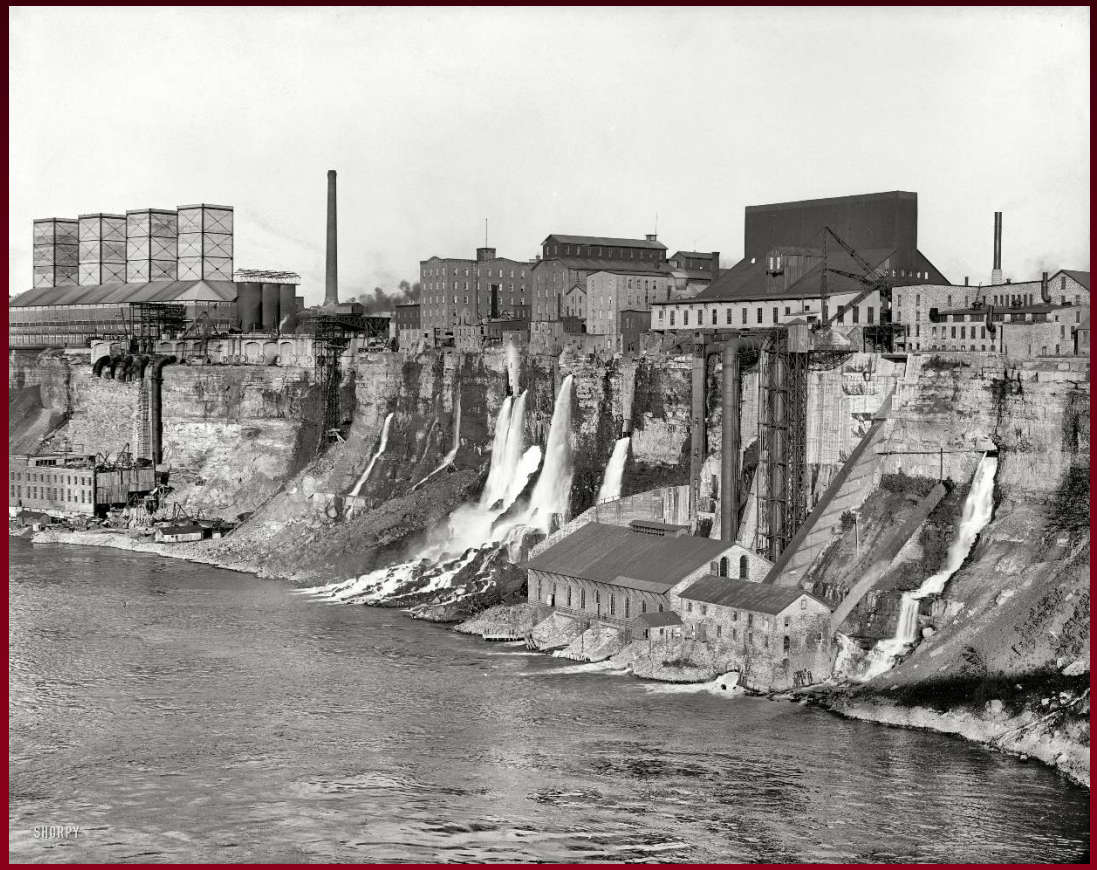
Water, Water, Everywhere

A Very Brief History of Energy in the U.S.



J.M. Pratte

But First…

- Energy is one of the least understood areas of modern society
- Standard K-12 curriculum has very little to no discussion of it

Next Generation Science Standards

K-2: Forces, Molecules, Earth Systems
3rd: Energy and Dynamics
4th: Electricity
5th: Food Energy
6th-8th: Forces, Energy, **Earth and Human Interactions**

