

# *Generate!*

## *A game for getting to a low carbon electric power system*

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*9 July 2014  
EPA's Environmental Science Institute  
Air Quality Workshop*

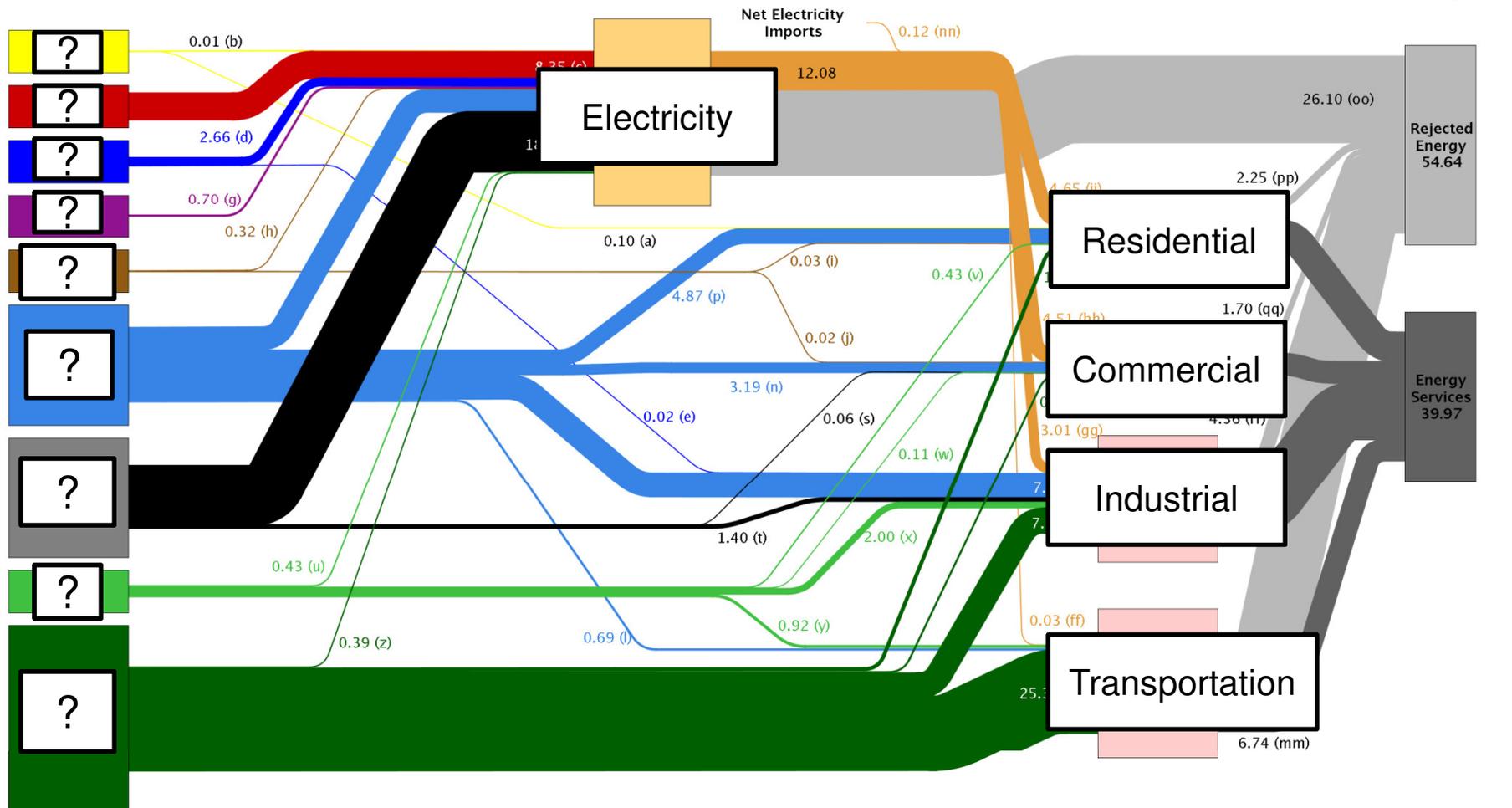
# What is the U.S. energy system?

- 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.
  - Refineries
  - Electric Power Generation
- End-use sectors that use electricity and fuels
  - Residential
  - Commercial
  - Industrial
  - Transportation



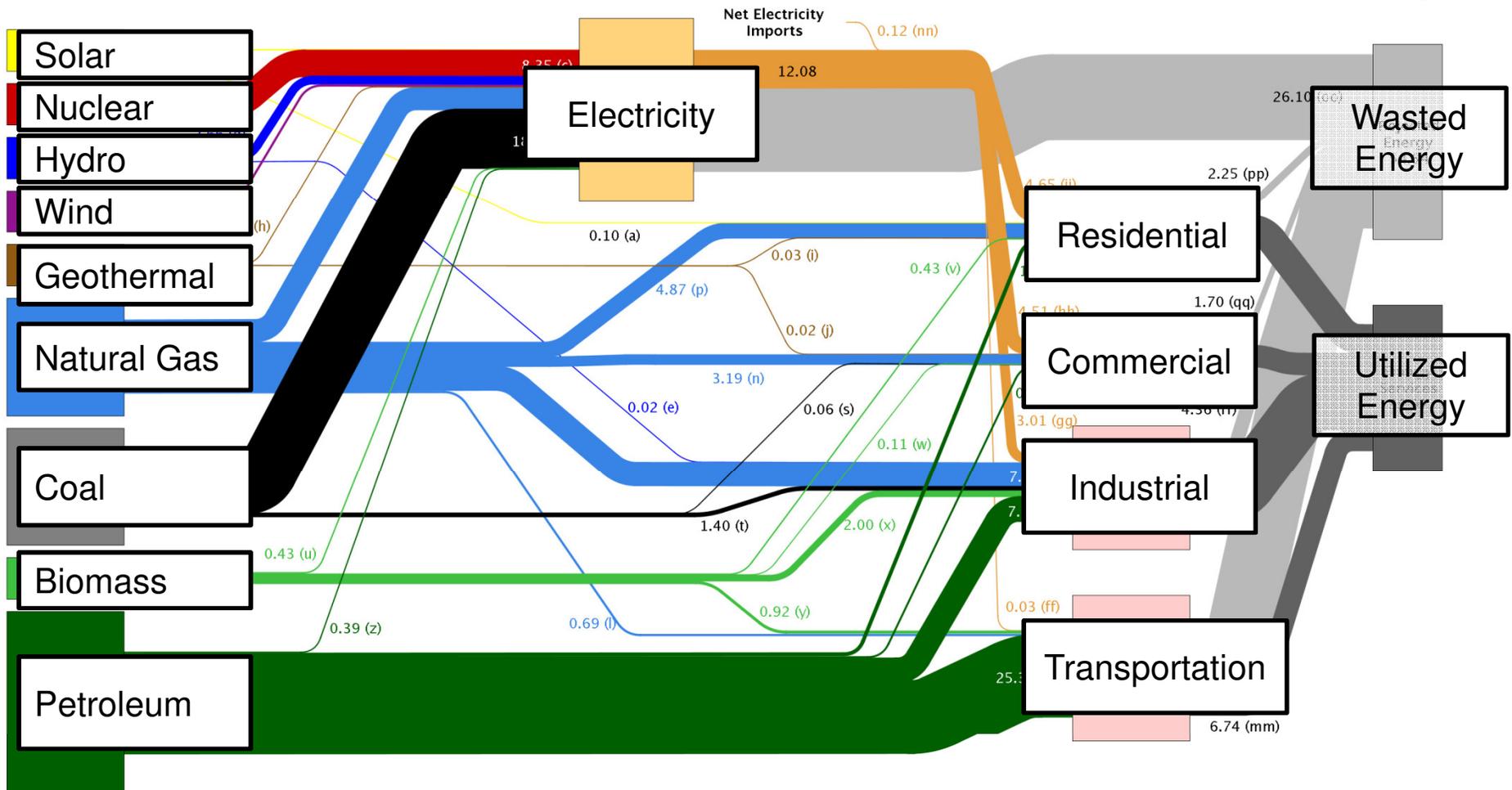
Simple, right?

