# Our Evolving Energy Mix

## Insights Into the Central Element of Our Economic Engine

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# A Perspective on Scale

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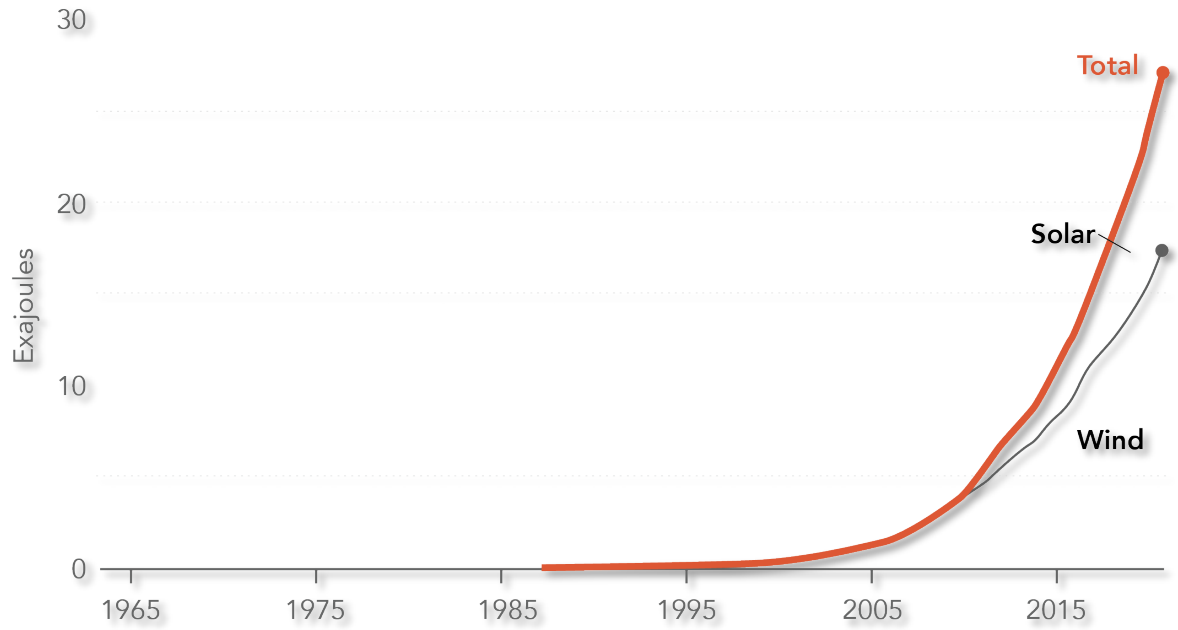
The New York Times

The Energy Transition

## The Clean Energy Future Is Arriving Faster Than You Think

The United States is pivoting away from fossil fuels and toward wind, solar and other renewable energy, even in



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**Completely Factual !**

**But Not Factually Complete !**

The New York Times

The Energy Transition

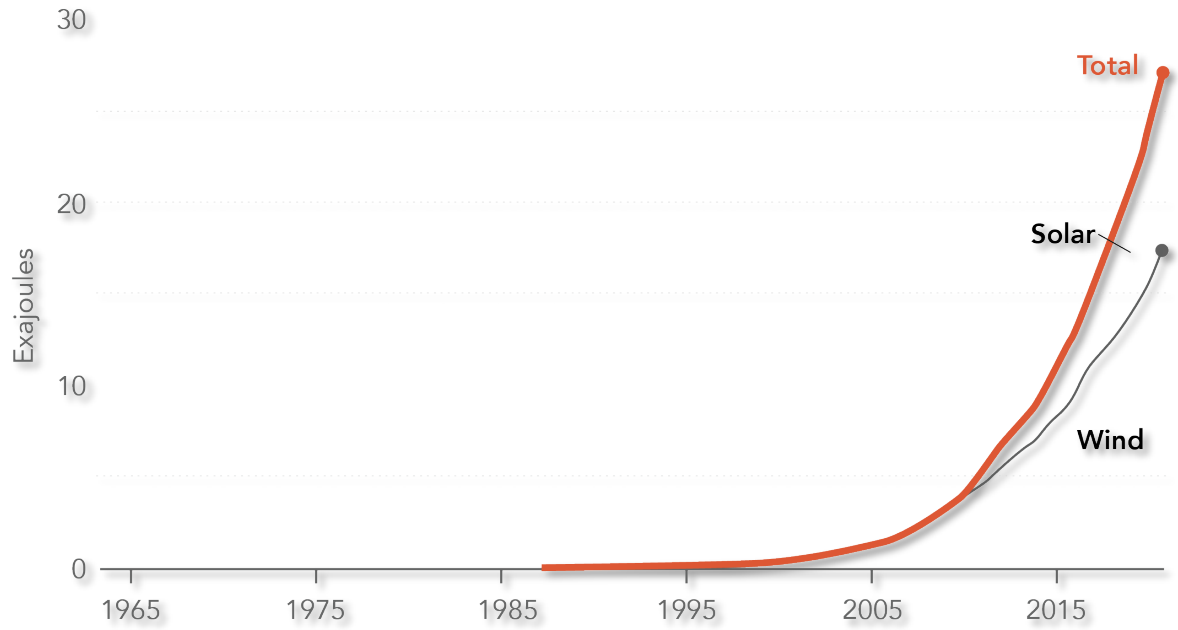
## The Clean Energy Future Is Arriving Faster Than You Think

The United States is pivoting away from fossil fuels and toward wind, solar and other renewable energy, even in

**Yearly U.S. wind and solar combined are equivalent to ~362 MMOEB**

**Equates to ~3.5 days of global oil consumption**

**… or 18 days of U.S. consumption**



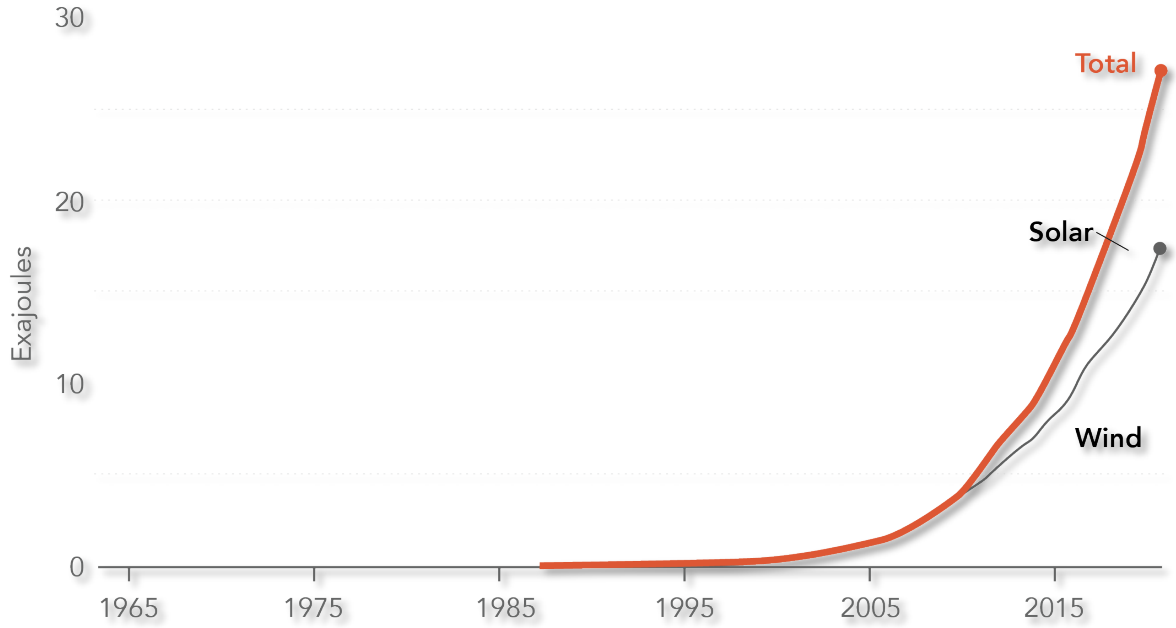
# A Perspective on Scale

“Yellowtail” Floating Production Storage and Offloading Vessel Offshore Guyana

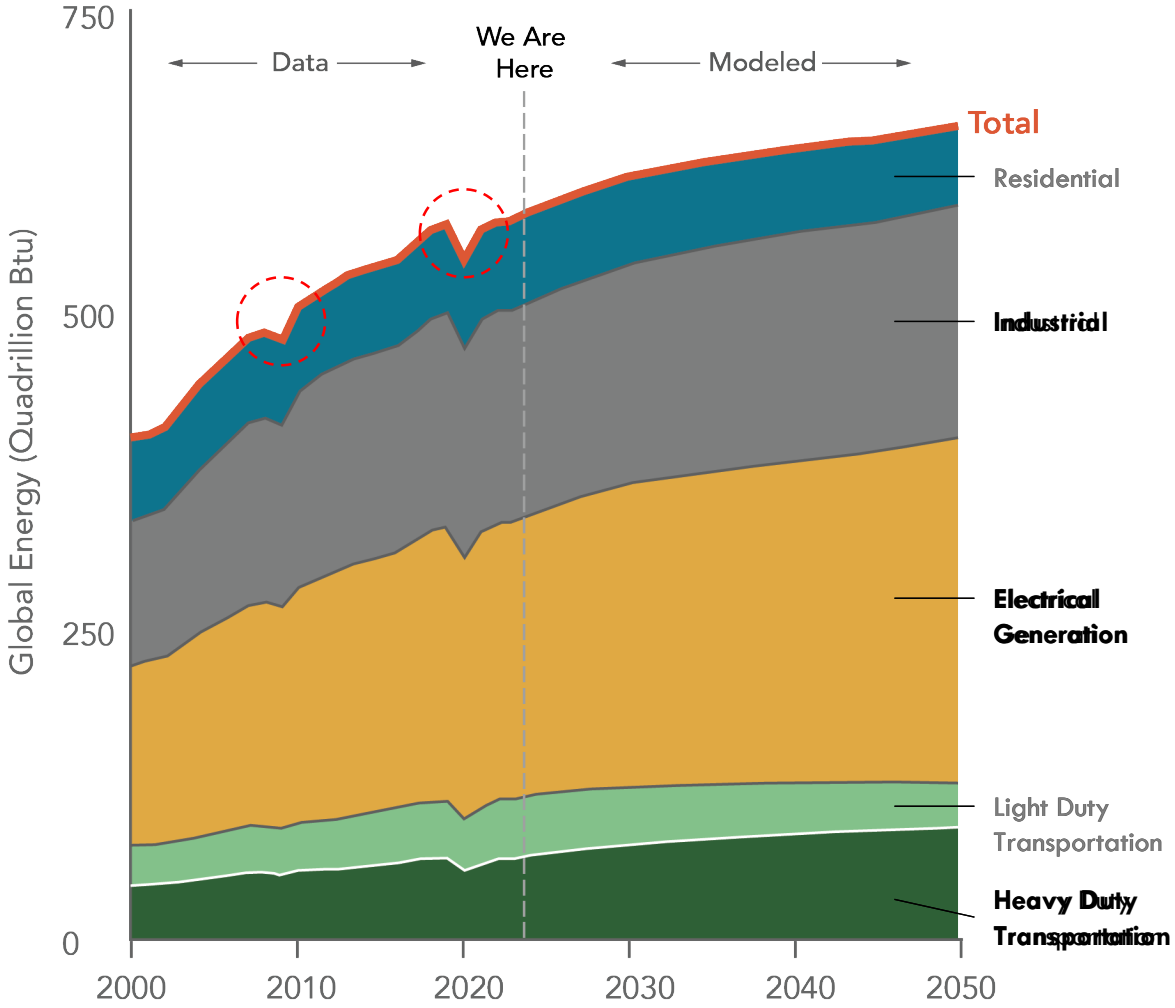
**Or …**

**The energy equal to 1 day of production from this vessel**

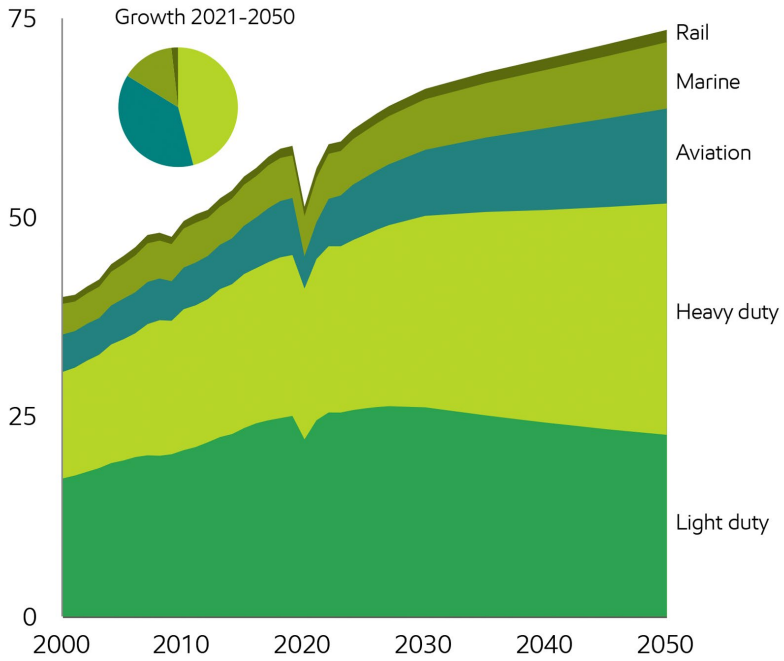
**… and there are 6 vessels in operation / being built right now!**



