# Net Zero: Materially Improbable

**Presented to the Indiana Oil and Gas Association, August 22, 2023**

**By Martin (Marty) Cornell**

**Vice Chairman, Communications**

**Member**

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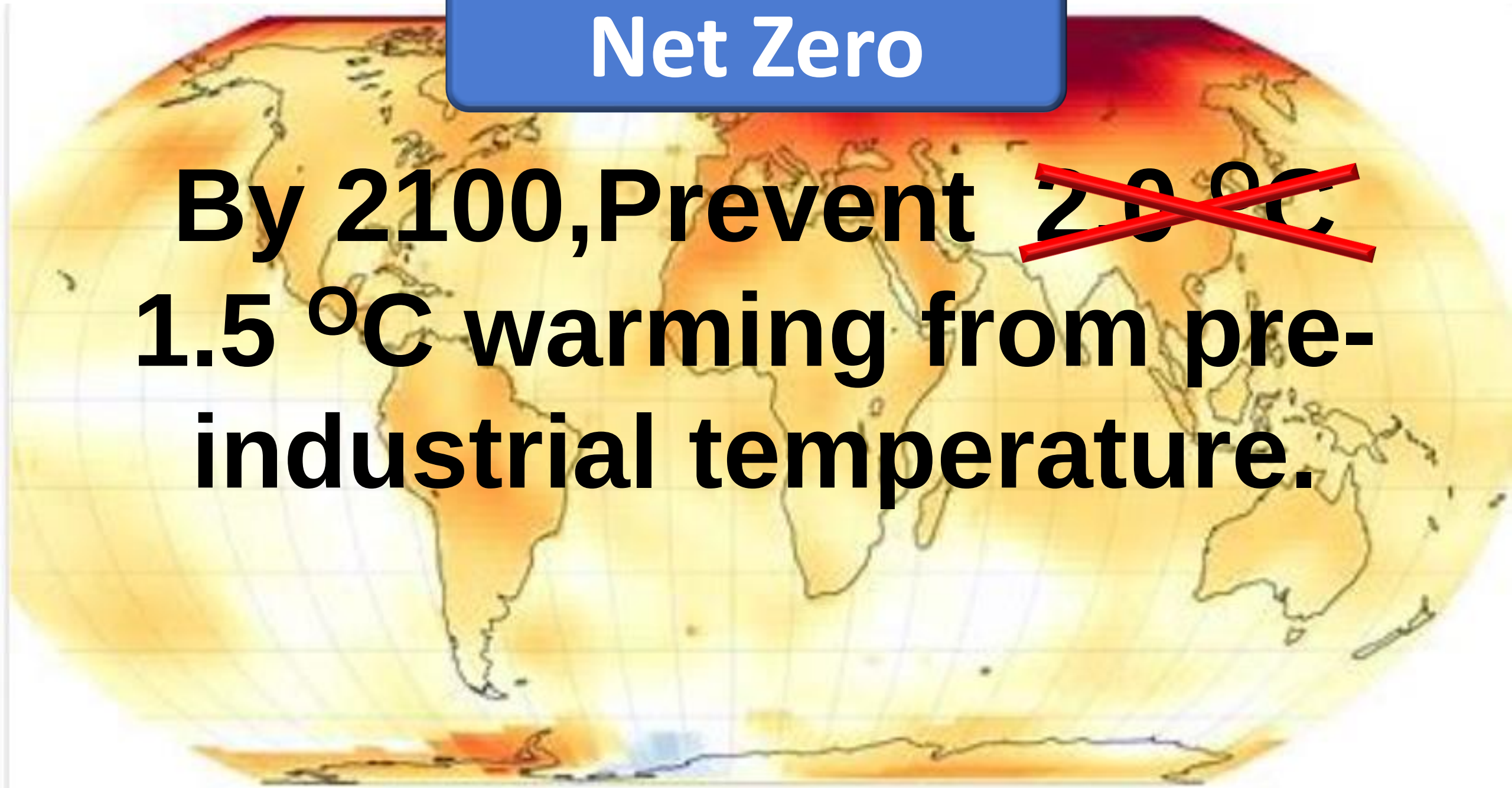
**Opinions expressed in this presentation are those of the presenter and not necessarily those of The Right Climate Stuff or the CO2 Coalition**

# Net Zero

**A state in which anthropogenic $CO_2$ and $CH_4$ going into the atmosphere are balanced by removal out of the atmosphere.**

**A ban on fossil fuels**

# Net Zero



**By 2100,Prevent ~~2.0 °C~~ 1.5 °C warming from pre-industrial temperature.**

# Net Zero

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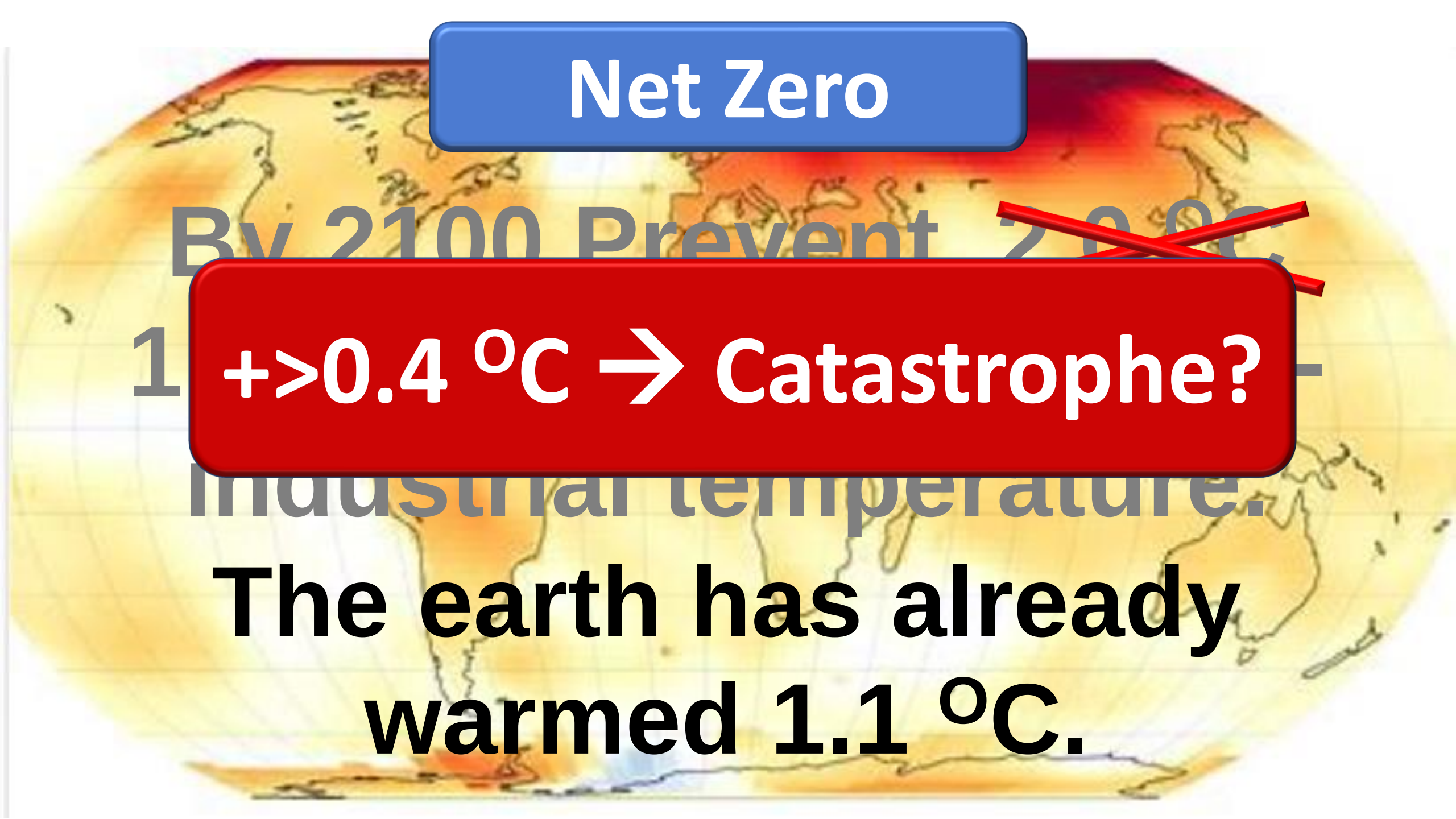
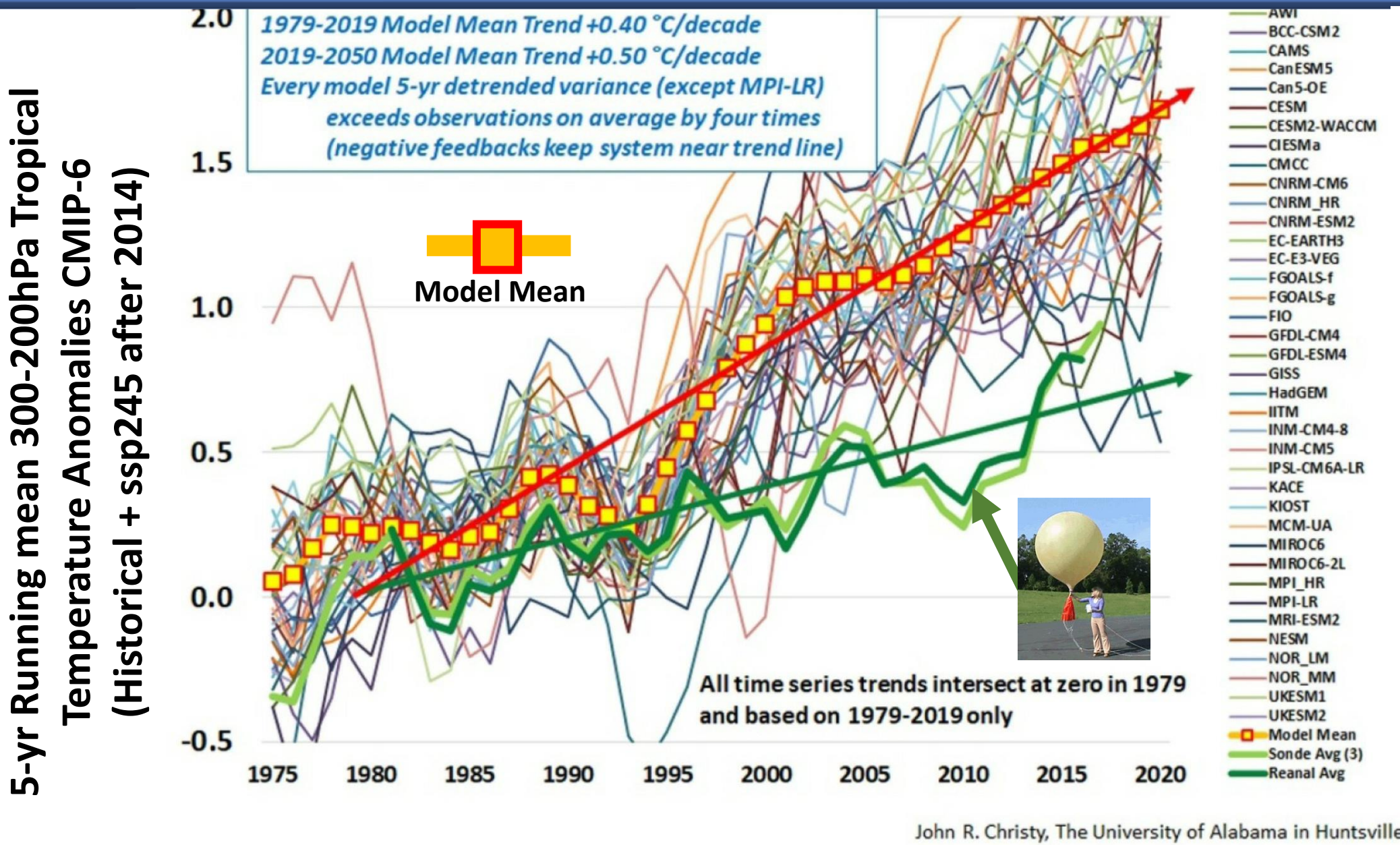
**The earth has already warmed 1.1 °C.**


Net Zero
By 2100 Prevent 2.0 °C
1
+>0.4 °C → Catastrophe?
Industrial temperature.
The earth has already warmed 1.1 °C.

# Reality: it ain't warming like its supposed to

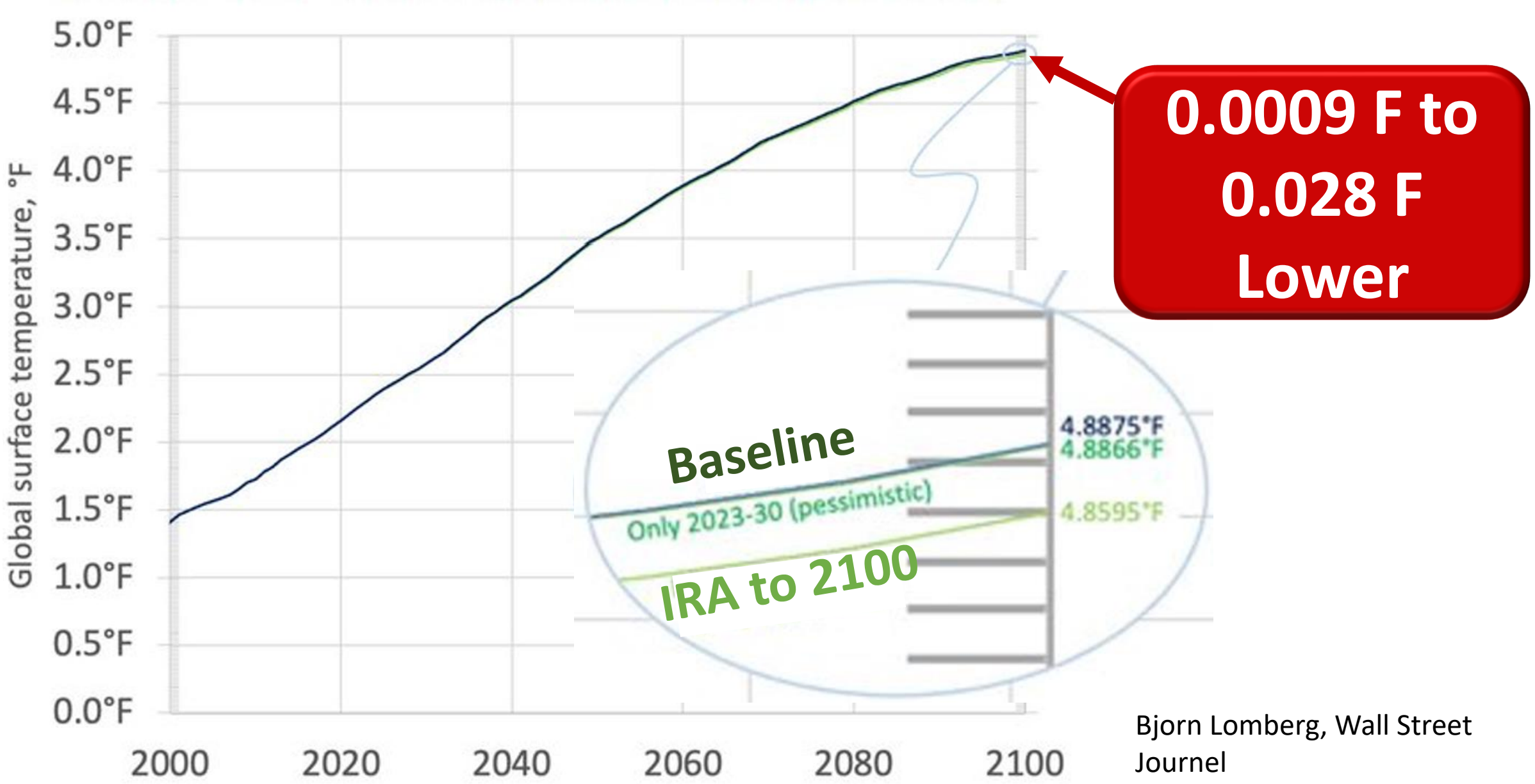



**Model average runs 2½ X hotter than reality**

John R. Christy, The University of Alabama in Huntsville


The
climate crisis
exists only in models,
not in the real world.

# Impact of Inflation Reduction Act




Bjorn Lomberg, Wall Street Journel

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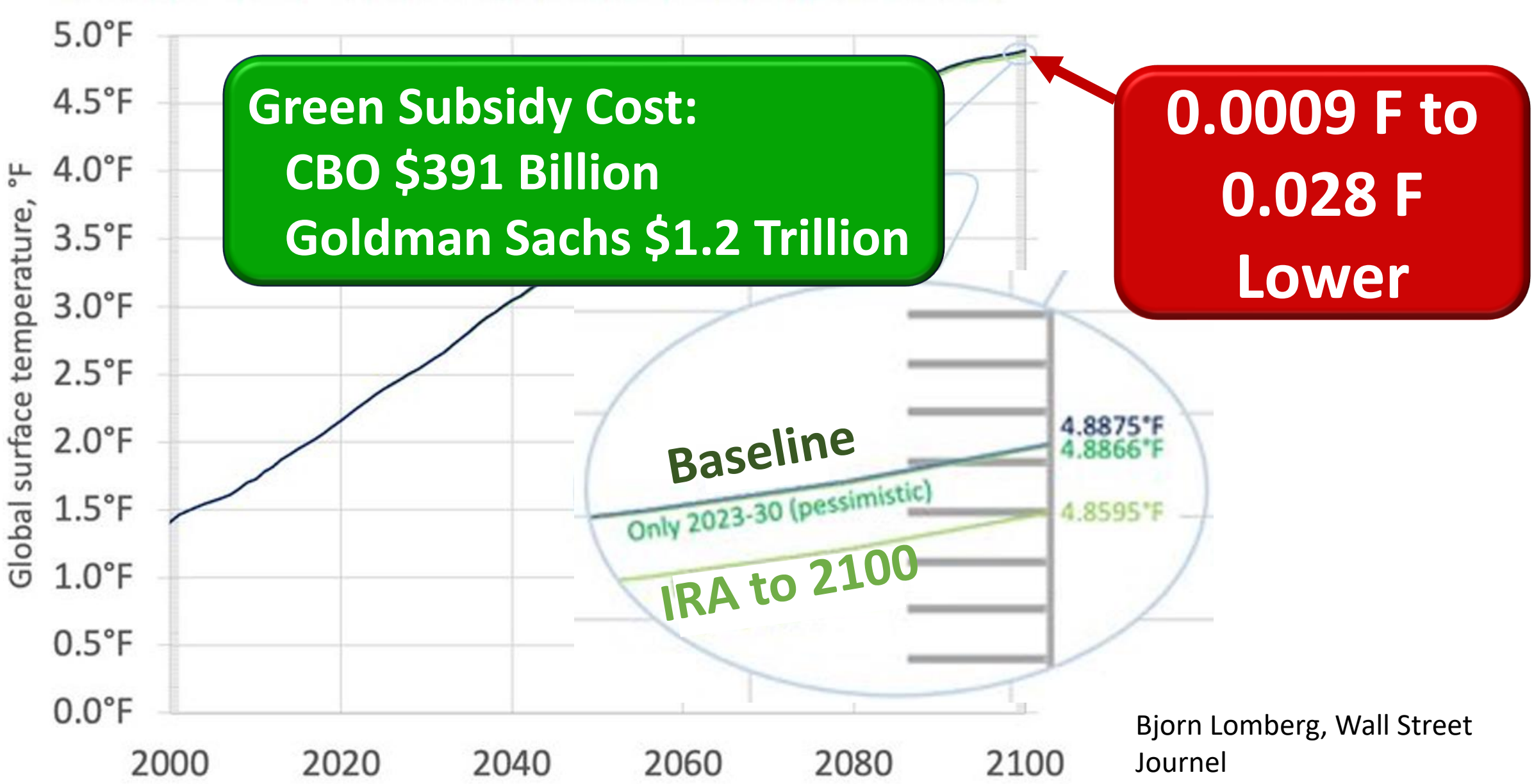


Bjorn Lomberg, Wall Street Journel

# Impact of USA Net Zero by 2050

100% Renewable Electricity → -0.083 C in 2100

Ban all Fossil Fuels (including cars) → -0.126 C in 2100

Life:Powered

MAGICC6 Model

# It’s Not About Climate Change

**Christiana Figueres, Secretary of the UN Framework Convention on Climate Change, 2015**

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**“This is the first time in the history of mankind that we are setting ourselves the task of intentionally, within a defined period of time, to change the economic development model that has been reigning for at least 150 years, since the Industrial Revolution.“**

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# It’s Not About Climate Change

White House National Economic Council director Brian Deese

BlackRock

Global head of Sustainable Investing,

**Re. $4.85 a gallon gasoline: "This is about the future of the liberal world order, and we have to stand firm.“ 1Jul22**

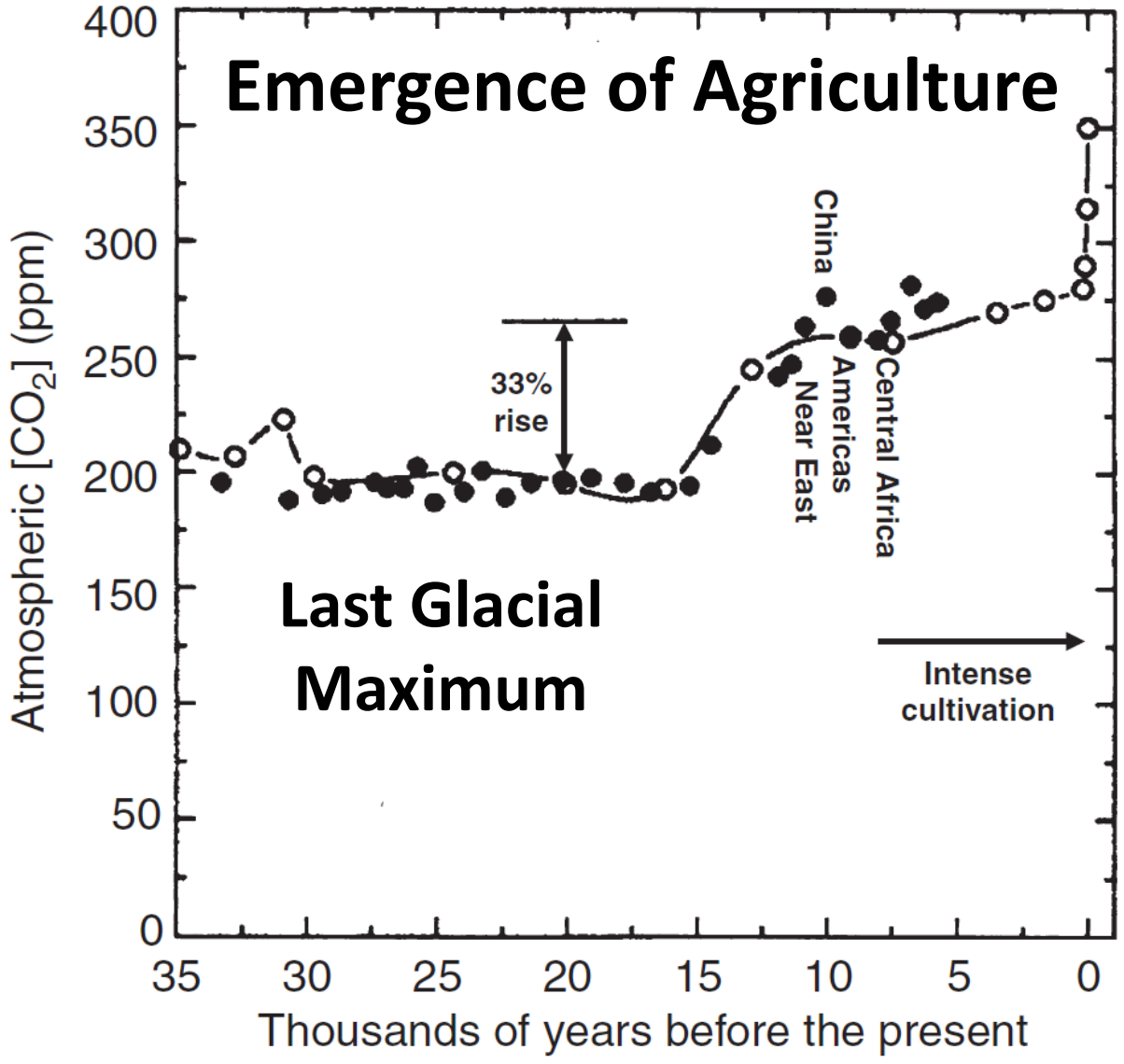
# The Liberal World Order Requires Ignoring Consequences

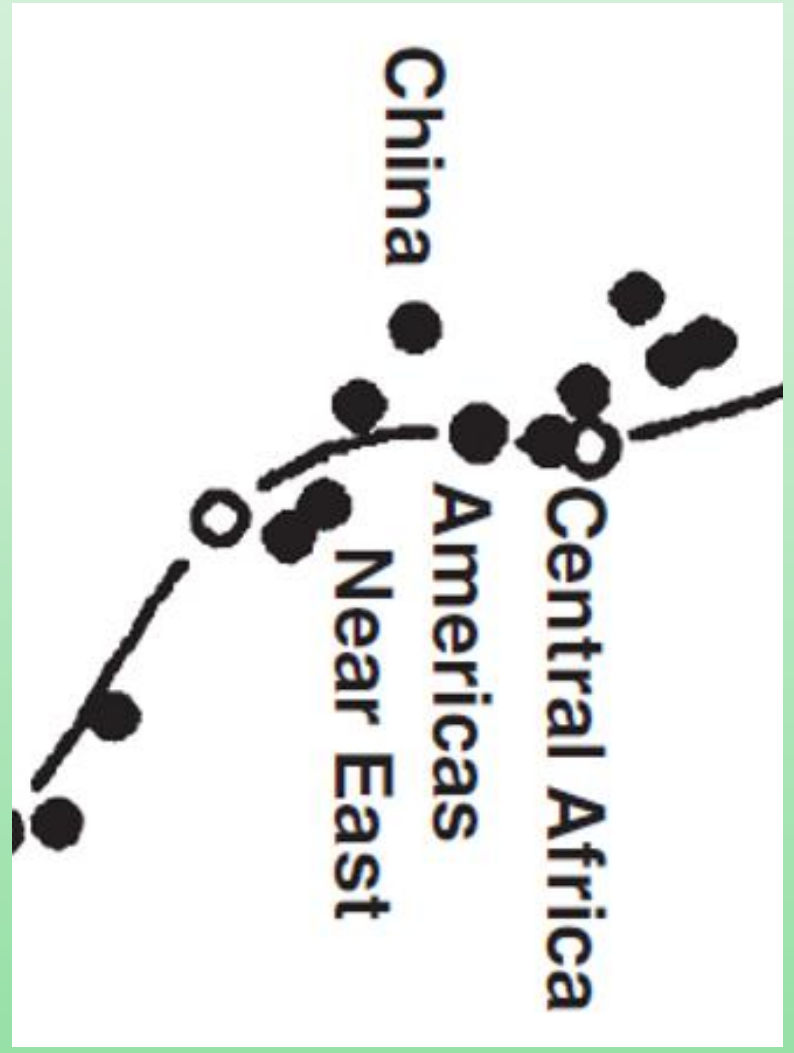
# Consider:

**Warmth is a Condition of Civilization**

# Consider:

**Warmth + More CO2 → Civilization**




~200 ppm

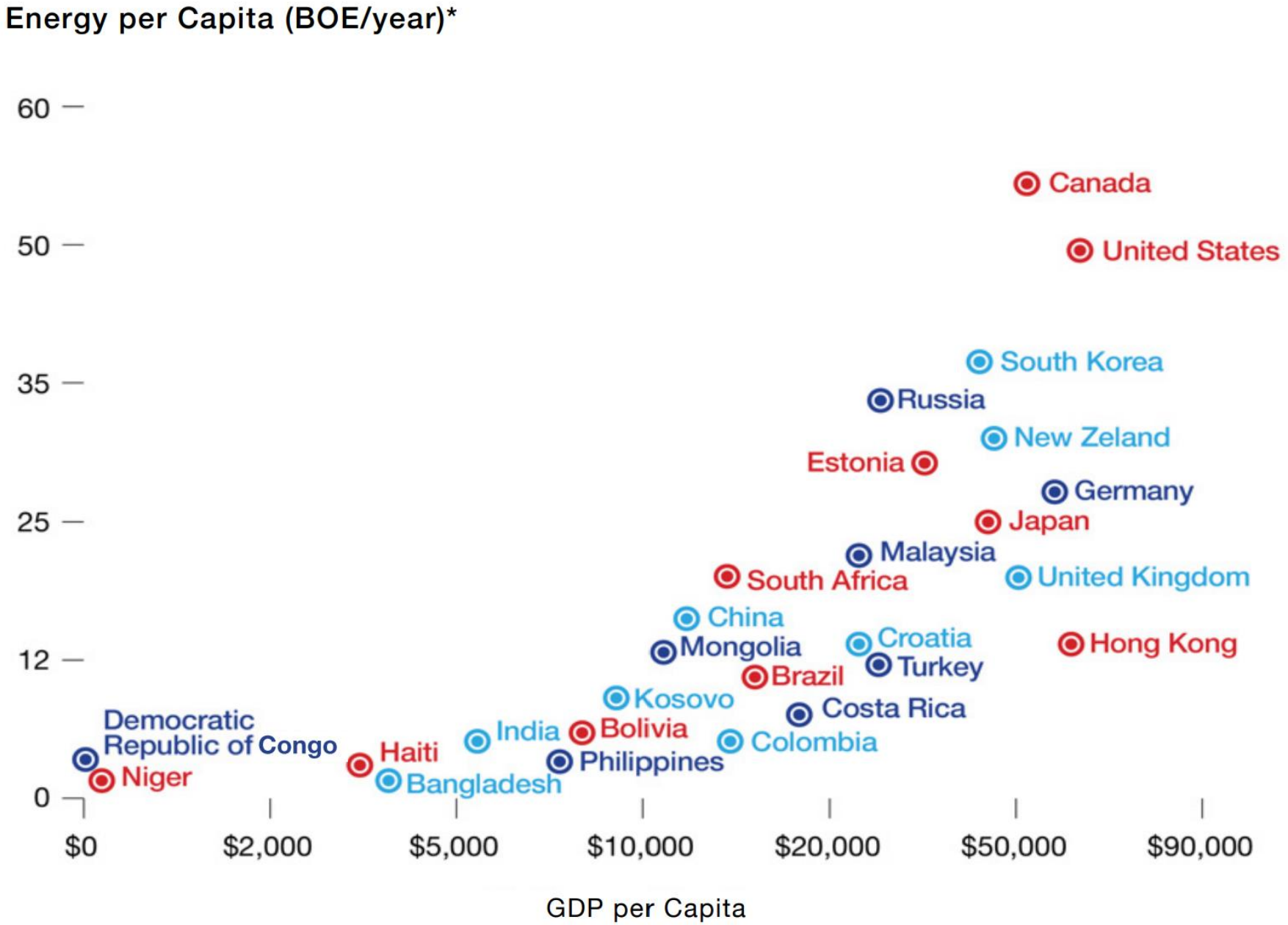
~260 ppm

Laci M. Gerhart and Joy K. Ward, Plant Response to Low CO2 of the Past, New Phytologist, 5July 2010

# Consider:

**Abundant, Reliable, & Low Cost energy is a condition of prosperity**

## Per Capita Wealth vs. per Capita Energy Use




Source: World Bank; Our World in Data as published in The "Energy Transition" Delusion: A Reality Reset Mark P. Mills, Manhattan Institute

# Consider:

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> Prosperity →

< pollution

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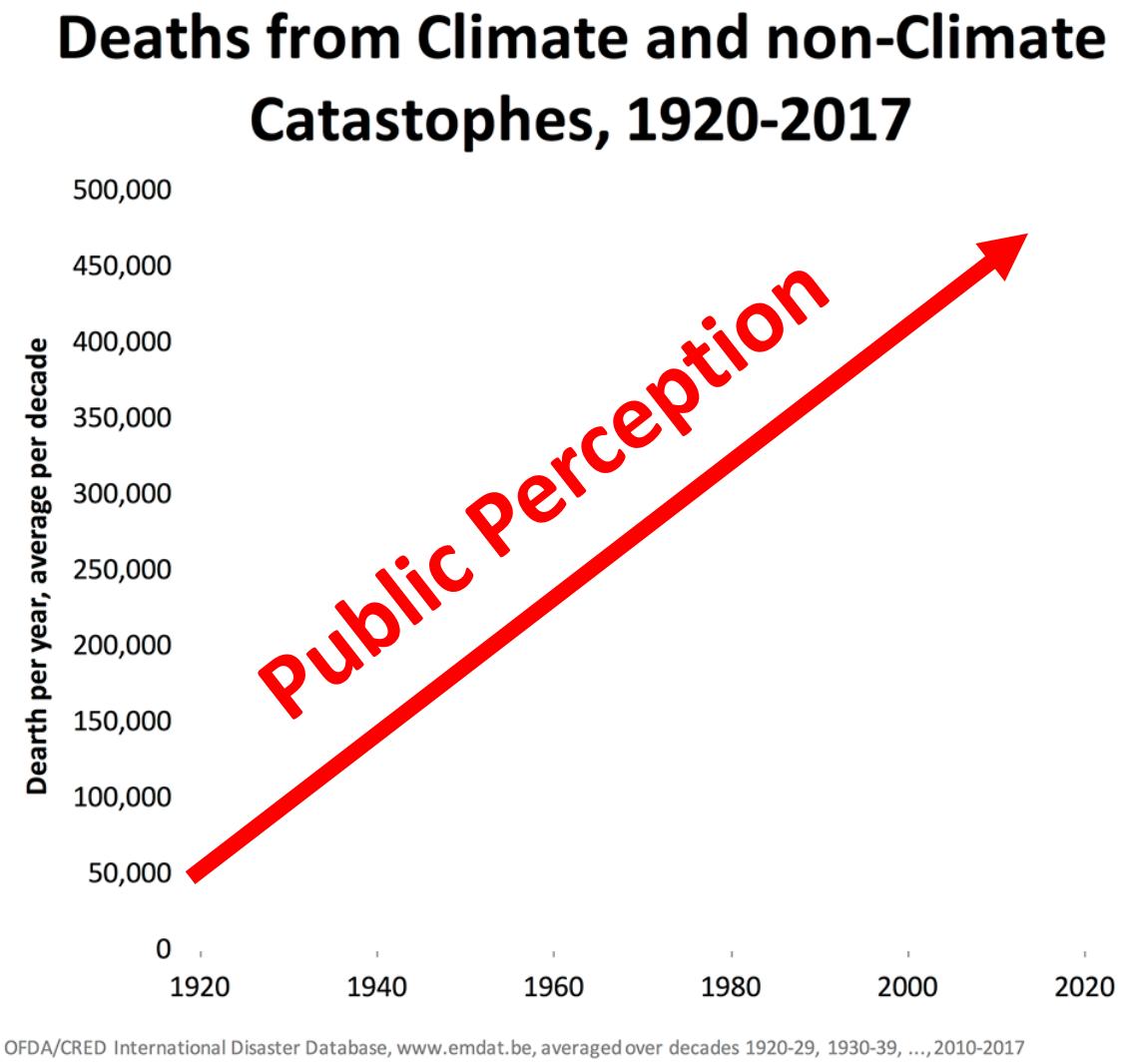
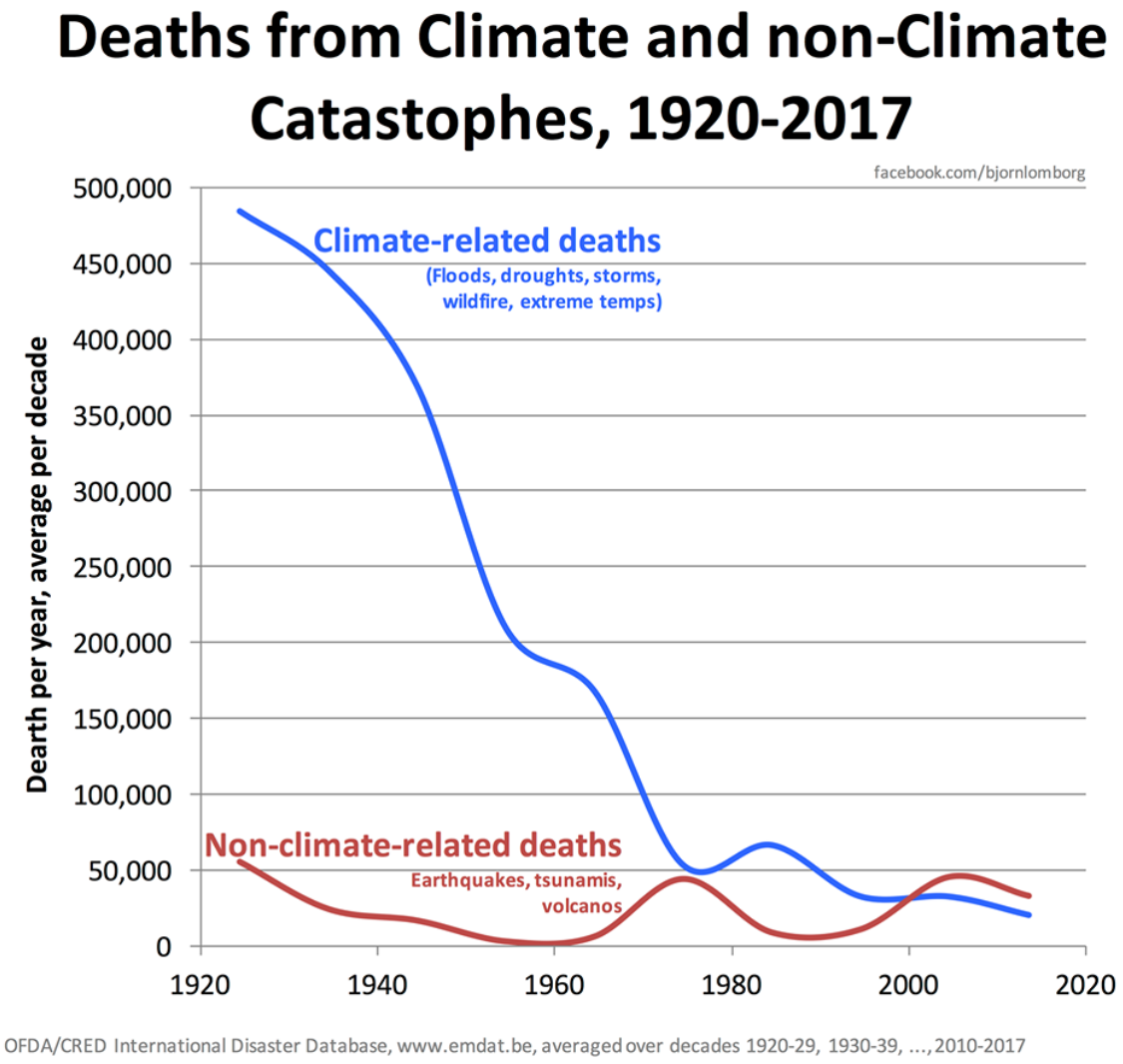
> Prosperity → < pollution

**> Prosperity → climate resiliency**




**“Climate change is the greatest threat to global health in the 21st century.” – World Health Organization (2018)**

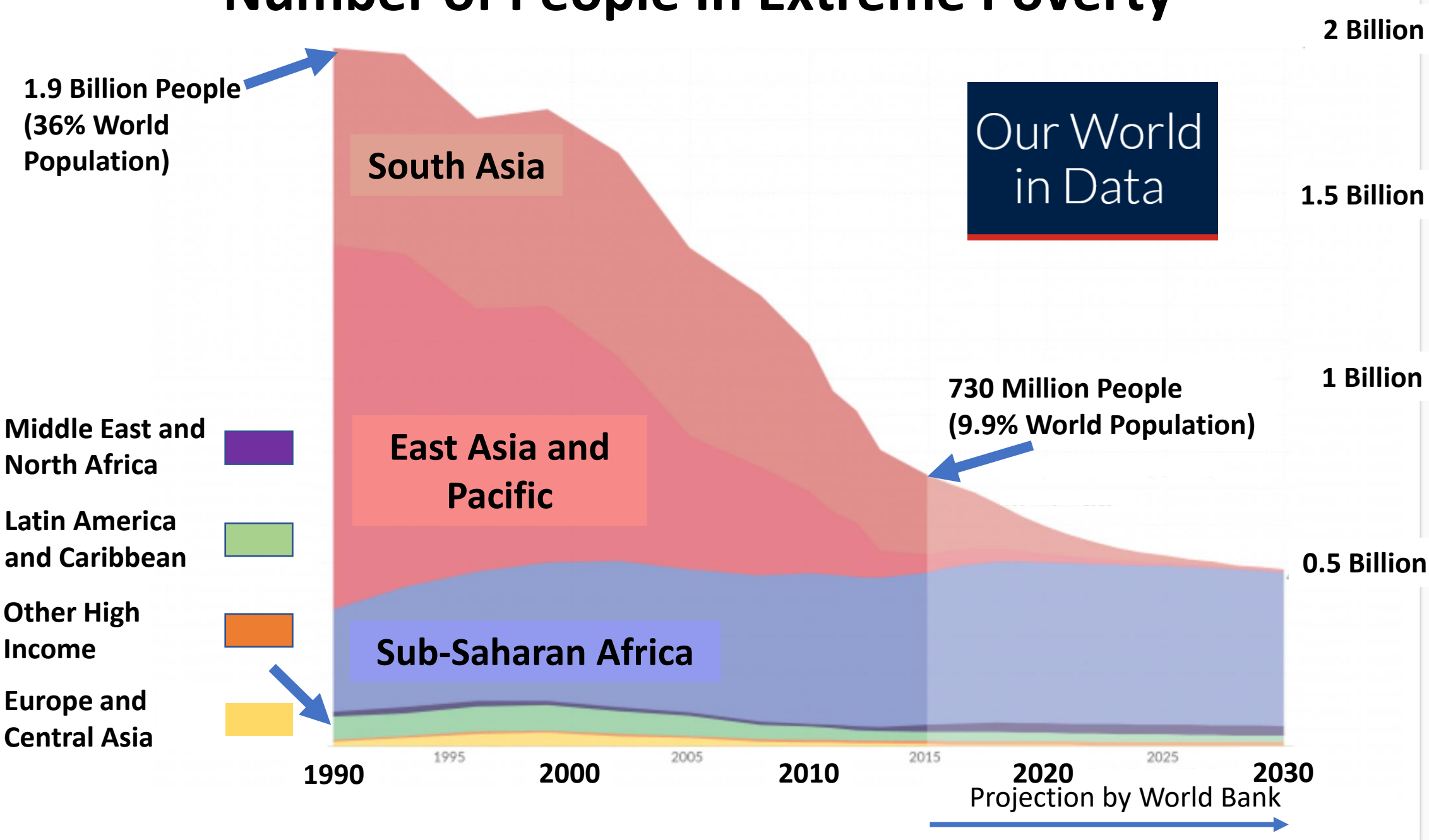



**Human Prosperity does not take a benign climate and make it dangerous.**

**It takes a dangerous climate and makes it safe.**

Paraphrasing Alex Epstein.

# Number of People In Extreme Poverty



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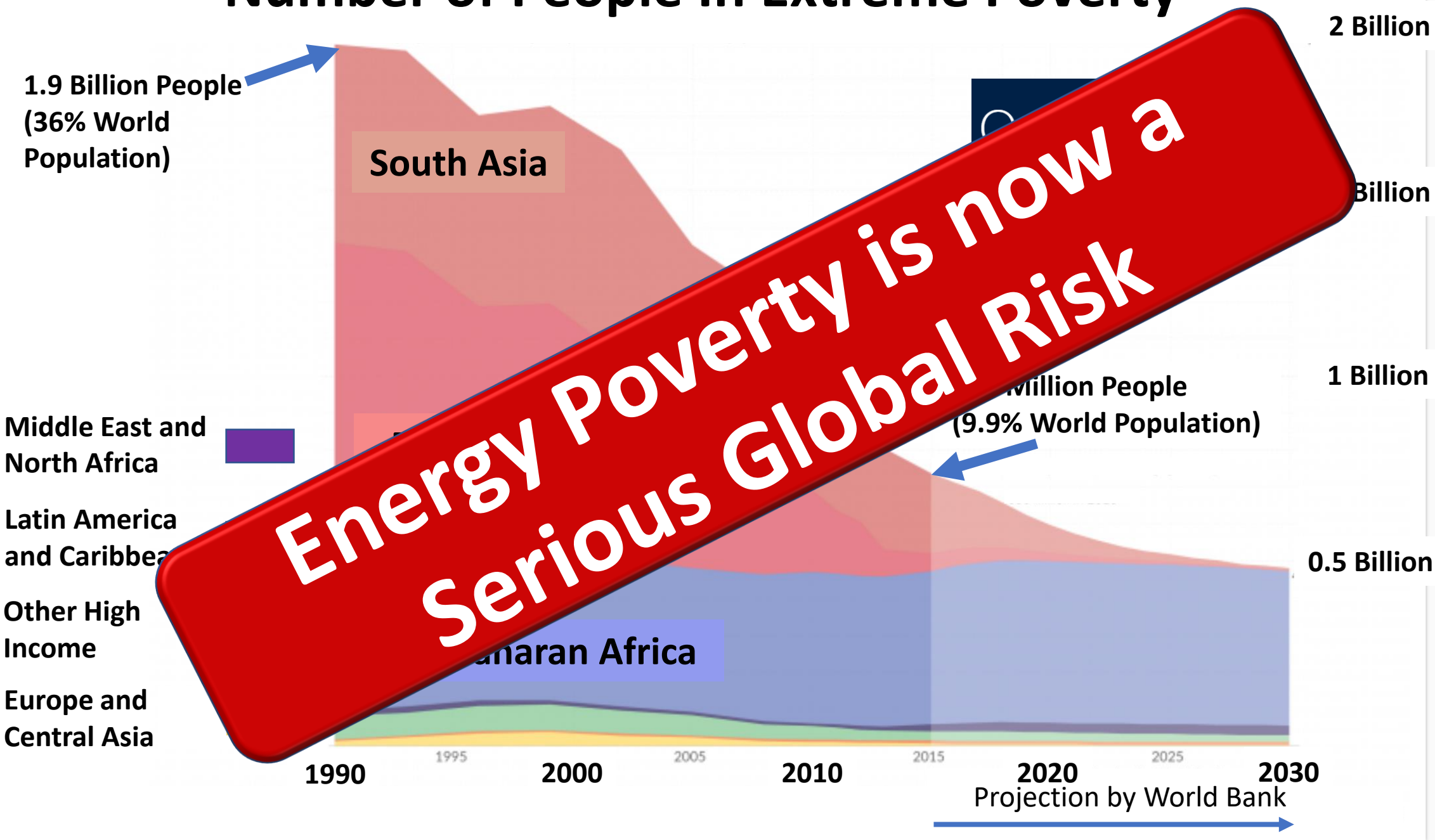



**Energy Poverty is now a Serious Global Risk**

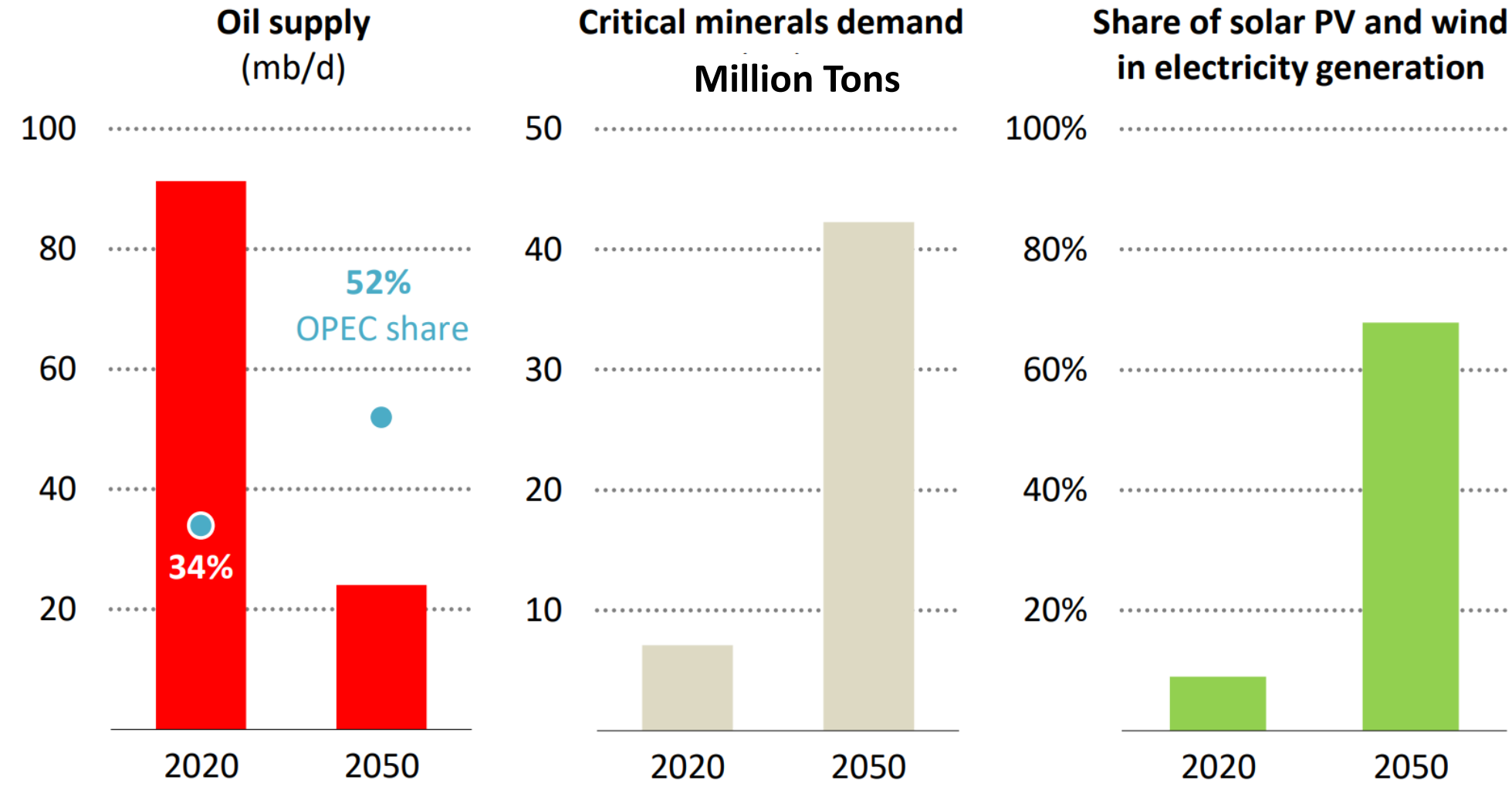
May, 2021

# Net Zero by 2050

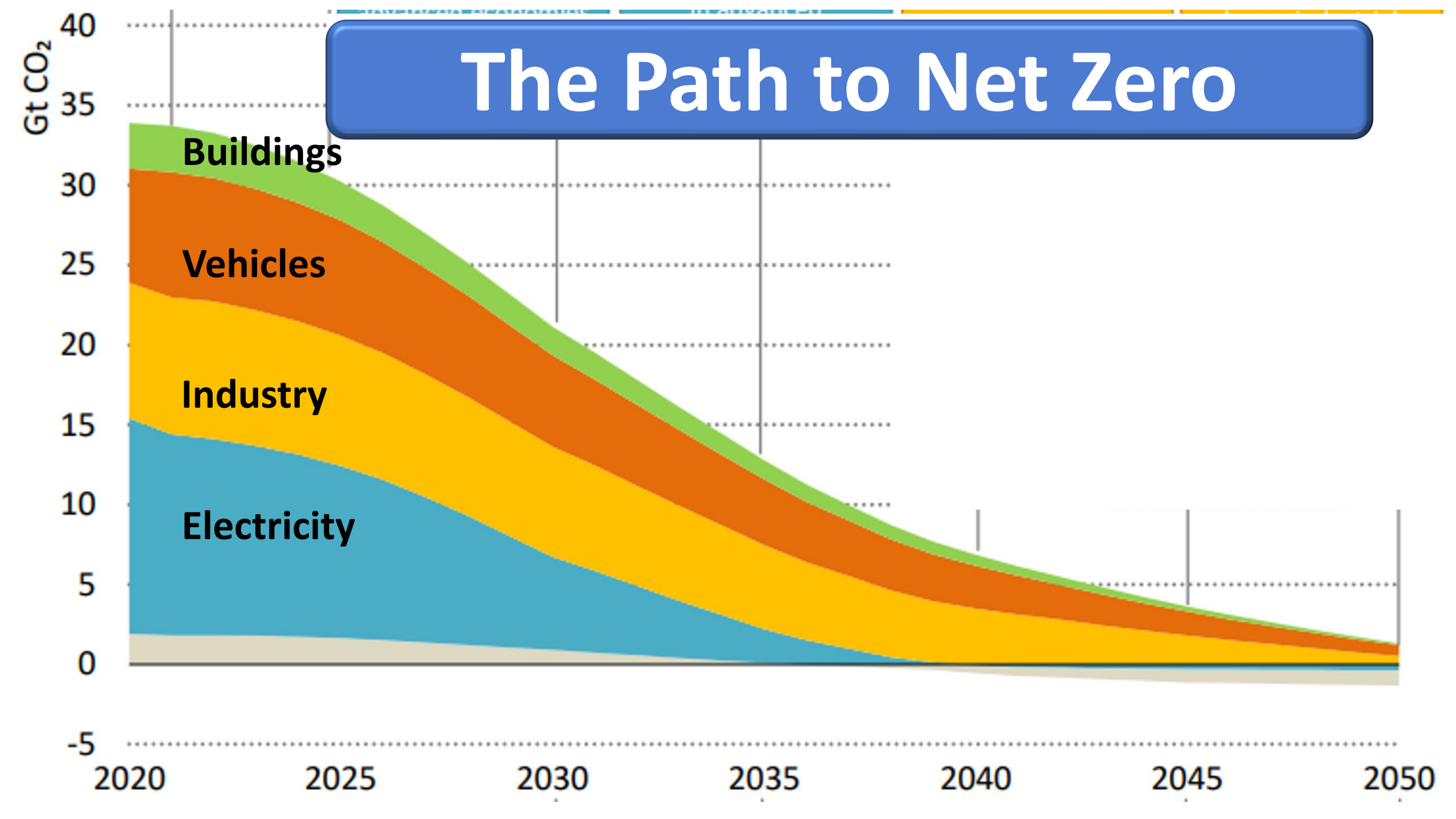
## A Roadmap for the Global Energy Sector