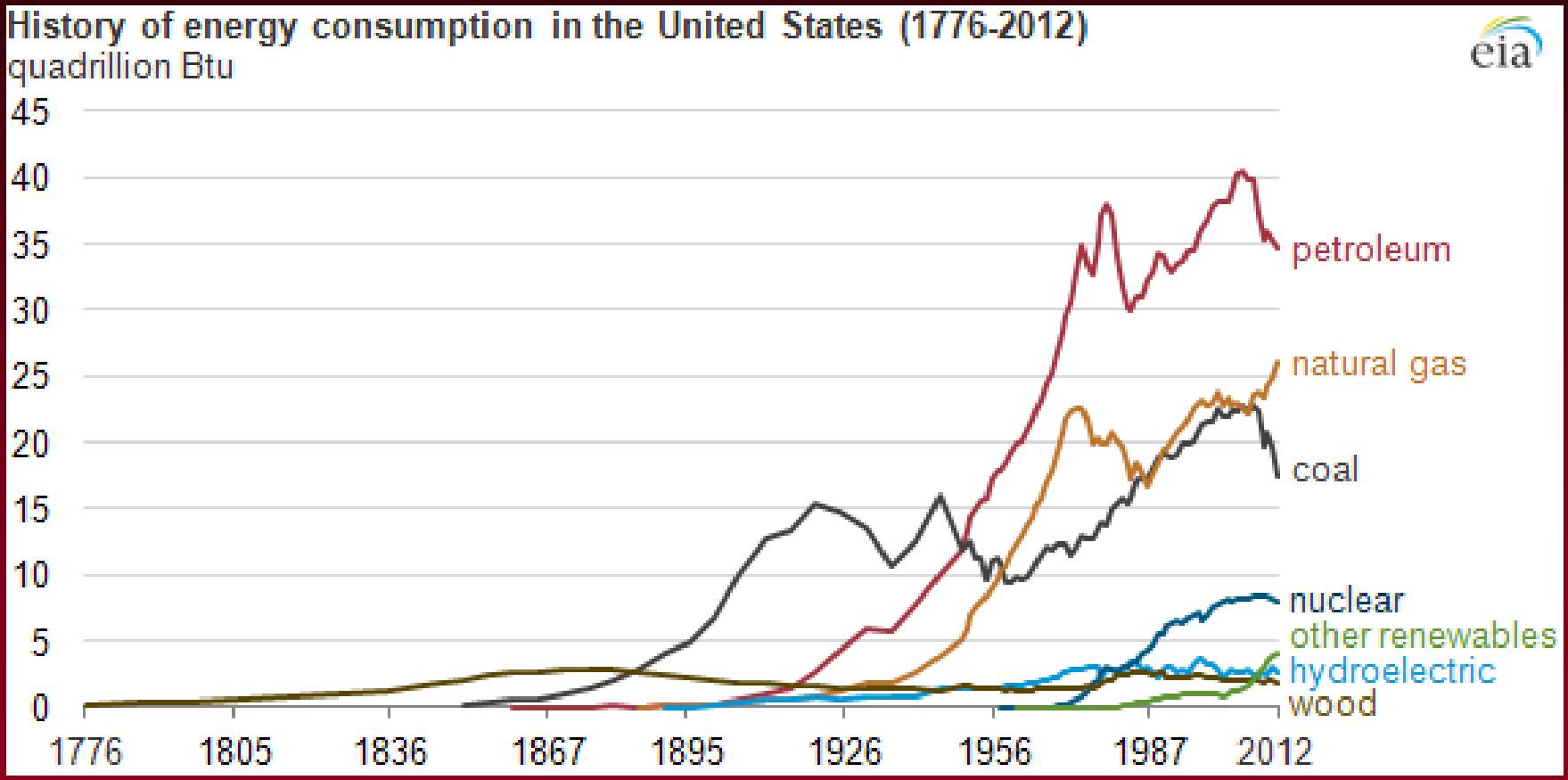
9th: Physical Science
10th: Biology
11th: Chemistry
12th: Variable **(ESS3-2)**

- Non-STEM majors unlikely to see it (standard general education does not include it)
- STEM majors are also unlikely to have it, as not in any of our disciplines

