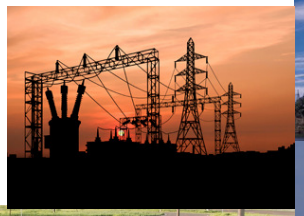
Introduction to GENERATE: The Game of Energy Choices

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

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

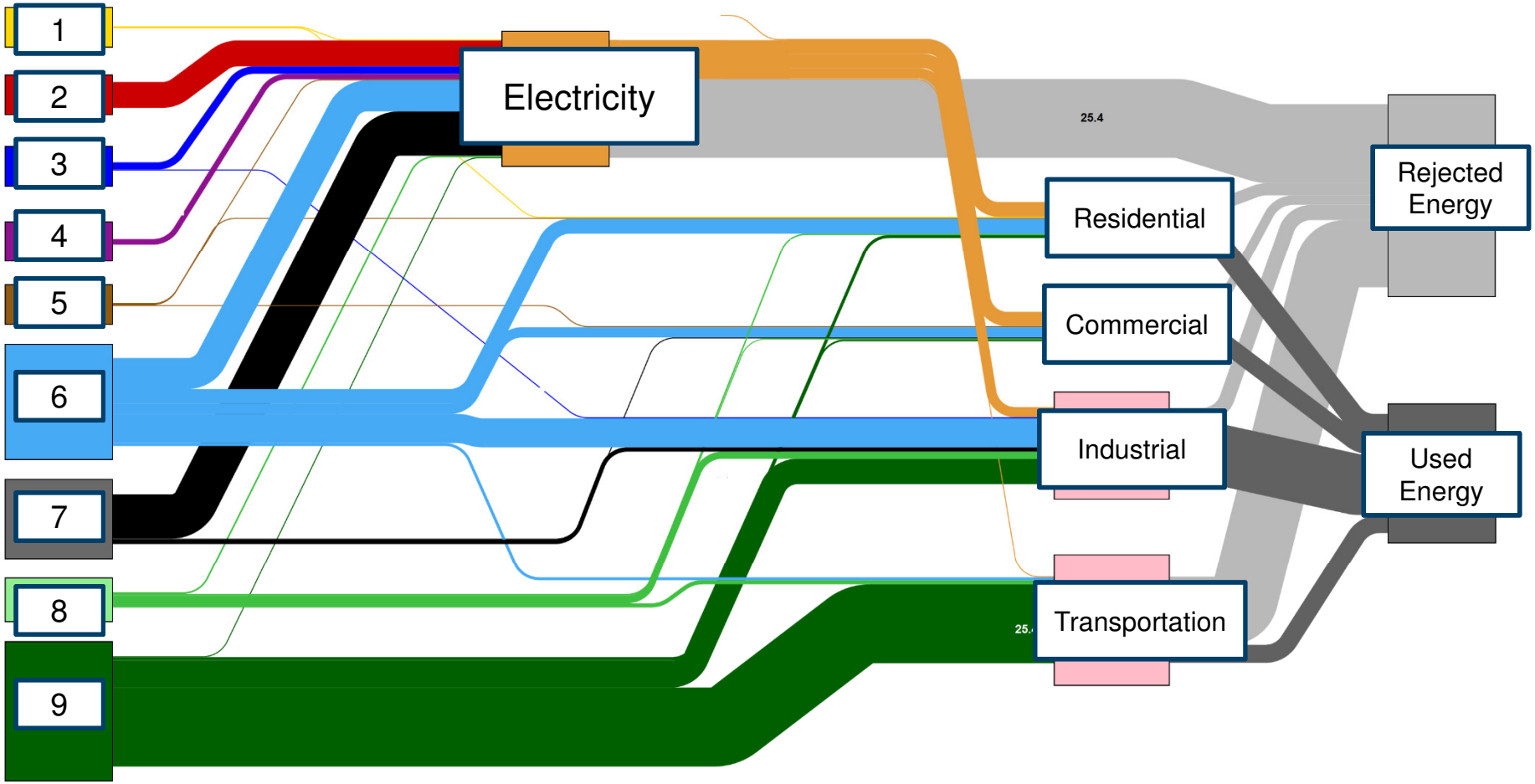


- **Energy services –** What people actually need and want: For example, mobility (vehicle miles of travel), lighting (lumens of light), comfort (space heating and cooling). Energy is a “derived demand”