International Energy Agency

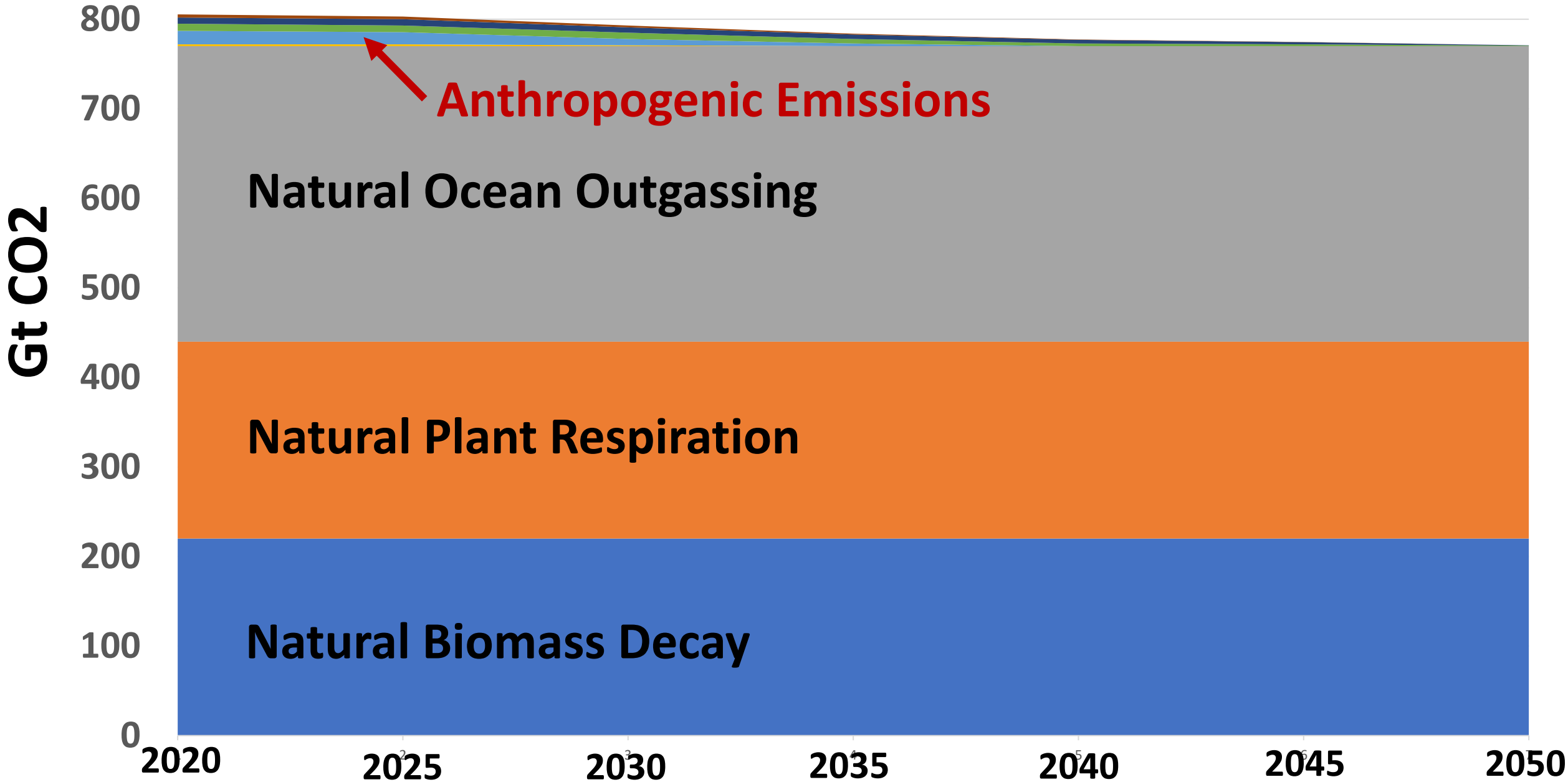
# The Path to Net Zero




Note: mb/d = million barrels per day; Mt = million tonnes.

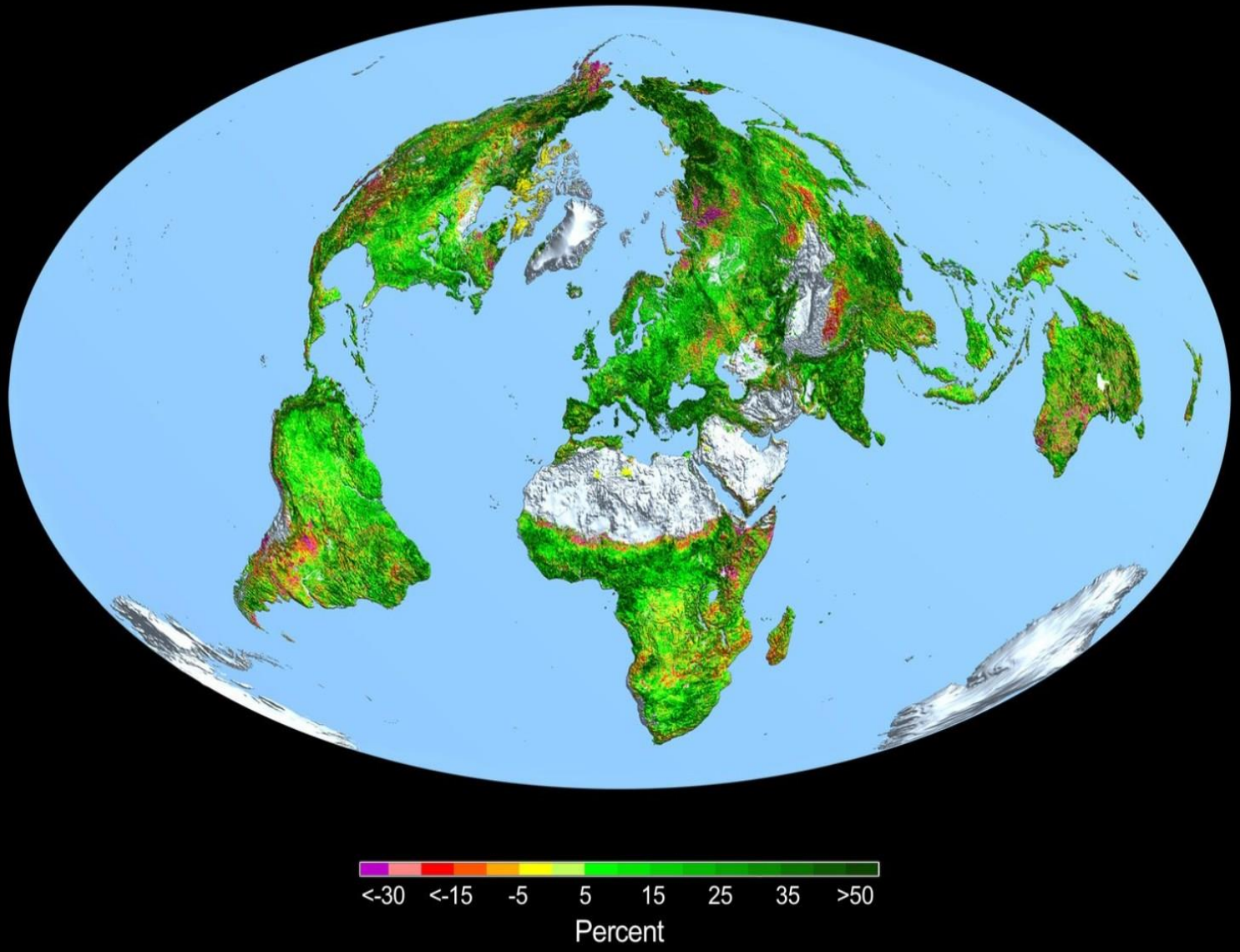

The Path to Net Zero
Gt $CO_2$
40
35
30
25
20
15
10
5
0
-5
Buildings
Vehicles
Industry
Electricity
2020
2025
2030
2035
2040
2045
2050

# Annual CO2 Emissions with Net Zero



GPP up 31 % since 1900

Campbell et al. 2017



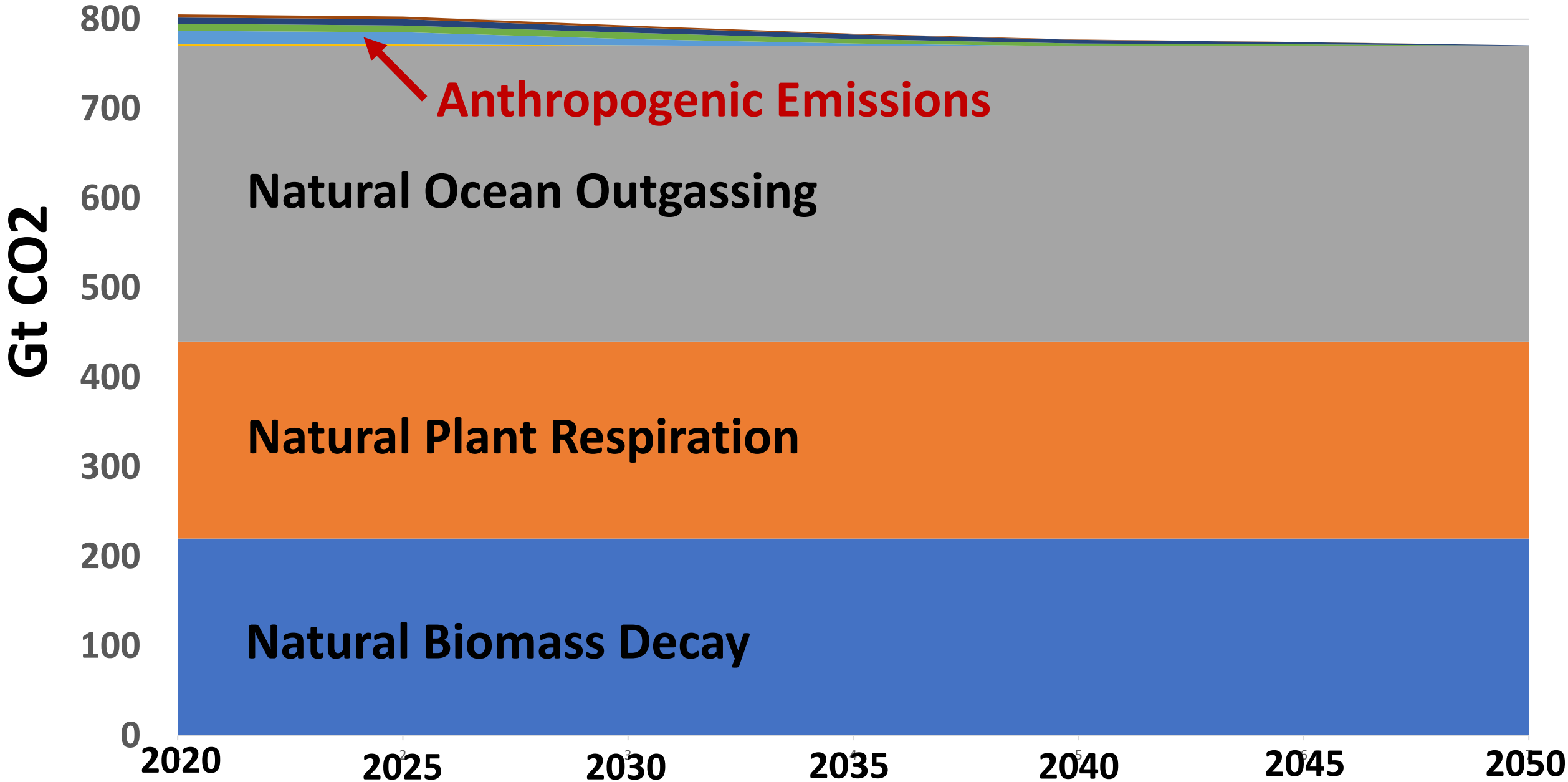

GPP +47 % with 560 ppm CO2 (2X pre-industrial)

Haverd, 2020

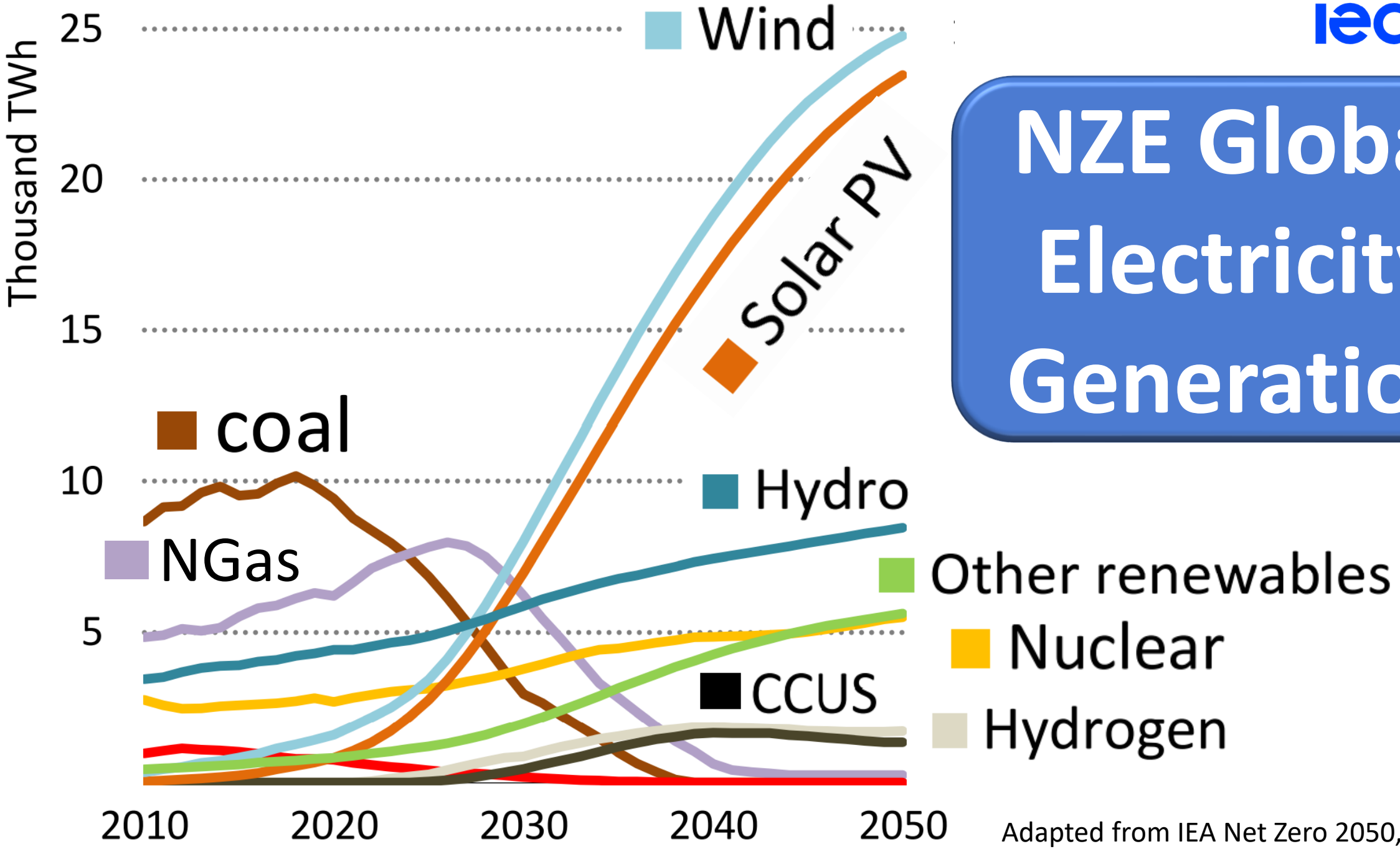
# Change in Leaf Area (1982-2015)

https://www.nasa.gov/feature/goddard/2016/carbon-dioxide-fertilization-greening-earth

# Annual CO2 Emissions with Net Zero



# NZE Global Electricity Generation



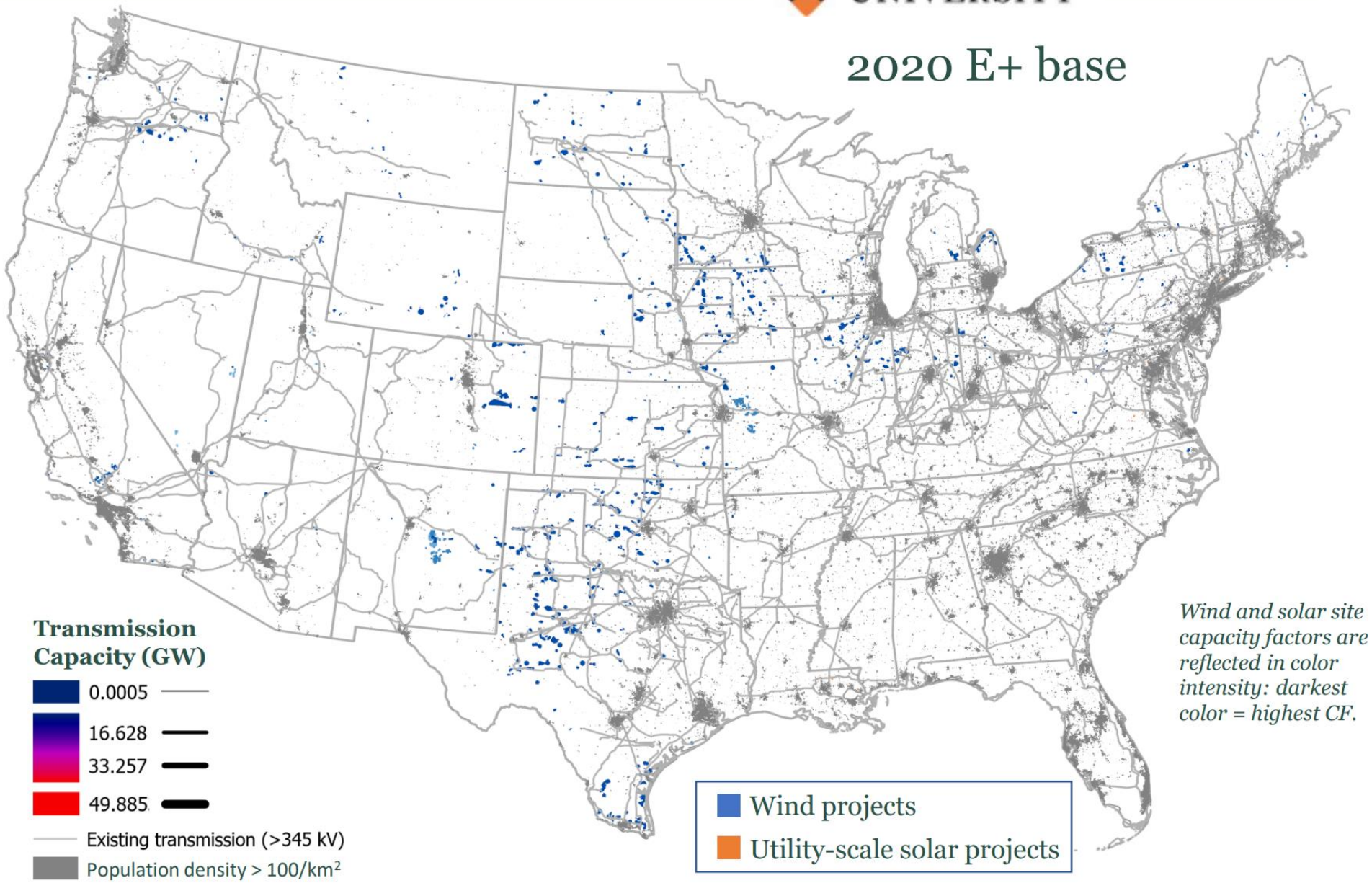

Adapted from IEA Net Zero 2050, Oct21

# Modeled 2020 wind and utility-scale solar capacity; Existing transmission lines (≥ 345 kV).

PRINCETON UNIVERSITY

| 2020 (modeled) | | |
|---|---|---|
| | **Wind** | **Solar** |
| **Cumulative capacity (TW)** | | |
| | 0.13 | 0.07 |
| **Land used (1000 km²)** | | |
| Total | 57.9 | 1.08 |
| Direct | 0.58 | 0.98 |
| **Cumulative capital (B$$_{2018}$)*** | | |
| Solar | - | 48 |
| Onshore wind | 55 | - |
| Offshore wind | 0 | - |
| **Existing transmission** | | |
| Capacity (GW-km)** | | 320,000 |
| Increase over 2020 | | - |

**22,780 square miles (.72% land area)**



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2020 E+ base

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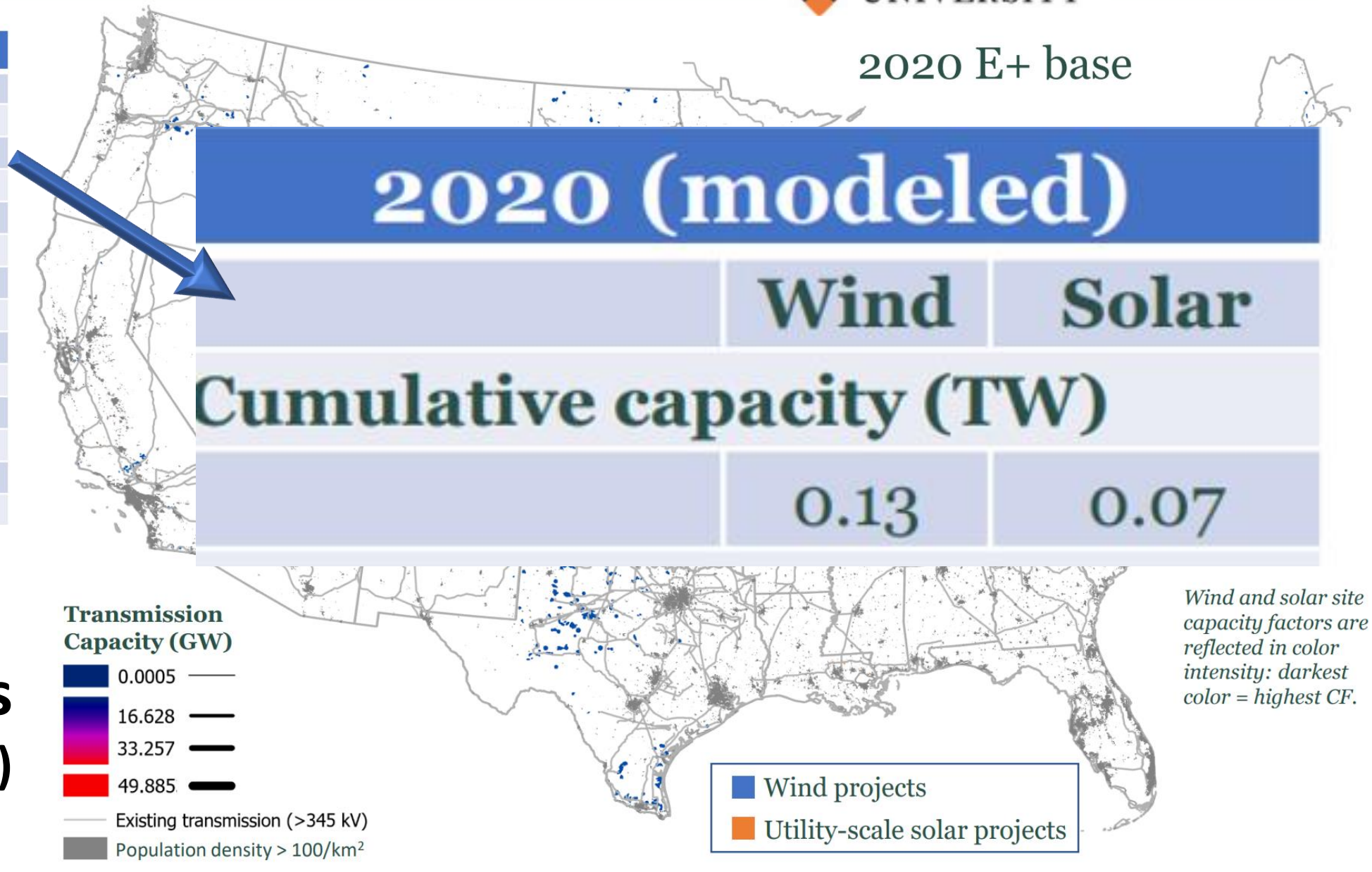


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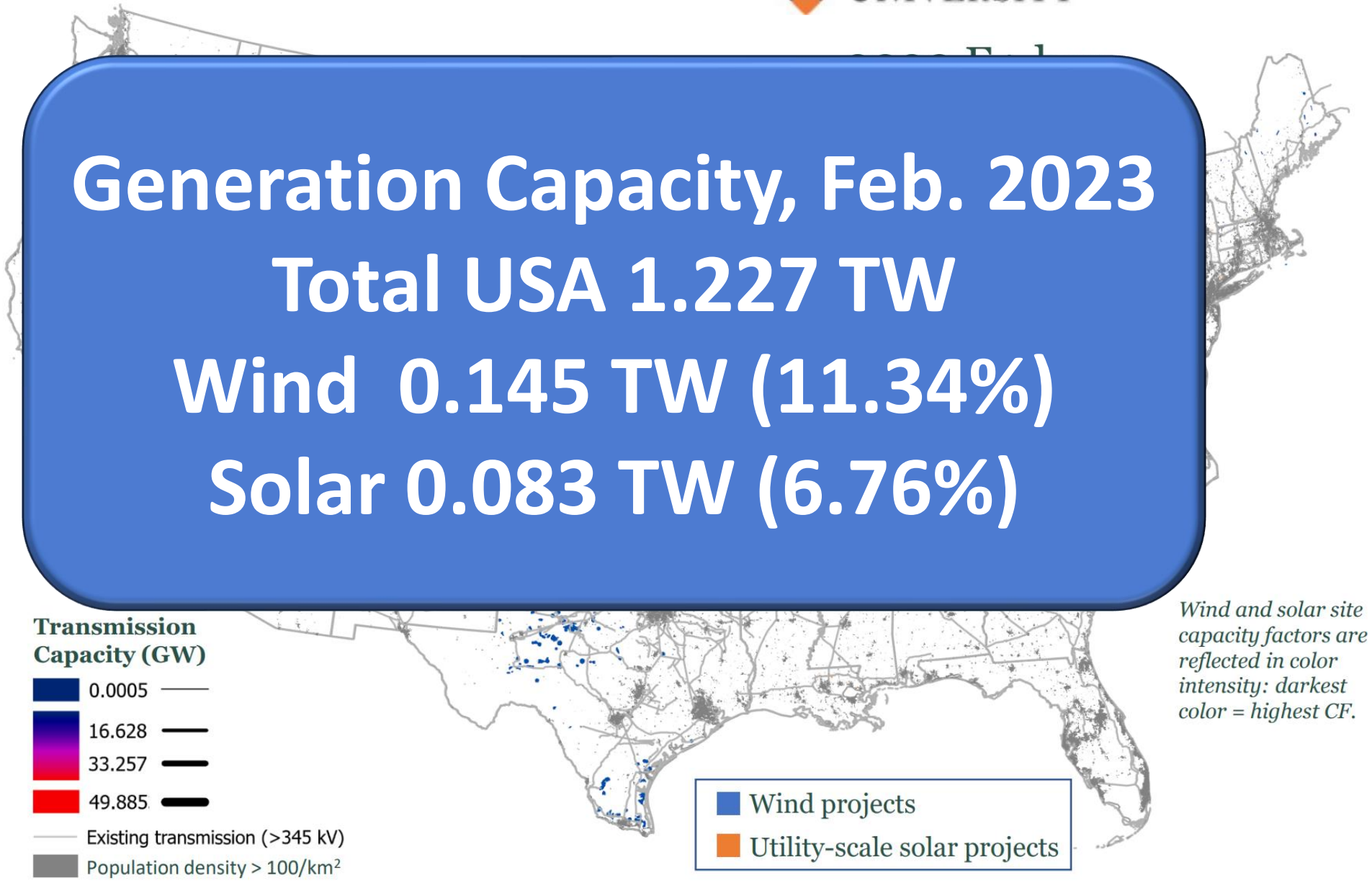
**Generation Capacity, Feb. 2023**
**Total USA 1.227 TW**
**Wind 0.145 TW (11.34%)**
**Solar 0.083 TW (6.76%)**