Beginnings

- There is a long history of changes in energy sources in the U.S.
- Abundance of forests in Northeast made wood king initially
- Rise of manufacturing and loss of forests caused coal to increase; numerous rivers led to use of hydropower
- Development of cars and electrical appliances changed everything

A Historical Look

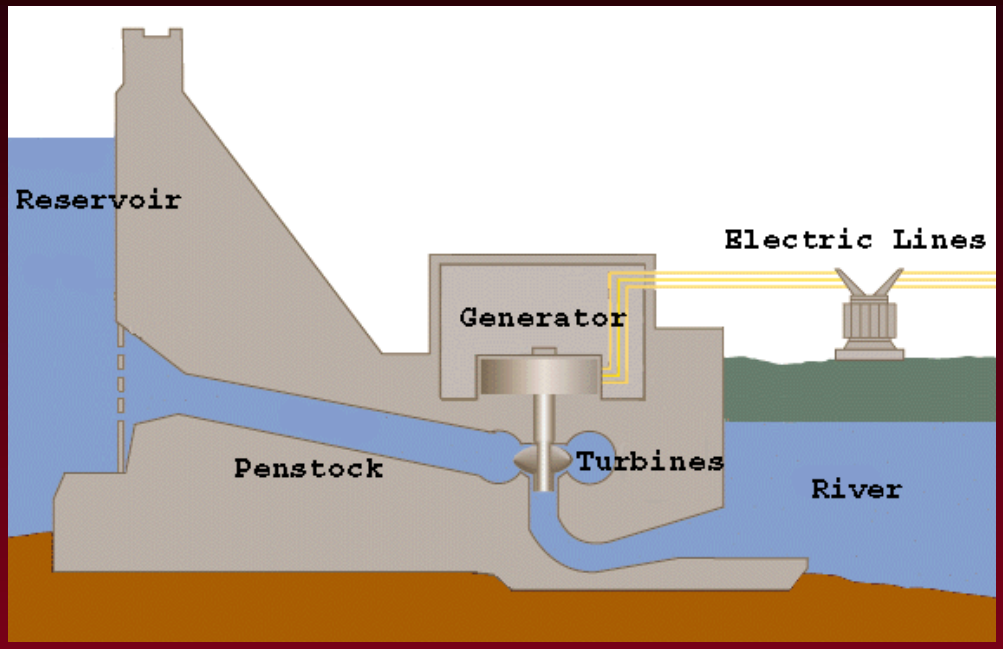


Hydroelectric

Hydropower has been used for over 2000 years

Estimates of 10,000 to 20,000 mills by 1800; over 55,000 by 1880

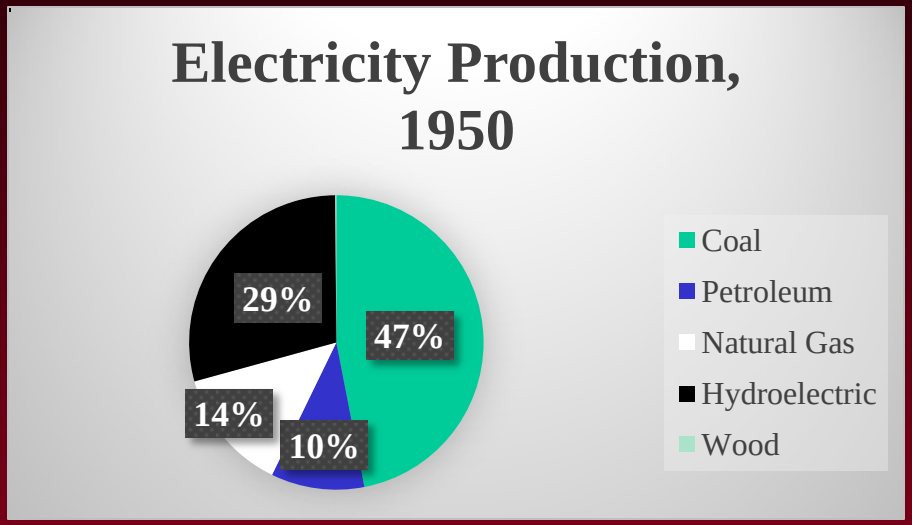
All mechanical energy; estimate at 1.5 TW-hr/year