Estimated U.S. Energy Use in 2009: ~94.6 Quads



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

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# Energy and the environment: what are the connections?

- Air Pollutant Emissions

- Contributions to US anthropogenic emissions

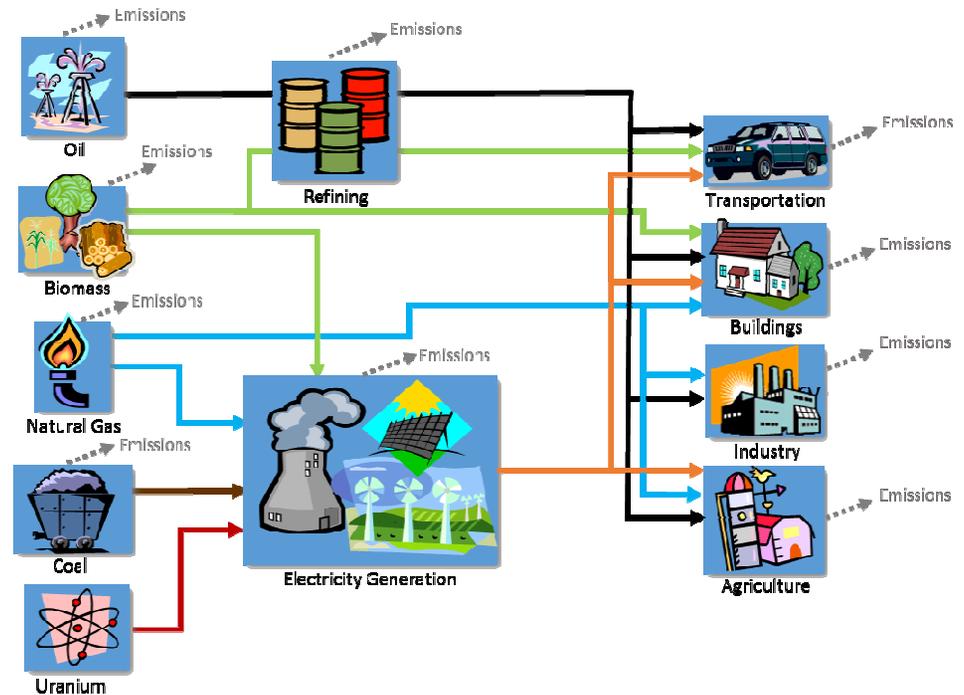
- $NO_x$  ~ 95%
    - $SO_2$  ~ 89%
    - $CO$  ~ 95%
    - $Hg$  ~ 87%

- Greenhouse Gas Emissions

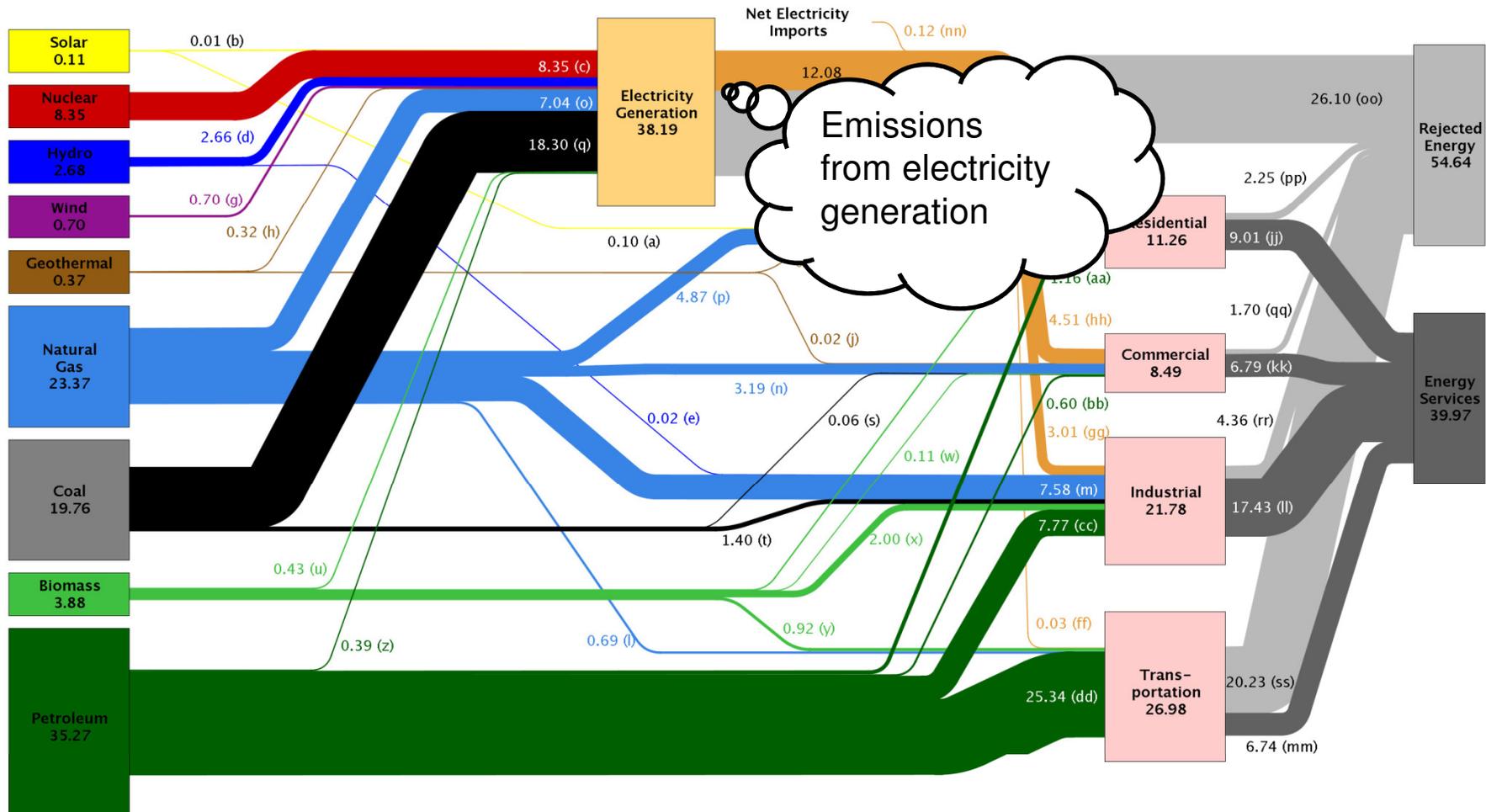
- Contributes 94% of US anthropogenic  $CO_2$  emissions