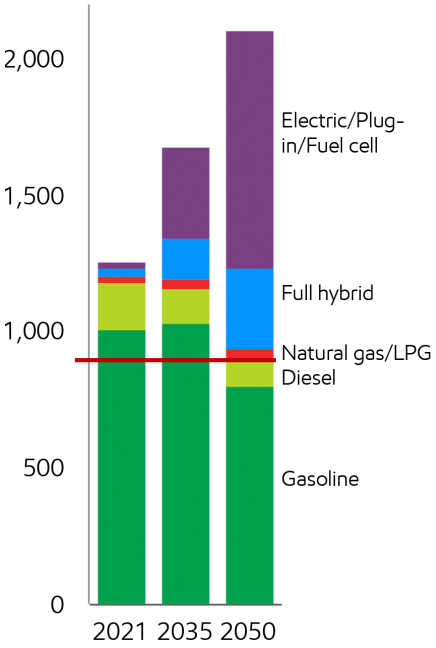
# A Global Perspective of Energy Demand




## Global sector demand
(million oil-equivalent barrels/day)




## Vehicles (million)




**Source:** ExxonMobil outlook for Energy

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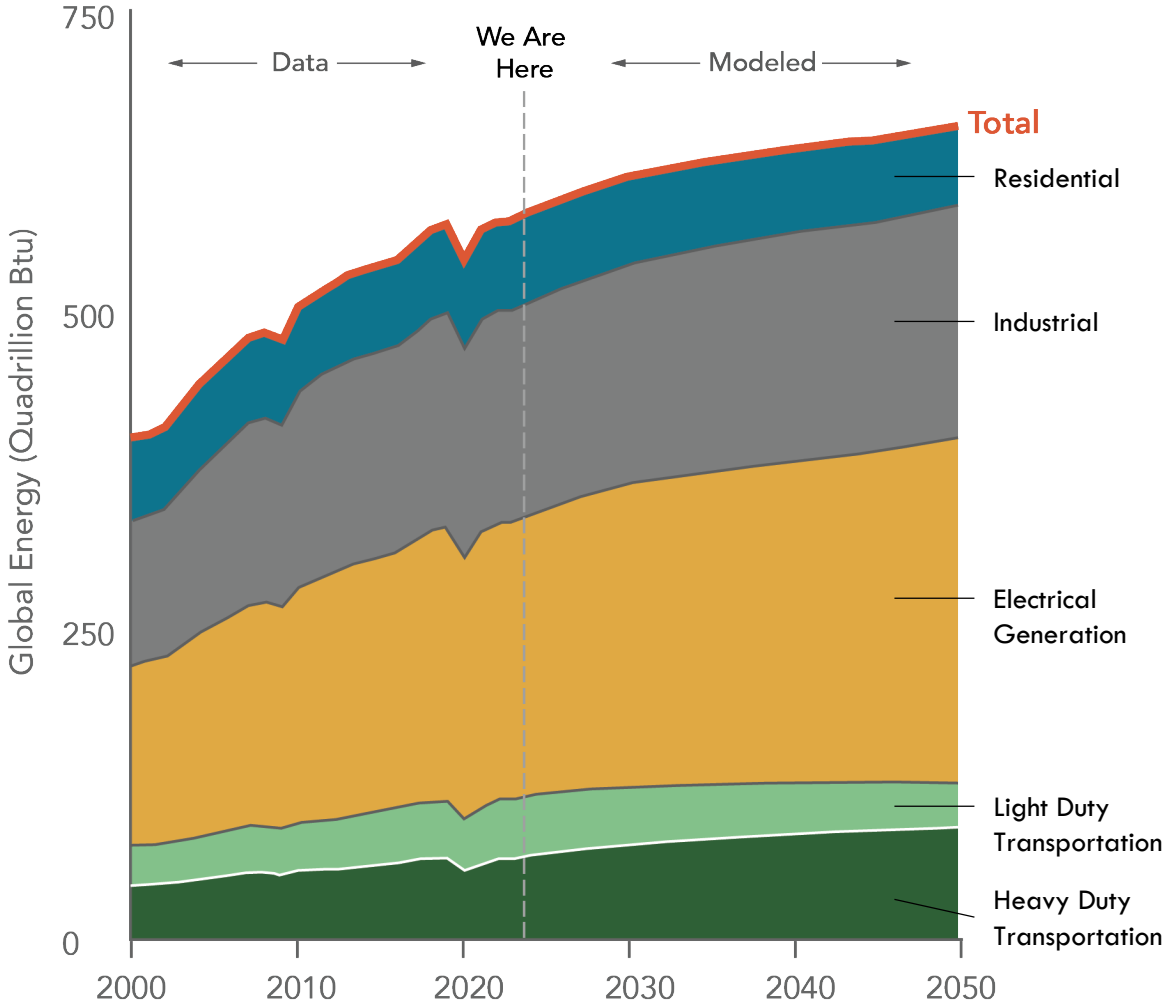
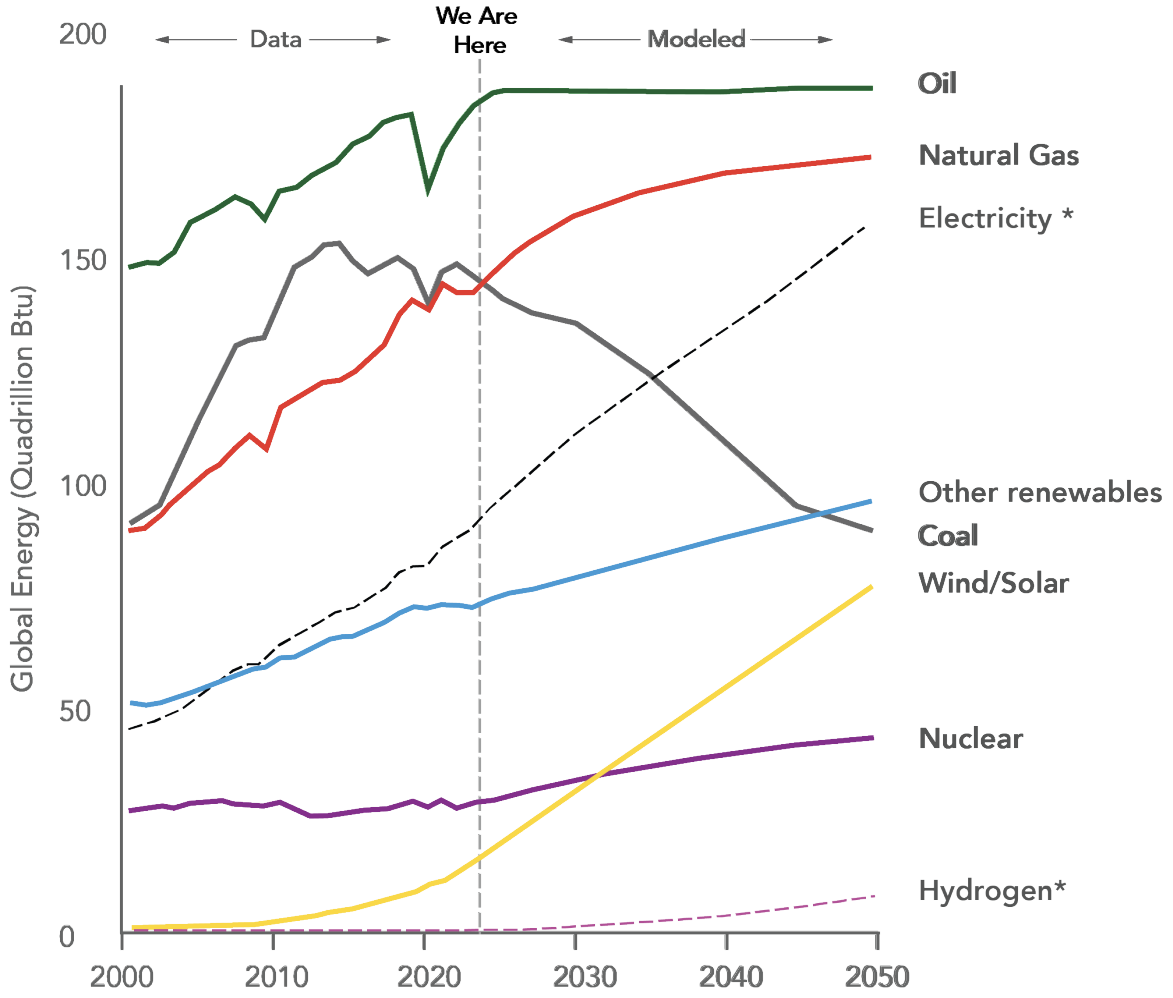
# A Global Perspective of Energy Demand




**Source:** ExxonMobil outlook for Energy

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# Conclusion #2

The Reality is that our appetite for energy is **enormous!**
It is growing and it is evolving!

Underscores the importance of **Energy Security**!

# U.S. Yearly Energy Consumption

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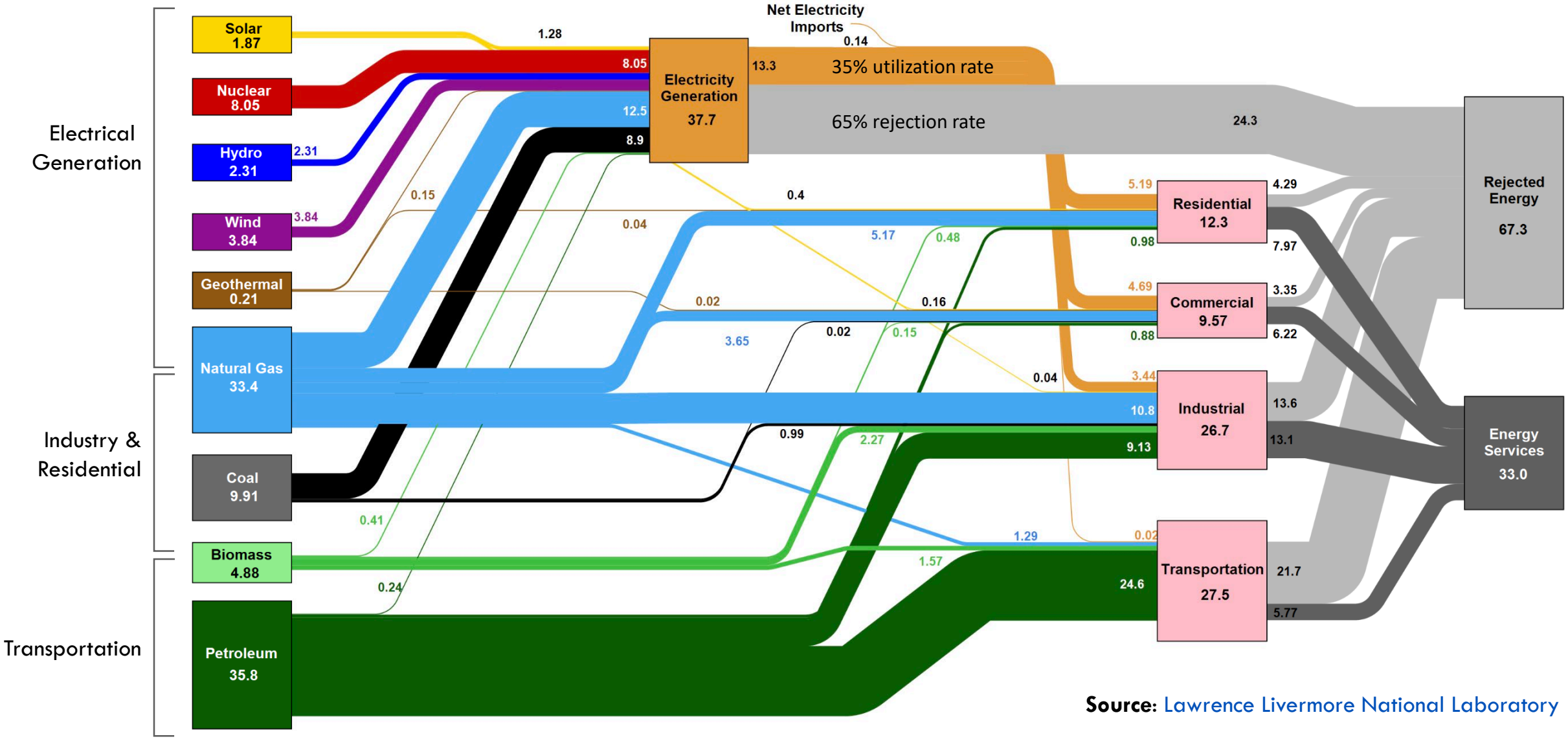
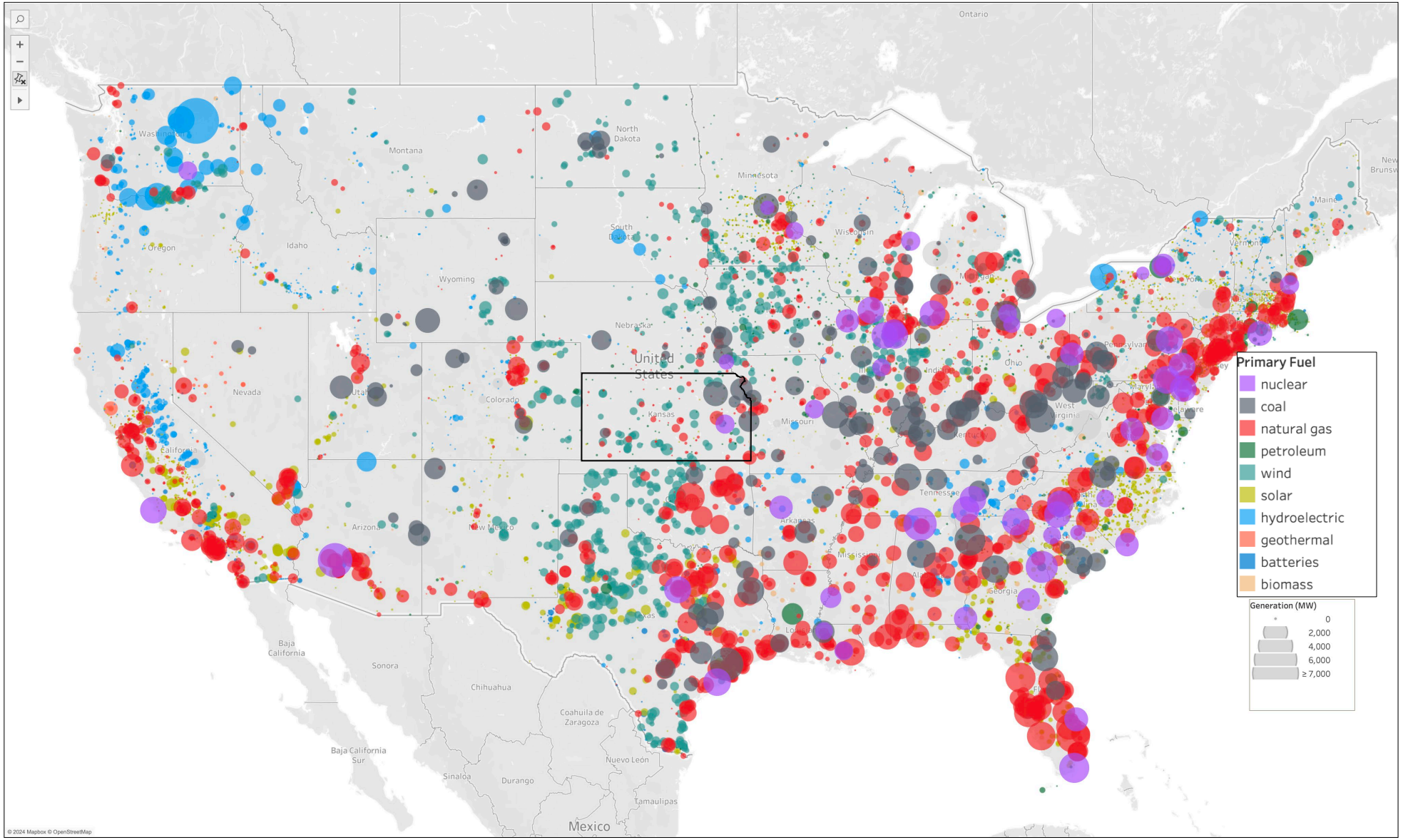
## Estimated U.S. Energy Consumption (2021) ~ 100.3 Quadrillion BTU