Connecting the dots: where we use what energy

U.S Energy Flows from Resource to End Uses

Lawrence Livermore National Laboratory



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

Connecting the dots: where we use what energy

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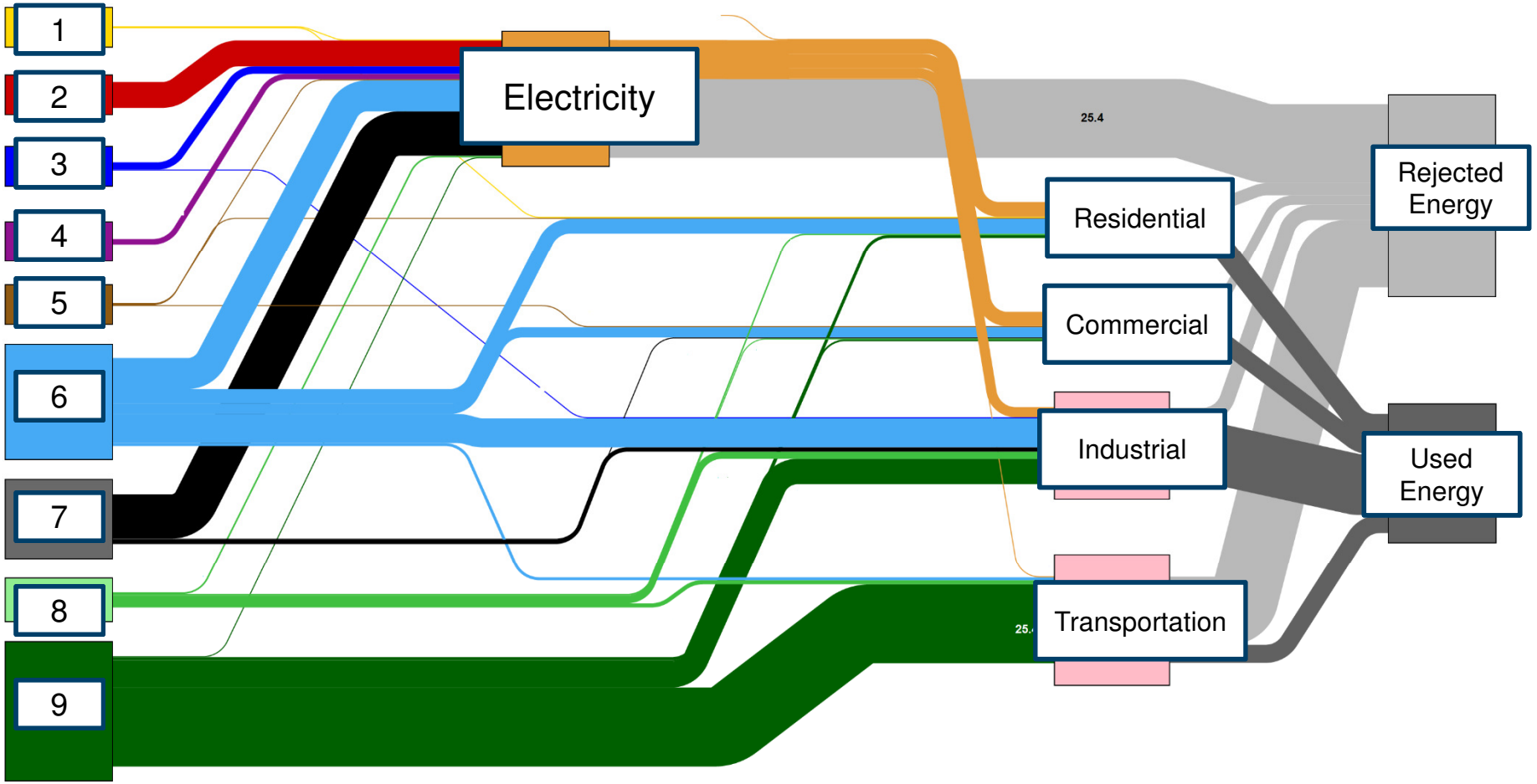


Coal = 7	Solar = 1	Biomass = 8
Natural Gas = 6	Wind = 4	Geothermal = 5
Petroleum (Crude Oil) = 9	Hydropower = 3	Nuclear = 2

Energy and our environment: why it matters

Energy-related impacts

Criteria air pollutants*

NO_X – 93%
CO – 61%
SO_2 – 81%
$PM_{2.5}$ – 63% (excl. misc.)

