Introduction to GENERATE: The Game of Energy Choices
The big picture: What is the energy system?

- **Primary energy resources**
  - Fossil: coal, natural gas, petroleum
  - Other: uranium
  - Renewable: wind, solar, hydro, geothermal, biomass

- **Technologies to convert primary resources to useable energy like electricity, gasoline, ...**
  - Petroleum Refineries
  - Electric Power Generation

- **End-use sectors**
  - Residential
  - Commercial
  - Industrial
  - Transportation

- **Energy services** – What people actually need and want: For example, mobility (vehicle miles of travel), lighting (lumens of light), comfort (space heating and cooling). Energy is a “derived demand”
Connecting the dots: where we use what energy

U.S Energy Flows from Resource to End Uses

1. Electricity
2. Residential
3. Commercial
4. Industrial
5. Transportation
6. Coal
7. Natural Gas
8. Petroleum (Crude Oil)
9. Solar
10. Wind
11. Hydropower
12. Biomass
13. Geothermal
14. Nuclear

Rejected Energy
Used Energy

EPACE
U.S. Environmental Protection Agency
Office of Research and Development

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Connecting the dots: where we use what energy

U.S Energy Flows from Resource to End Uses

1. Electricity
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6. Rejected Energy
7. Used Energy

Coal = 7
Natural Gas = 6
Petroleum (Crude Oil) = 9
Solar = 1
Wind = 4
Hydropower = 3
Biomass = 8
Geothermal = 5
Nuclear = 2
Energy and our environment: why it matters

**Energy-related impacts**

**Criteria air pollutants***
- NO\textsubscript{x} – 93%
- CO – 61%
- SO\textsubscript{2} – 81%
- PM\textsubscript{2.5} – 63% (excl. misc.)

**Greenhouse gases:**
- CO\textsubscript{2} – 97%
- Methane – 42%
- Nitrous oxide – 12%

**Water use**
- 51% of total surface freshwater withdrawals are used for electric power

*Includes fuel combustion (elec., ind. & other), petroleum & related industries, highway & off-highway from 2016 Air Pollutant Emissions Trends Data
Generate: The Game of Energy Choices

- A simple “simulation” of an energy system
- Helps us to see some of the challenges and tradeoffs involved in making energy choices
- Each team has roughly the same total energy (area of available pieces)
- Each team *does not* have the same mix of energy pieces
- Goal is to fill the game board with energy types to achieve the *lowest total score*

**Score = purchase cost + operating cost + \( \text{CO}_2 \text{ cost} \)**
The game board = the “grid”

- Students teams are the decision makers for how they want to produce energy
- They will use this board for multiple rounds of game play
- Each team can be thought of as a town, state, region or country
Types of energy pieces
(each team will have a different mix)
Parts of the energy pieces

**Type:**
What primary energy resource does it use?

**Size:**
How much energy does it produce?

**CO₂ emissions:**
How much CO₂ does it produce each year?

**Lifetime:** All energy pieces will last 30 years

**Purchase Cost:**
How much does it cost up front to build/purchase?

**Annual Cost:**
How much does it cost each year to run/operate?

\[
\text{Cost per piece} = 785 + (20 \times 30) + (4.5 \times 30) \times \text{CO₂ cost (for 30 years)} = 1385 \text{ (if CO₂ cost is zero)}
\]
Now let’s play a few rounds of Generate!