**Source:** Lawrence Livermore National Laboratory

# National Electrical Energy Trends

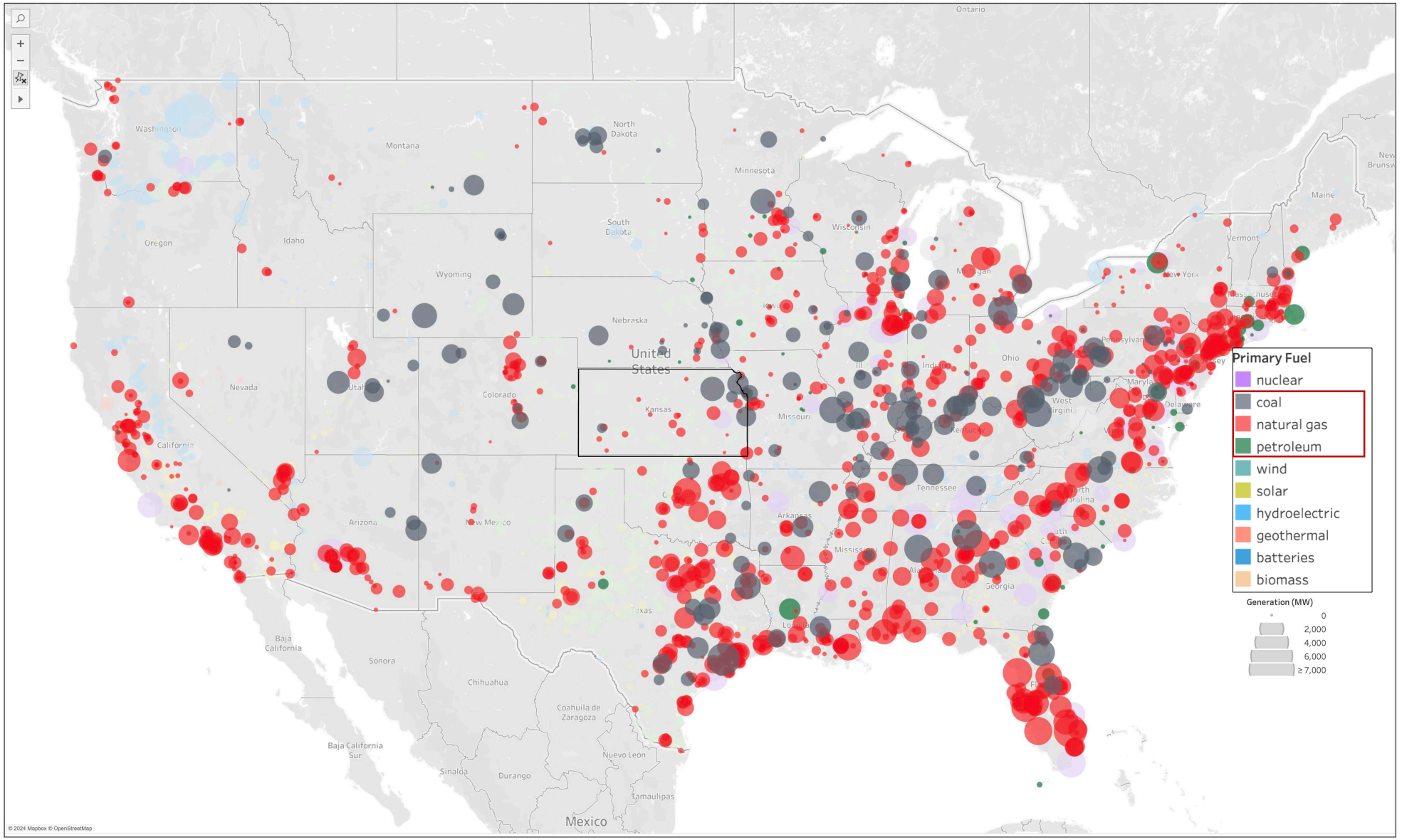



**Utility-Scale Generation Capacity, as of 4Q,2023**

- **Total Energy Generation = 1,186,275 MW**
- **Total Fossil Energy = 724,804 MW (61%)**
- **Total Renewable Energy = 348,474 MW (29%)**
- **Total Nuclear Energy = 95,773 MW (8%)**

**Data Source:** U.S. Energy Information Administration

# Fossil Fuel Electrical Energy Generation




**Data Source:** U.S. Energy Information Administration

**Utility-Scale Generation Capacity, as of 4Q,2023**

- **Combination of Coal, Natural Gas, and Petroleum**
- **>55% of electrical generation**
- **U.S. Coal generation dropped by 23% from 2021-2023:**
- **Operators have retired ~37 GW (or 17%) of coal fleet since 2021**

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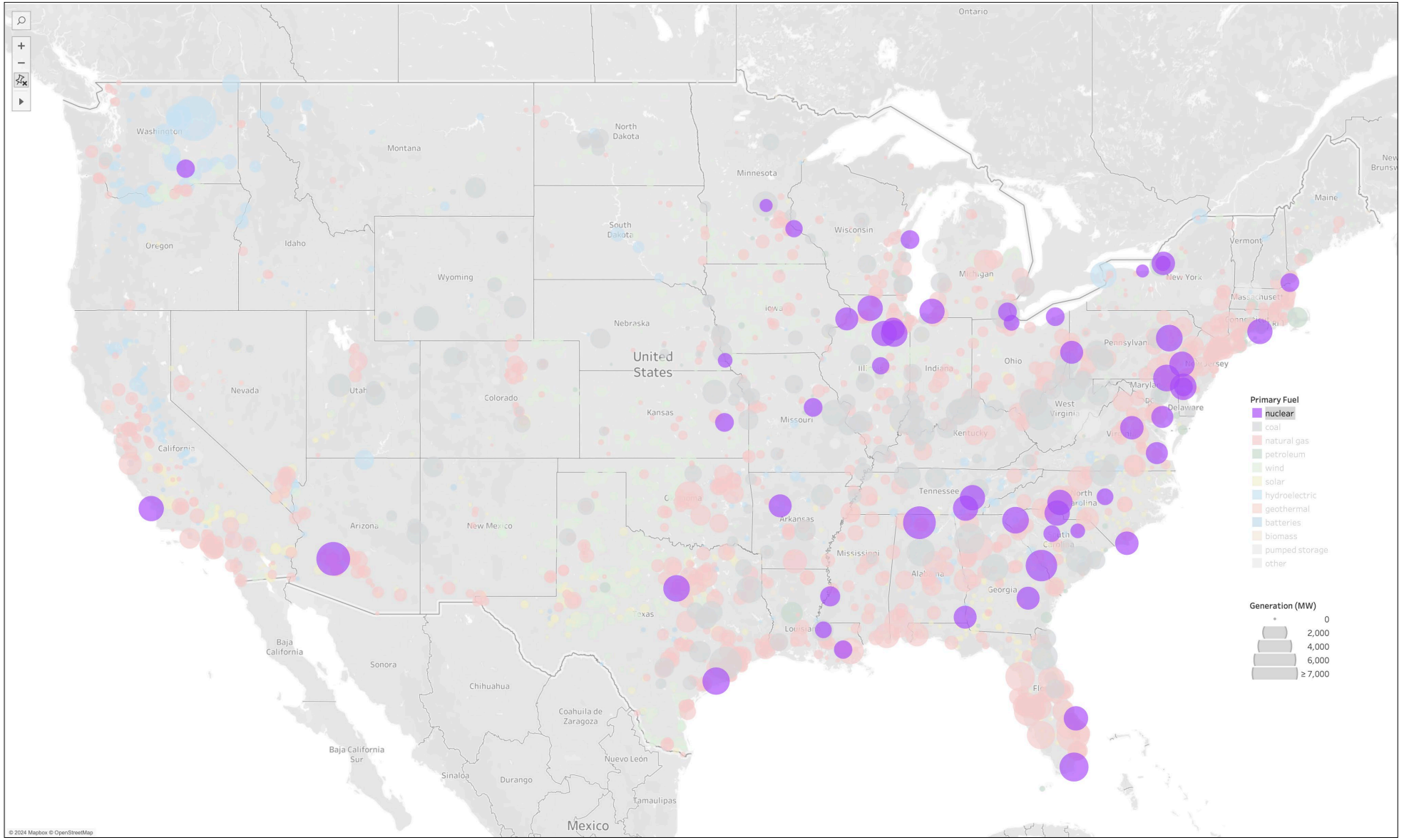
# Nuclear Electrical Generation

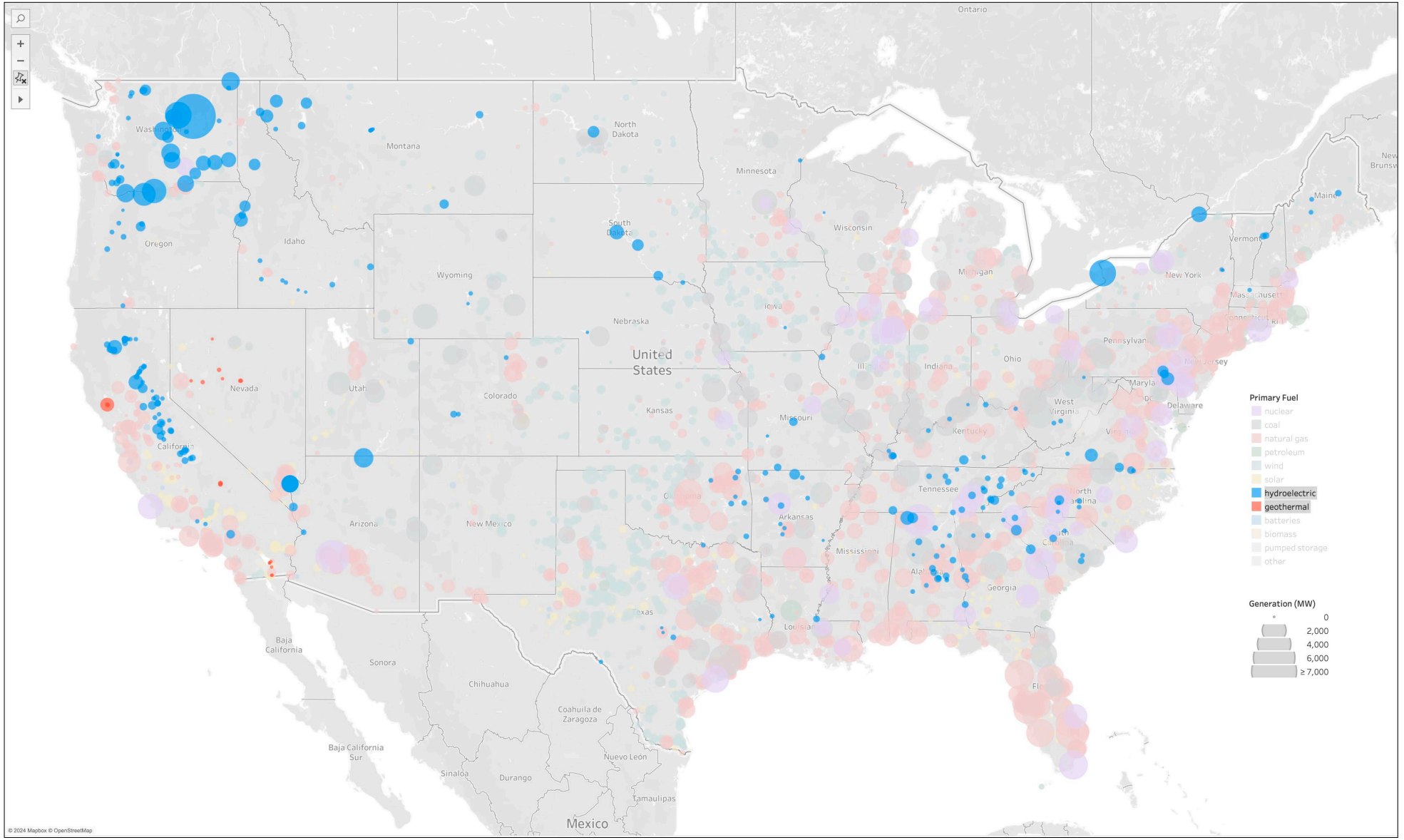



**Utility-Scale Generation Capacity, as of 4Q,2023**

- **Total Nuclear Energy = 95,773 MW (8%)**
- **Essentially flat since the Three-Mile Island accident in 1979**