**22,780 square miles (.72% land area)**

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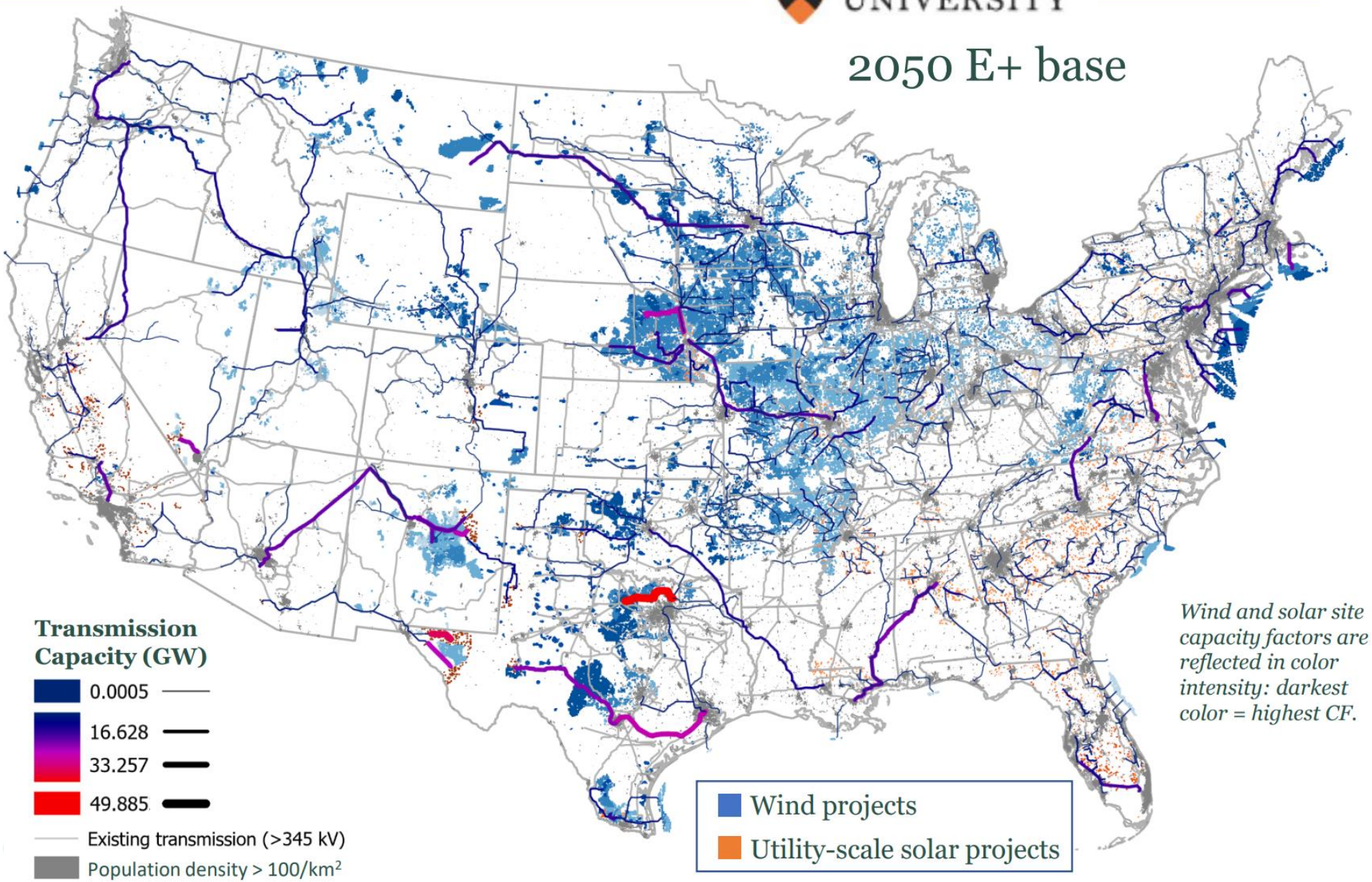
# 3.2 TW of wind and solar capacity operating in 2050; transmission capacity grows to 3.1x the 2020 level.

PRINCETON UNIVERSITY

| 2050 | | |
|---|---|---|
| | Wind | Solar |
| **Capacity installed (TW)** | | |
| | 1.67 | 1.50 |
| **Land used (1000 km²)** | | |
| Total | 551 | 38.3 |
| Direct | 5.51 | 34.9 |
| **Capital invested (Billion $$_{2018}$$)*** | | |
| Solar | - | 1,488 |
| Onshore wind | 1,609 | - |
| Offshore wind | 301 | - |
| **Transmission added vs. 2020**** | | |
| Capacity (GW-km) | | 673,000 |
| Increase over 2020 | | 210% |
| Capital in serv (B$$_{2018}$$) | | 2,210 |

**227,530 square miles (7.2% land area)**



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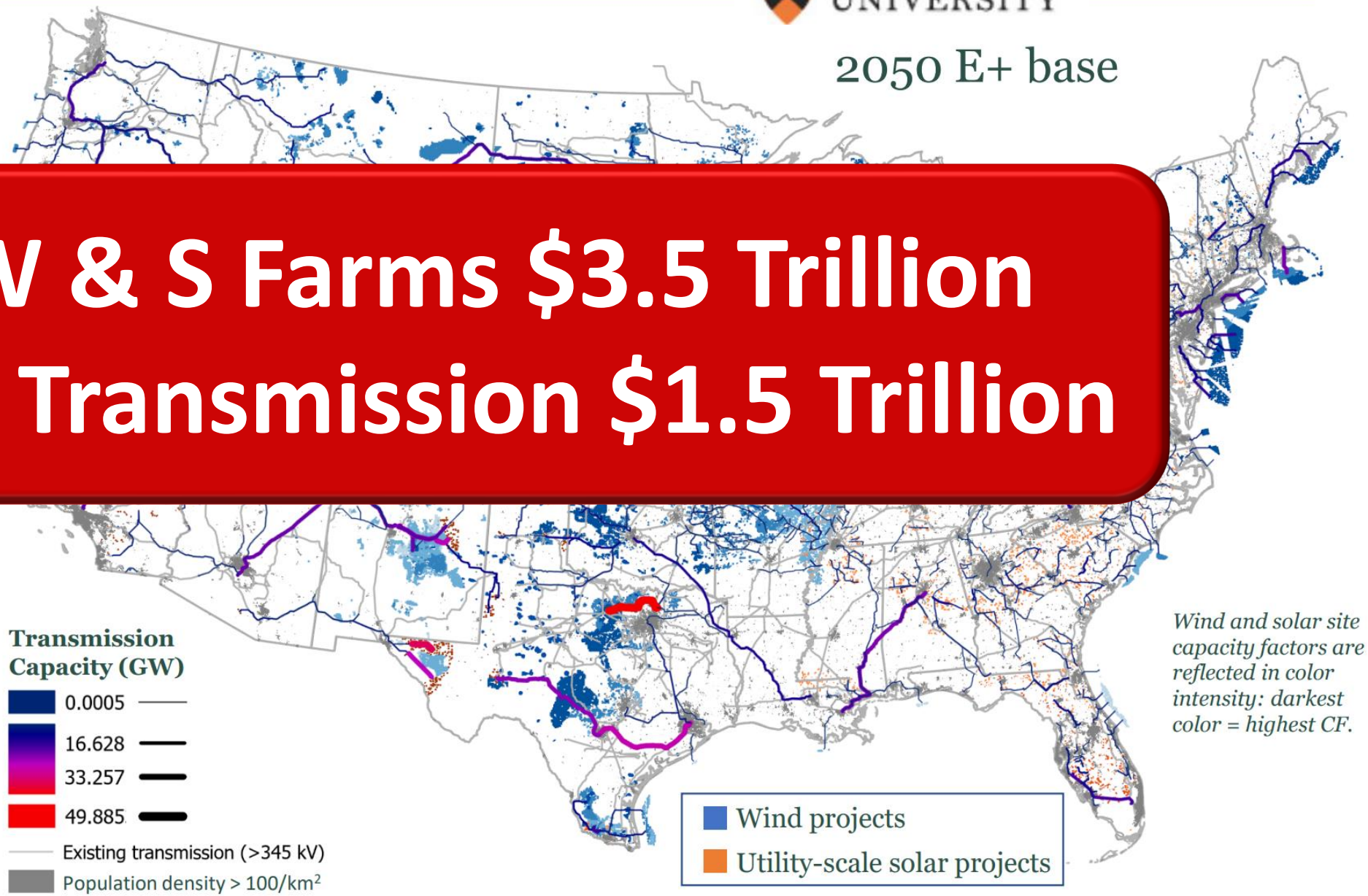
**W & S Farms $3.5 Trillion**
**HV Transmission $1.5 Trillion**

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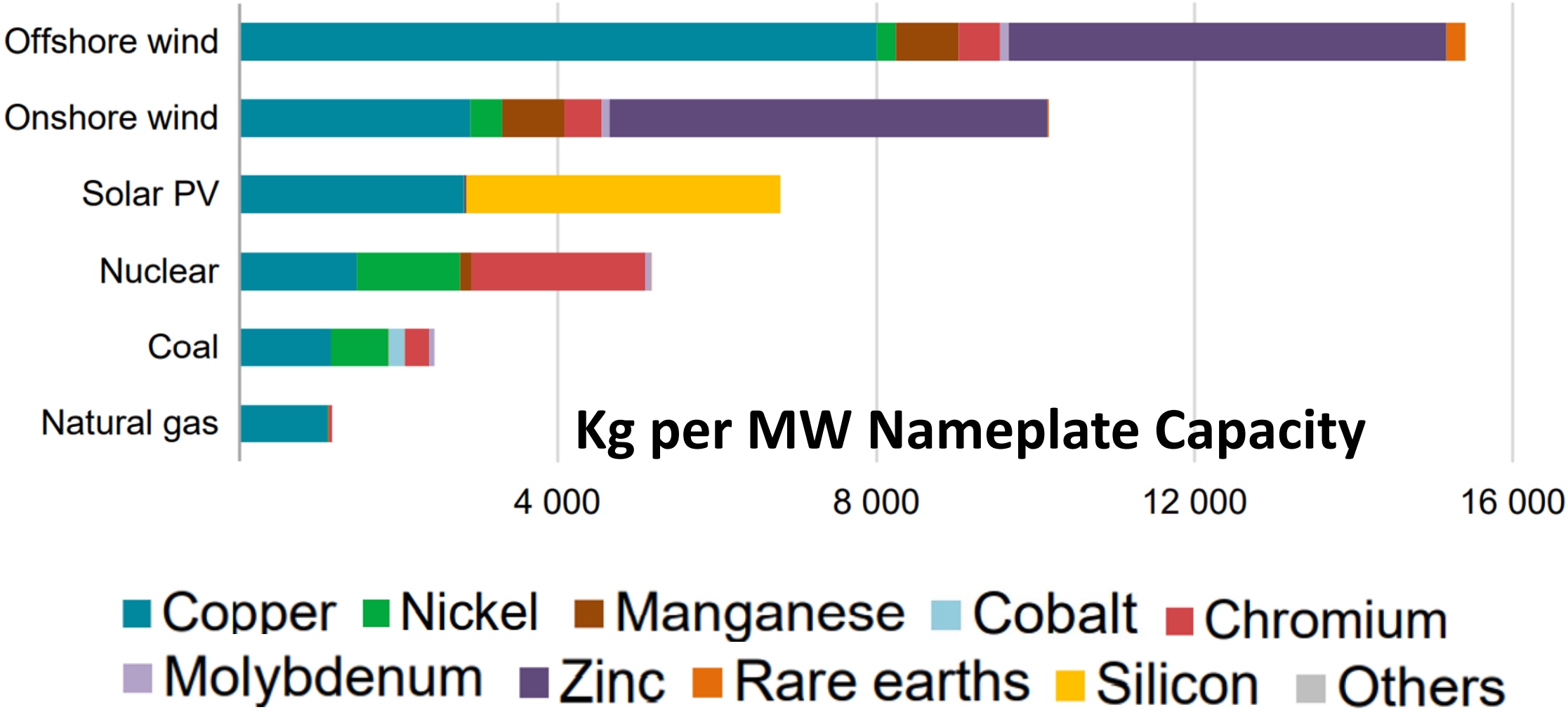
# Materials Intensity for Power Generation




Adapted from IEA March, 2022

Steel, concrete, and aluminum not included

# The Iron Law of Power Density

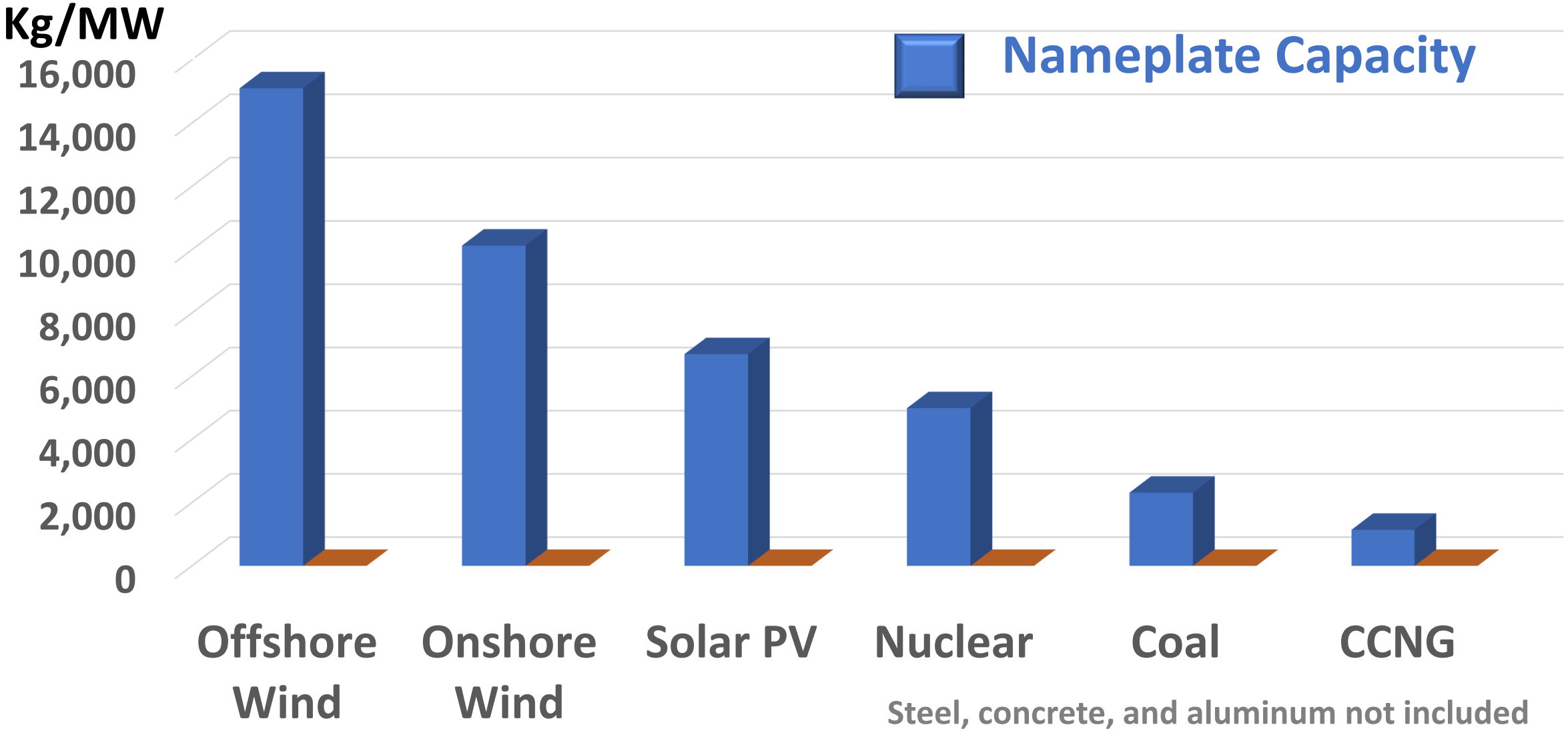

**The lower the power density, the greater the resource intensity**

**Adapted from** iea **March, 2022**

Steel, concrete, and aluminum not included


30 feet deep; 2,500 tons
of steel and concrete

# Materials Intensity for Power Generation

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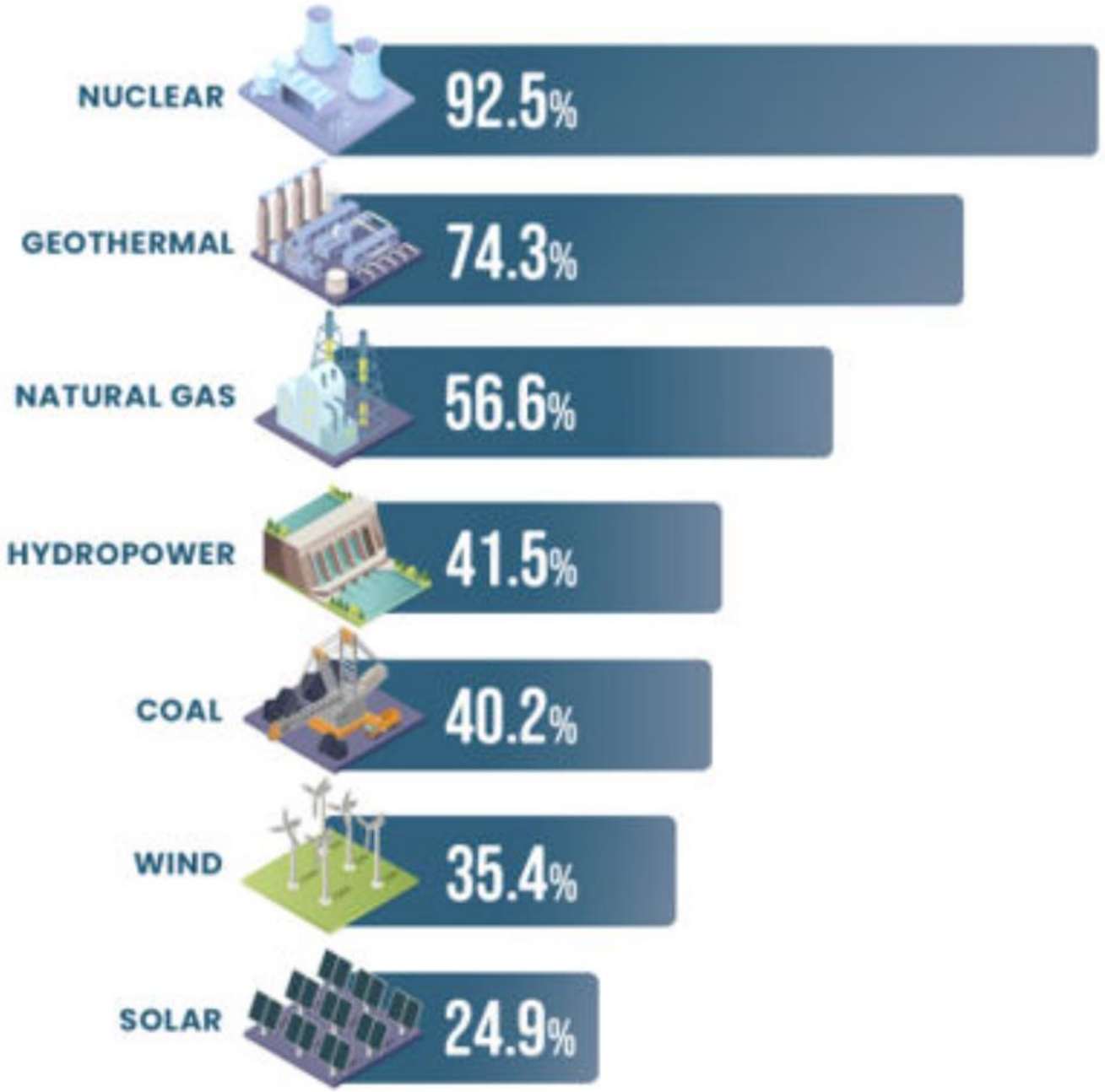
# Actual

## Capacity Factor by Energy Source in 2020

Source: U.S. Energy Information Administration

eia | U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY




**Edward A. Reid, Jr.**

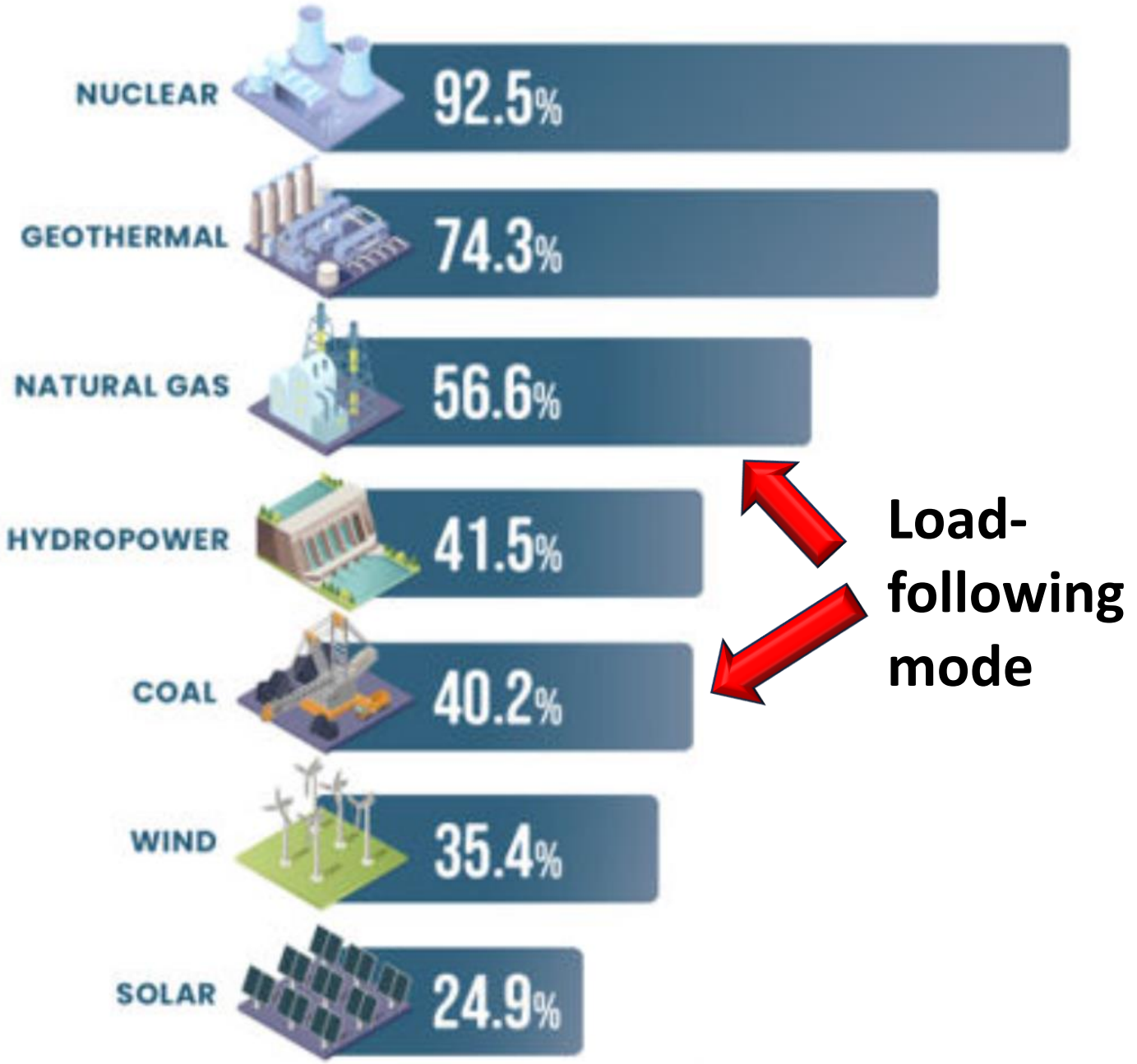
# Constrained

## Capacity Factor by Energy Source in 2020

Source: U.S. Energy Information Administration

# For Coal & NG

eia | U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY



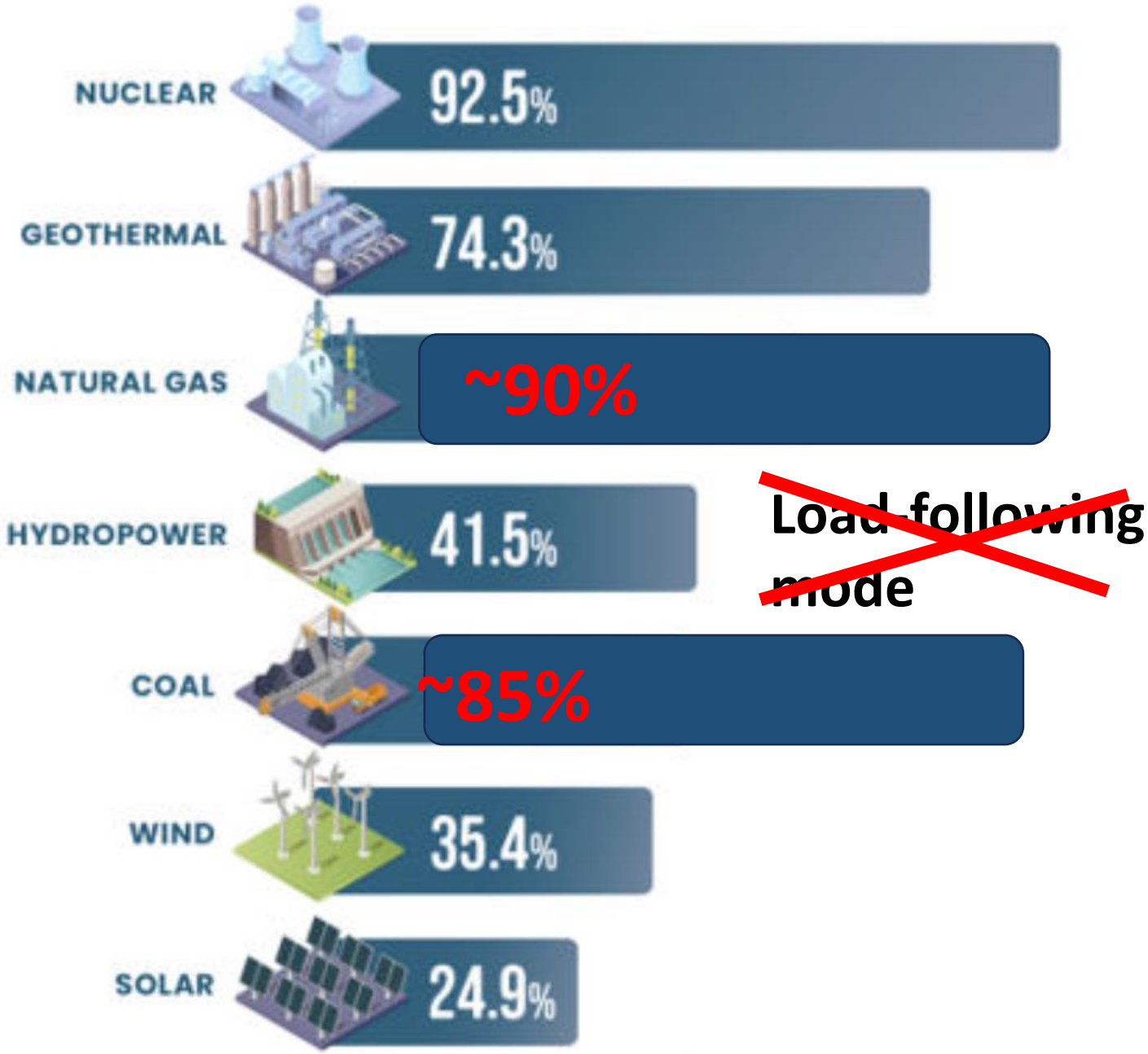

Load-following mode

Edward A. Reid, Jr.

