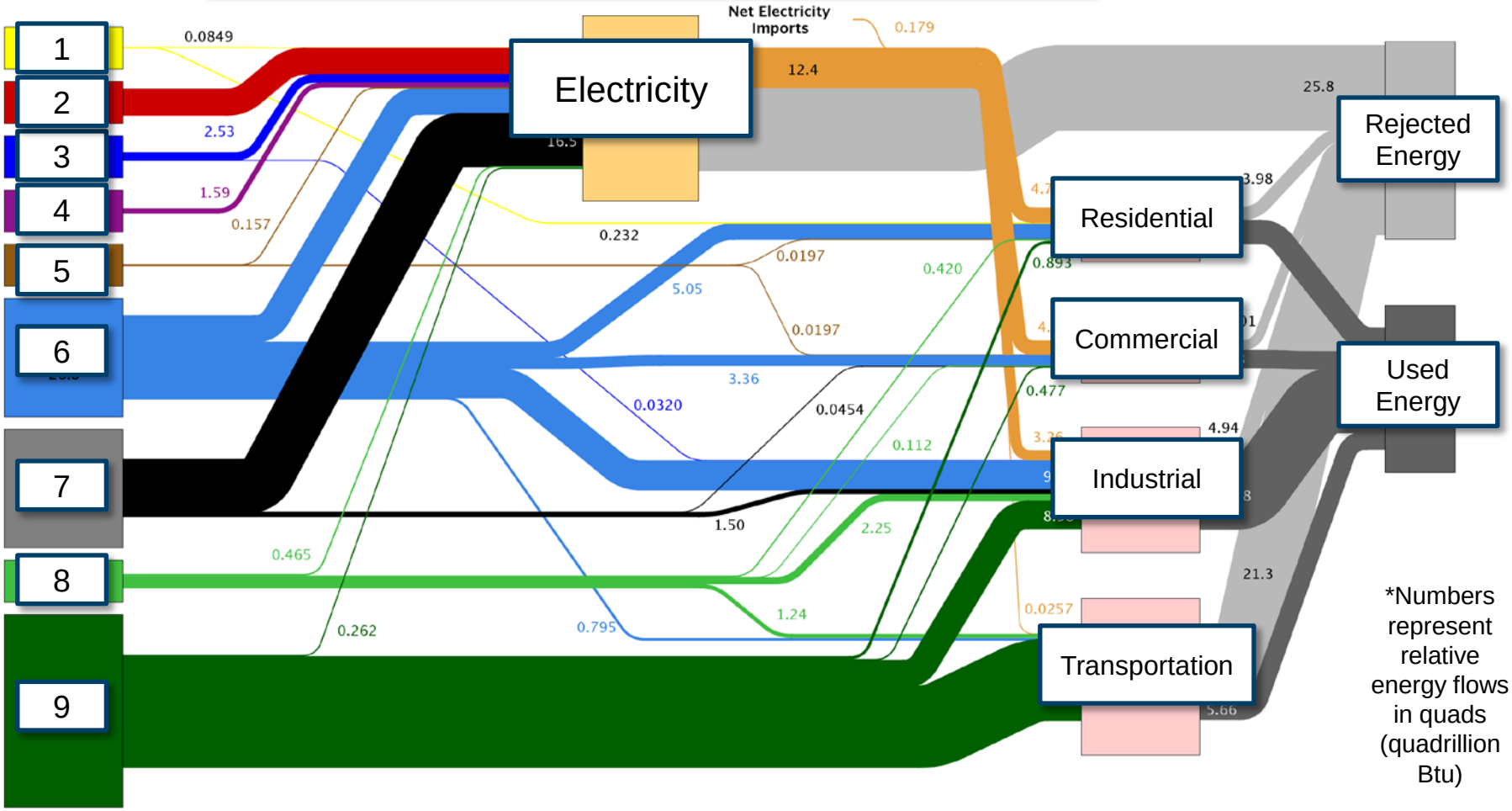
Generate!
A game for understanding energy system choices and challenges

What is the U.S. energy system?