**Data Source:** U.S. Energy Information Administration

# Hydroelectric Electrical Energy



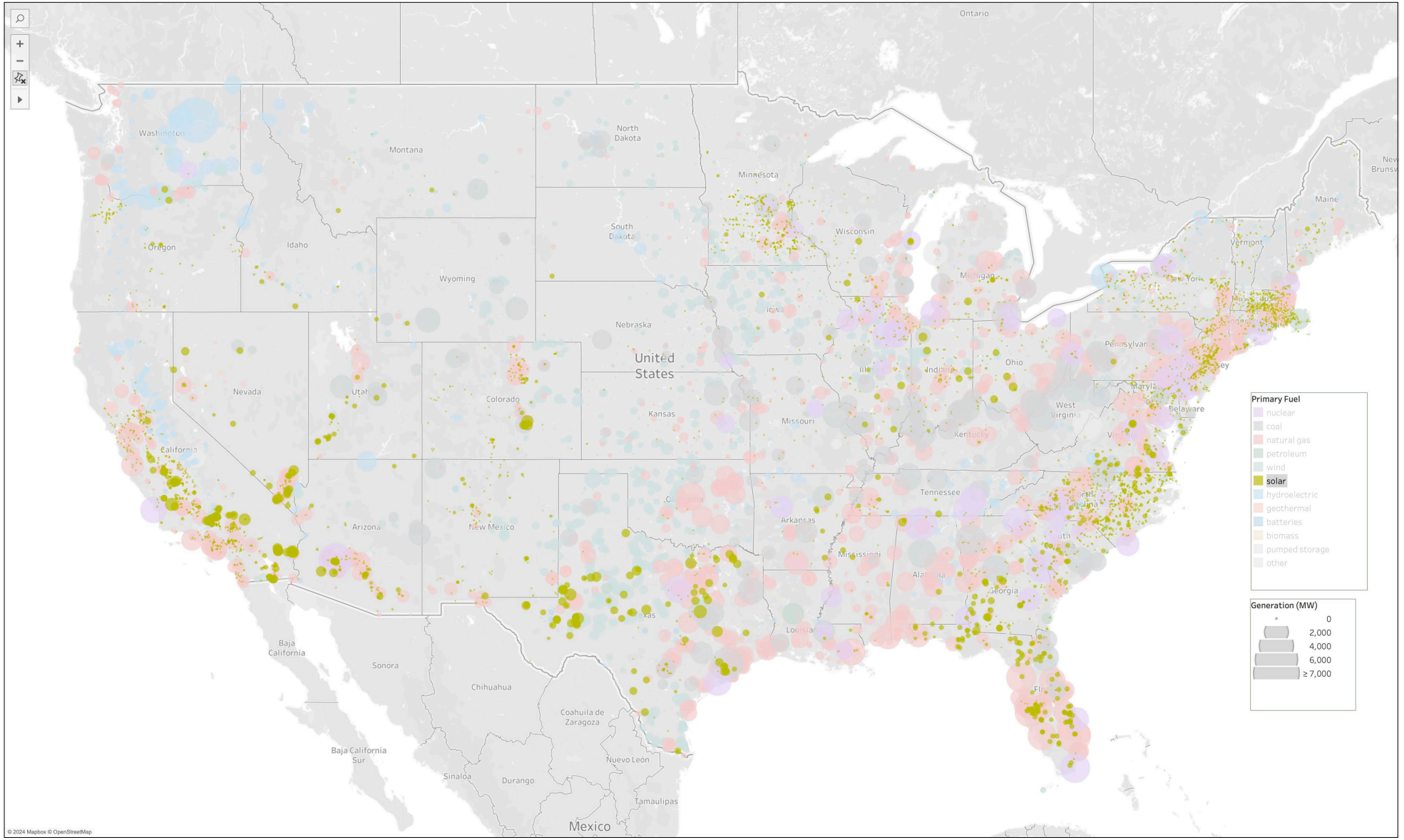

**Utility-Scale Generation Capacity, as of 4Q,2023**

- **Total Hydroelectric Energy = 80,190 MW (7%)**
- **Difficult to grow**
- **Intensifies consumptive use of water**

| USA | Total MW | Percentage |
|---|---|---|
| Nuclear | 95,773 | 8% |
| Coal | 181,922 | 15% |
| Natural Gas | 509,375 | 43% |
| Batteries | 14,073 | 1% |
| Biomass | 12,020 | 1% |
| Geothermal | 2,674 | 0% |
| Hydroelectric | 80,190 | 7% |
| Pumped | 23,167 | 2% |
| Oil | 33,506 | 3% |
| Solar | 84,893 | 7% |
| Wind | 145,532 | 12% |
| Other | 3,150 | 0% |
| | 1,186,275 | |

**Data Source:** U.S. Energy Information Administration

# Solar Electrical Energy




**Utility-Scale Generation Capacity, as of 4Q,2023**

- **Total Solar Energy = 84,890 MW (7%)**
- **Concentrated in the sun belt**
- **Mineral resource intensive**

| USA | Total MW | Percentage |
|---|---|---|
| Nuclear | 95,773 | 8% |
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| Natural Gas | 509,375 | 43% |
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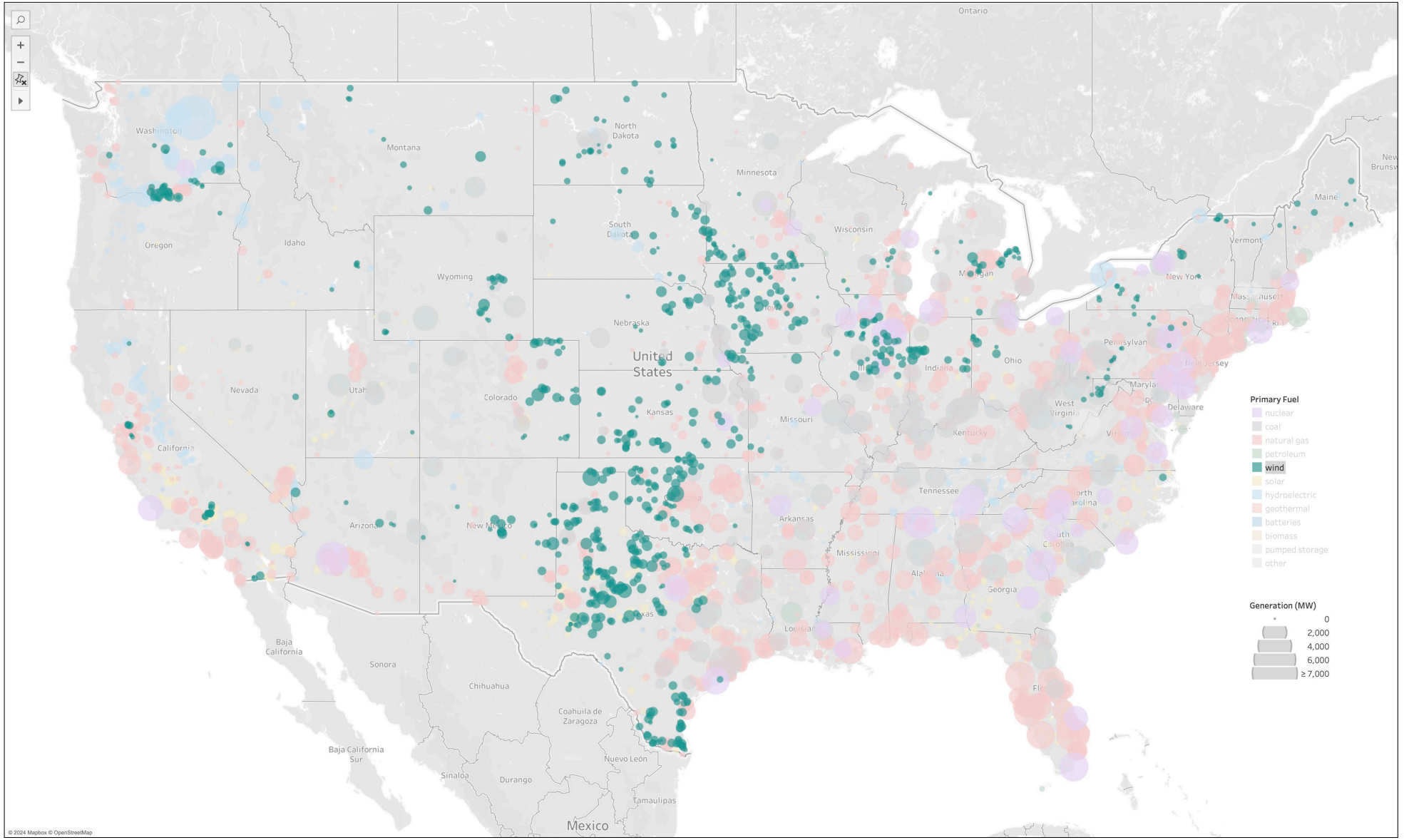
**Data Source:** U.S. Energy Information Administration

# Wind Electrical Energy




**Utility-Scale Generation Capacity, as of 4Q,2023**

- **Total Wind Energy = 145,532 MW (12%)**
- **Concentrated in the Midwest**

| USA | Total MW | Percentage |
|---|---|---|
| Nuclear | 95,773 | 8% |
| Coal | 181,922 | 15% |
| Natural Gas | 509,375 | 43% |
| Batteries | 14,073 | 1% |
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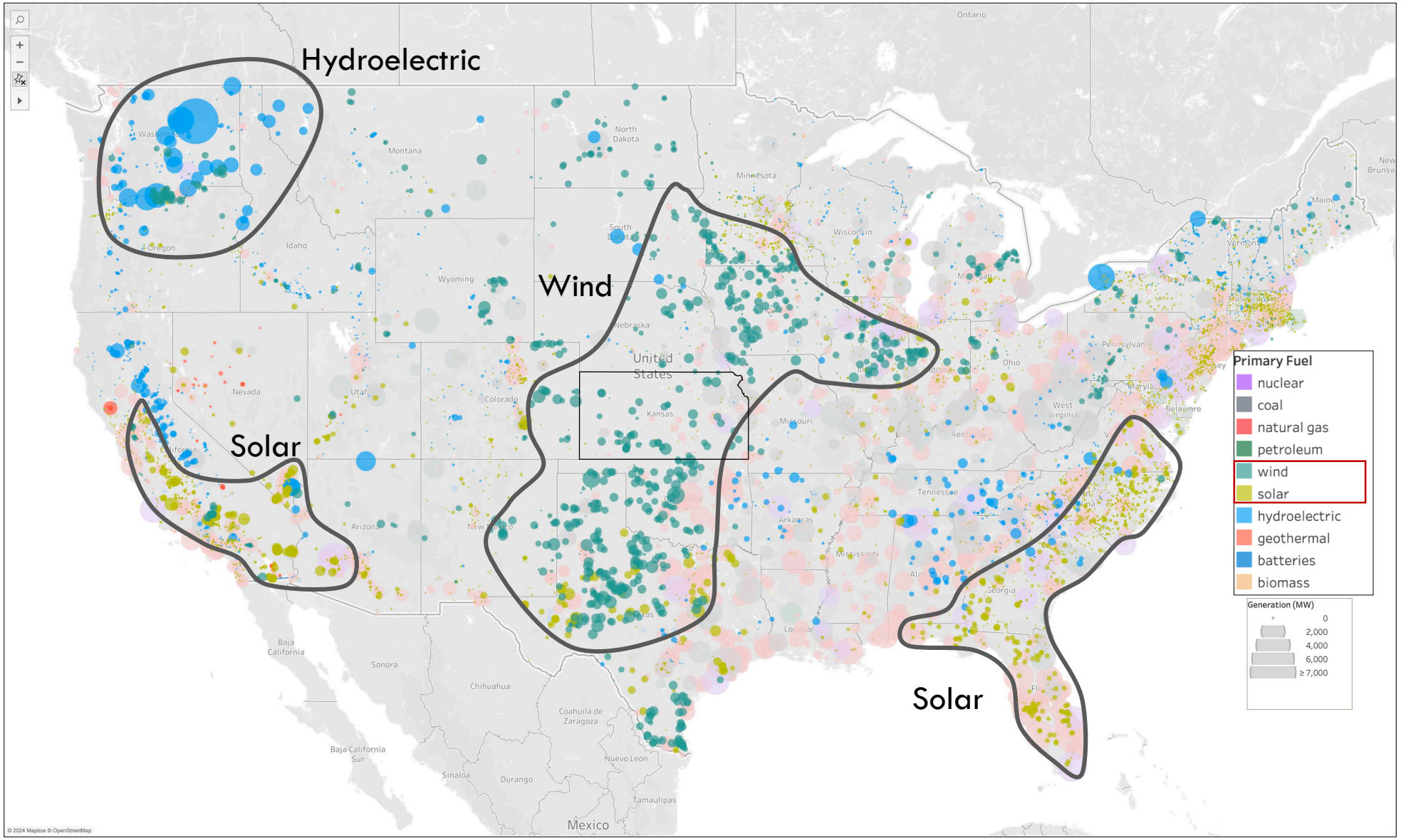
**Data Source:** U.S. Energy Information Administration

# Renewable Electrical Energy Generation




**Utility-Scale Generation Capacity, as of 4Q,2023**

- **Renewable power is a growth sector across the U.S.**
- **Highly regional trends in fuel source**

| USA | Total MW | Percentage |
|---|---|---|
| Nuclear | 95,773 | 8% |
| Coal | 181,922 | 15% |
| Natural Gas | 509,375 | 43% |
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| Wind | 145,532 | 12% |
| Other | 3,150 | 0% |
| | 1,186,275 | |

**Data Source:** U.S. Energy Information Administration

# Conclusion #3

Our energy mix is Complex.