# Unconstrained

## Capacity Factor by Energy Source in 2020

Source: U.S. Energy Information Administration

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eia | U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Edward A. Reid, Jr.

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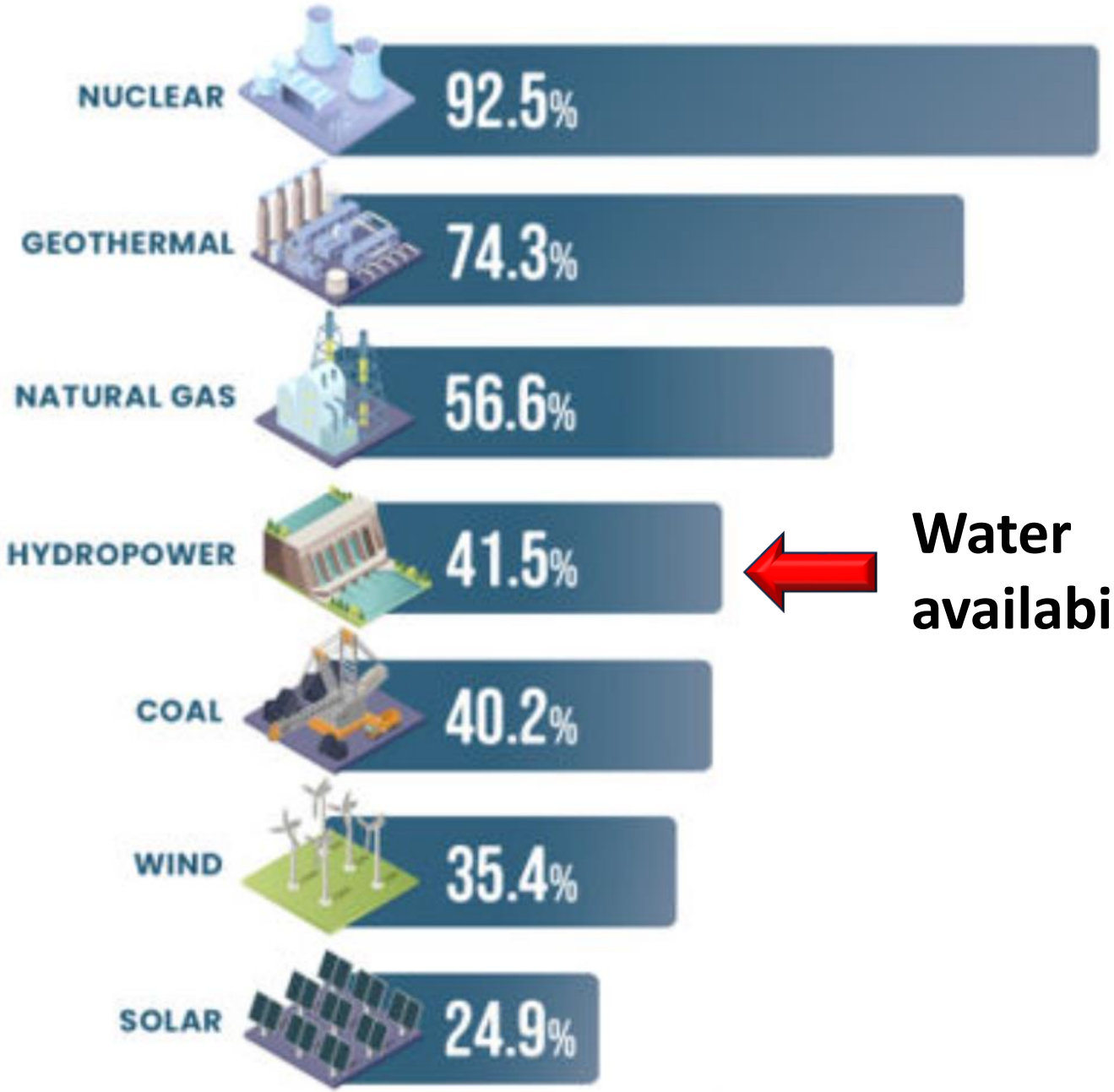



**Water availability**

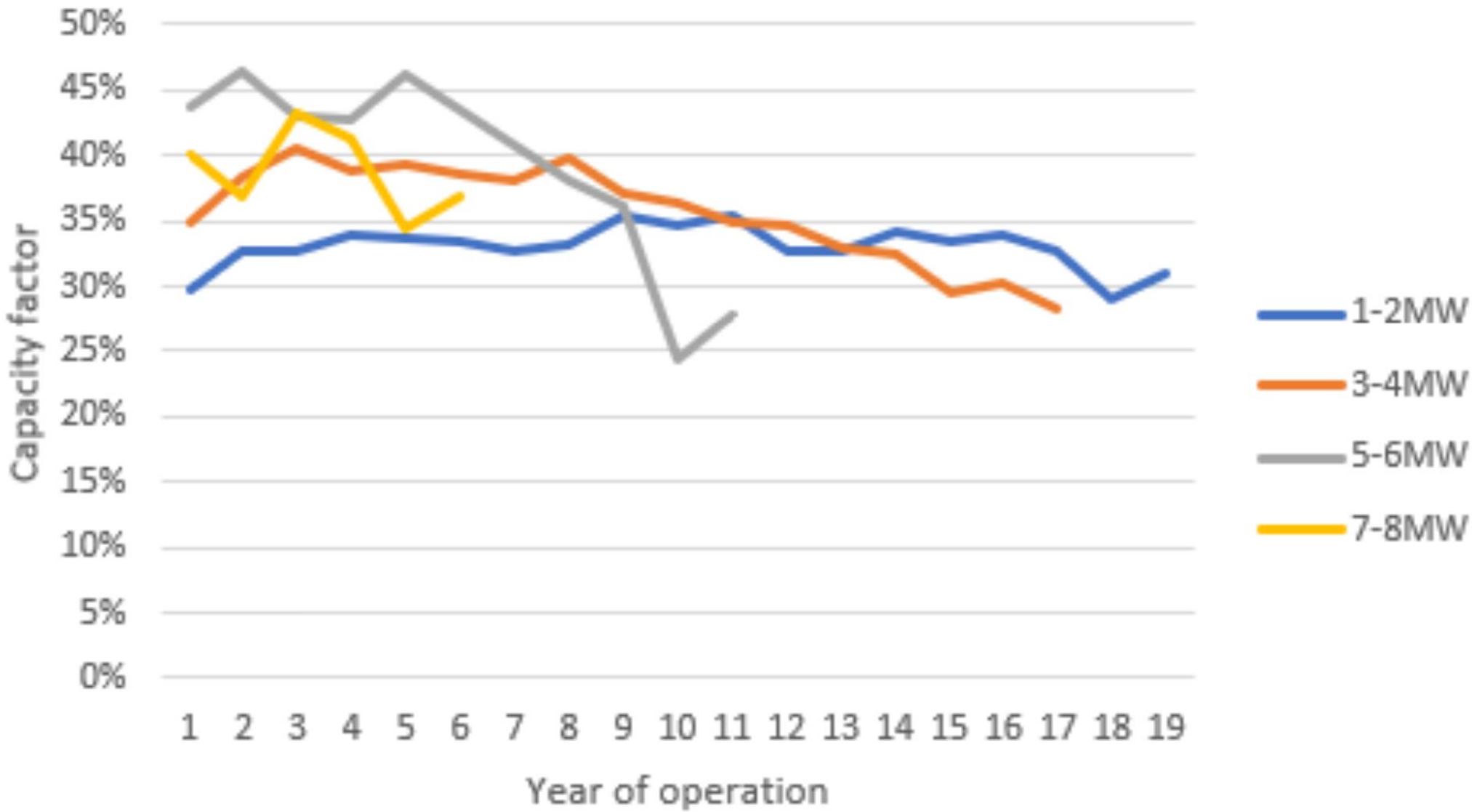
eia | U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

**Edward A. Reid, Jr.**

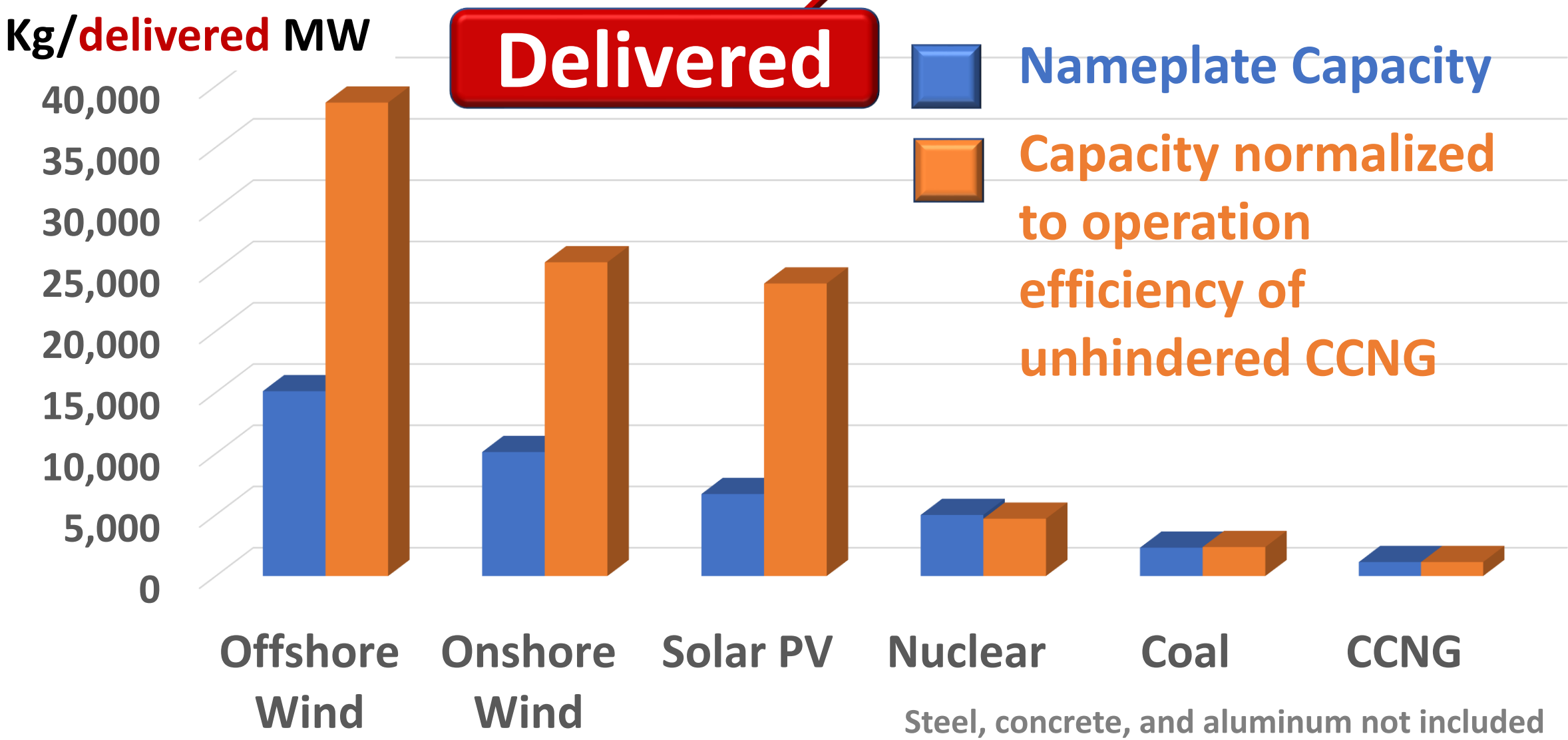
# UK offshore windfarms

## Capacity factor by turbine size

NETZERO WATCH



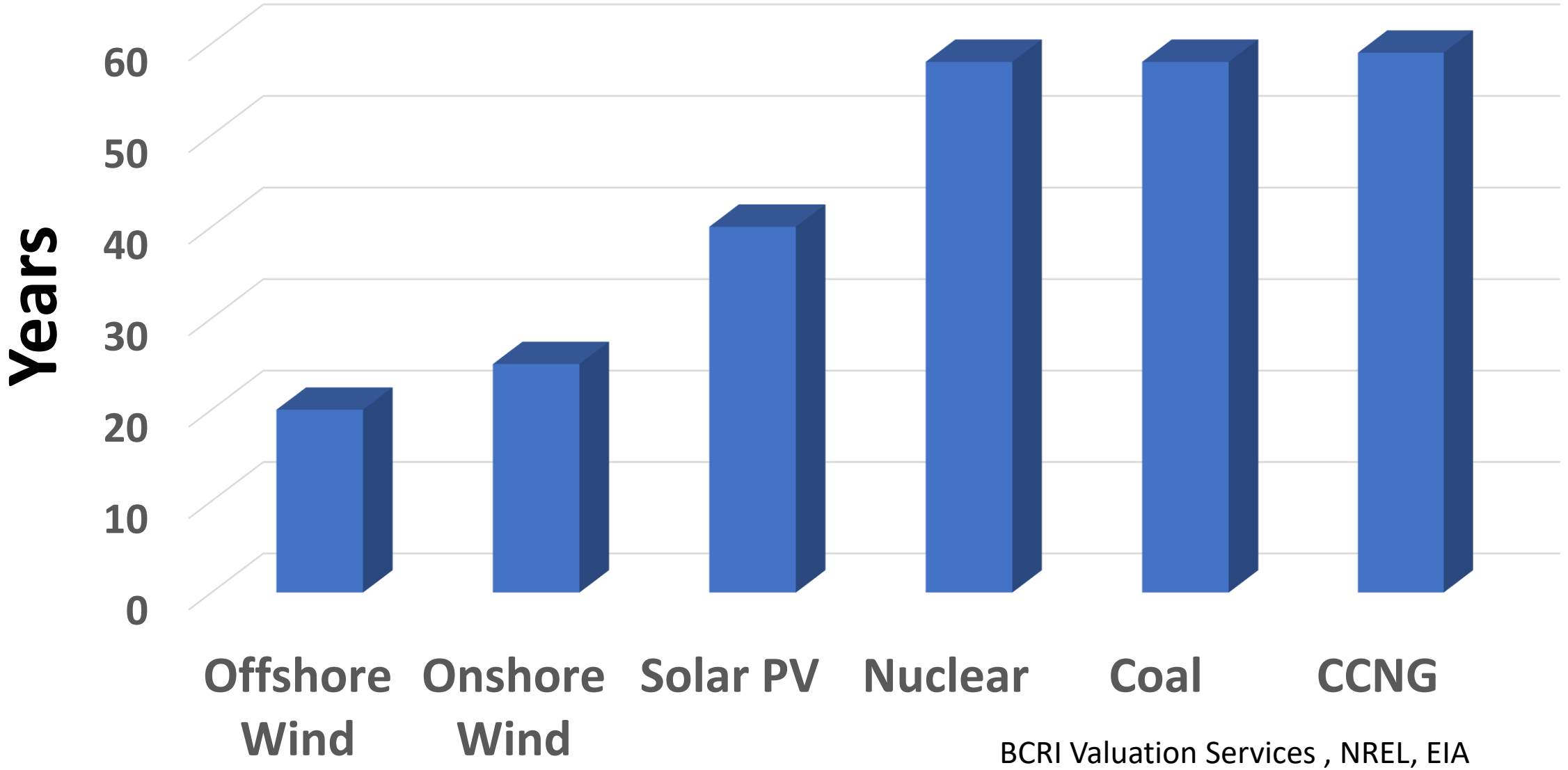
# Materials Intensity for Power Generation




Steel, concrete, and aluminum not included

# Materials Intensity for Power Generation

# Useful Lifetime of Electrical Power Generators




BCRI Valuation Services , NREL, EIA

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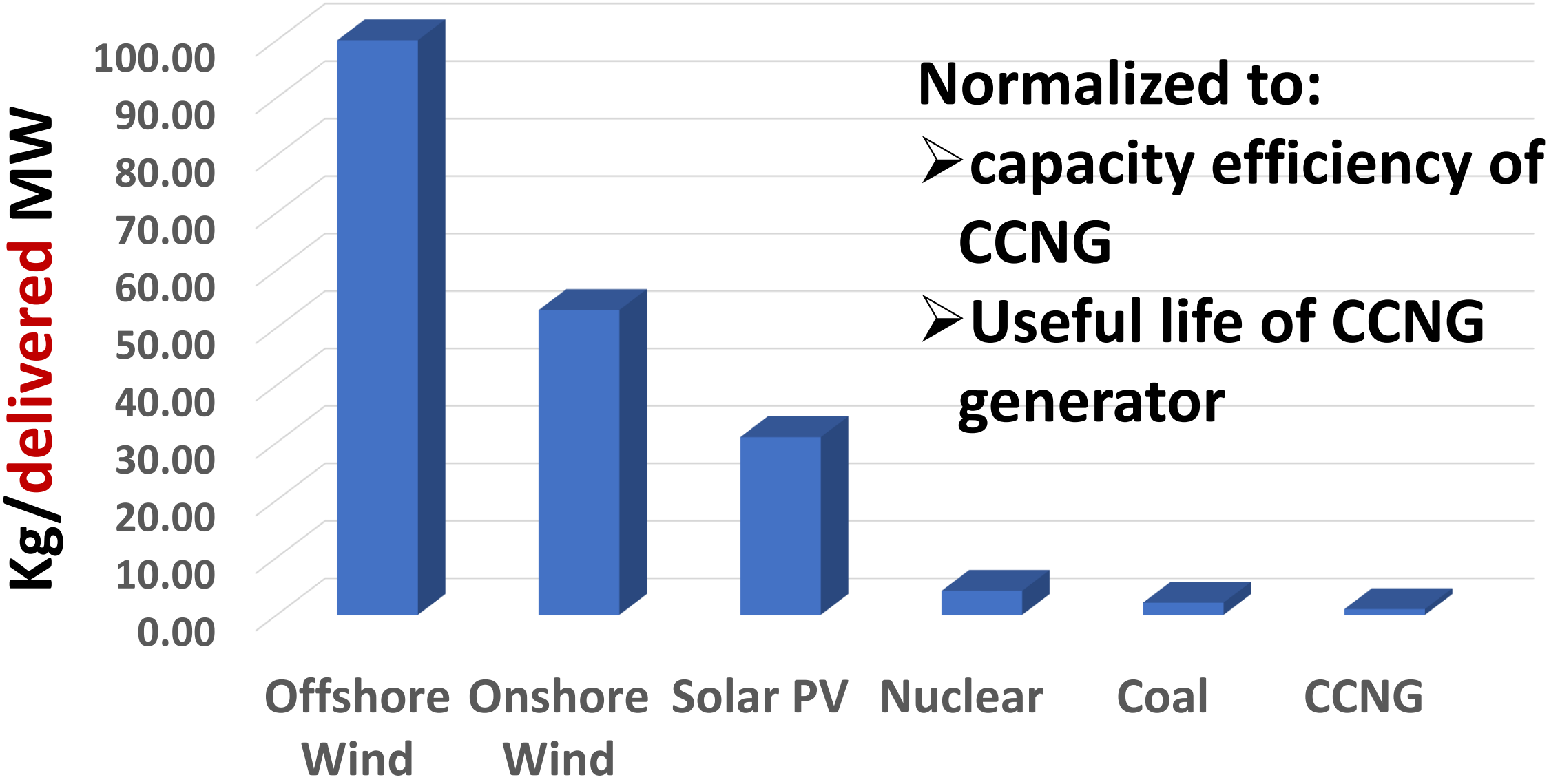


**Normalized to:**

- **capacity efficiency of CCNG**
- **Useful life of CCNG generator**

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PRINCETON UNIVERSITY

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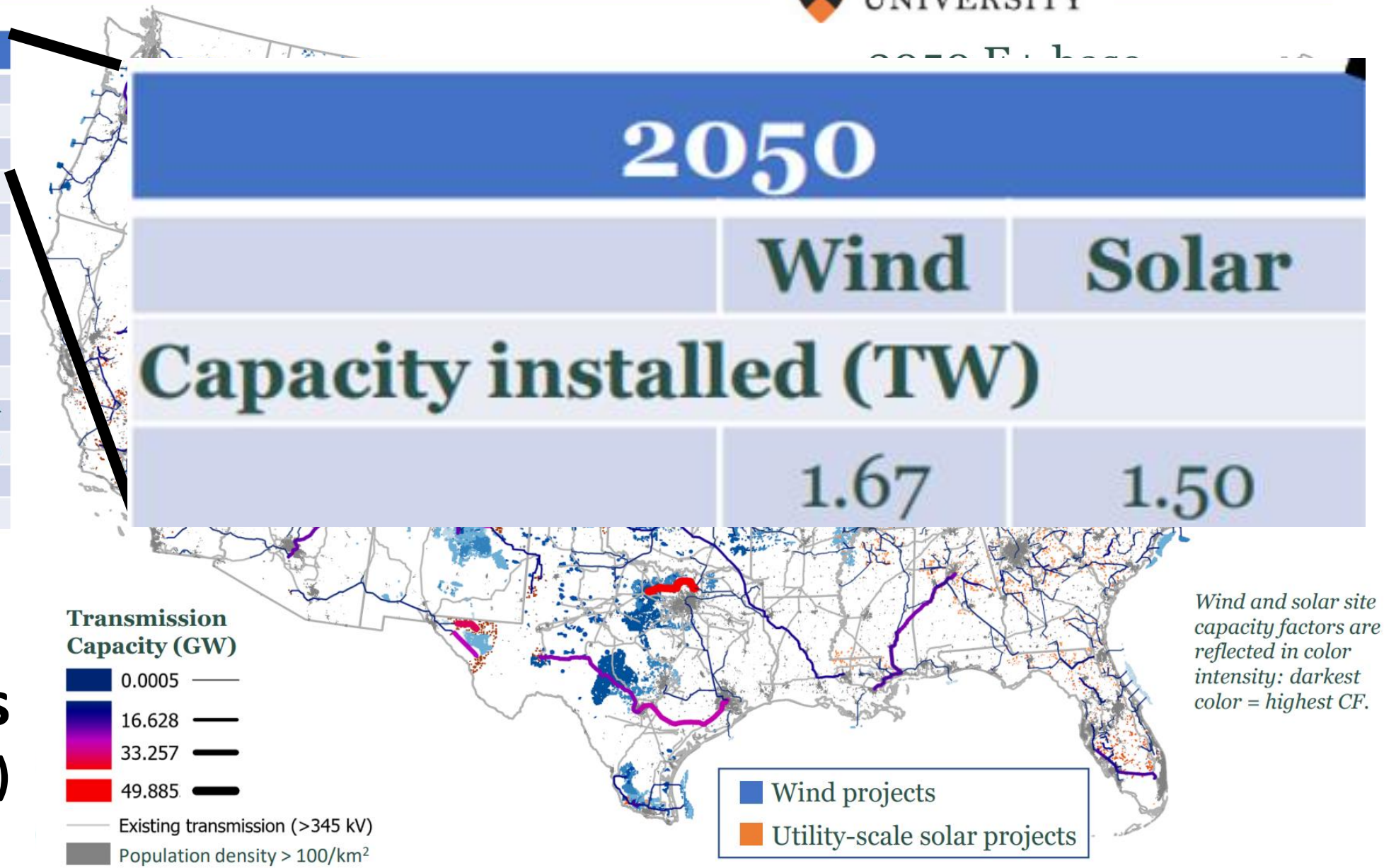



*Wind and solar site capacity factors are reflected in color intensity: darkest color = highest CF.*