- **Primary energy resources:**
  - Fossil: coal, natural gas, petroleum
  - Renewable: wind, solar, hydro, geothermal, biomass
  - Other: uranium
- **Technologies to convert primary resources to useable energy like electricity, gasoline, etc.**
  - Petroleum/oil refineries
  - Electric power generation
- **End-use sectors that use electricity and fuels**
  - Residential
  - Commercial
  - Industrial
  - Transportation

U.S Energy Flows from Resource to End Uses

Lawrence Livermore National Laboratory



*Numbers represent relative energy flows in quads (quadrillion Btu)

Coal	Solar	Biomass
Natural Gas	Wind	Geothermal
Petroleum (Crude Oil)	Hydropower	Nuclear

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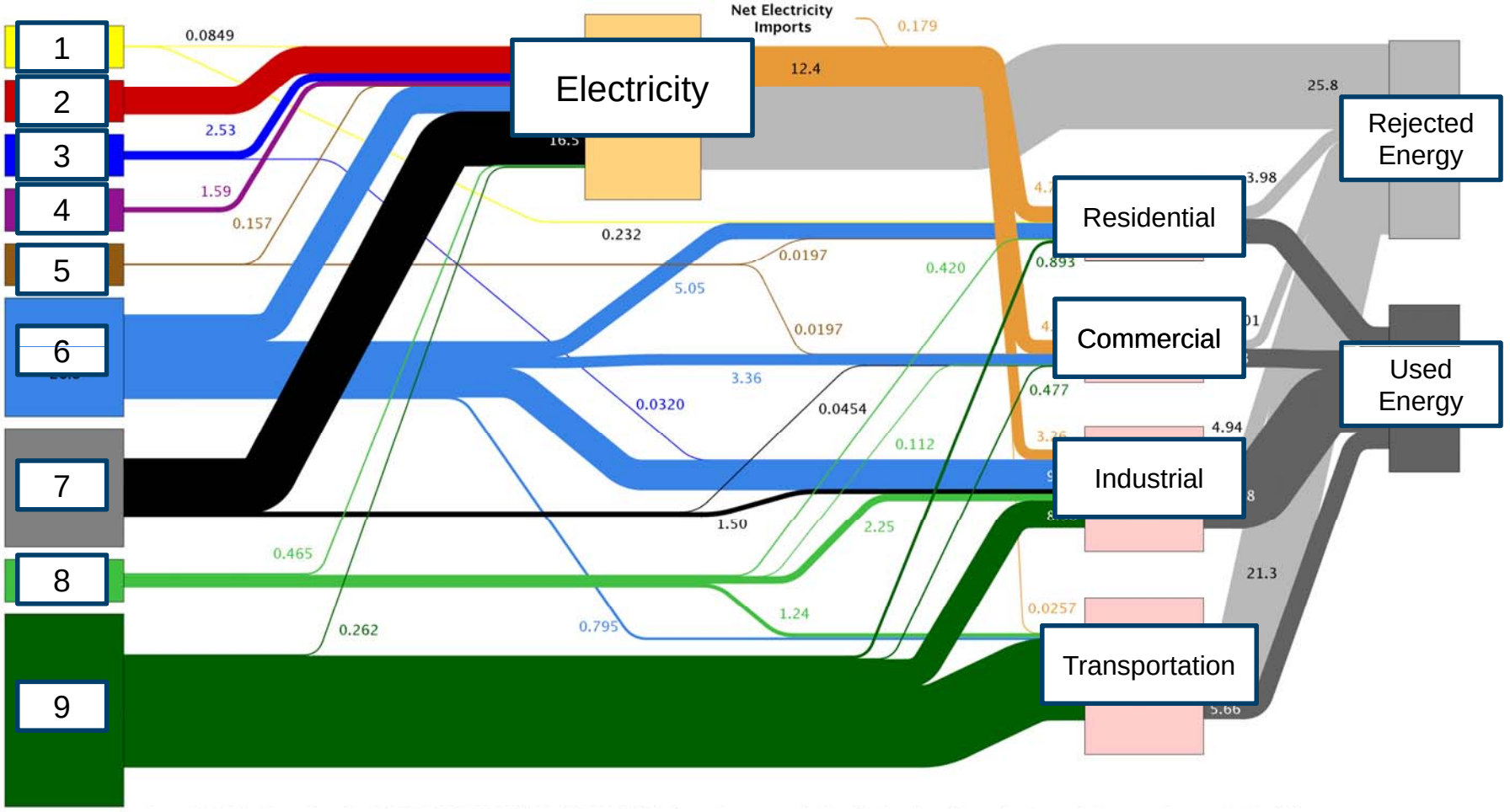

Coal = 7	Solar = 1	Biomass = 8
Natural Gas = 6	Wind = 4	Geothermal = 5
Petroleum (Crude Oil) = 9	Hydropower = 3	Nuclear = 2

Energy and its role in air, climate and water

Air Pollutant Emissions

- Contributions to U.S. anthropogenic emissions
  - Nitrogen Oxides (NO_X) ~ 95%
  - Sulfur Dioxide (SO_2) ~ 89%
  - Carbon Monoxide (CO) ~ 95%
  - Mercury (Hg) ~ 87%