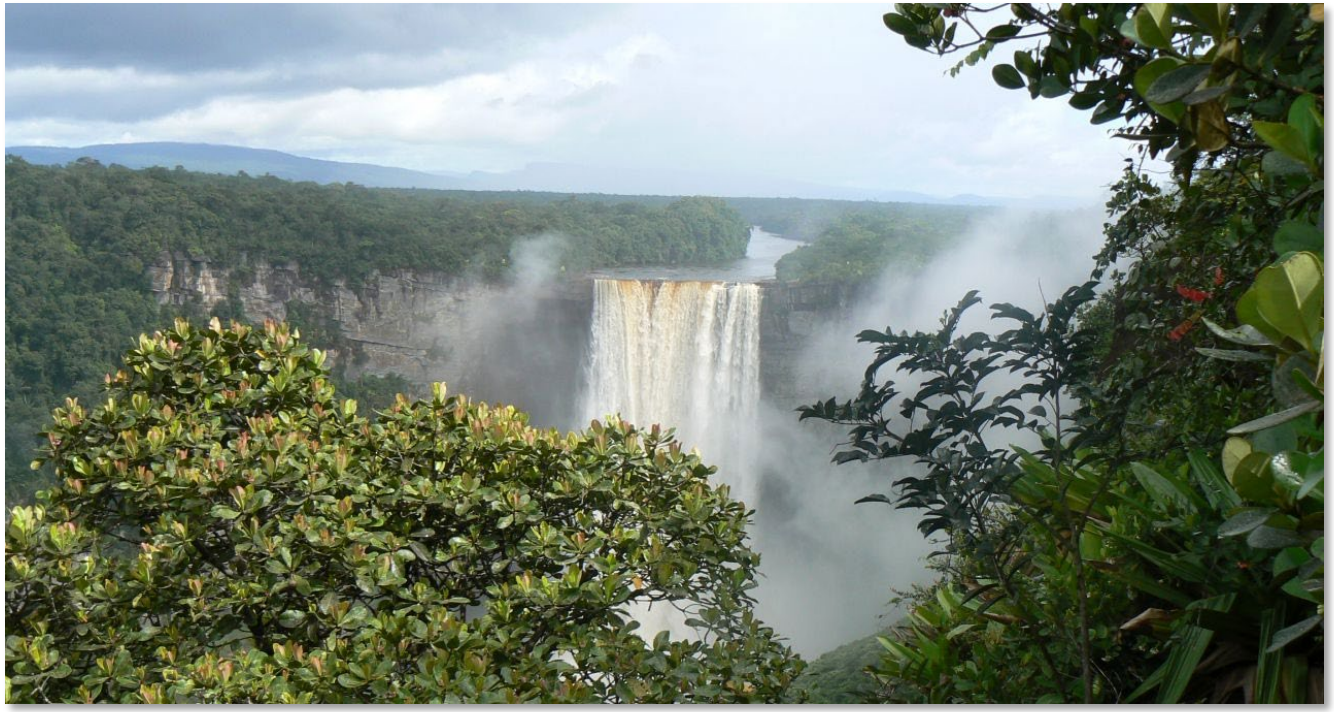
It is driven by **market demand** and (especially with renewable energy) **resource availability**

Underscores the impact of **regionality** and the importance of **Economic Security**!

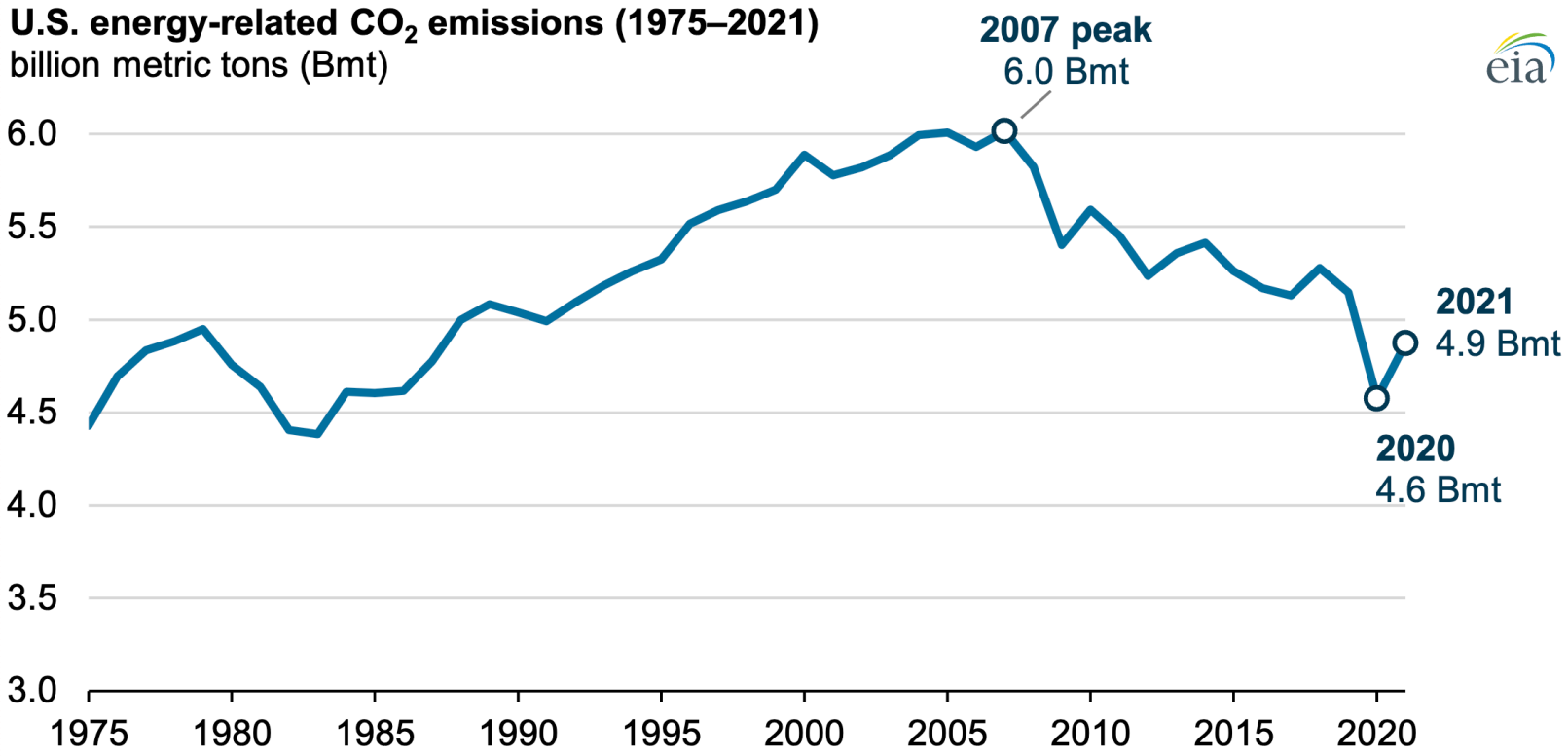
# Tradeoffs in the Energy Mix

“Yellowtail” Floating Production Storage and Offloading Vessel Offshore Guyana

- The Gov. of Guyana maintains a goal of limiting scope-1 greenhouse gas emissions from its oil and gas production
- The country wants to remain a carbon negative country
- Significant emissions restrictions imposed on the production joint ventures operating there

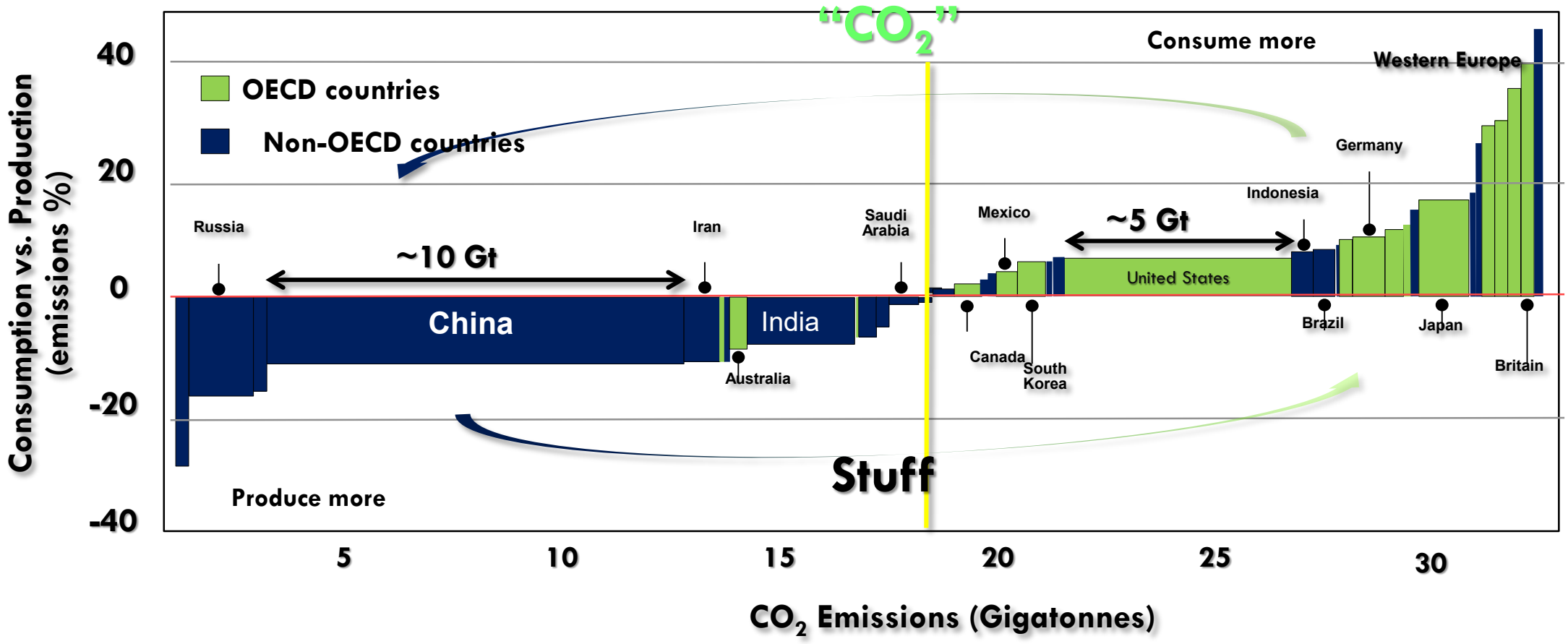


# U.S. $CO_2$ Emissions




**Source:** Energy Information Administration, April 2022; **Primary Contributors:** Kevin Nakolan, Michael Francis

# Consumption vs. Production




Courtesy Scott Tinker, 2024
Sources: Global Carbon Project; World Bank; The Economist

# Conclusion #4

In all sectors, the imperative to **reduce greenhouse gas** emissions is recognized

Underscores the importance of **Environmental Security**!