Greenhouse gases:

CO_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 + CO_2 cost

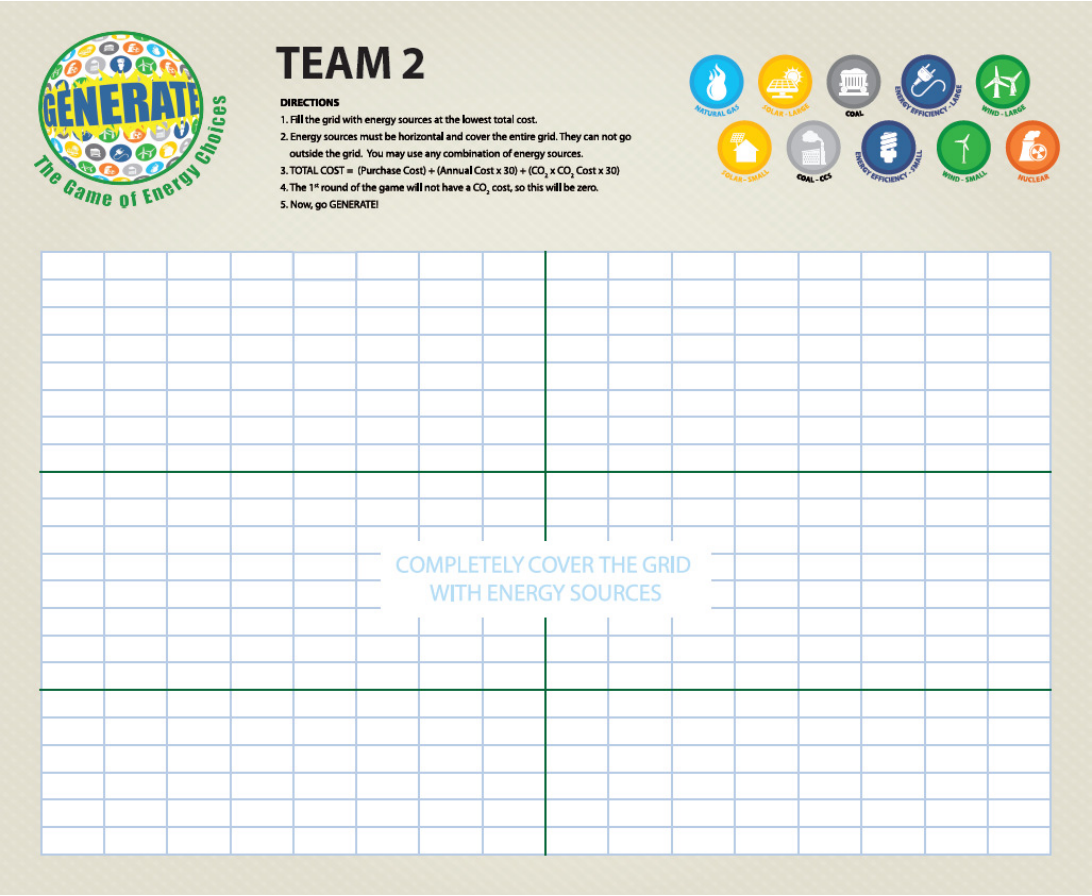
Team ___

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.