- Water Supply, Use and Quality

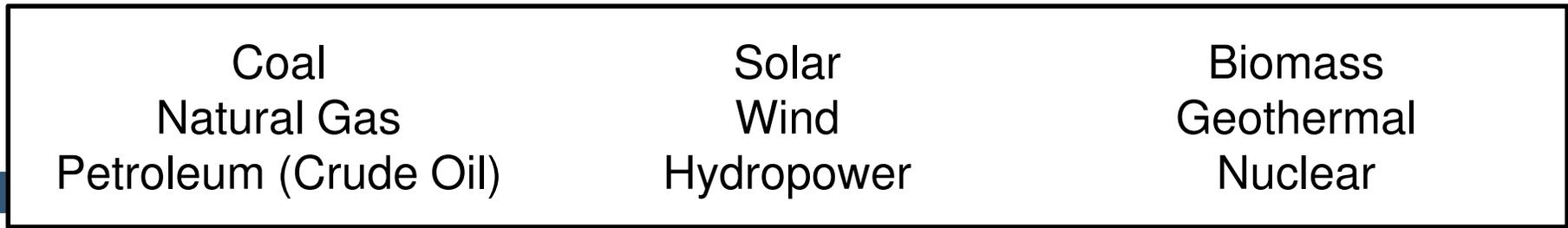
- 49% of US water withdrawals (agriculture ~ 31%; public supply ~ 11%)
  - 201 billion gallons of water per day is required



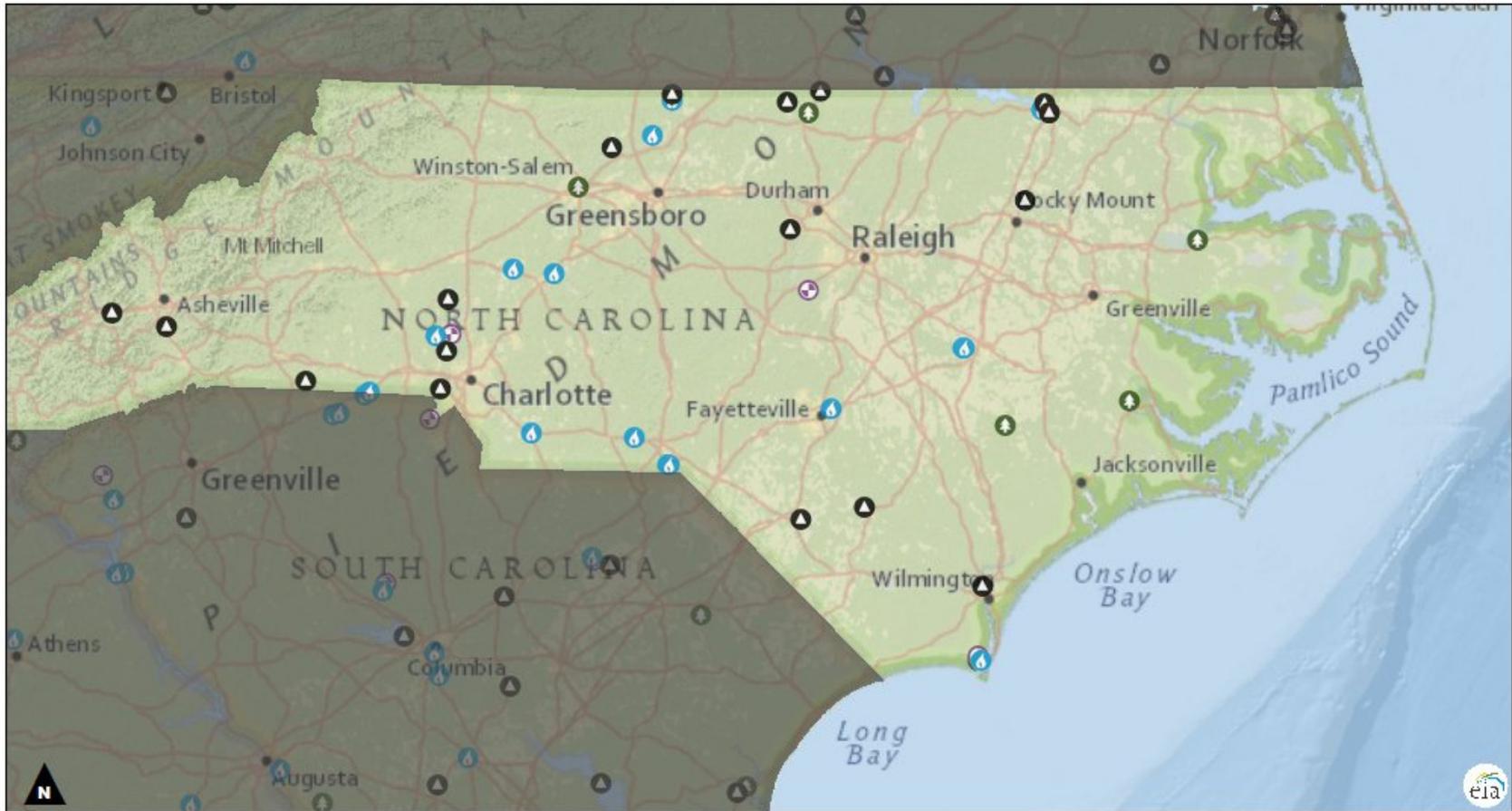
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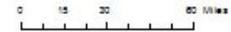
Emissions from electricity generation