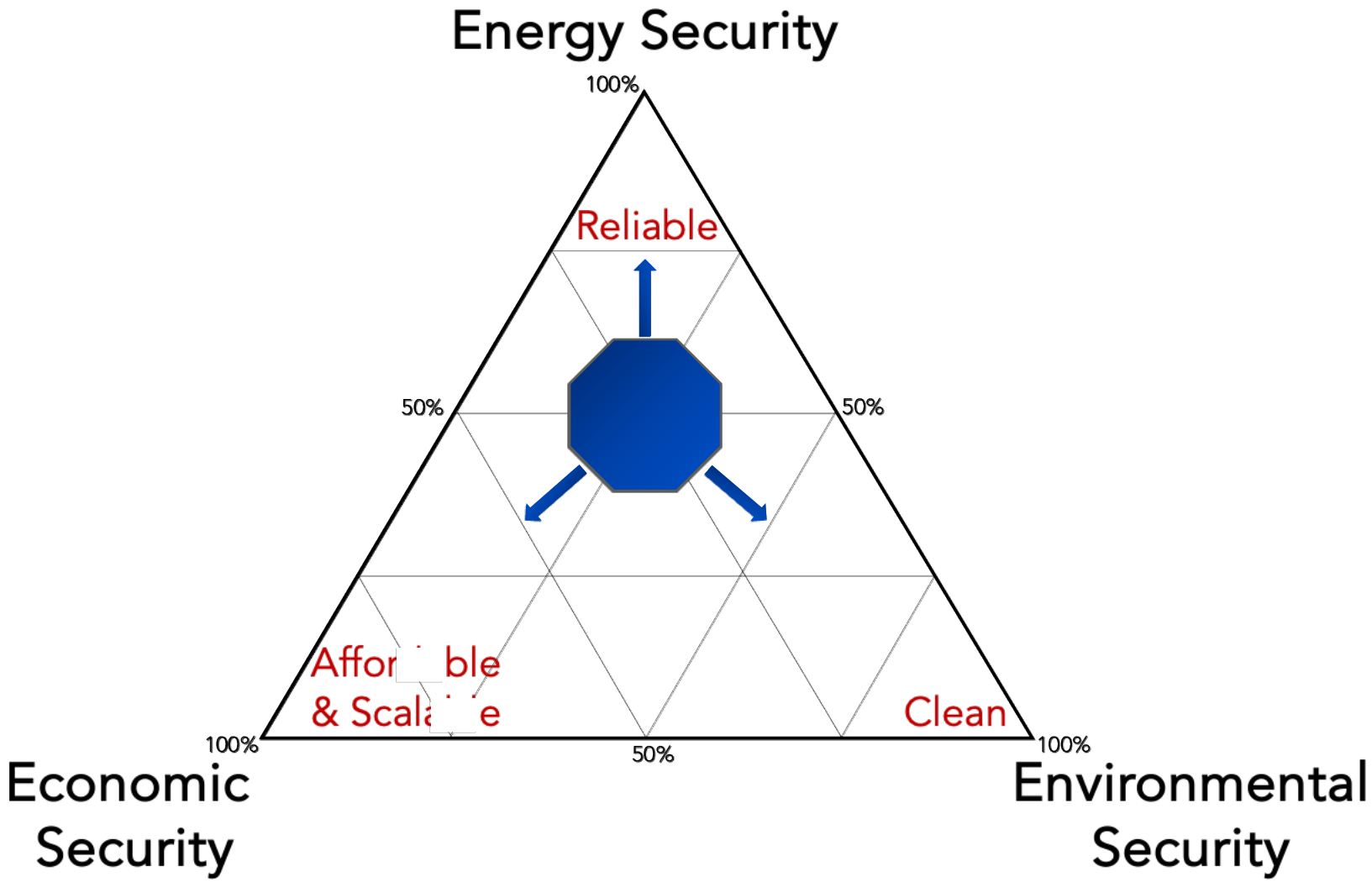
# The Energy Mix – Drivers & Tradeoffs

**Energy Security**

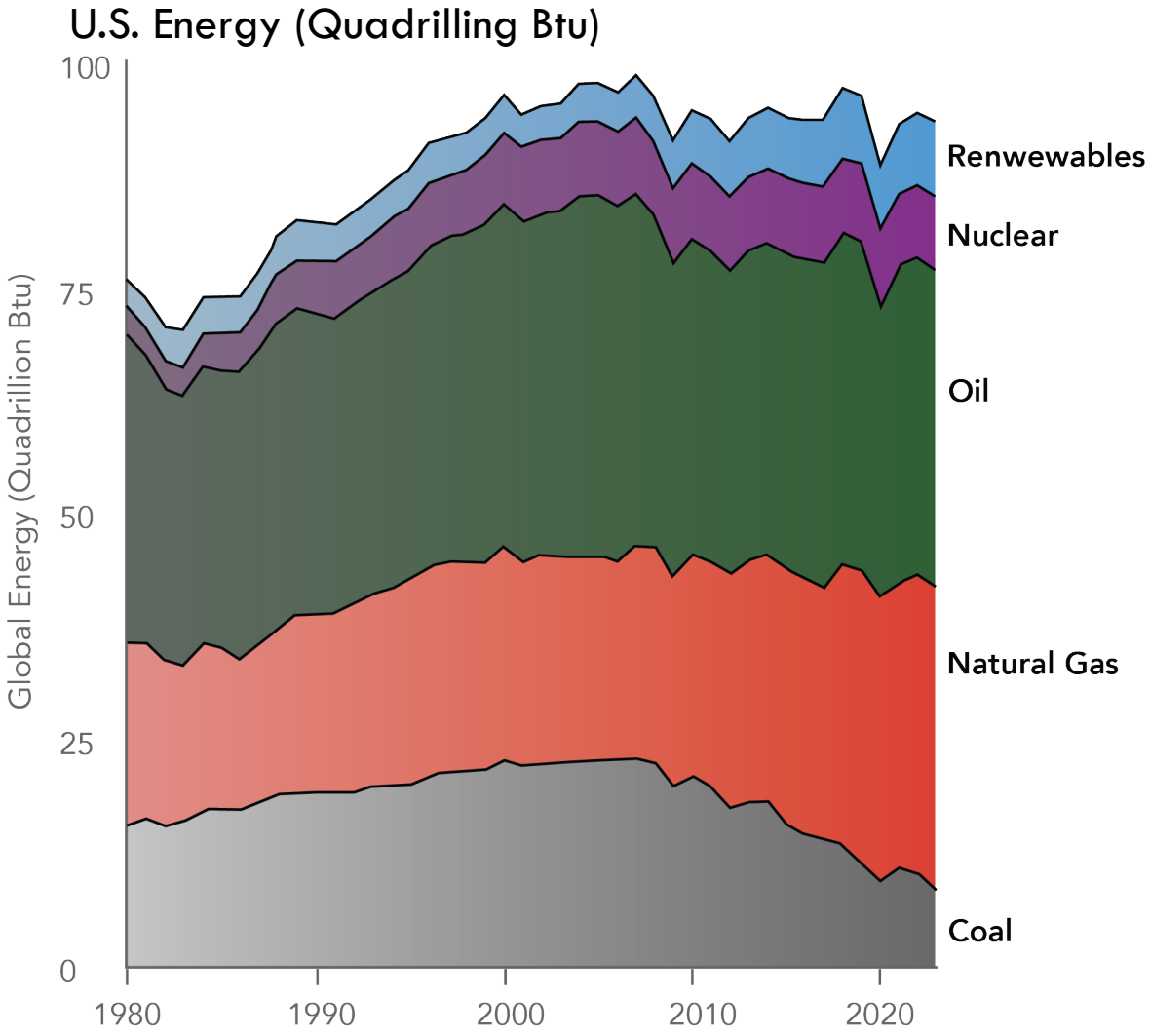
**Economic Security**

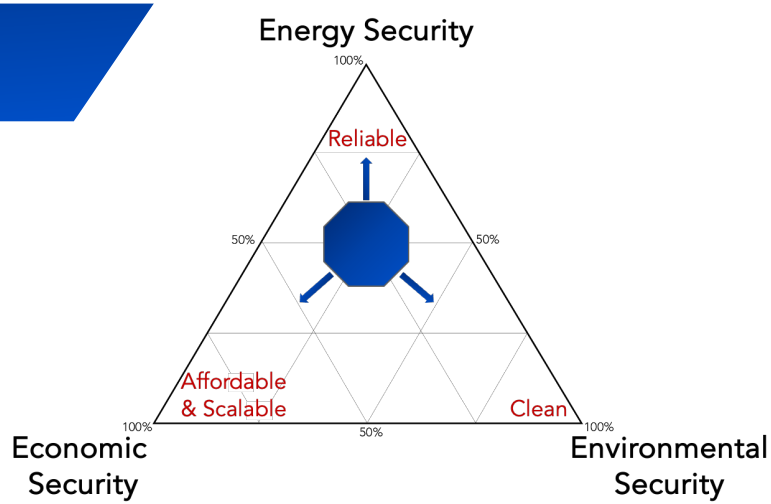
**Environmental Security**

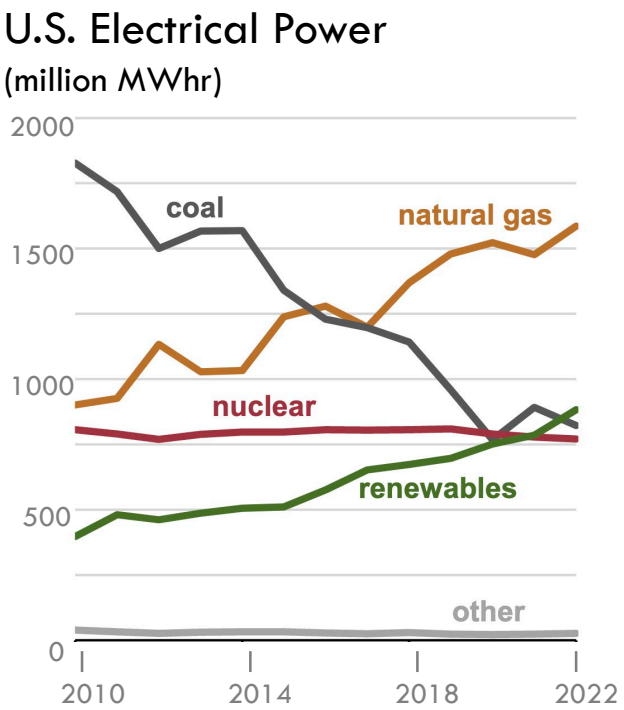
# The Energy Mix – Drivers & Tradeoffs



# The Energy Mix – Drivers & Tradeoffs




Data Source: U.S. Energy Information Administration

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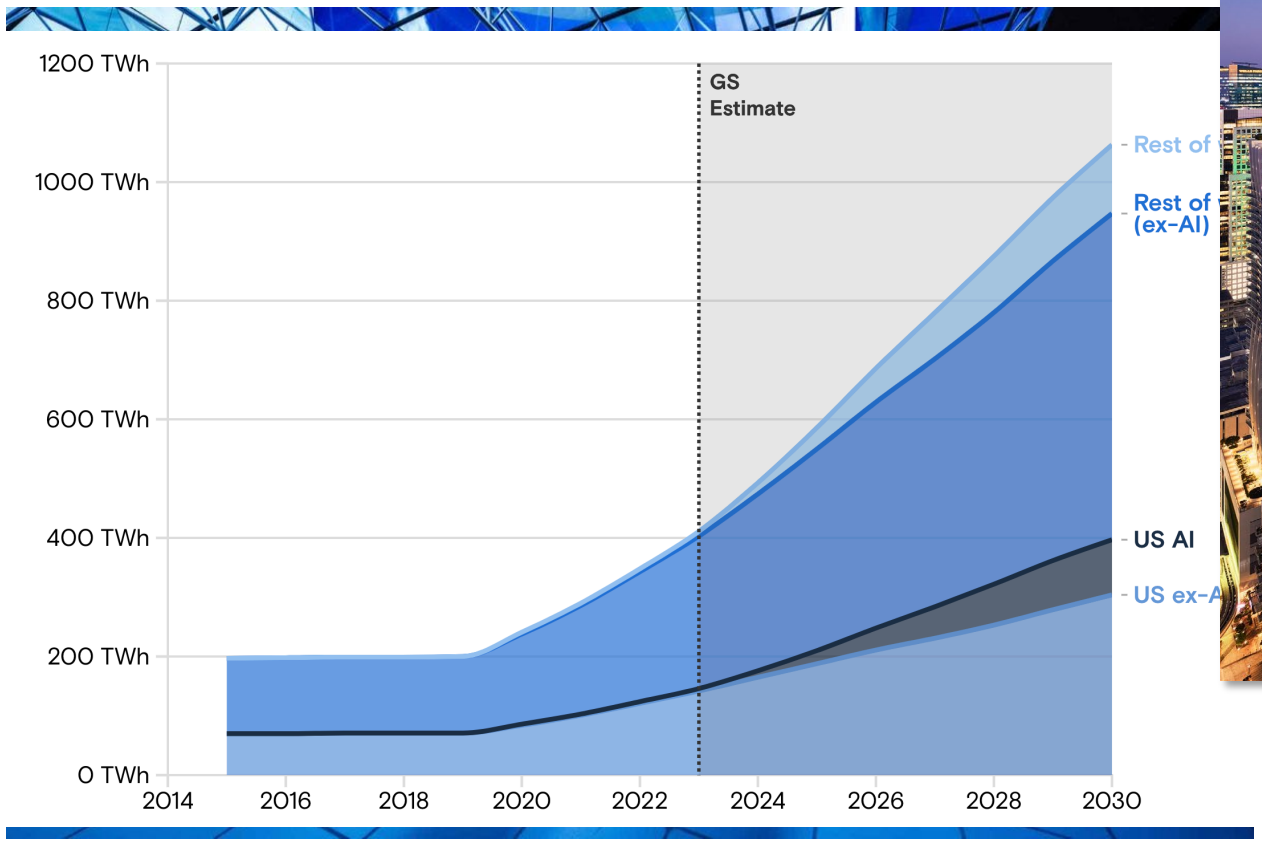
# Let's Consider Just One Kind of New Load

Sector Growth in U.S. Power Demand
(2022-2030)





- Machine learning and A.I. applications demand "data centers" with massive computational power
- And massive energy requirements for power and cooling
- The requirement for new dispatchable power is at a scale not previously contemplated!