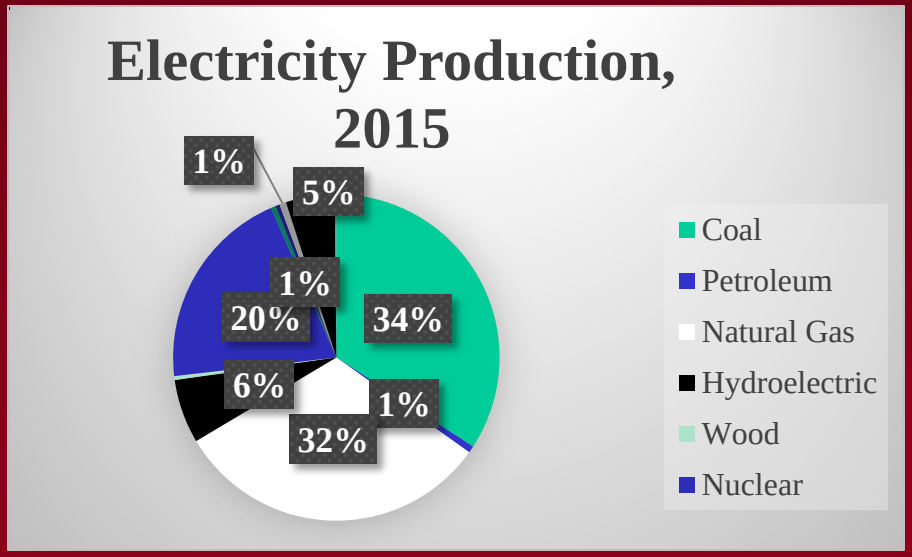


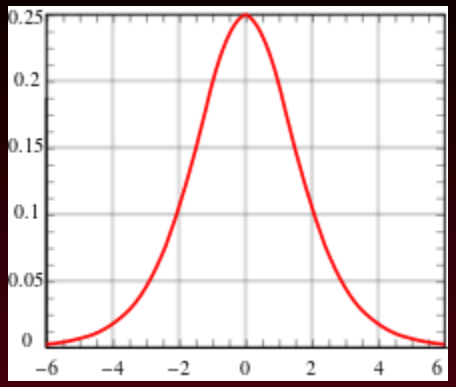
In 1882, began electrical production at Niagara Falls

At one time, accounted for over 40% of the U.S.'s electrical needs; today, it is only about 7%

Comparison


Electricity Production, 1950
29%
47%
14%
10%
Coal
Petroleum
Natural Gas
Hydroelectric
Wood


Electricity Production, 2015
1%
5%
1%
20%
34%
6%
1%
32%
Coal
Petroleum
Natural Gas
Hydroelectric
Wood
Nuclear



Hubbert Curve

- Developed by M. King Hubbert at Shell Oil in 1950's
- Theoretical model of how a natural resource is used over time
- Three main features:

  1. Rapid rise as new markets develop based on cheaply-extracted resources
  2. Peak as more expensive sources are exploited
  3. Rapid drop as other resources or technologies replace it