# Electric power plants in North Carolina



Electricity Transmission Lines - Ventyx, Velocity Suite; National Geographic: National Geographic, Esri, DeLorme, HERE,



- Mask
- Coal Power Plant
- Natural Gas Power Plant
- Nuclear Power Plant
- Wood Power Plant





# An Energy Game

- A simple “simulation” of an energy system
- Helps us to see some of the challenges and tradeoffs involved in making energy and policy decisions
- Each team has the same total energy (area of pieces)
- Each team **does not** have the same mix of energy types
- Goal is to fill the game board with energy types to achieve the **lowest total score**
- Score = purchase cost + operating cost + CO<sub>2</sub> cost
- Can do variations/extensions on the game, e.g., water use in the electric sector



# Generate! Filling up the grid



## TEAM 1

**DIRECTIONS**

1. Fill the grid with energy sources at the lowest total cost.
2. Energy sources must be horizontal and cover the entire grid. They can not go outside the grid. You may use any combination of energy sources.
3. TOTAL COST = (Purchase Cost) + (Annual Cost x 30) + (CO<sub>2</sub> x CO<sub>2</sub> Cost x 30)
4. The 1<sup>st</sup> round of the game will not have a CO<sub>2</sub> cost, so this will be zero.
5. Now, go GENERATE!



COMPLETELY COVER THE GRID  
WITH ENERGY SOURCES

WWW.EPA.GOV

GENERATE! CREDITS INCLUDE ORIGINAL CONCEPT: C. ANDY MILLER; ORIGINAL DESIGN: BERNINE KHAN; GAME DEVELOPER: REBECCA DODDER; OUTREACH COORDINATOR: KELLY LEOVIC; GRAPHIC DESIGN: CAMDEN WATTS AND DUSTIN RIEGO.

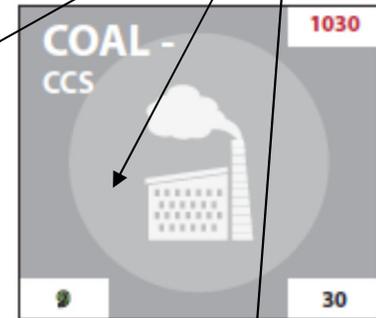
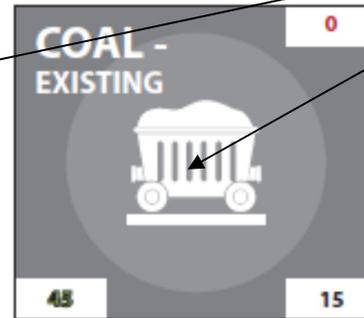
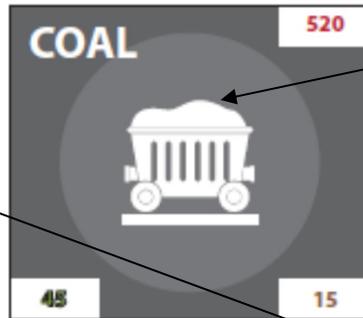
Nuclear



Fossil Fuels

Renewables

<b>WIND</b>	<b>130</b>
0	2
<b>SOLAR</b>	<b>420</b>
0	2
<b>EE</b>	<b>20</b>
0	-2



What primary energy resource does it use?



How much does it cost to build/purchase?

How much energy does it produce?

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

How much CO<sub>2</sub> does it produce?

$$\begin{aligned} \text{Total Score} &= 2000 + (46 * 30) + (0 * 30) * \text{CO}_2 \text{ cost} \\ \text{(over 30 years)} &= 3380 \end{aligned}$$



**Now let's play a few rounds of the energy game....**





# Teachback: What did we learn?

## Types of energy resources

- What are the different types of energy?
- How can we classify them? How do they differ?

## Where we get our electricity

- In an ideal world, what energy mix would you like to see, and why?
- What are the challenges with that? How could those challenges be met?
- How did CO<sub>2</sub> prices changes what energy mixes got the best score?





# Teachback: What can you do?

## What can we do now?

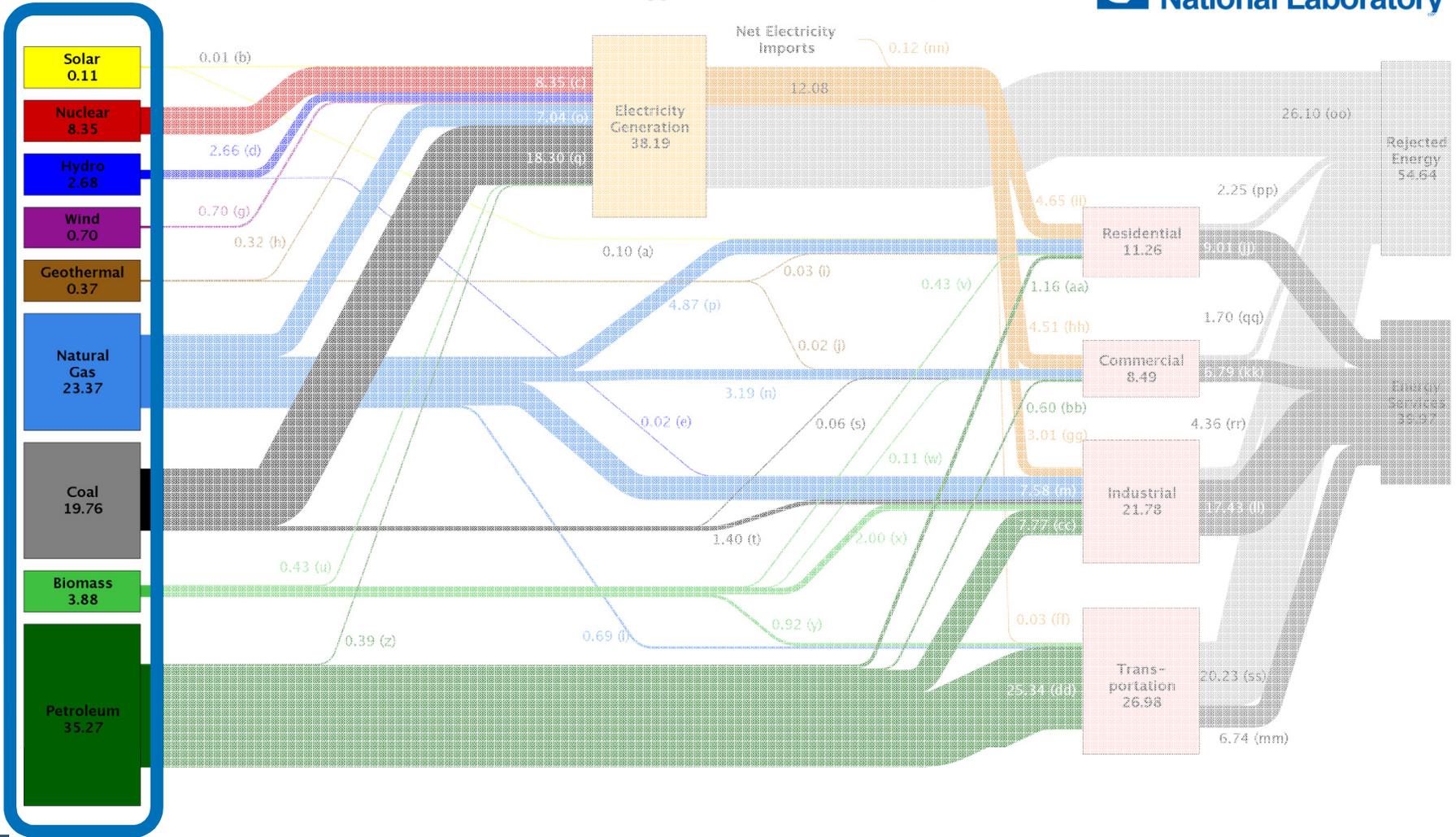
- How did energy efficiency affect the game?
- What can you do to improve energy efficiency and conserve electricity?