**Source:** Masanet et al. (2020), Cisco, IEA, Goldman Sachs Research

# The Energy Transition Must Bring:

1. Affordable and reliable **dispatchable power** and **transportation fuels**

2. At a **scale** never before contemplated

3. While reducing **GHG emissions**

4. In a severely **grid-constrained environment**

# Put Simply – The Energy Transition Must:

1. Add considerable (dispatchable & affordable) power

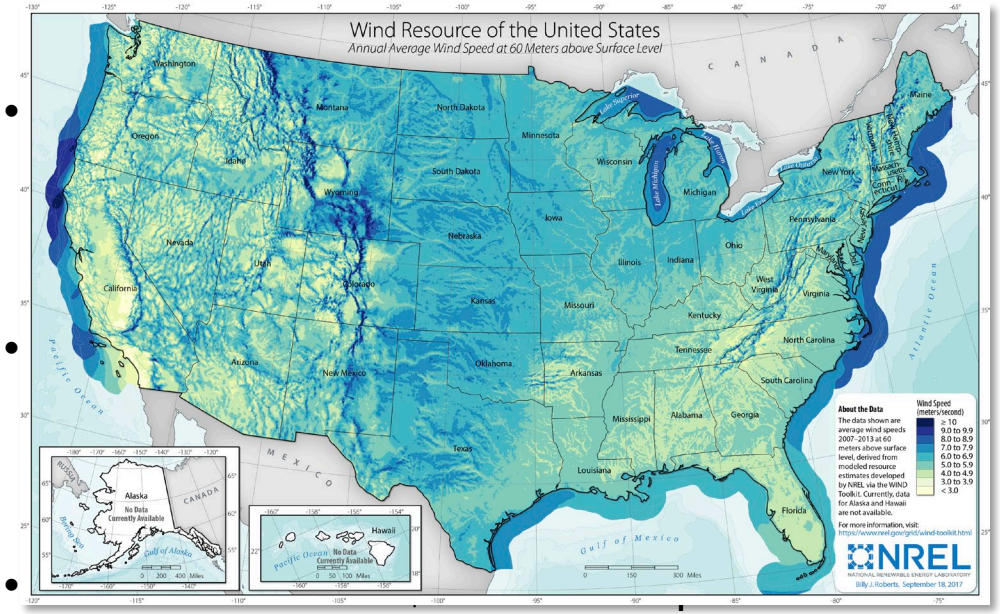
   while

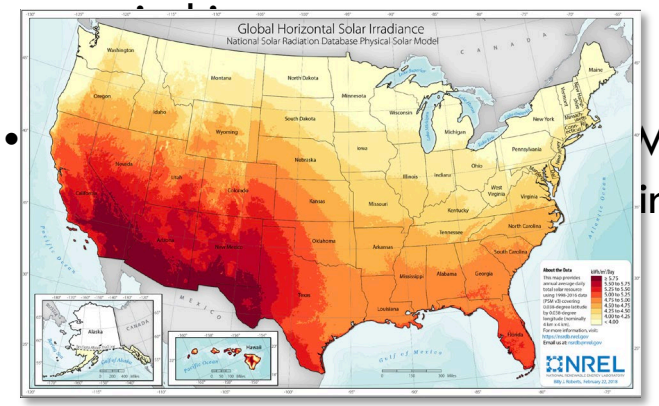
2. Reducing net emissions


Let's use Kansas as an example of "the art of the possible"

# Regional Electric Generation – Wind and Solar

- Kansas' high sustained wind speeds and high solar irradiance have allowed it to  has aggressively grow its renewable energy infrastructure
- Third nationally in wind-generated electricity




- MW of utility-ind power by

# Metro Areas Demand Dispatchable Energy

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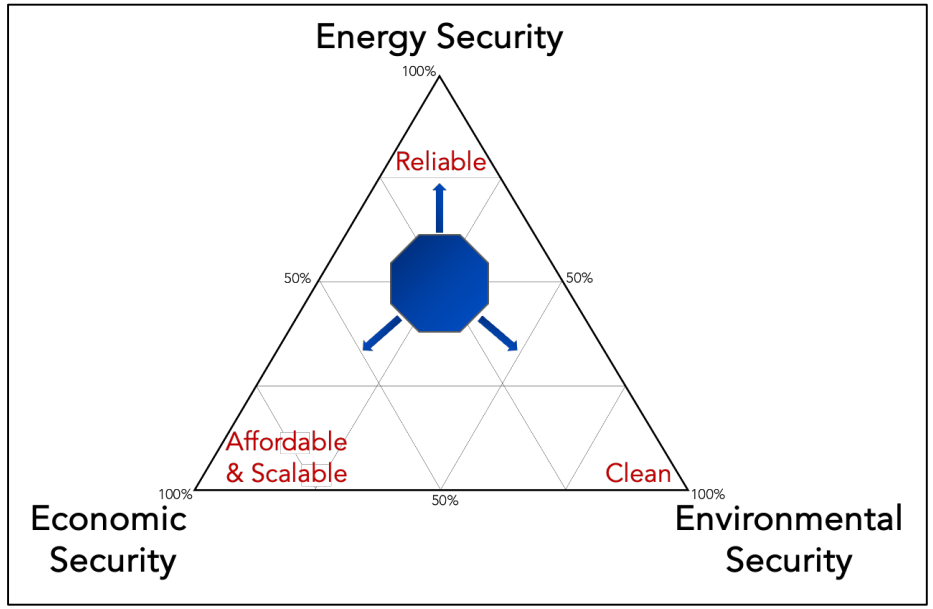
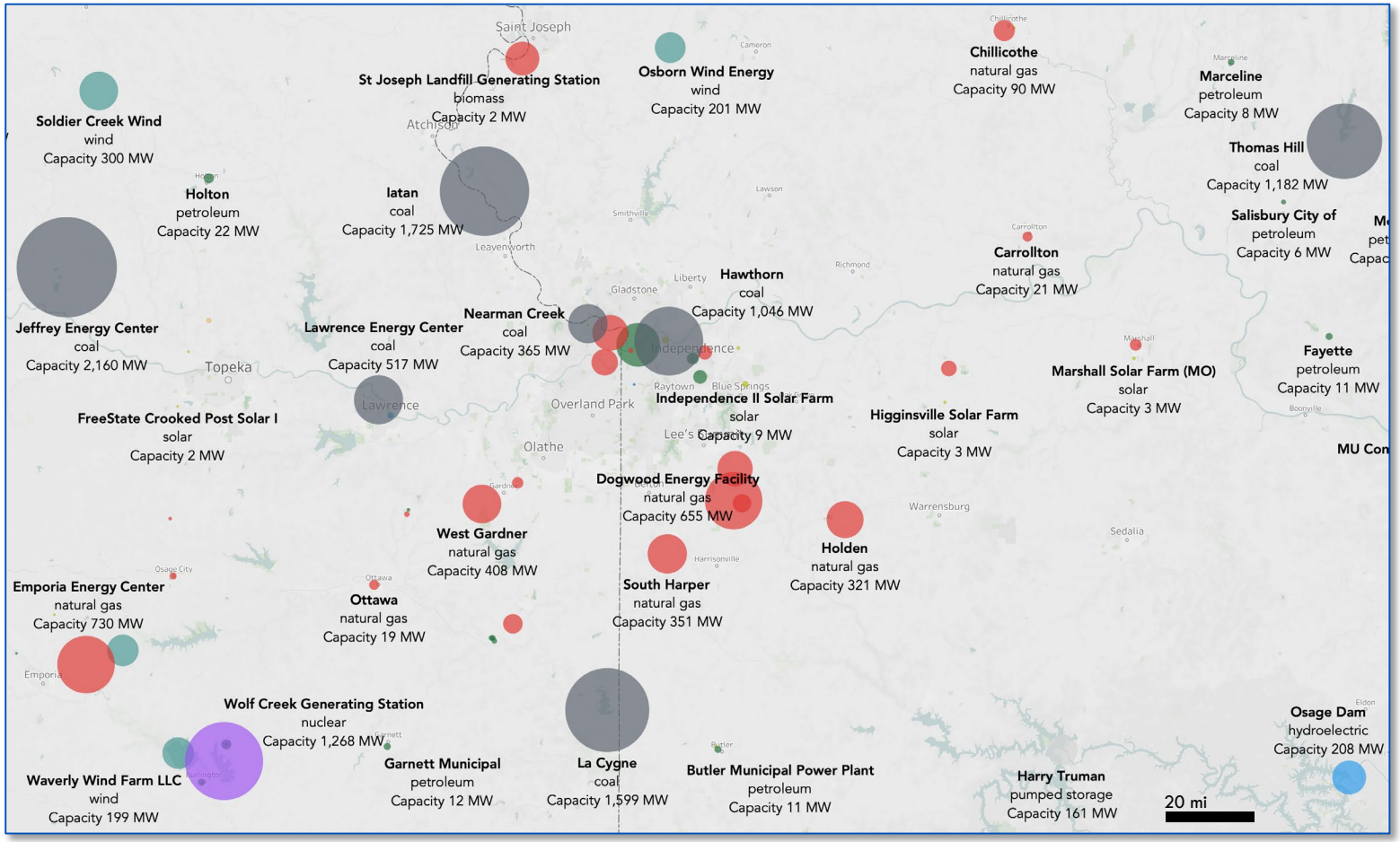


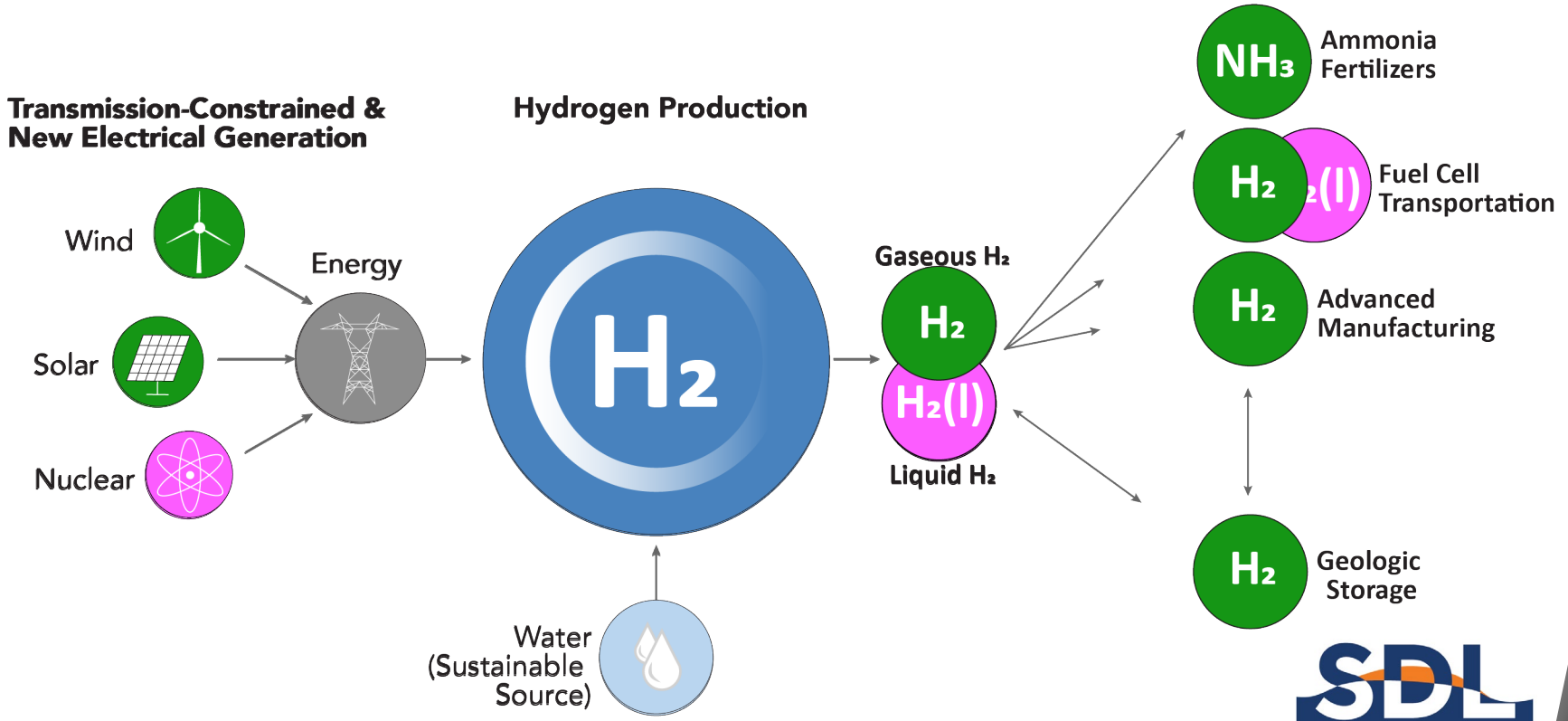

But we have world class resources on our doors step!

We have options!