**227,530 square miles (7.2% land area)**

# NZE Material Needs by 2050, Contiguous USA

1.5 TW Solar

Copper

Silicon

1.5 TW Onshore Wind

Copper

Nickel

Molybdenum

Manganese

Chromium

Zinc

Rare Earth

0.2 TW Offshore Wind

0

5,000,000

10,000,000

15,000,000

20,000,000

Million tons

Adapted from Princeton E+ Pathway

Steel, concrete, and aluminum not included

# Bingham Canyon Open Pit Copper Mine

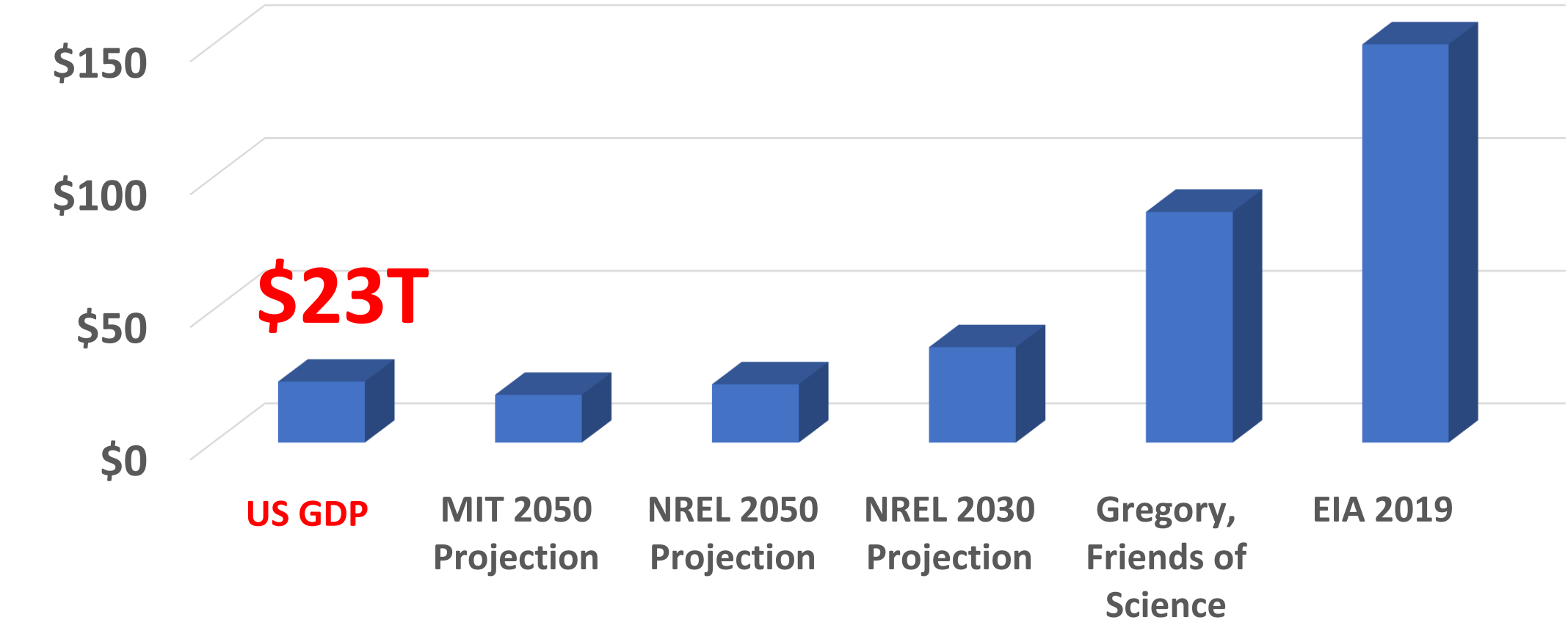

**Enabled by Fossil Fuels**

# Battery Backup for NZE U.S. Grid

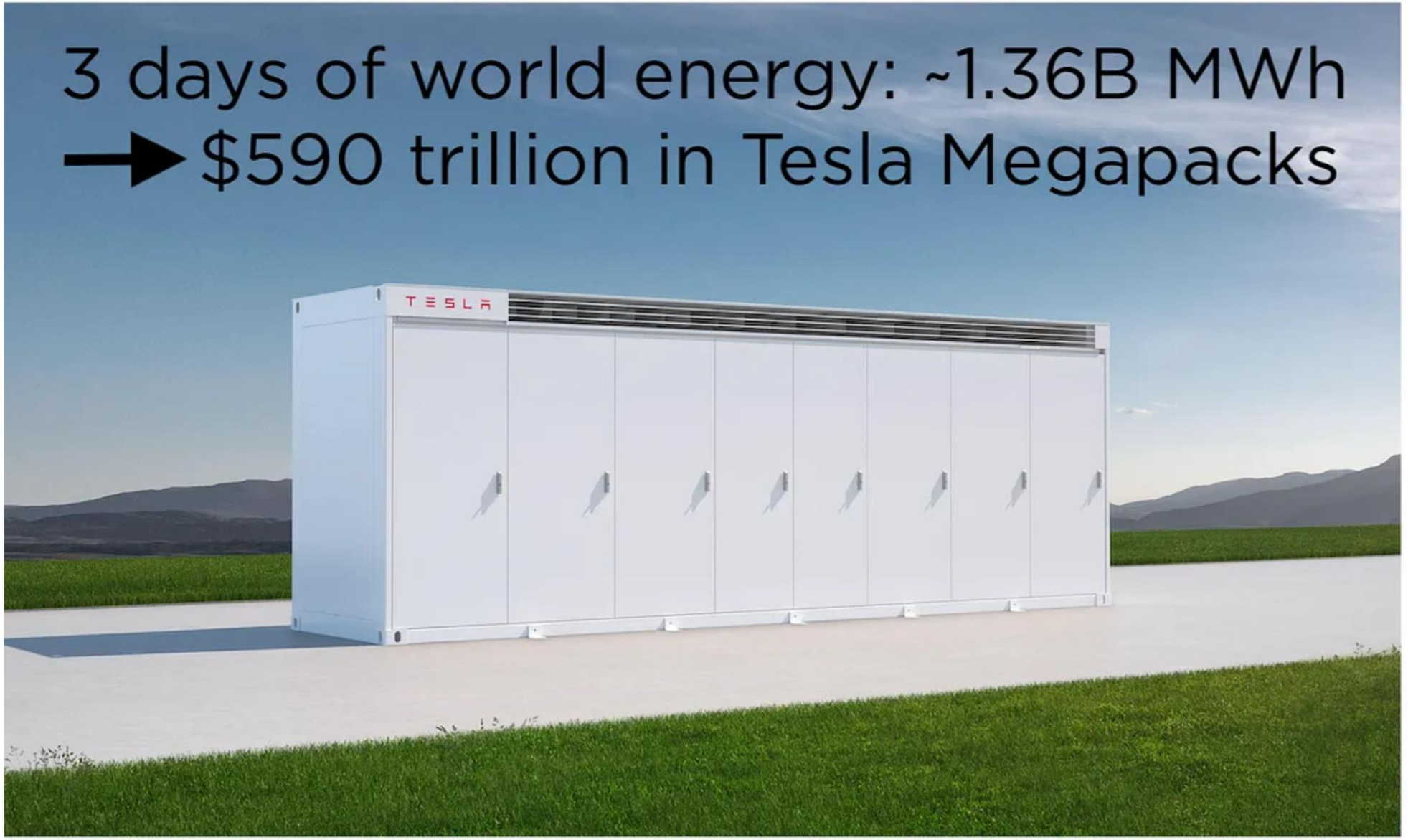
**250 million MWh for Contiguous 48 States**

# Battery Backup for NZE U.S. Grid

## 250 million MWh for Contiguous 48 States




Adapted from Astronomical battery cost looms over “renewables”; CFACT 15Dec22, David Wojick




## Select Megapack

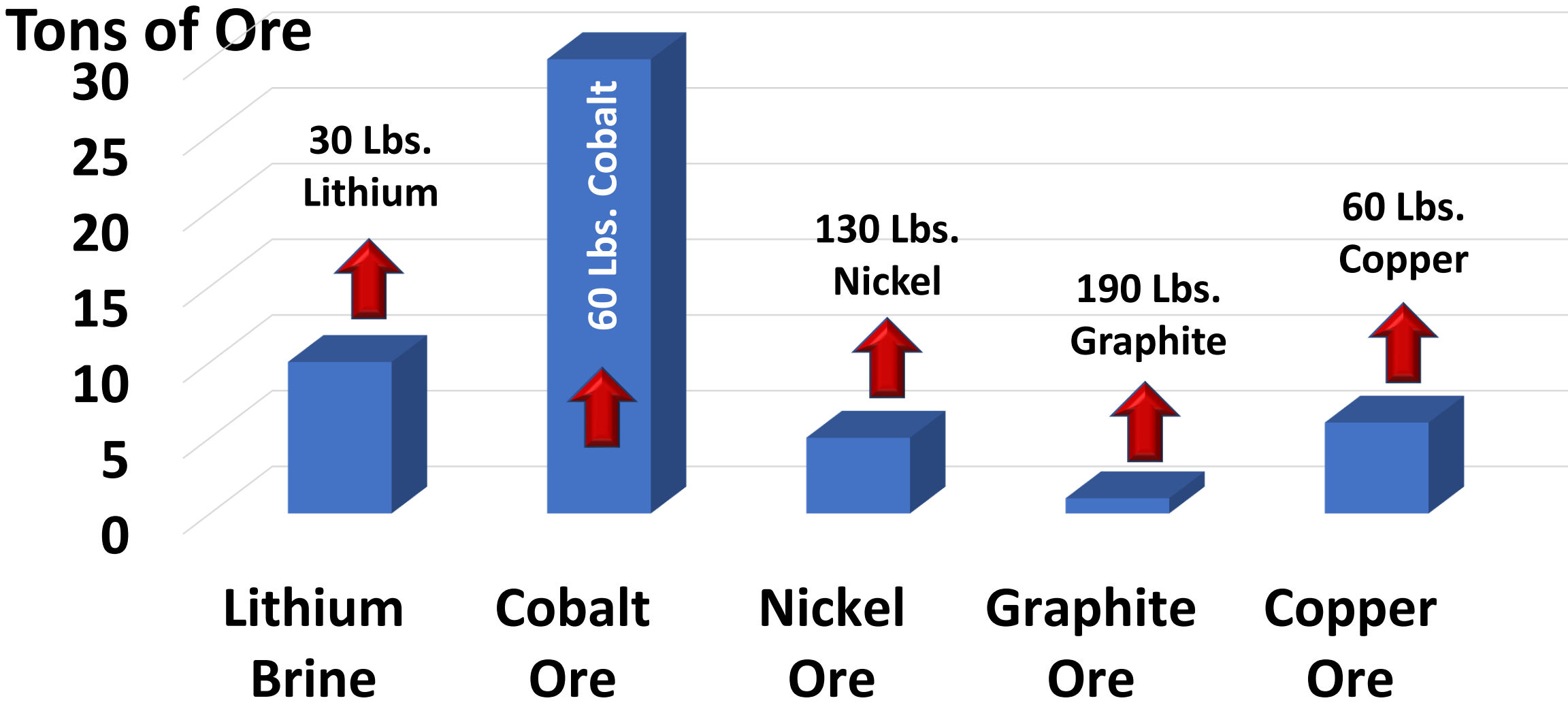
Megapack enables low-cost, high-density commercial and utility projects at large scale. It ships ready to install with fully integrated battery modules, inverters, and thermal systems. View Product Details

| 969.6 MW | 3916 MWh |
|---|---|
| Power | Energy |

| | |
|---|---|
| Megapack Quantity | 1000 |
| Megapack Duration | 2 hr / 4 hr |
| Include Installation (Learn More) | Yes / No |
| Site Location | California |
| Desired Delivery Date | Q4 2024 |
| Estimated Price (Subject to change, taxes not included) | $1,702,568,070 |
| Est. Annual Maintenance (Price escalates at 2% per year) | $4,821,480 |
| Due Today (Non-refundable Reservation Deposit) | $1,000 |

Alex Epstein [Refuting the myth that just a small area of solar panels plus storage can power the world (substack.com)]

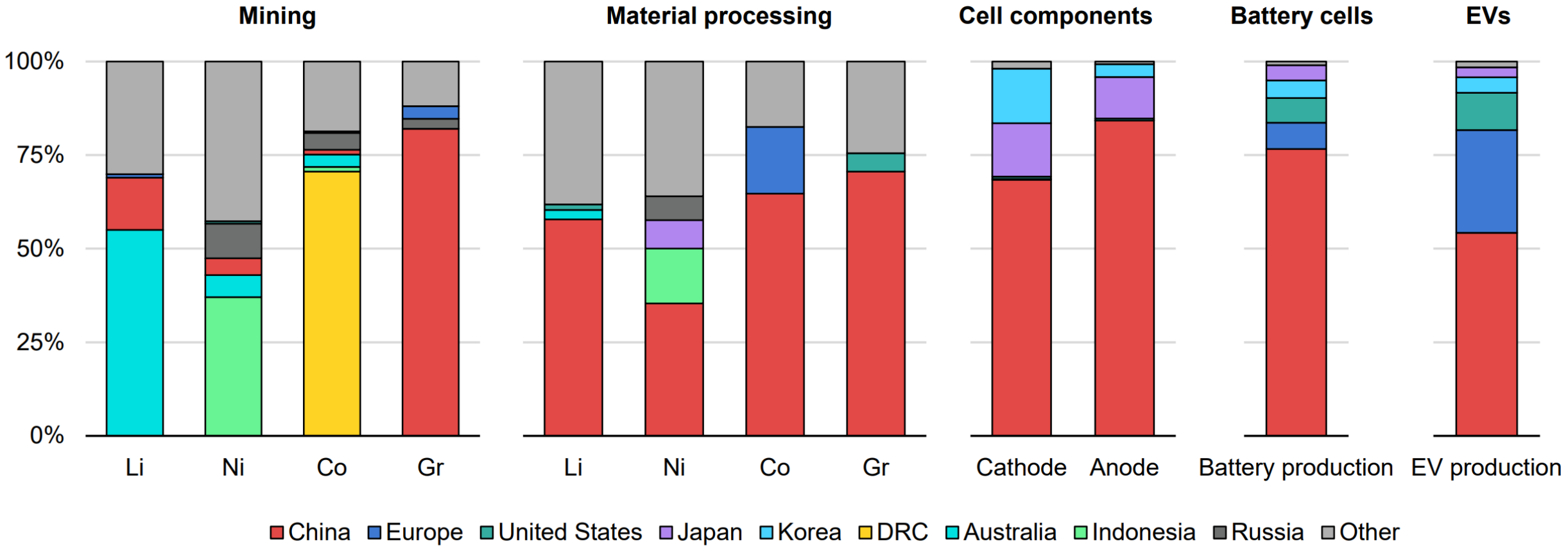
# 227 Tons of Earth* per 1,000 Lb. EV Battery




* Includes overburden removal

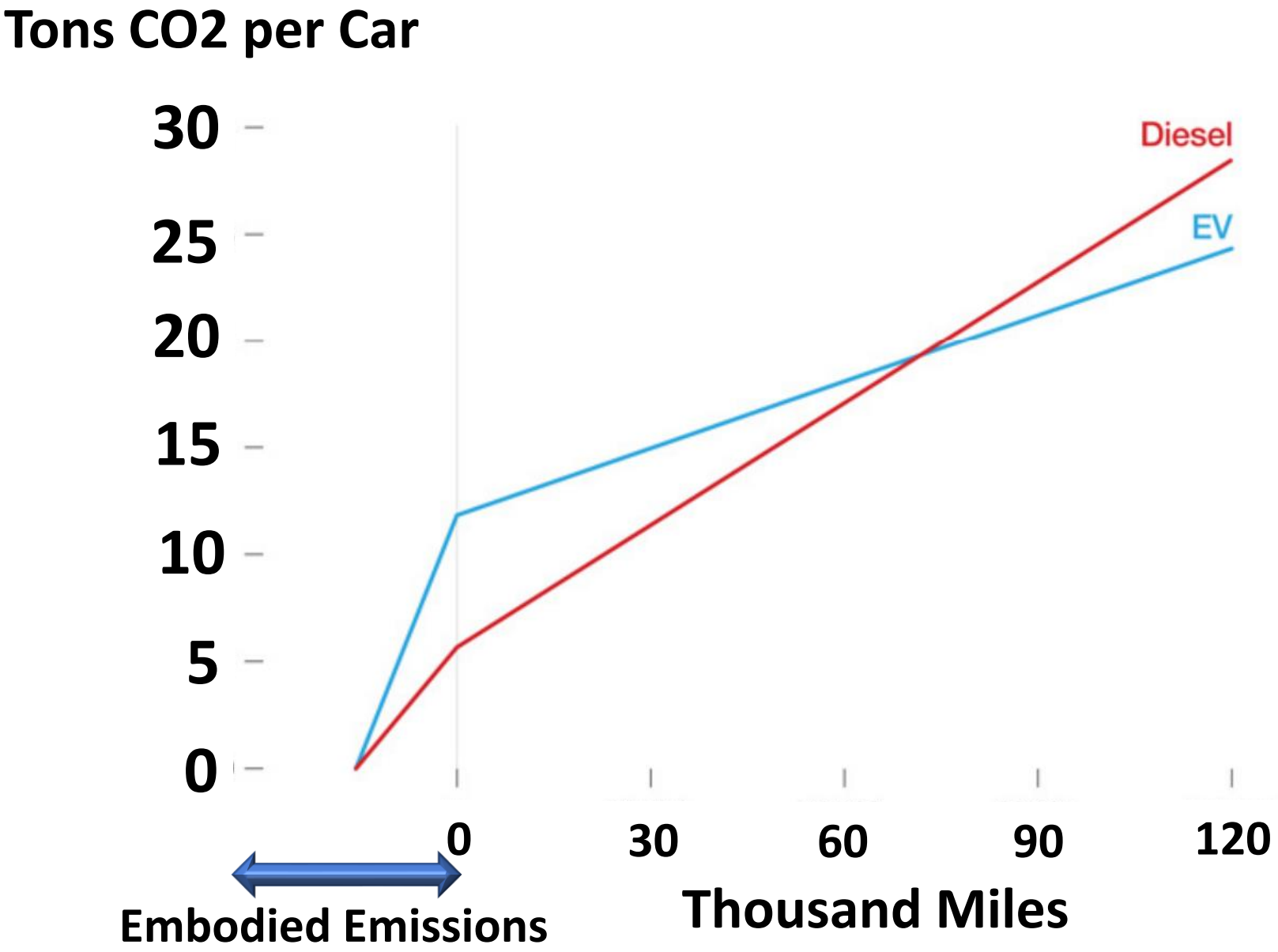
# China Dominates the EV Battery Supply Chain

Geographical distribution of the global EV battery supply chain




[Global Supply Chains of EV Batteries (windows.net)]

# Miles Driven Before an EV Emits Less CO2 than a Diesel Car




Adapted from “Energy Transition” Delusion: A Reality Reset Mark P. Mills

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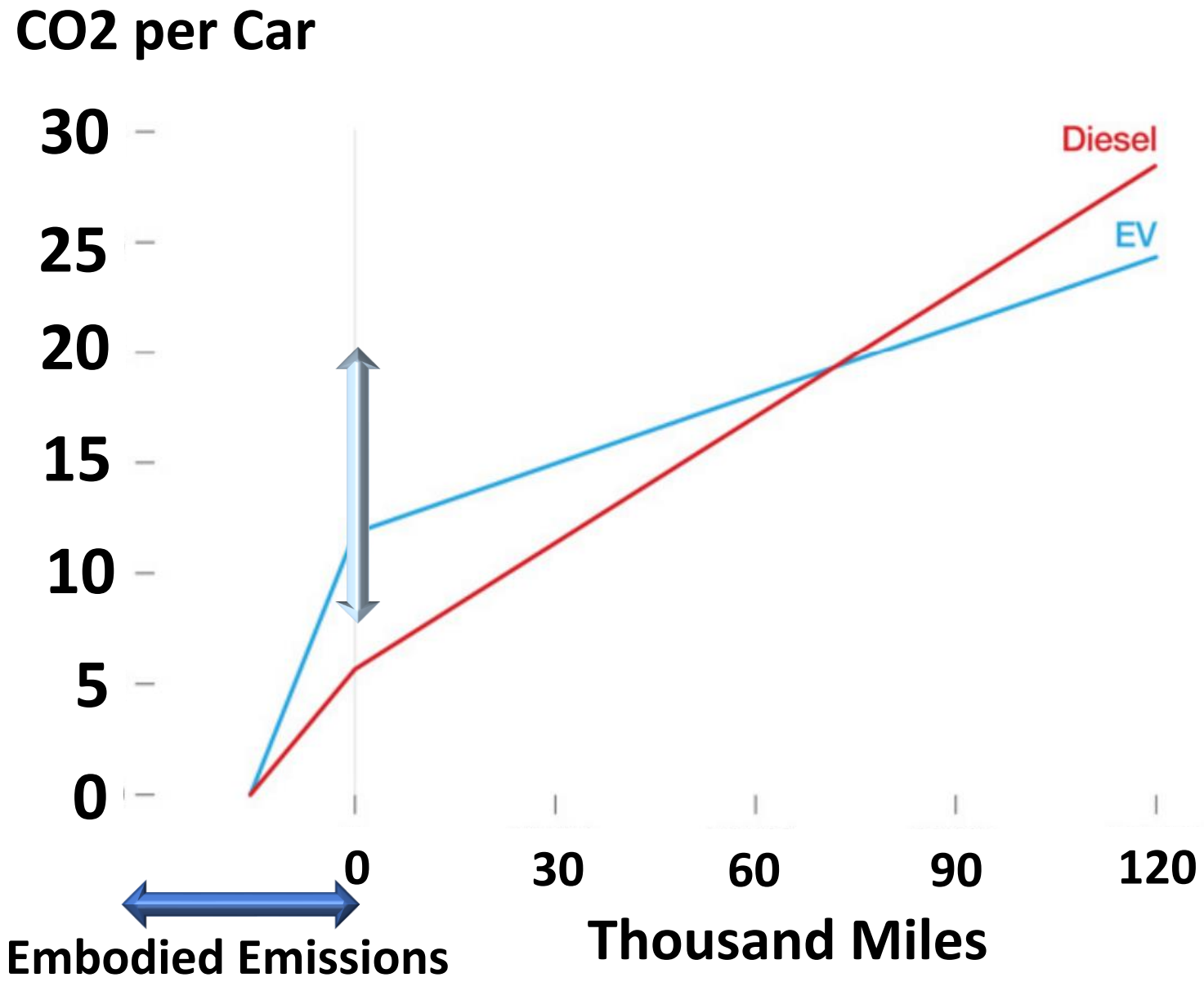


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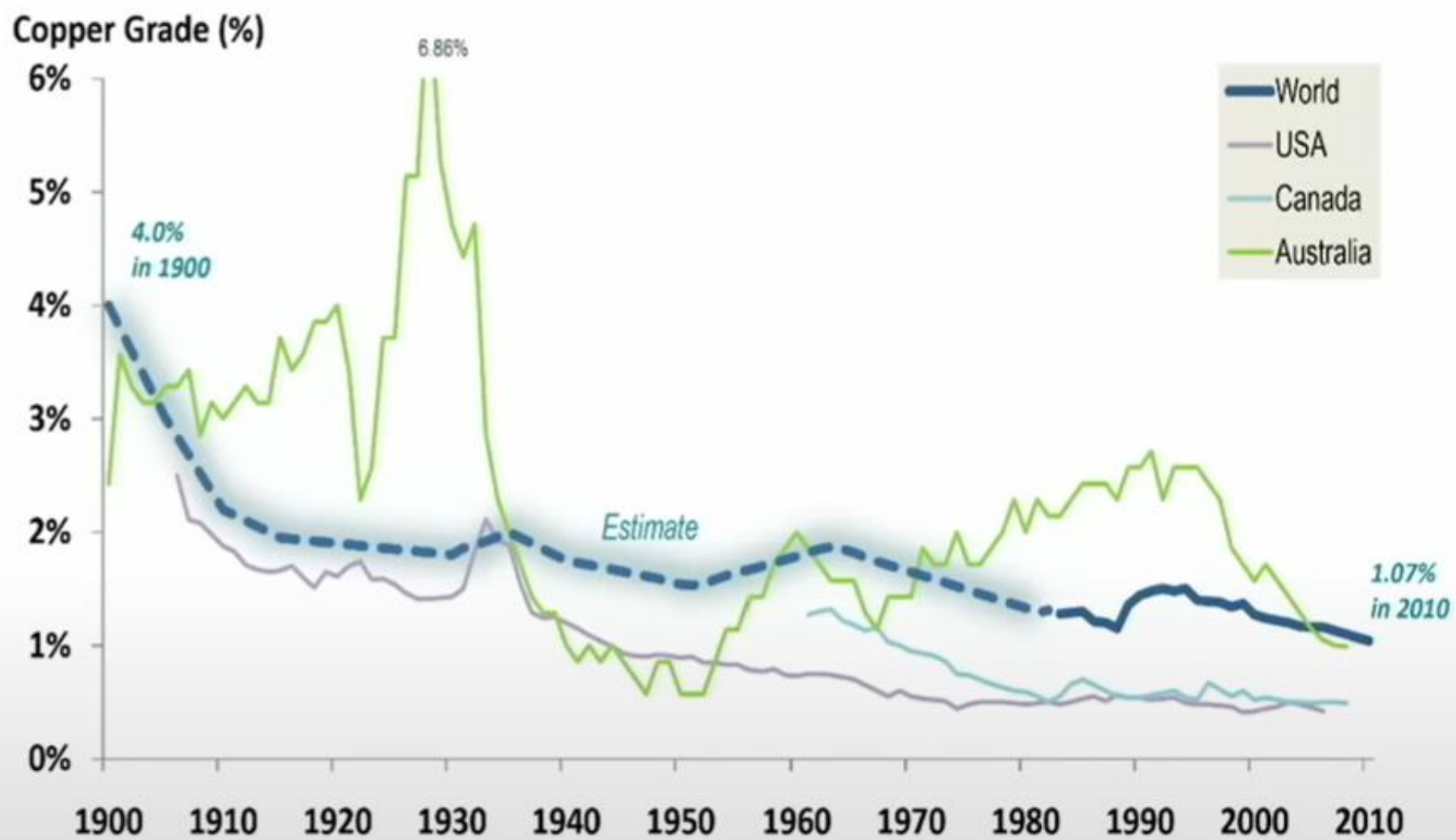
# Iron Law of Declining Metal Ore Grades




Mark Mills: The energy transition delusion: inescapable mineral realities - YouTube