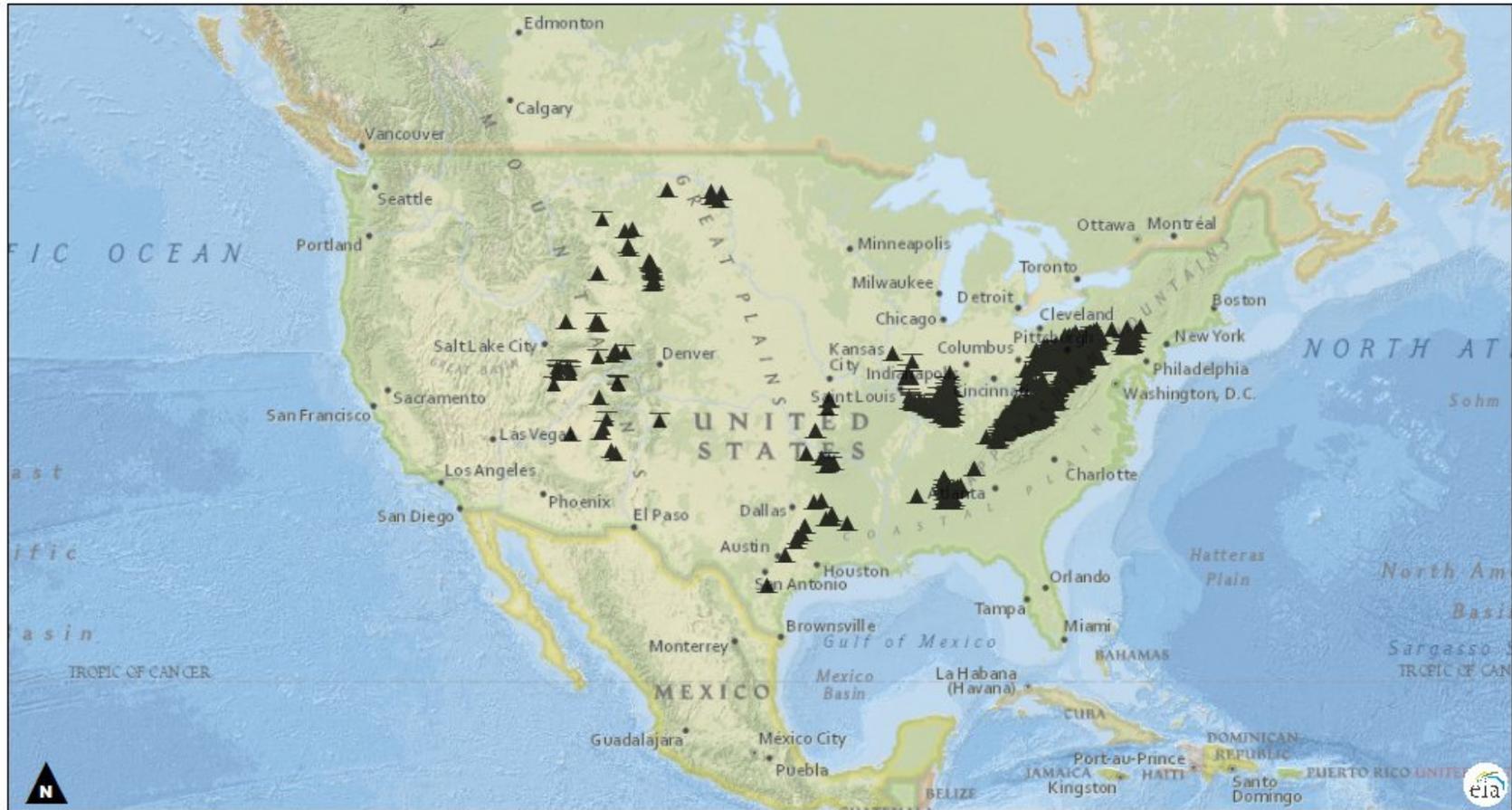
**Additional slides**



### Estimated U.S. Energy Use in 2009: ~94.6 Quads



# Coal mines



Electricity Transmission Lines - Ventyx, Velocity Suite; National Geographic: National Geographic, Esri, DeLorme, HERE,

- ▲ Surface Coal Mine
- ▴ Underground Coal Mine

Source: DOE's Energy Information Administration,  
[www.eia.gov/state](http://www.eia.gov/state)

