Water, Water, Everywhere
A Very Brief History of Energy in the U.S.

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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

History of energy consumption in the United States (1776-2012)

- petroleum
- natural gas
- coal
- nuclear
- other renewables
- hydroelectric
- wood

Quadrillion Btu

Time: 1776-2012
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%
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 \( t \)
BoR Historical Power Capacity

Generating Power (MW) vs. Year

- Data
- Model
Energy Data

**Historical Hydroelectric Production**

- **Energy Production (Trillion BTU)**
- **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