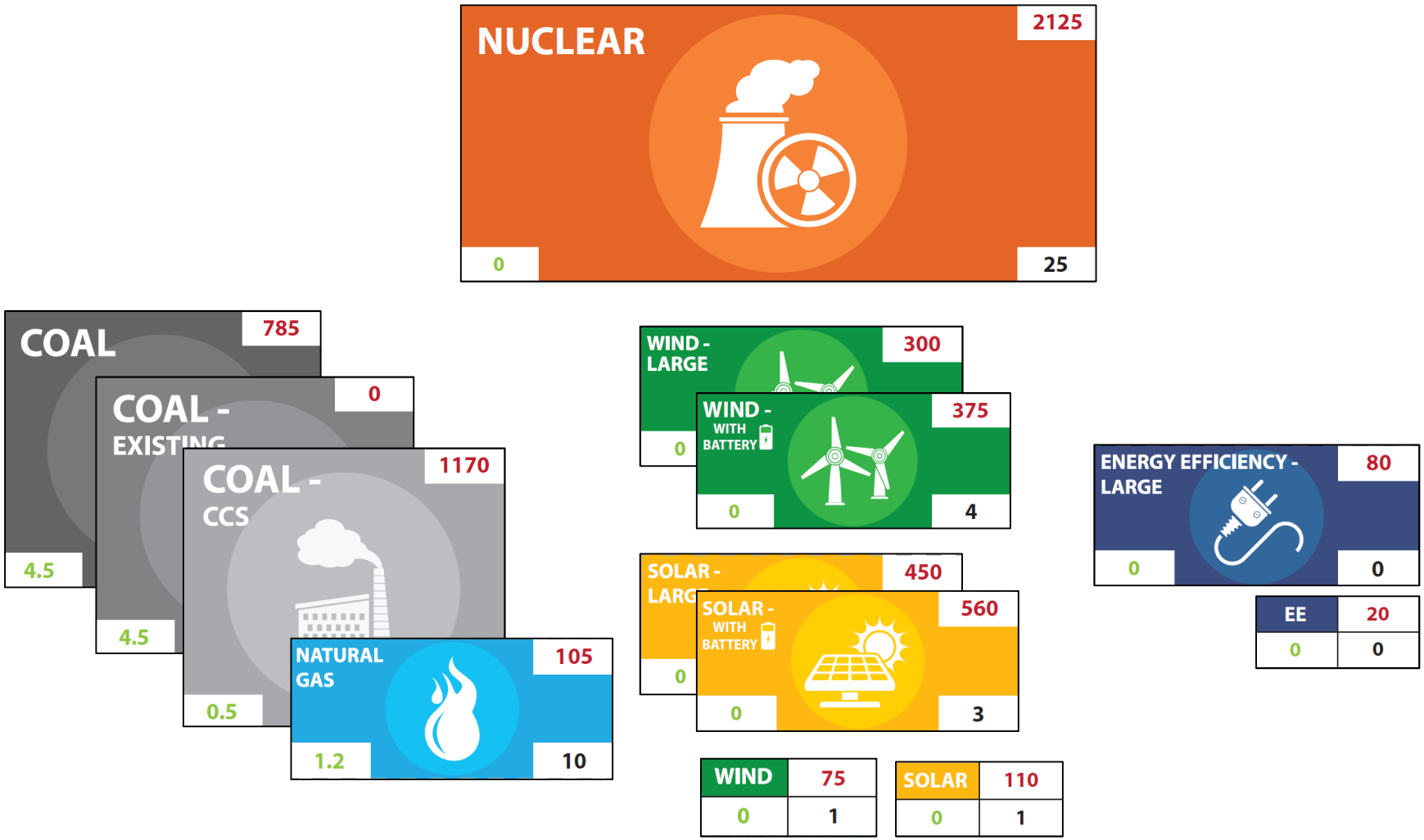
	Round 1	Round 2	Round 3	Round 4	Round 5
Nuclear					
Coal					
Coal – Existing					
Coal with CCS					
Natural Gas					
Wind – Small					
Wind – Large					
Wind – Large w. Battery					
Solar – Small					
Solar – Large					
Solar – Large w. Battery					
Small Efficiency					
Large Efficiency					
Score					
Rank					

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)

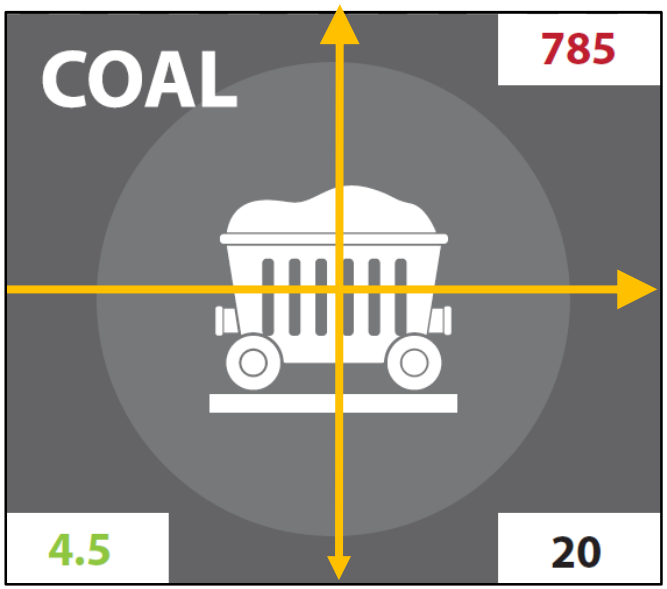


Parts of the energy pieces

Type:
What primary energy resource does it use?

Size:
How much energy does it produce?

CO_2 emissions:
How much CO_2 does it produce *each year*?



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

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

Lifetime: All energy pieces will last 30 years

Cost per piece = **785** + (**20** * 30) + (**4.5** * 30) * CO_2 cost
(*for 30 years*) = 1385 (if CO_2 cost is zero)

Now let’s play a few rounds of Generate!