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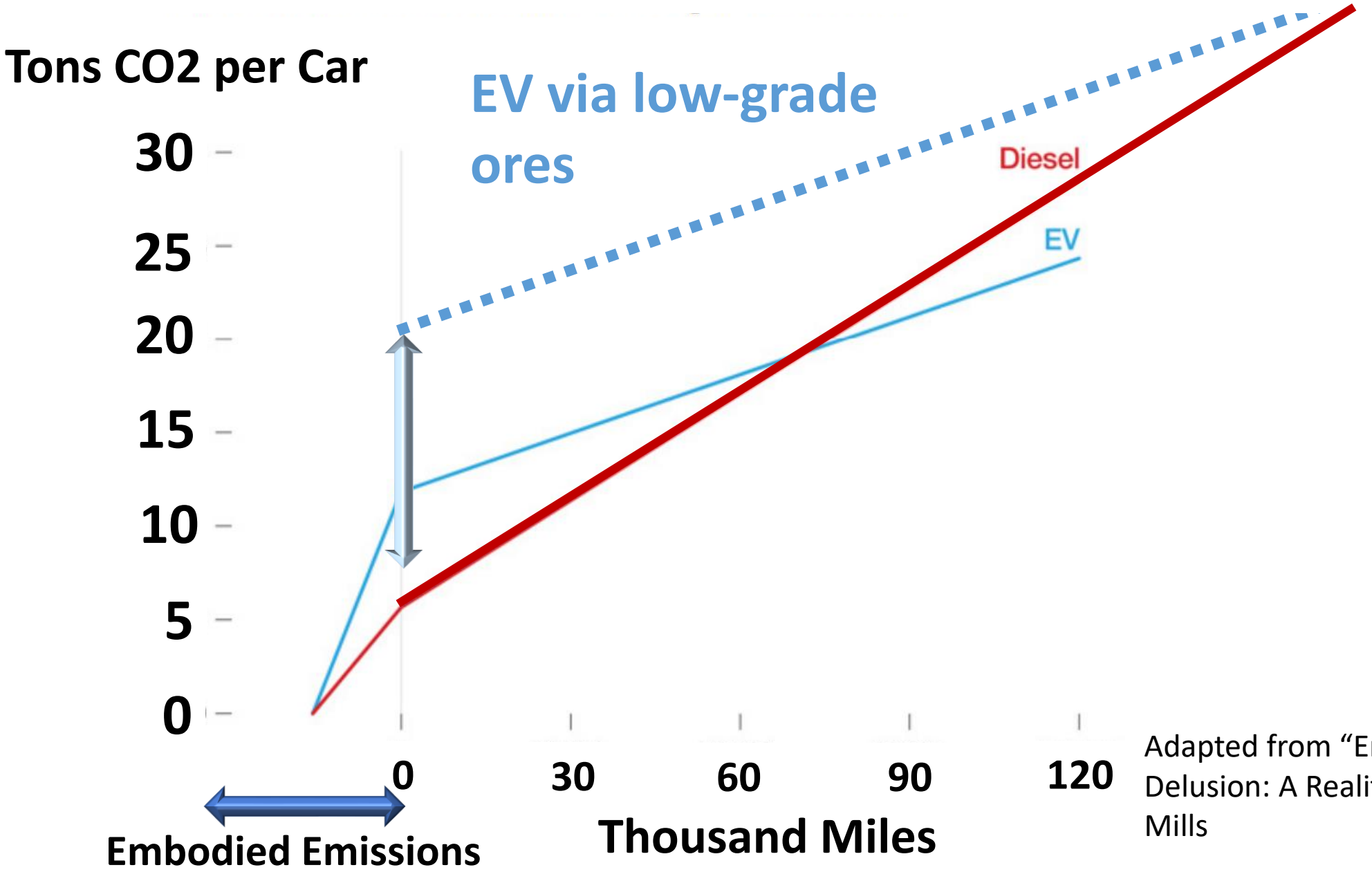


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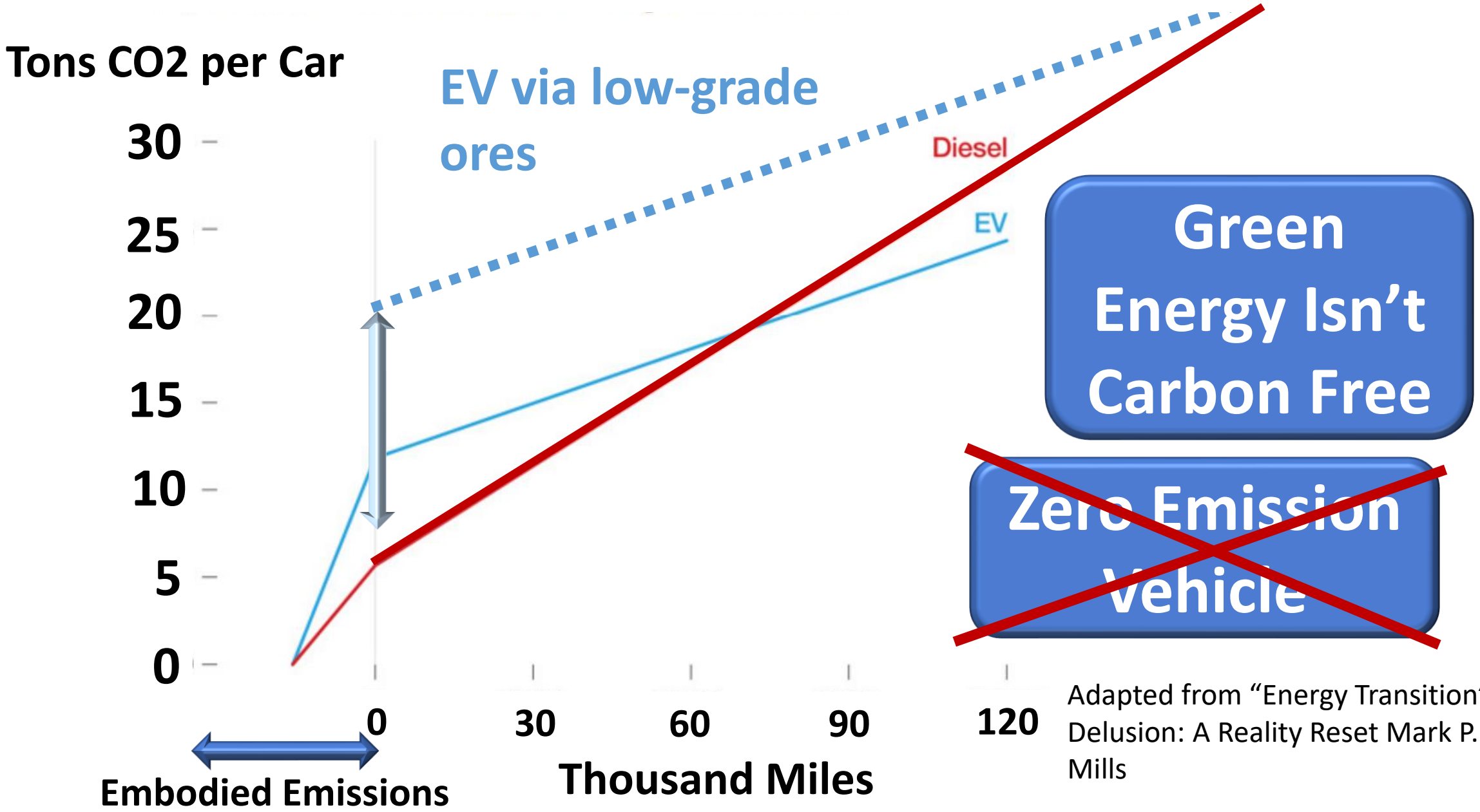



Green Energy Isn't Carbon Free

~~Zero Emission Vehicle~~

Adapted from "Energy Transition" Delusion: A Reality Reset Mark P. Mills

# Wrenches in the Net Zero Machinery

**Surging coal demand**

# 277 GW New Coal Power Capacity

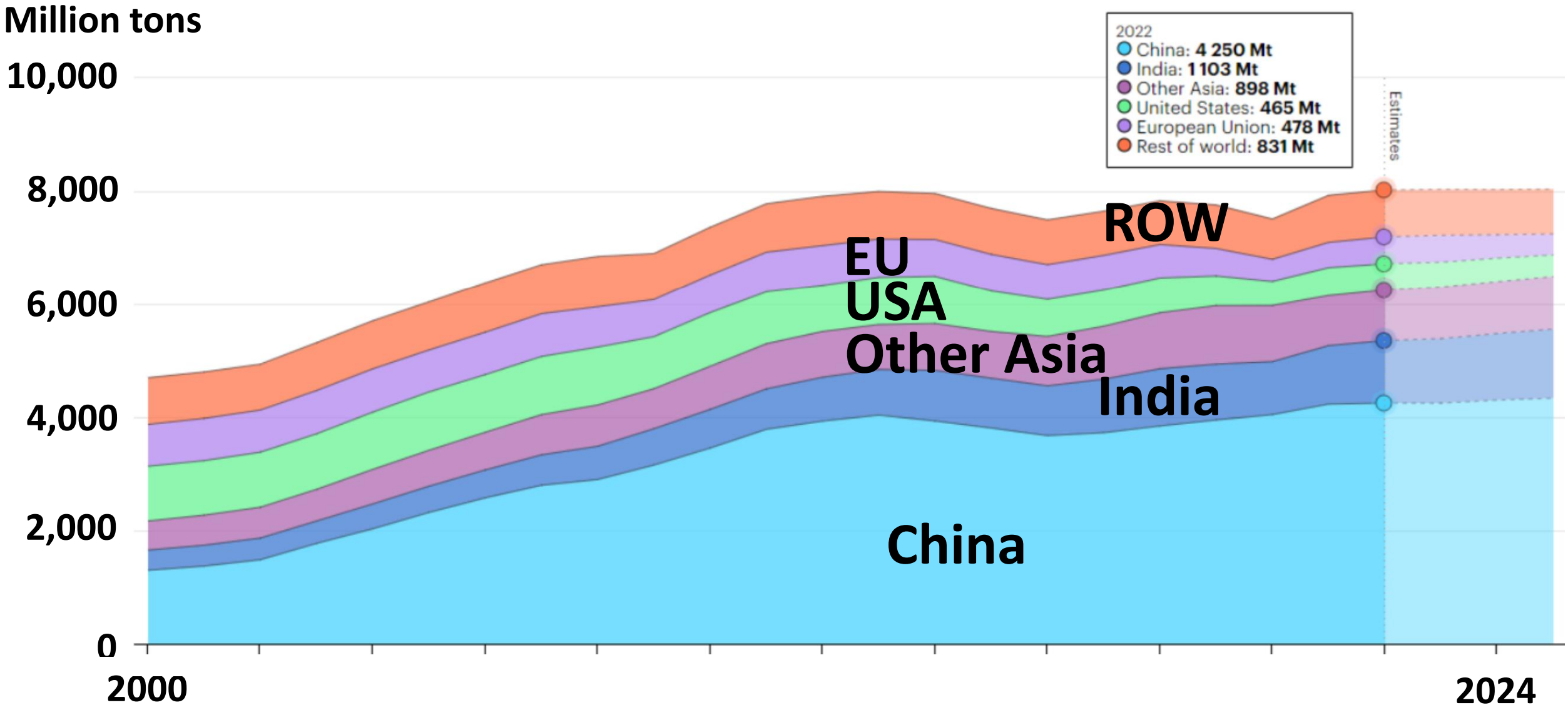

Global Energy Monitor

# 277 GW New Coal Power Capacity


Global Energy Monitor

# Global coal consumption, 2000-2025

Last updated 16 Dec 2022



# Wrenches in the Net Zero Machinery

## Europe's energy security wakeup call

# Wrenches in the Net Zero Machinery

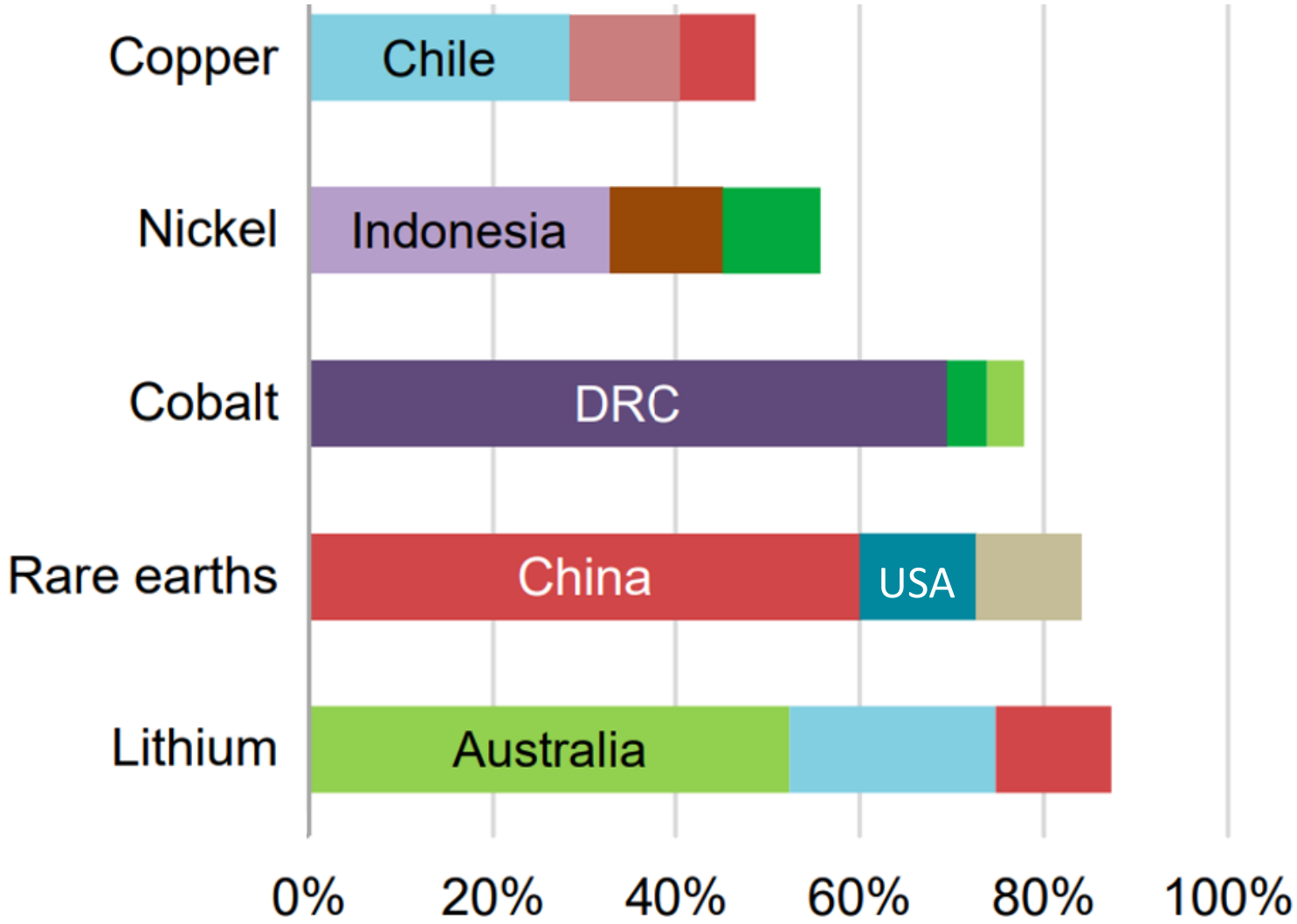
**Disrupted supply of key materials**

# Vulnerabilities of Critical Materials Supply for Net Zero

- **High geographical concentration of production**

# Energy Transmission Materials, 2019

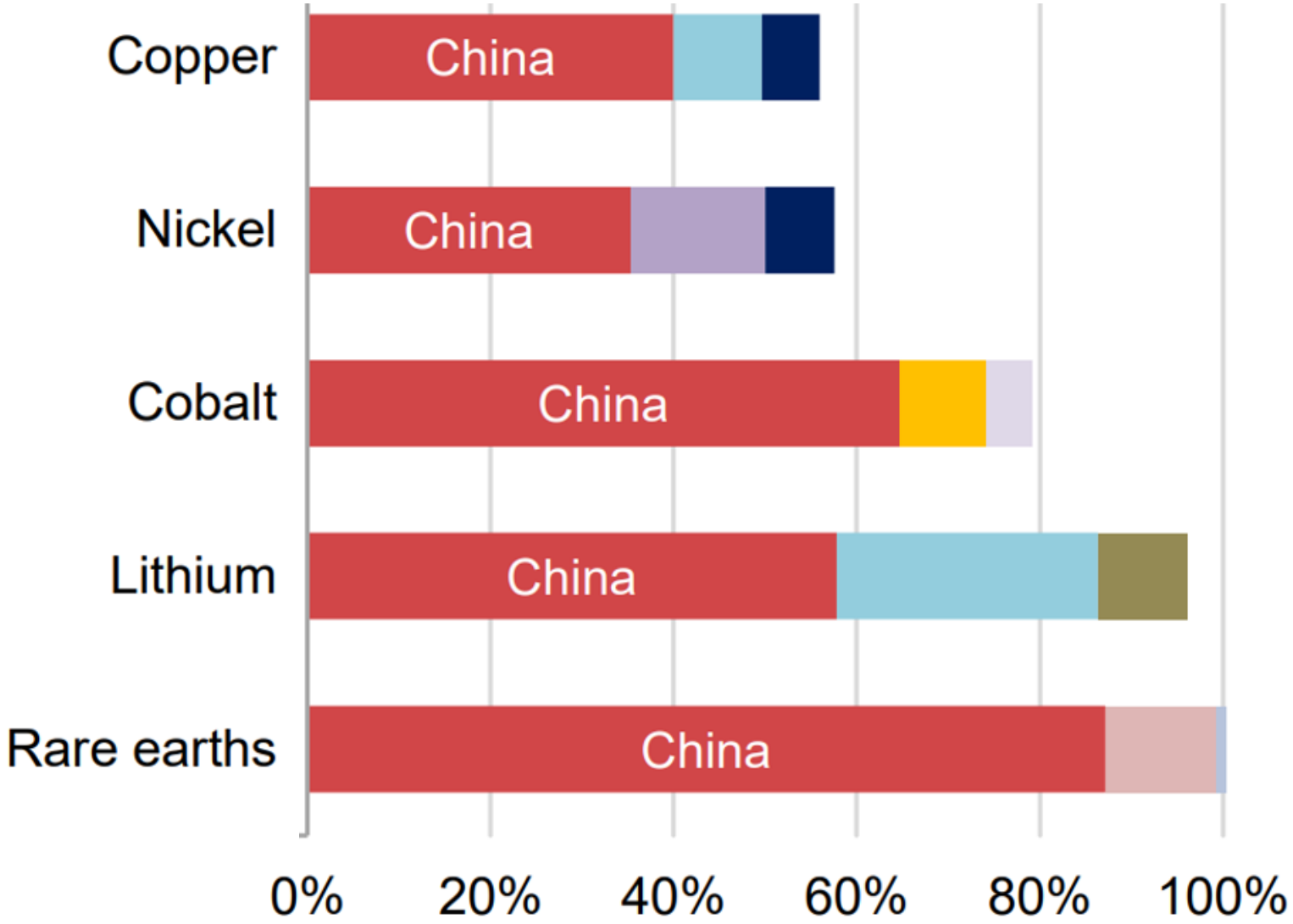
Extraction




International Energy Agency

# Energy Transmission Materials, 2019

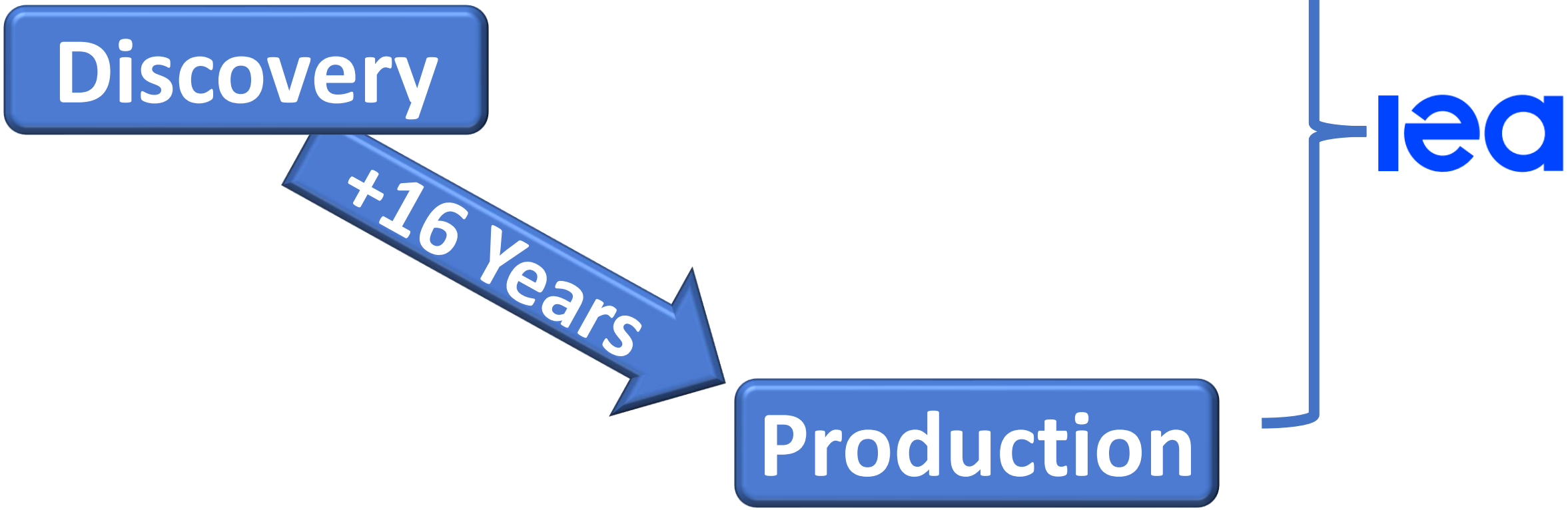
Processing




International Energy Agency

# Vulnerabilities of Critical Materials Supply for Net Zero

- High geographical concentration of production
- Long project development lead times



# Vulnerabilities of Critical Materials Supply for Net Zero

- High geographical concentration of production
- Long project development lead times
- Declining resource quality
- Growing scrutiny of environmental and social performance
- Higher exposure to climate risks

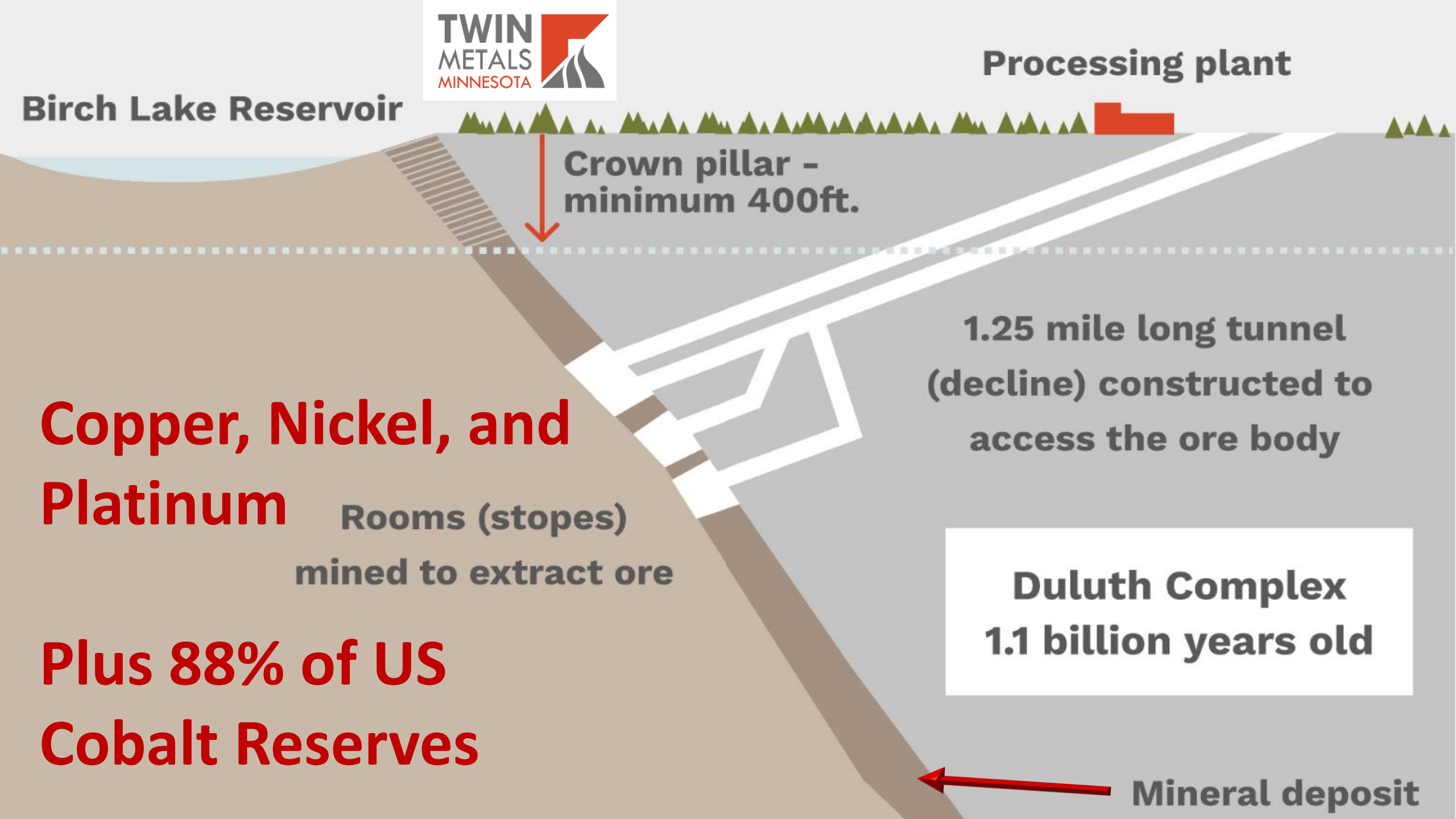
# Vulnerabilities of Critical Materials Supply for Net Zero

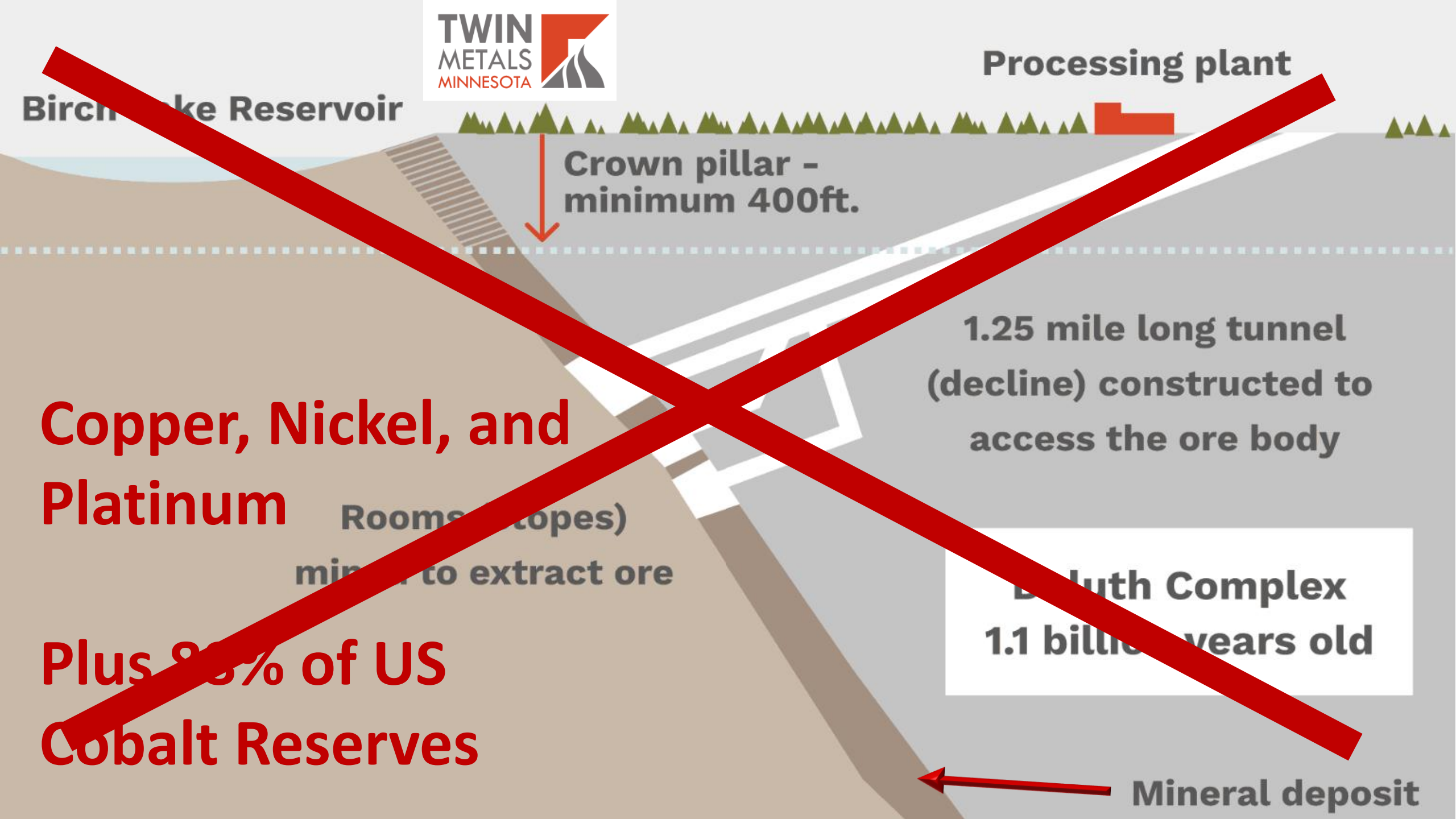
- High geographical concentration of production
- Long project development lead times
- Declining resource quality
- Growing scrutiny of environmental and social performance
- Higher exposure to ~~climate risks~~ weather disruption (water stress, floods)