Greenhouse Gas Emissions

- Contributes 94% of US anthropogenic carbon dioxide (CO_2) emissions

Water Supply, Use and Quality

- 41% of US water withdrawals (agriculture ~ 37%; public supply ~ 13%)
- ~200 billion gallons of water per day are required for power plant cooling
- Water quality issues for energy resource extraction and processing

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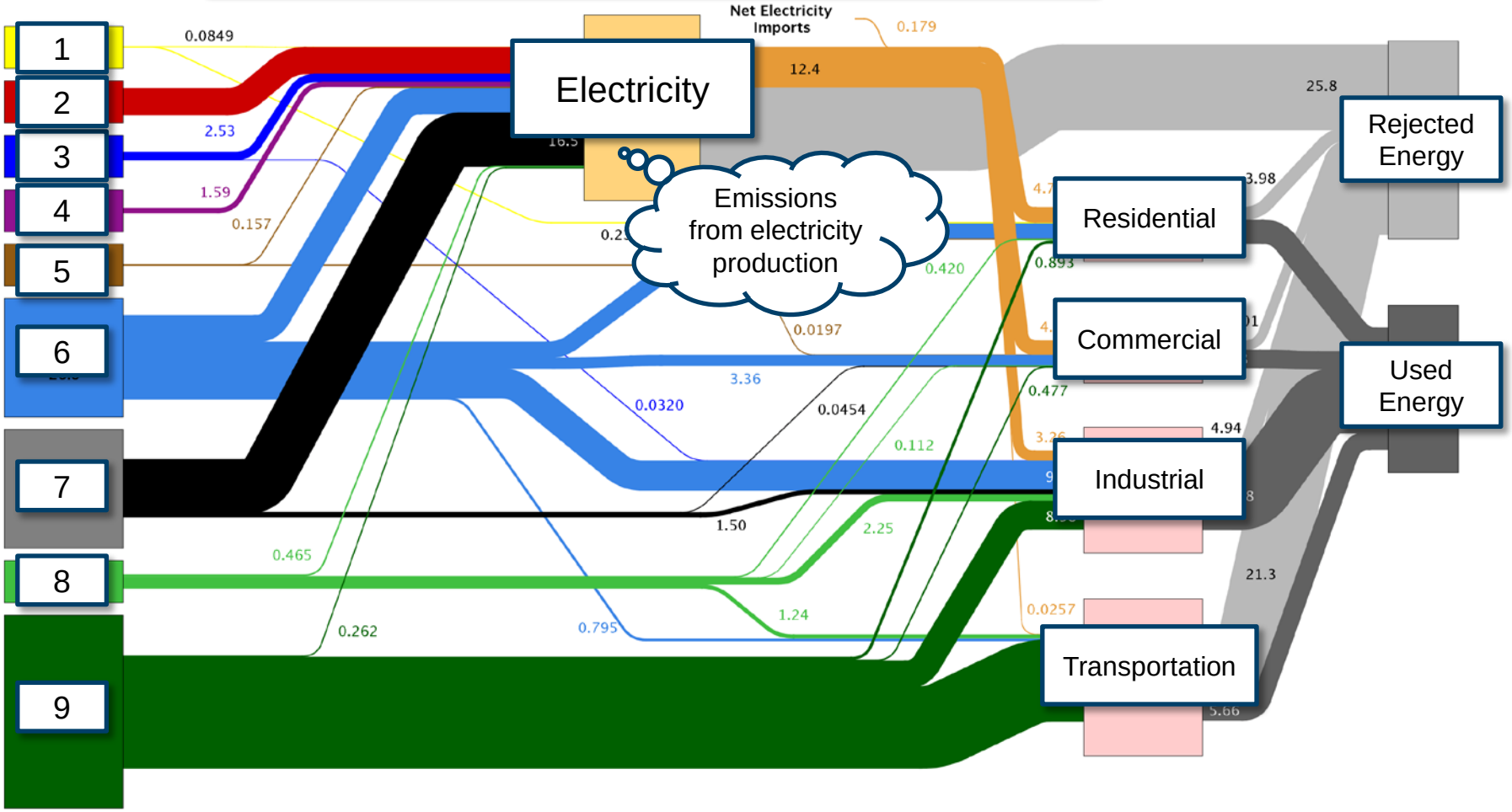