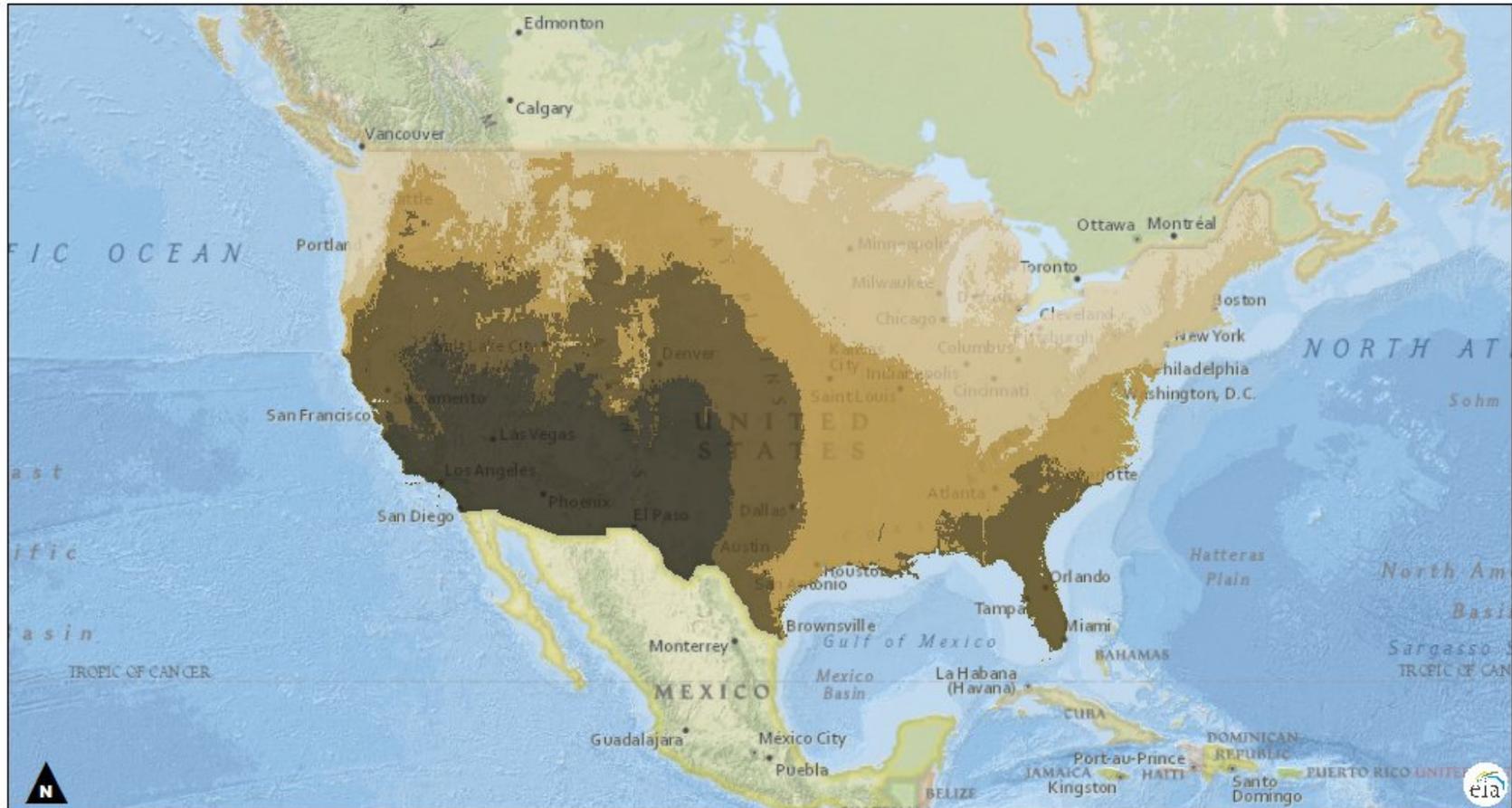
# Oil and natural gas



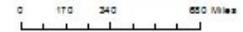
:Electricity Transmission Lines - Ventyx, Velocity Suite;National Geographic:National Geographic, Esri, DeLorme, HERE,

- Oil Wells: High-Level View (z)
- Gas Wells: High-Level View (z)
- Shale Basin
- Shale Play

# Solar potential

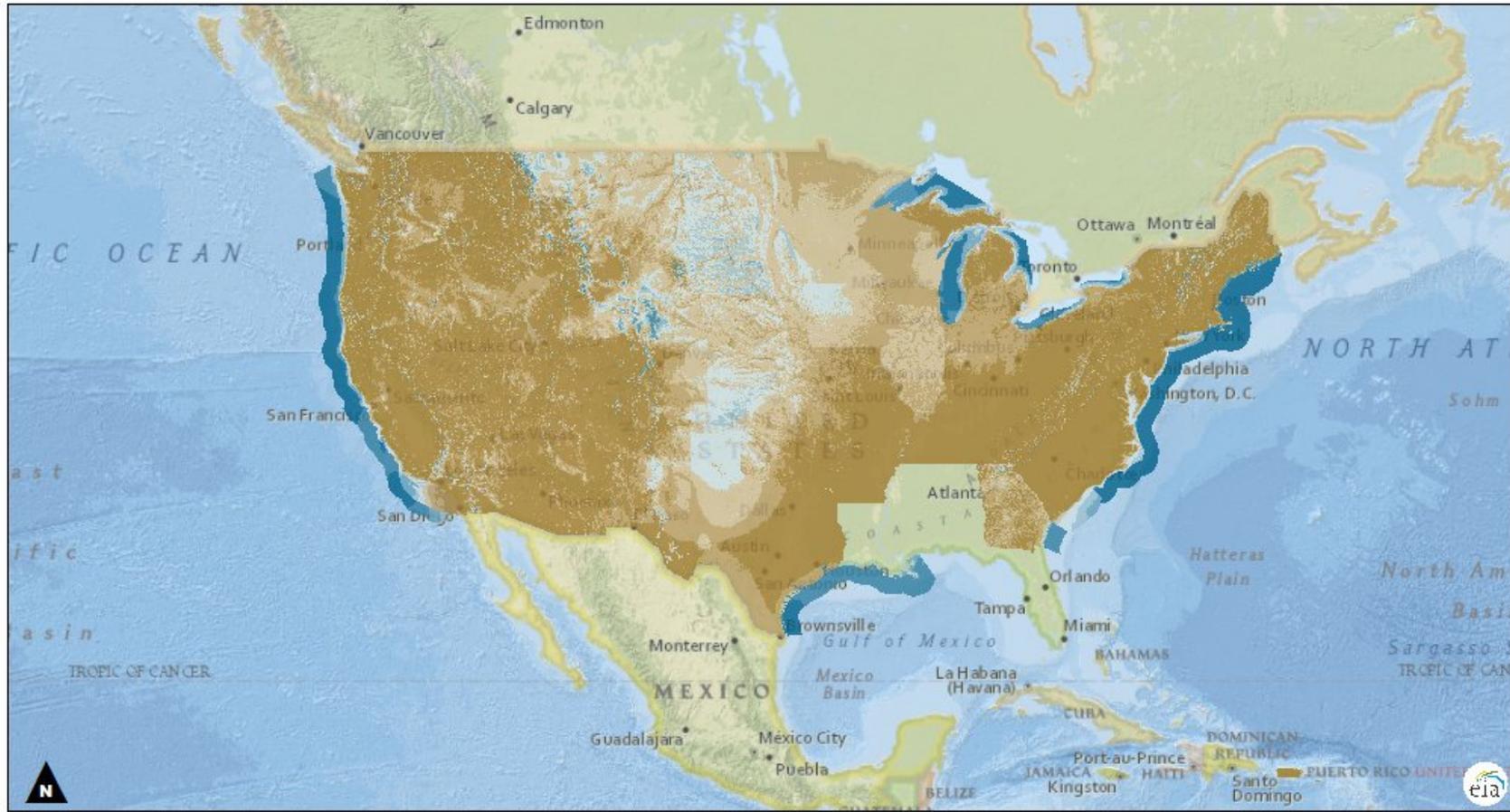


Electricity Transmission Lines - Ventyx, Velocity Suite; National Geographic: National Geographic, Esri, DeLorme, HERE,