- Was used to predict peak oil in Continental U.S. in 1970

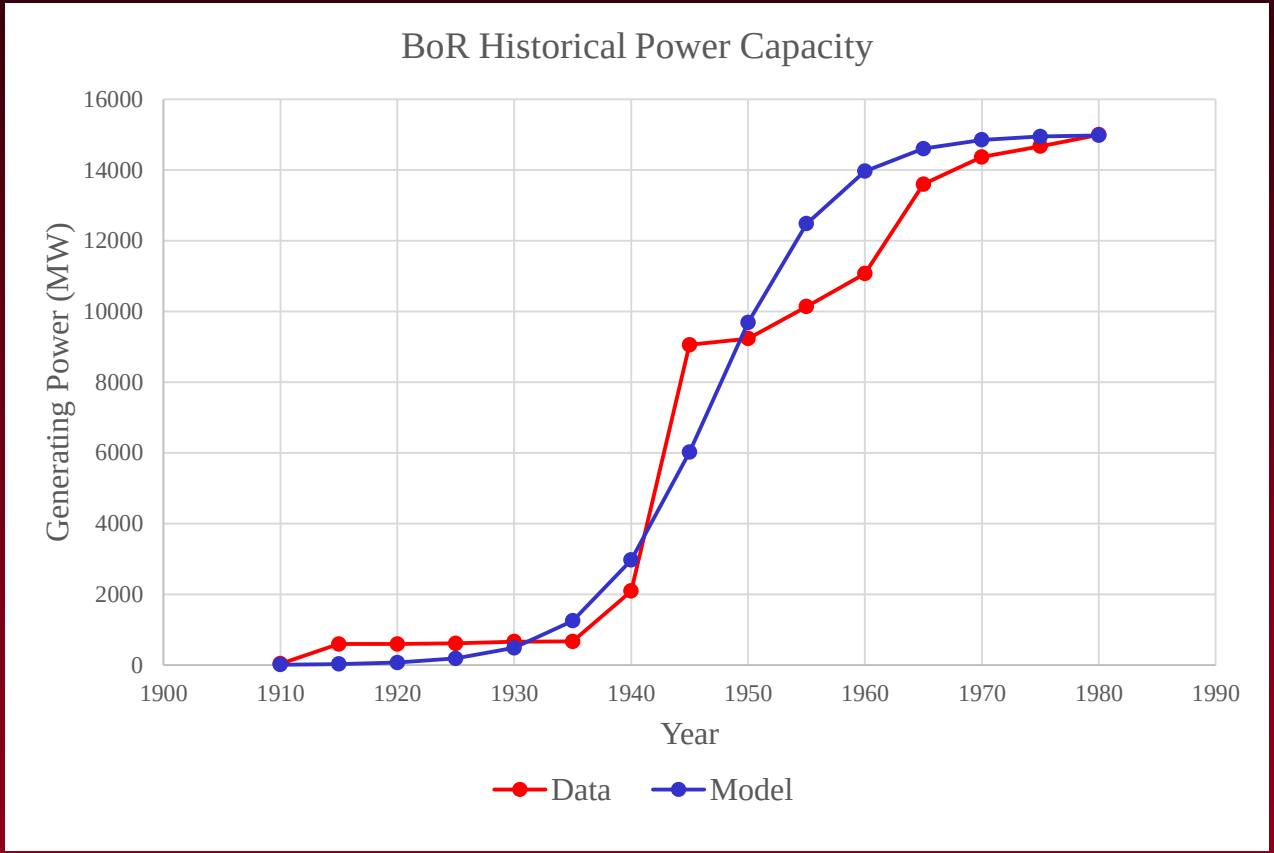
Applied to Hydroelectric

- Since hydroelectric is renewable, cannot use the same formula for a non-renewable like oil
- Have to integrate the curve in the previous example for a renewable resource
- Result has the form