# Goal 1: Add Dispatchable, Affordable Power

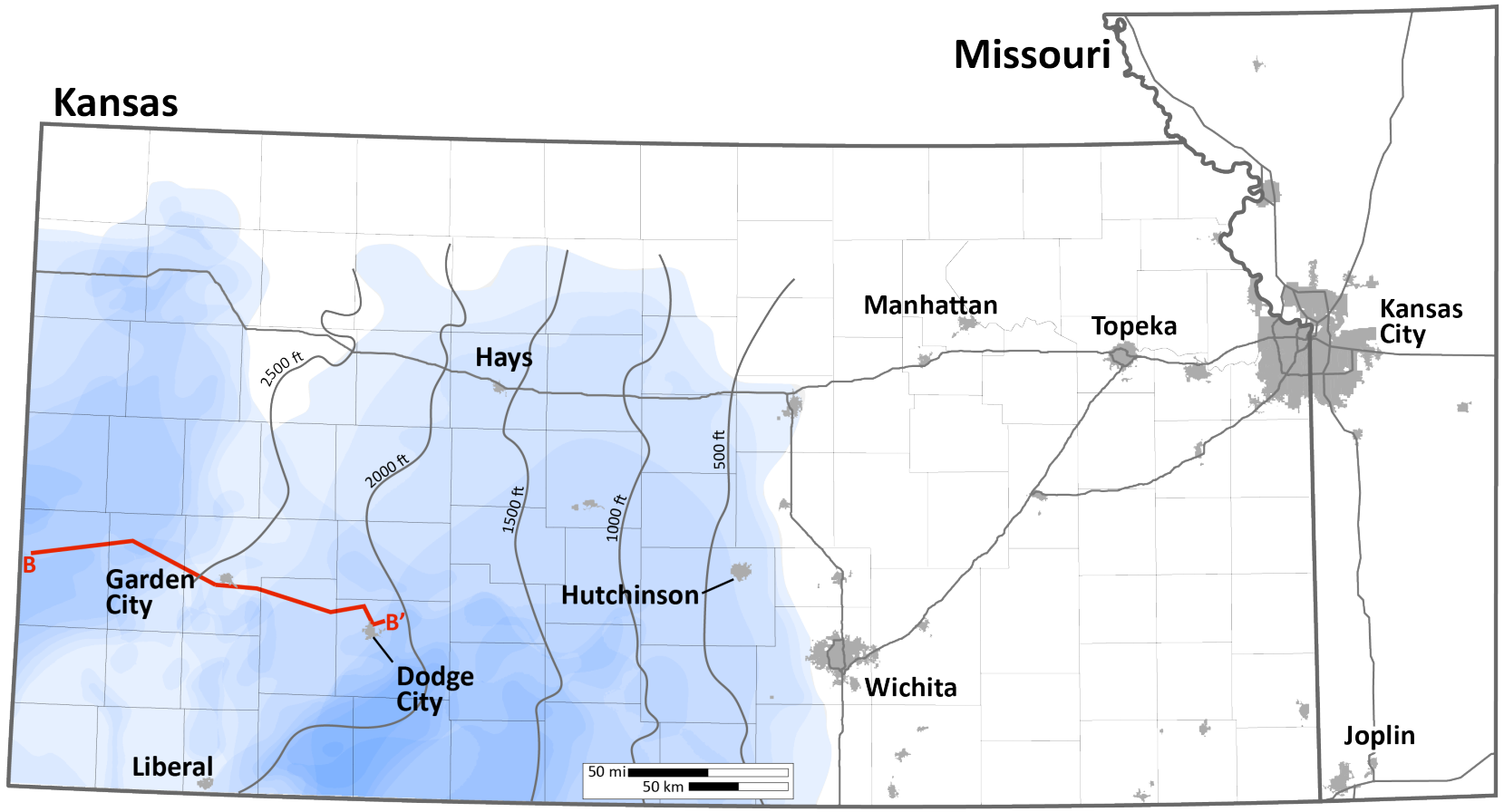
## Link Intermittent Power to Energy Storage & Transportation

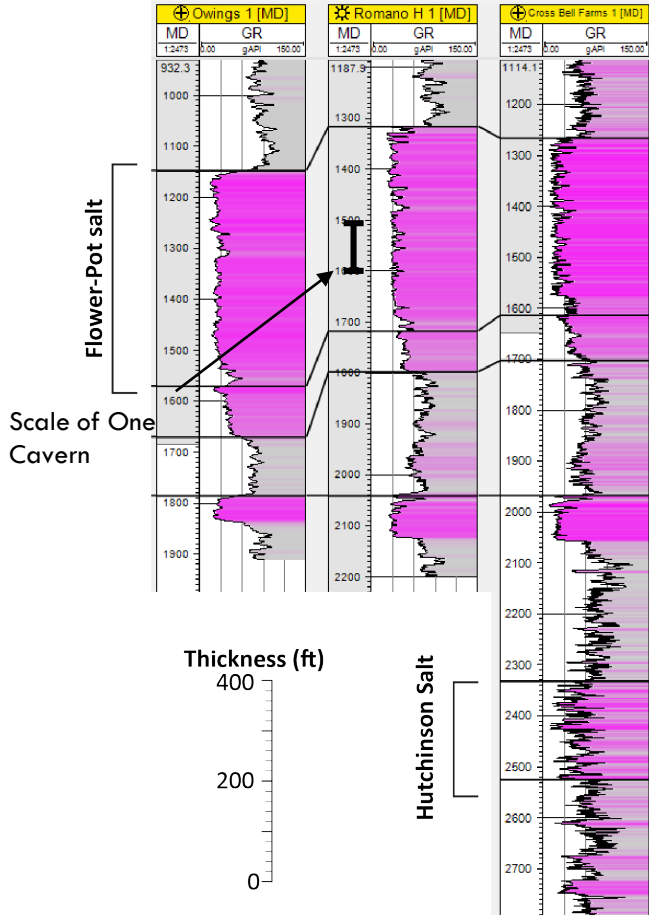
- Excess & new electrical energy can be harnessed
- And used to generate hydrogen from water
- To make diverse energy and chemical commodities



# Goal 1: Add Dispatchable, Affordable Power

## Link Intermittent Power to Energy Storage & Transportation




**Salt Storage Resources**

Thickness 0 1,000 ft

**Geology**

Cross Section

Contour line (depth to top of salt)

Map showing thickness of salt formations.

Current Storage Facility

Thickness 0 1,000 ft

SDL KGS Subsurface Dynamics Laboratory

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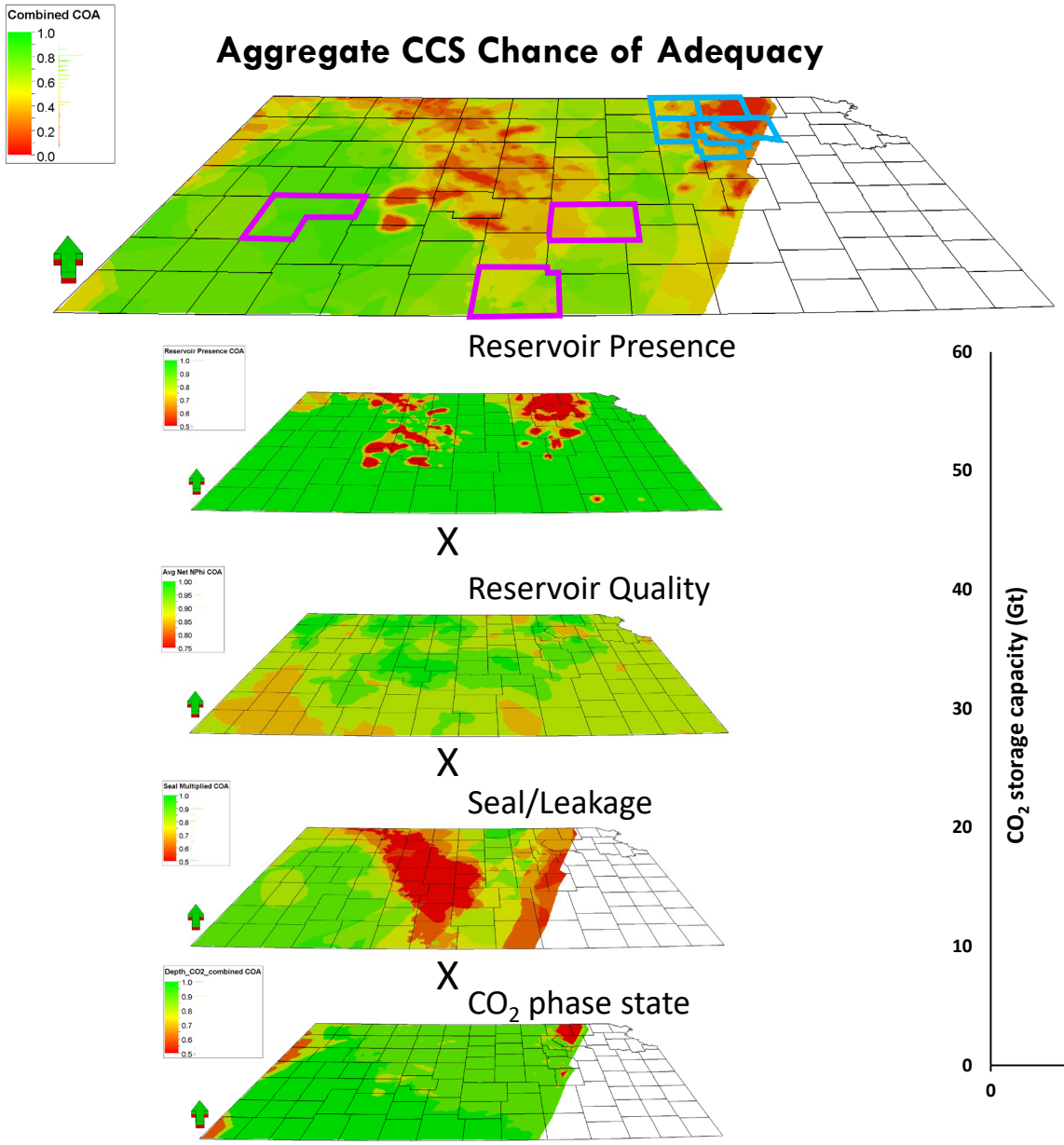
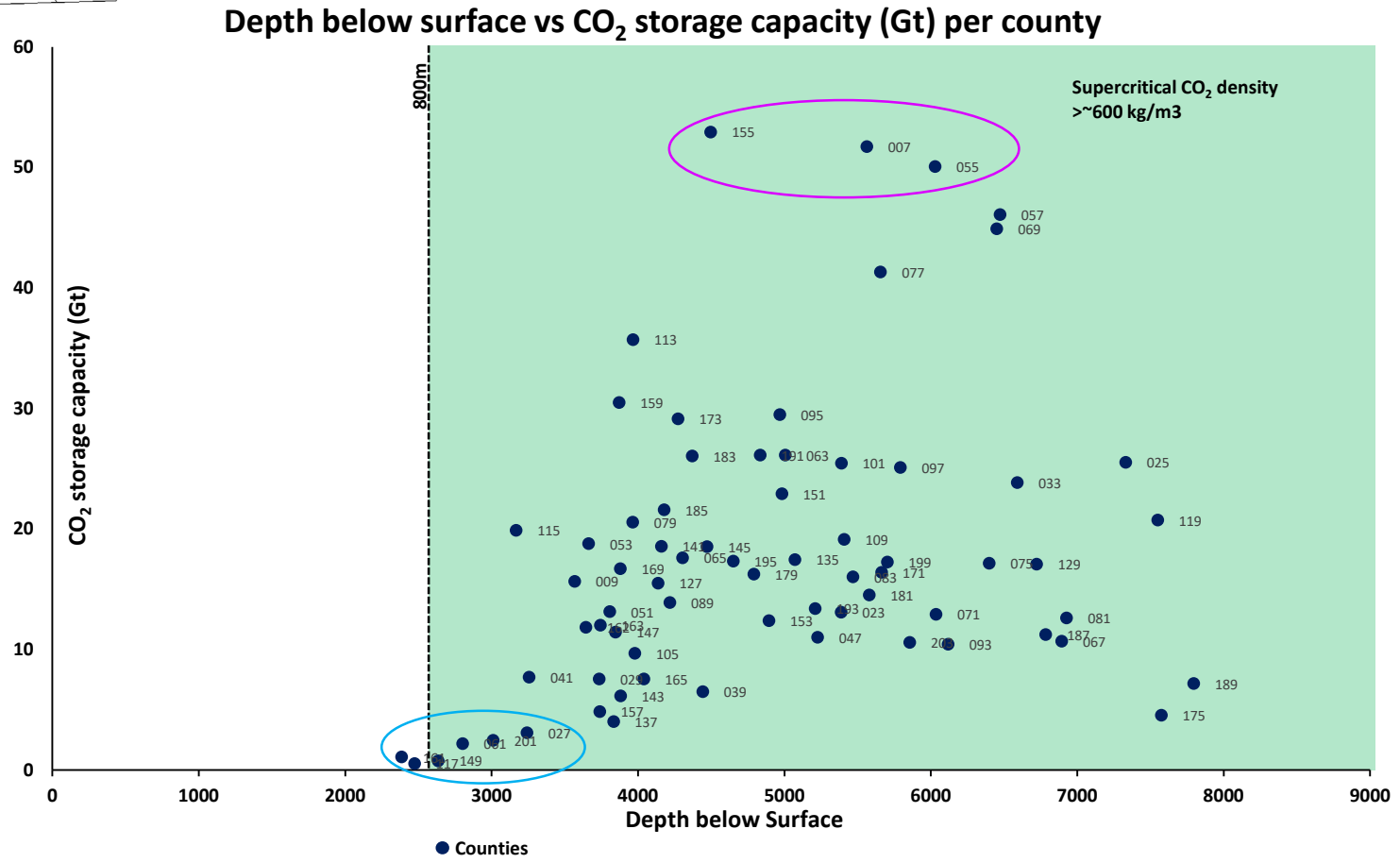
# Goal 2: Reduce Net Emissions – CCUS




New KGS analysis shows we can hypothetically store 50 Gt of $CO_2$ in three counties !



# Adding Up Our Conclusions

#1 – Energy drives industry.  No doubt about it.

#2 – Our appetite for energy is enormous and growing,

#3 – The energy mix is complex. It is driven by market demand and modulated by resource availability (especially in renewables),

#4 – Energy Transition, in reality, means development of:

- Affordable and reliable Power *and* Transportation Fuels
- That are dispatchable *and* (rapidly) scalable, and that
- Yield lower greenhouse gas emissions

# Adding Up Our Conclusions

To add new advanced industries to Kansas' economy (e.g., biotech, advanced manufacturing, and data computation),

Kansas needs to not only be a player in energy portfolio growth,

It can and should be a national leader!