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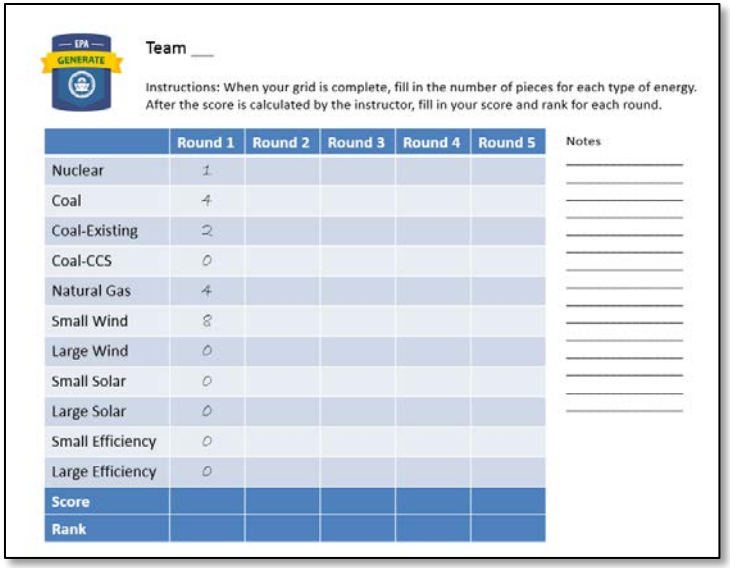
An Energy Game

- 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 the same total energy (area of 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 + CO_2 cost



EPA GENERATE

Team ___

Instructions: When your grid is complete, fill in the number of pieces for each type of energy. After the score is calculated by the instructor, fill in your score and rank for each round.

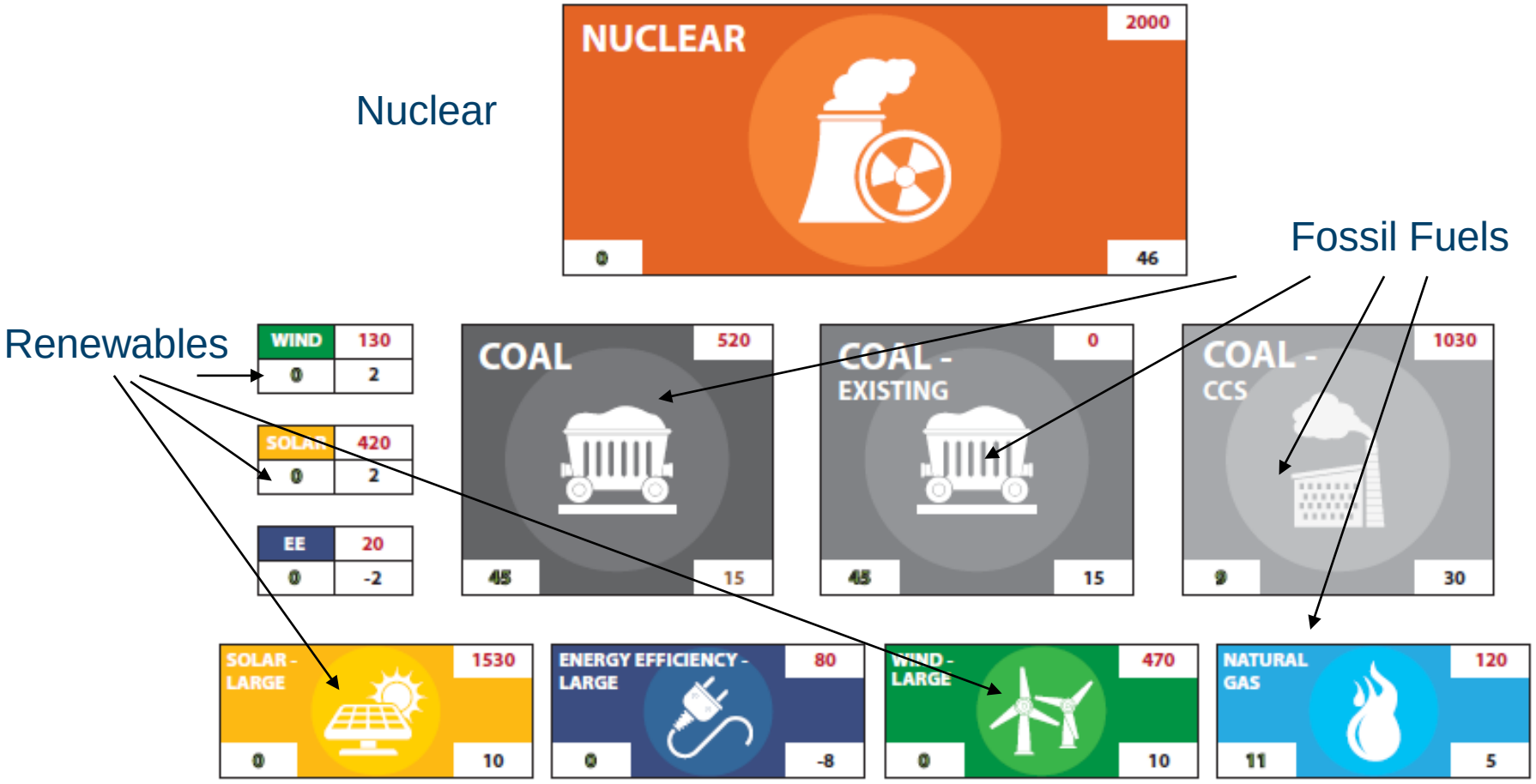
	Round 1	Round 2	Round 3	Round 4	Round 5
Nuclear	1				
Coal	4				
Coal-Existing	2				
Coal-CCS	0				
Natural Gas	4				
Small Wind	8				
Large Wind	0				
Small Solar	0				
Large Solar	0				
Small Efficiency	0				
Large Efficiency	0				
Score					
Rank					