- 5.93 to 7.03 kWh/m2/Day PV Solar Potential
- 5.21 to 5.92
- 4.78 to 5.2
- 4.35 to 4.77
- 3.92 to 4.34

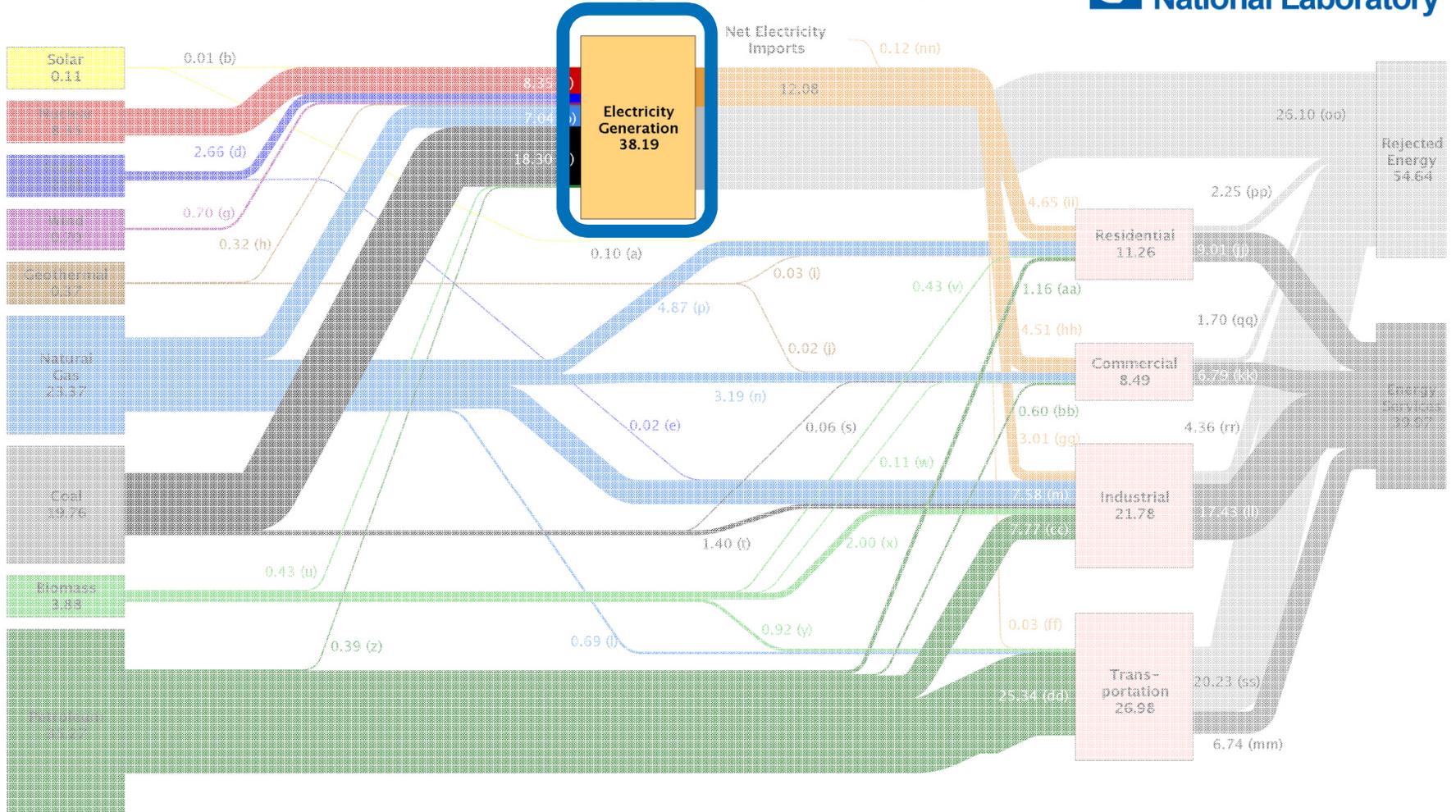
# Wind potential



Electricity Transmission Lines - Ventyx, Velocity Suite; National Geographic: National Geographic, Esri, DeLorme, HERE,

 7 Superb On Shore Wind Potential	 2 Marginal	 4.89 to 6.13
 6 Outstanding	 1 Poor	 1.63 to 4.88
 5 Excellent	 8.14 to 11.63 Off Shore Wind Speed (meters/second)	
 4 Good	 6.89 to 8.13	
 3 Fair	 6.14 to 6.88	