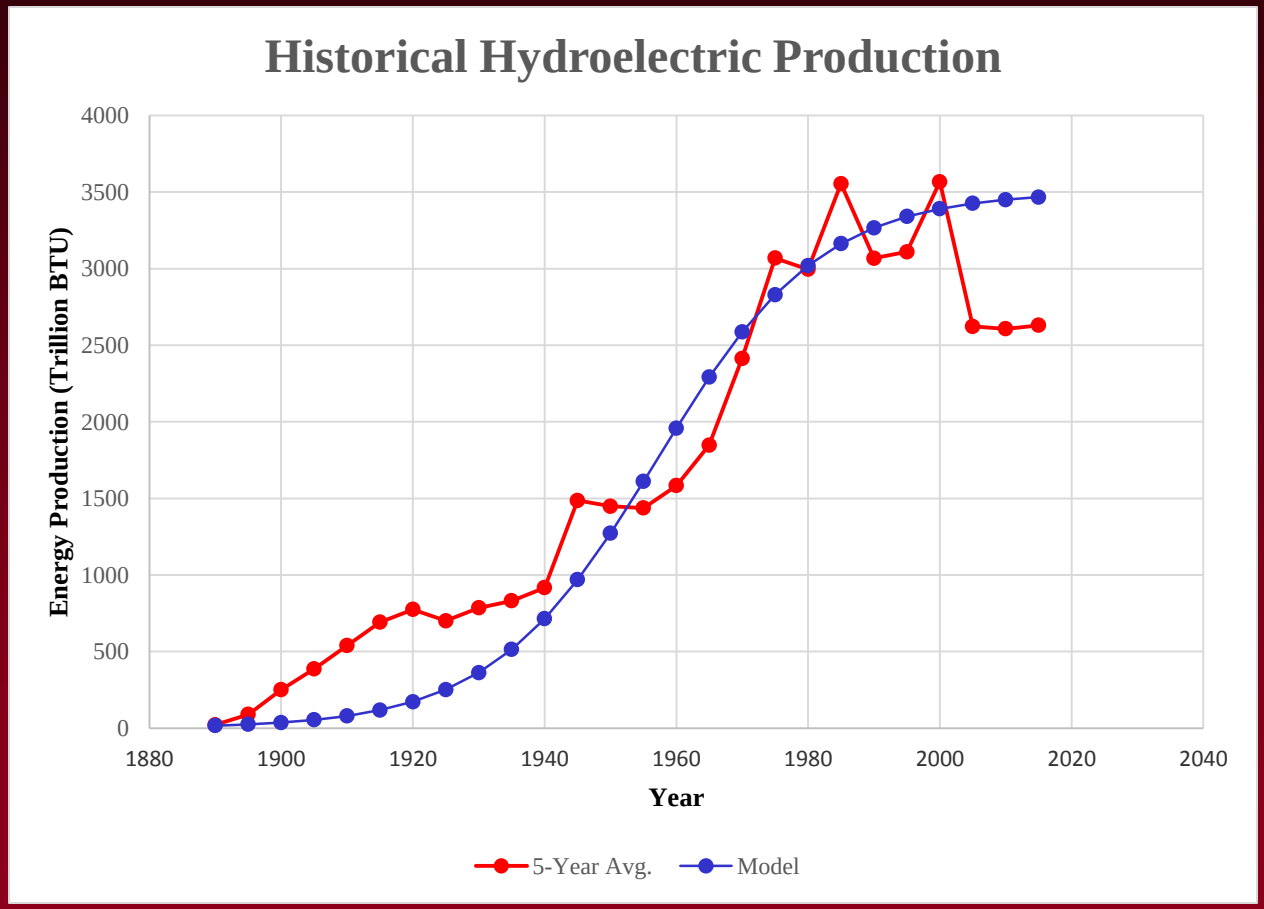
$$Q(t) = \frac{Q_\infty}{1 + e^{\omega(\tau - t)}}$$

where Q(t) is energy production at time t

Power Data


BoR Historical Power Capacity
Generating Power (MW)
16000
14000
12000
10000
8000
6000
4000
2000
0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
Year
Data
Model

Energy Data


Historical Hydroelectric Production
Energy Production (Trillion BTU)
4000
3500
3000
2500
2000
1500
1000
500
0
1880
1900
1920
1940
1960
1980
2000
2020
2040
Year
5-Year Avg.
Model

Removal

- Converts river environment to lake; different organisms live in each
- Silt build-up hurts electricity production
- Produce significant amounts of methane
- Potential hazard

- Between 1990 and 2016, over 900 dams have been removed in the U.S.

However, globally, hydropower is still increasing, with over 3,700 projects under construction

New Technology

- Inline and hydrokinetic systems could re-vitalize the U.S. market
- Use in both rivers and ocean environments
- First grid-connected arrays were deployed in Scotland this August
- French plan to have a 14 MW facility operating within a year