Notes

The game board = the “grid”

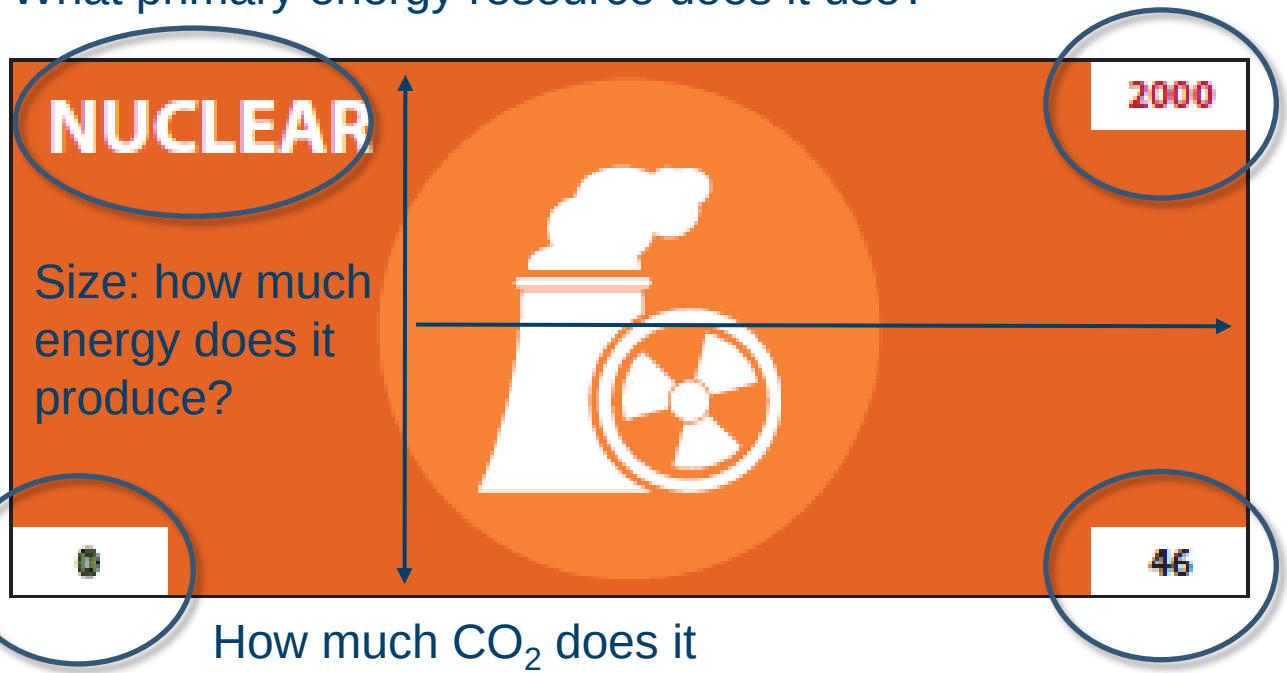
- Students teams are the decision makers for how they want to produce energy
- You will use this board for multiple rounds of game play
- Each team can be thought of as a town, state, region or country

Types of energy pieces



Parts of the energy pieces

What primary energy resource does it use?



How much does it cost to build/purchase?

How much does it cost each year to run/operate?

How much CO_2 does it produce?

Total Score	= 2000 + (46 * 30) + (0 * 30) * CO_2 cost
(over 30 years)	= 3380

** Units are generic, but represent relative costs of energy sources*

Now let’s play a few rounds of Generate!