Estimated U.S. Energy Use in 2009: ~94.6 Quads



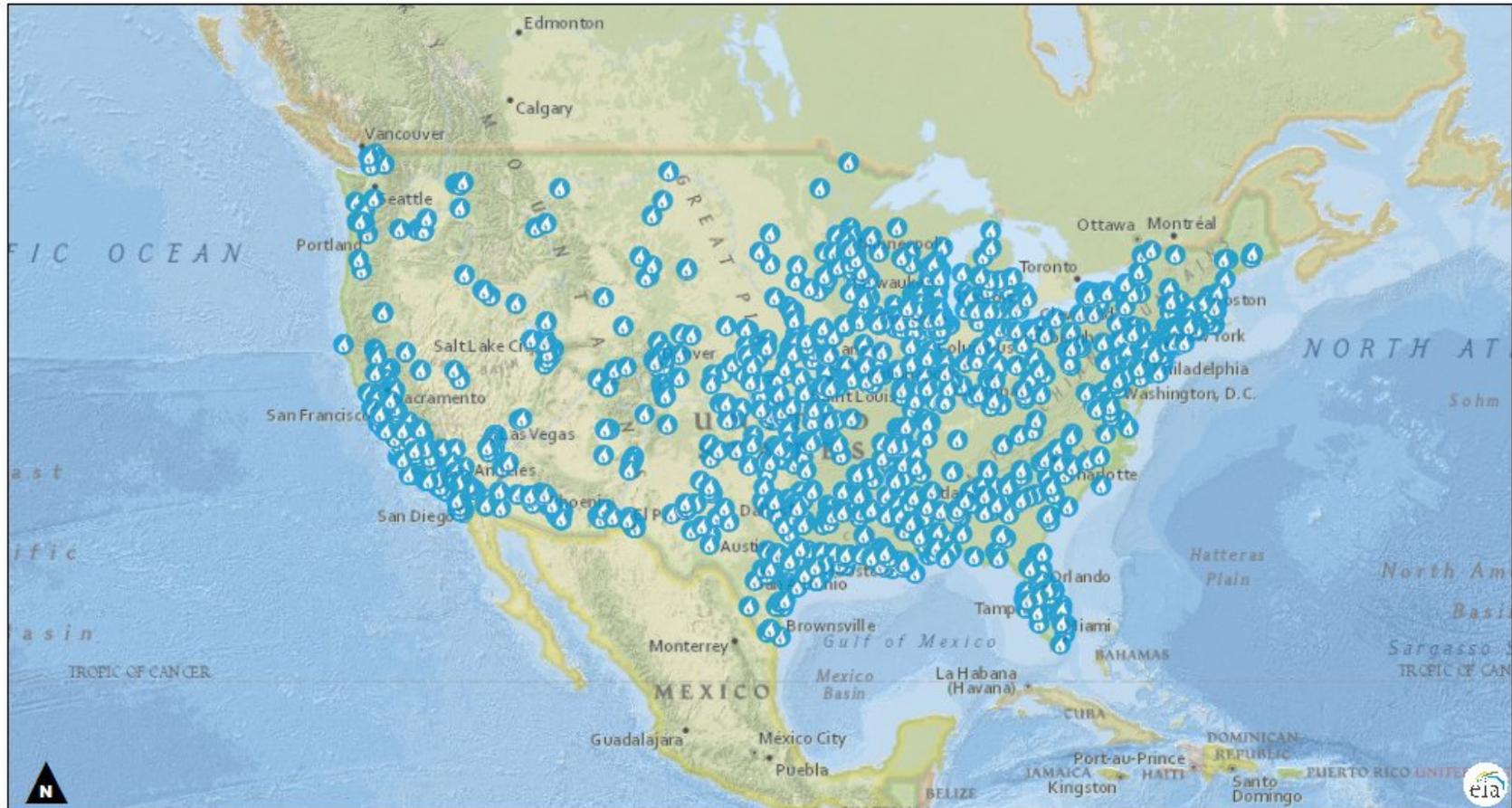
# Coal power plants



Electricity Transmission Lines - Ventyx, Velocity Suite; National Geographic: National Geographic, Esri, DeLorme, HERE,

▲ Coal Power Plant

# Natural gas power plants



Electricity Transmission Lines - Ventyx, Velocity Suite; National Geographic: National Geographic, Esri, DeLorme, HERE,

 Natural Gas Power Plant

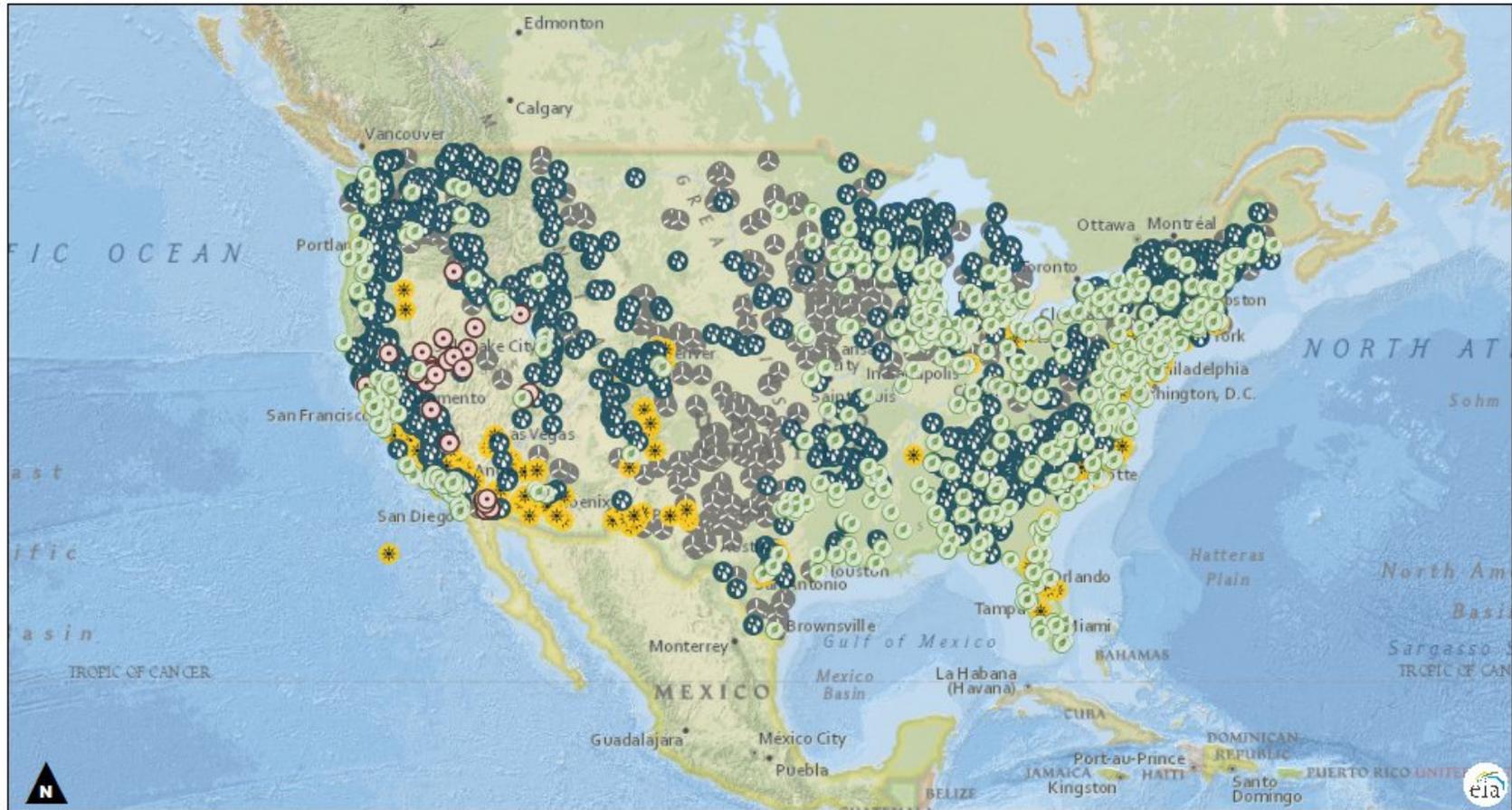
# Nuclear power plants



:Electricity Transmission Lines - Ventyx, Velocity Suite;National Geographic:National Geographic, Esri, DeLorme, HERE,

⊕ Nuclear Power Plant

# Renewable electric power



Electricity Transmission Lines - Ventyx, Velocity Suite; National Geographic: National Geographic, Esri, DeLorme, HERE,

-  Biomass Power Plant
-  Geothermal Power Plant
-  Hydroelectric Power Plant
-  Solar Power Plant
-  Wind Power Plant