# Vulnerabilities of Critical Materials Supply for Net Zero

- High geographical concentration of production
- Long project development lead times
- Declining resource quality
- Growing scrutiny of environmental and social performance
- Higher exposure to weather disruption
- Security of mineral supply
- Recycling, e.g. spent batteries, turbine blades


- Not in my backyard, e.g., USA


TWIN METALS MINNESOTA
Processing plant
Birch Lake Reservoir
Crown pillar - minimum 400ft.
1.25 mile long tunnel (decline) constructed to access the ore body
Copper, Nickel, and Platinum
Rooms (stopes) mined to extract ore
Duluth Complex 1.1 billion years old
Plus 88% of US Cobalt Reserves
Mineral deposit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ENERGY · **Published** January 26, 2023 5:53pm EST

# Biden admin issues 20-year mining ban as it turns to foreign supply chain amid green energy push

Artisanal miners work at a cobalt mine in the Democratic Republic of the Congo on Oct. 12, 2022. (Junior Kannah / AFP via Getty Images)

# UNICEF Estimates 40,000 Children Work in Congo Cobalt Mines

- DRC 72% World's reserves
- ~30% Artisanal mined
- Children $1 to $2 per day

ioneer

CENTER *for* BIOLOGICAL DIVERSITY

# Rhyolite Ridge Lithium-Boron Project

# Tiehm's buckwheat

Source: Nevada Natural Heritage Program

Bloomberg Law

# Wrenches in the Net Zero Machinery

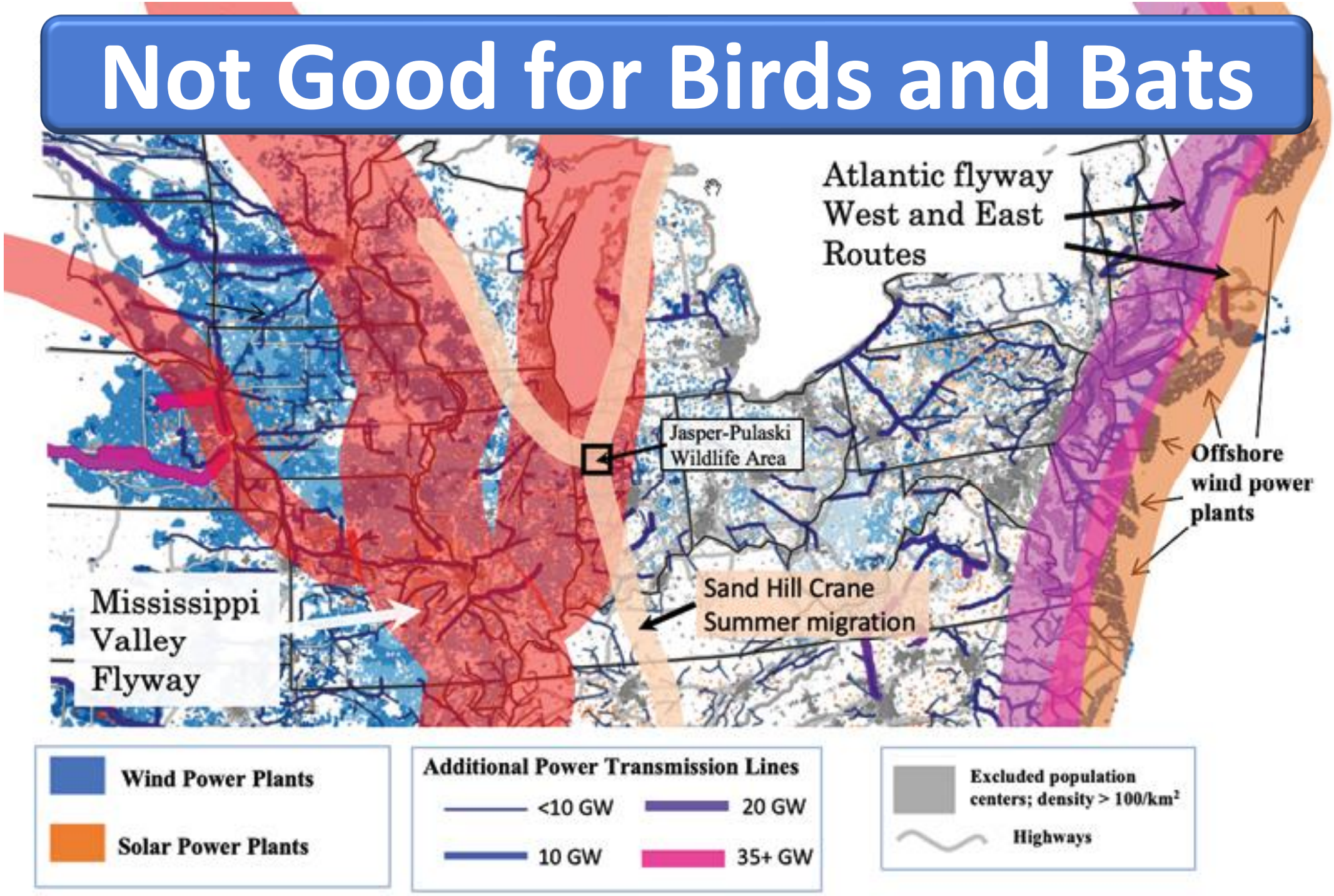
**Public awareness, (less censoring?)**

# Wrenches in the Net Zero Machinery

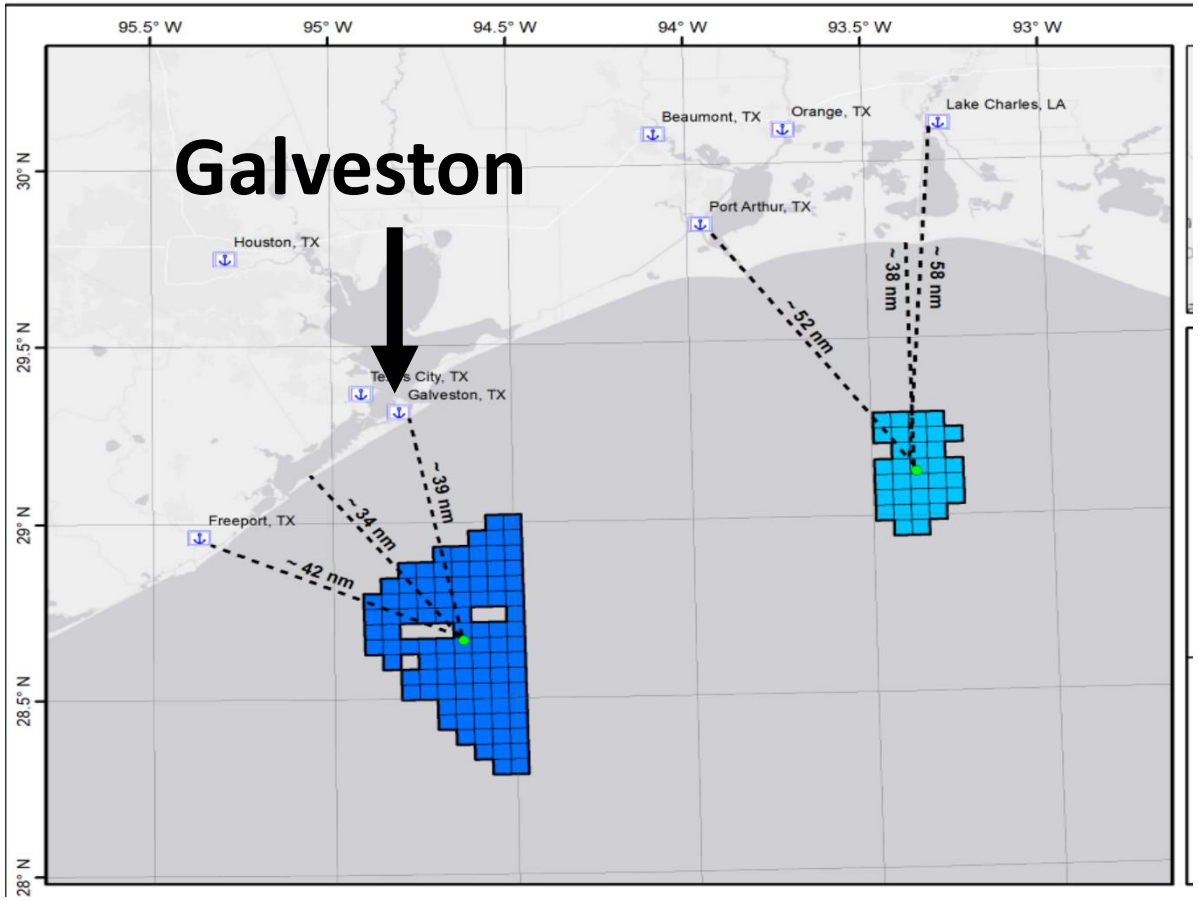
NIMBY

Green vs. Green

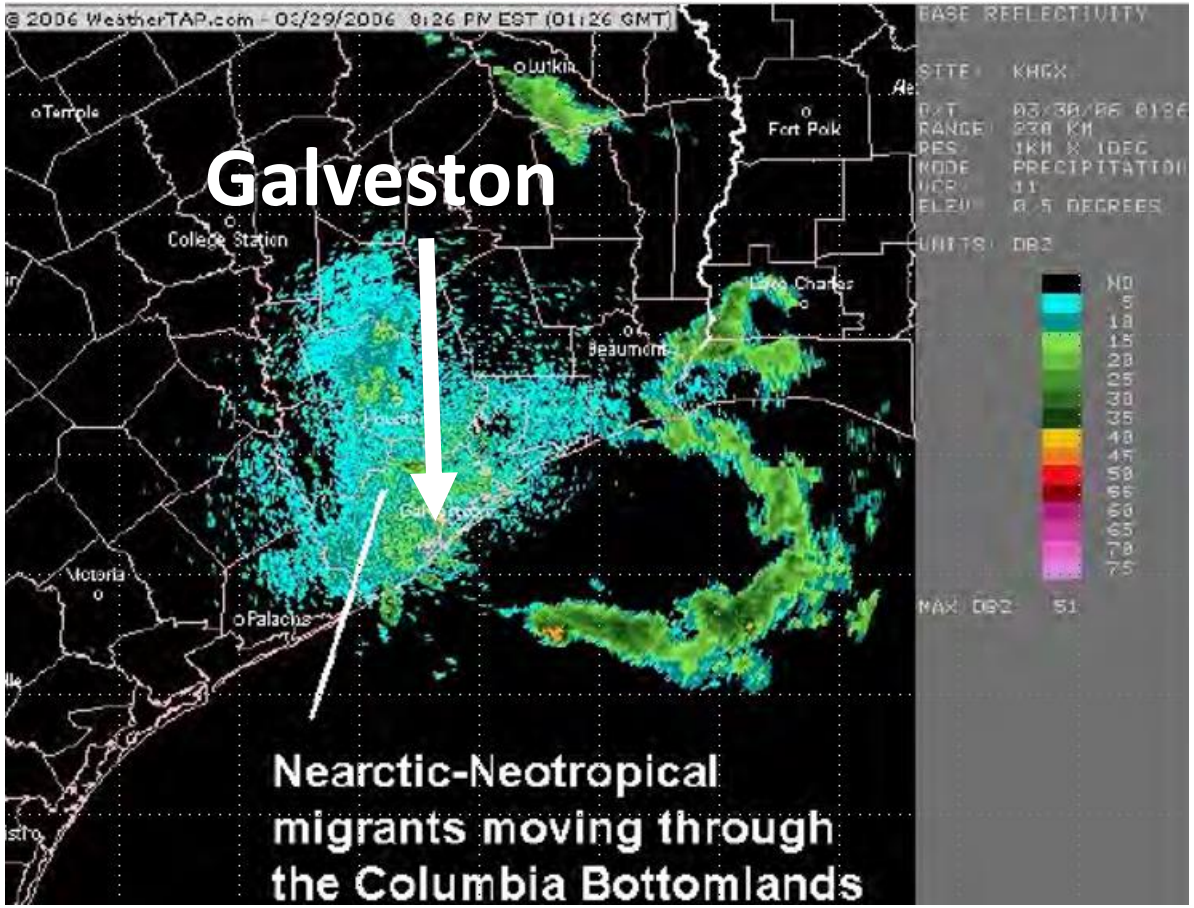
# Not Good for Birds and Bats



# BOEM Gulf of Mexico Wind Farm Areas




# Doppler Radar of Spring Bird Migration



# USF&WS Declines to Enforce Regulations

"For golden eagles, a goal of the 2016 Eagle Rule was to increase compliance and improve consistency and efficiency relating to permitting golden eagle take at wind-energy projects. However, those goals have not been realized. While participation in the permit program by wind energy projects has increased since 2016, it still remains well below our expectations. Low application rates and permit-processing requirements that some have perceived as burdensome have resulted in few permits being issued for wind projects as compared to the number of operational wind projects in areas where golden eagles occur. As a result, golden eagles continue to be taken without implementation of conservation actions to offset that take."

How much wind killing do we want? - CFACT

# USF&WS Declines to Enforce Regulations

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How much wind killing do we want? - CFACT

# Not Good for Whales

Right Whale Migration Route

Offshore wind power plants

Right Whale Migration Route

Wind Power Plants

Solar Power Plants

Additional Power Transmission Lines

<10 GW

20 GW

10 GW

35+ GW

Excluded population centers; density > 100/km²

Highways

The Washington Post
Democracy Dies in Darkness

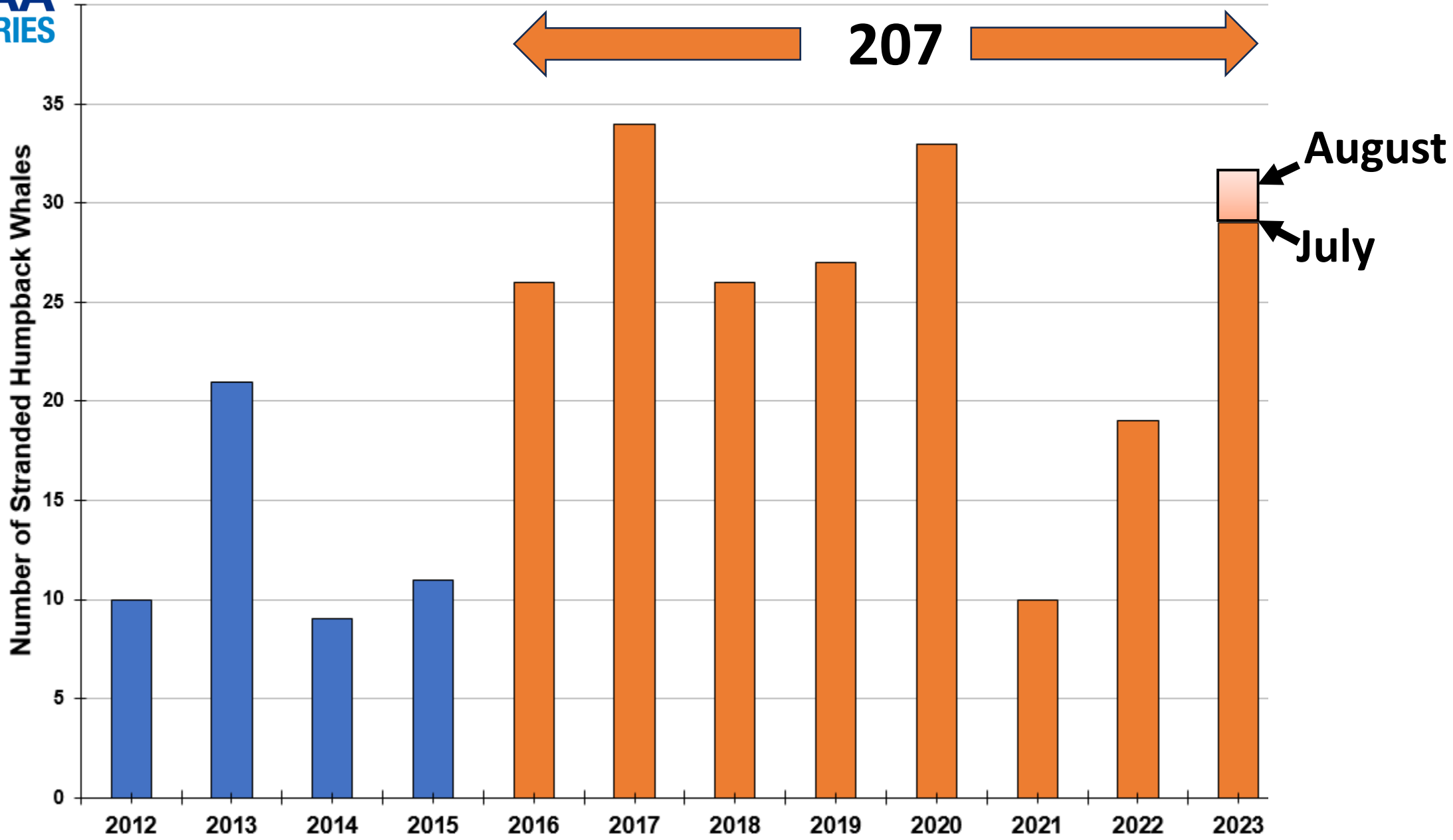
January 25, 2023 at 8:00 a.m. EST

# Dead whales and tough economics bedevil Biden's massive wind energy push

People stand next to a dead humpback whale that washed up on the beach in Brigantine, N.J., this month. (Rachel Wisniewski/Reuters)

NOAA FISHERIES

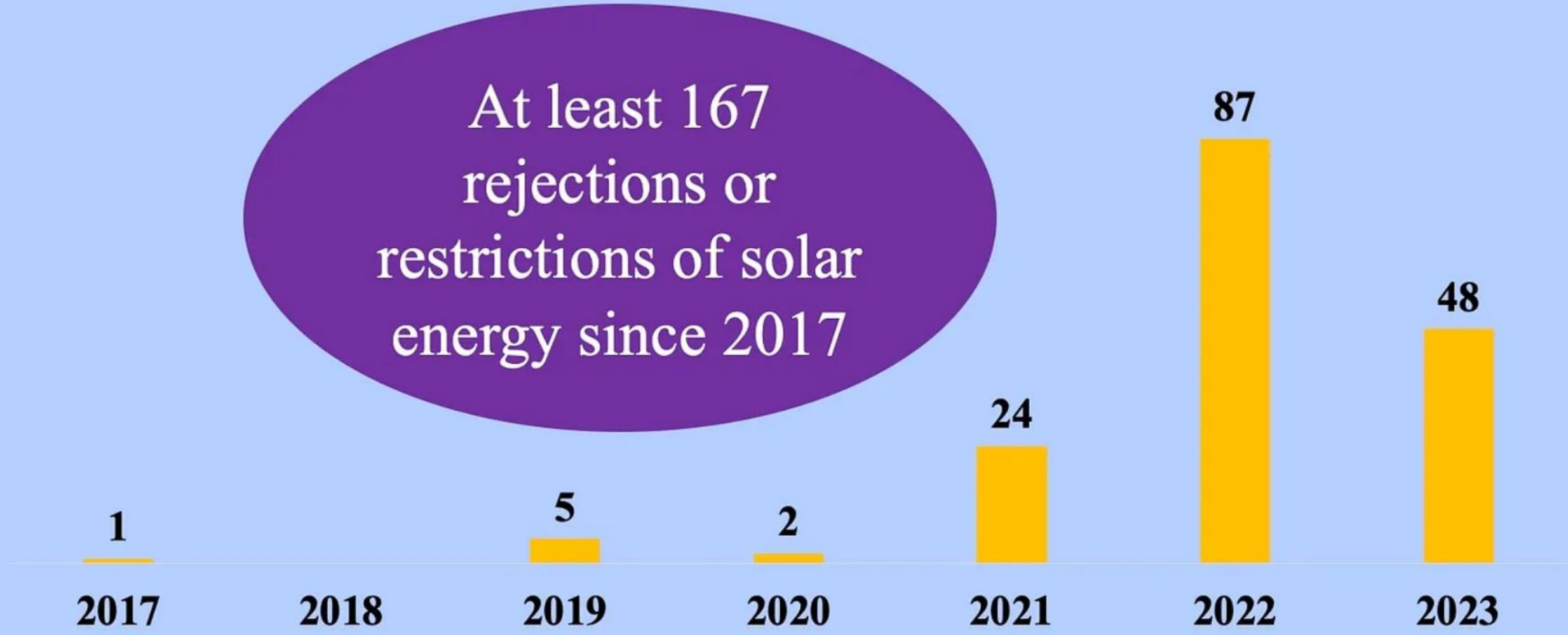
# Annual Humpback Whale Strandings from Maine to Florida



# US Wind Energy Rejections, 2015 to 2023


Source: Renewable Rejection Database

# US Solar Energy Rejections, 2017 to 2023




Source: Renewable Rejection Database

# Wrenches in the Net Zero Machinery

**>>$28T USA**

# Wrenches in the Net Zero Machinery

**W & S Farms $3.5 Trillion**

**HV Transmission $1.5 Trillion**

**Battery Backup >>$23Trillion**

# How Much Would It Cost to Reduce Global Warming? $131 Trillion Is One Answer

WSJ

# Wrenches in the Net Zero Machinery

**NZE $275 Trillion for physical assets, 2021 to 2050**

**“The cost will not be net zero”**

McKinsey & Company

# Wrenches in the Net Zero [illegible]inery

The impact on Global Temperature will be ~zero
With a negative impact on the environment

[illegible] 2050

"Th[illegible]ll not be net zero"

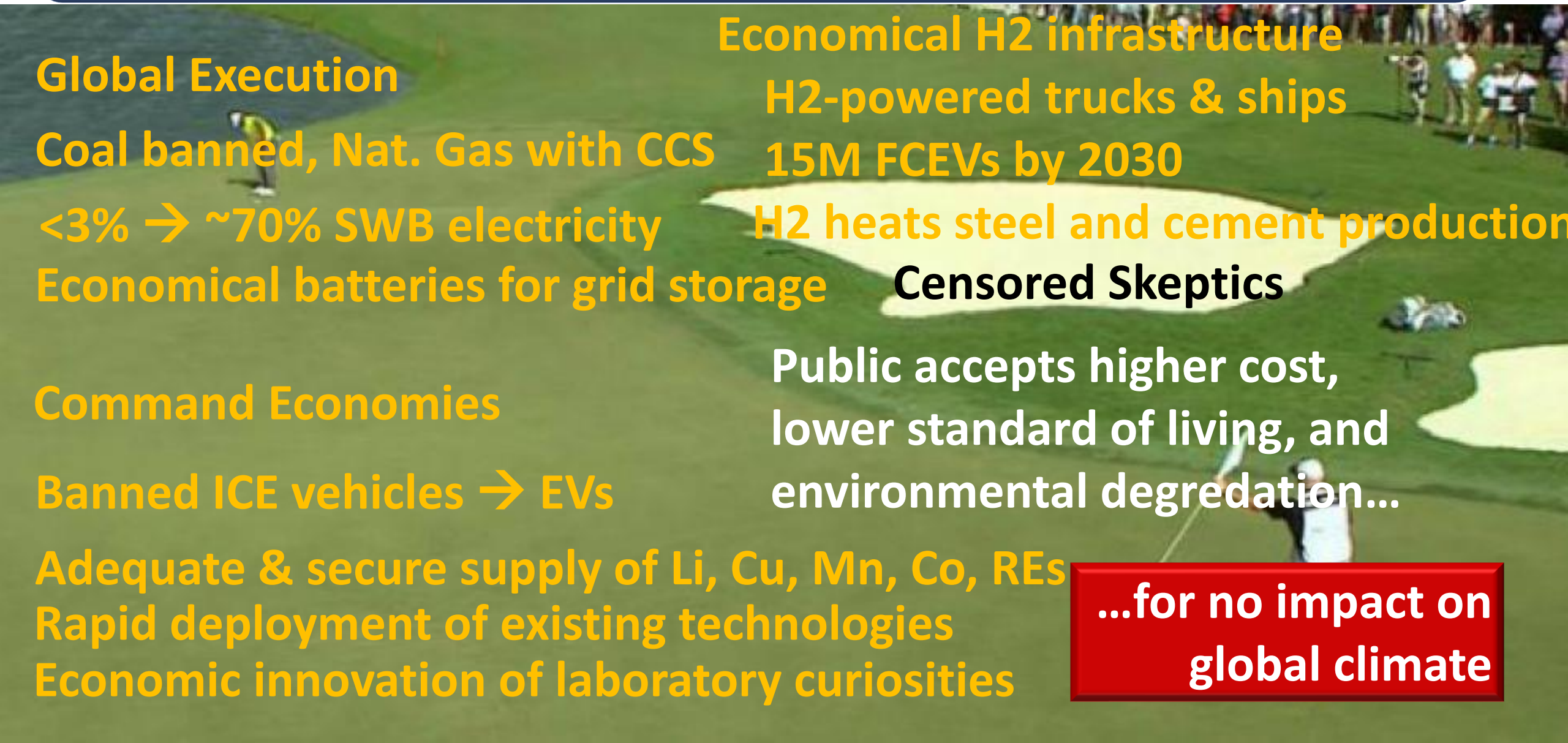
McKinsey & Company

# Wrenches in the Net Zero Machinery

**West Virginia vs. EPA 30Jun22**

**Unambiguous Congressional instruction required for Executive regulations having national impact.**

# The "Long Putts" of Net Zero



Global Execution

Coal banned, Nat. Gas with CCS

<3% → ~70% SWB electricity

Economical batteries for grid storage

Economical H2 infrastructure

H2-powered trucks & ships

15M FCEVs by 2030

H2 heats steel and cement production

Censored Skeptics

Command Economies

Banned ICE vehicles → EVs

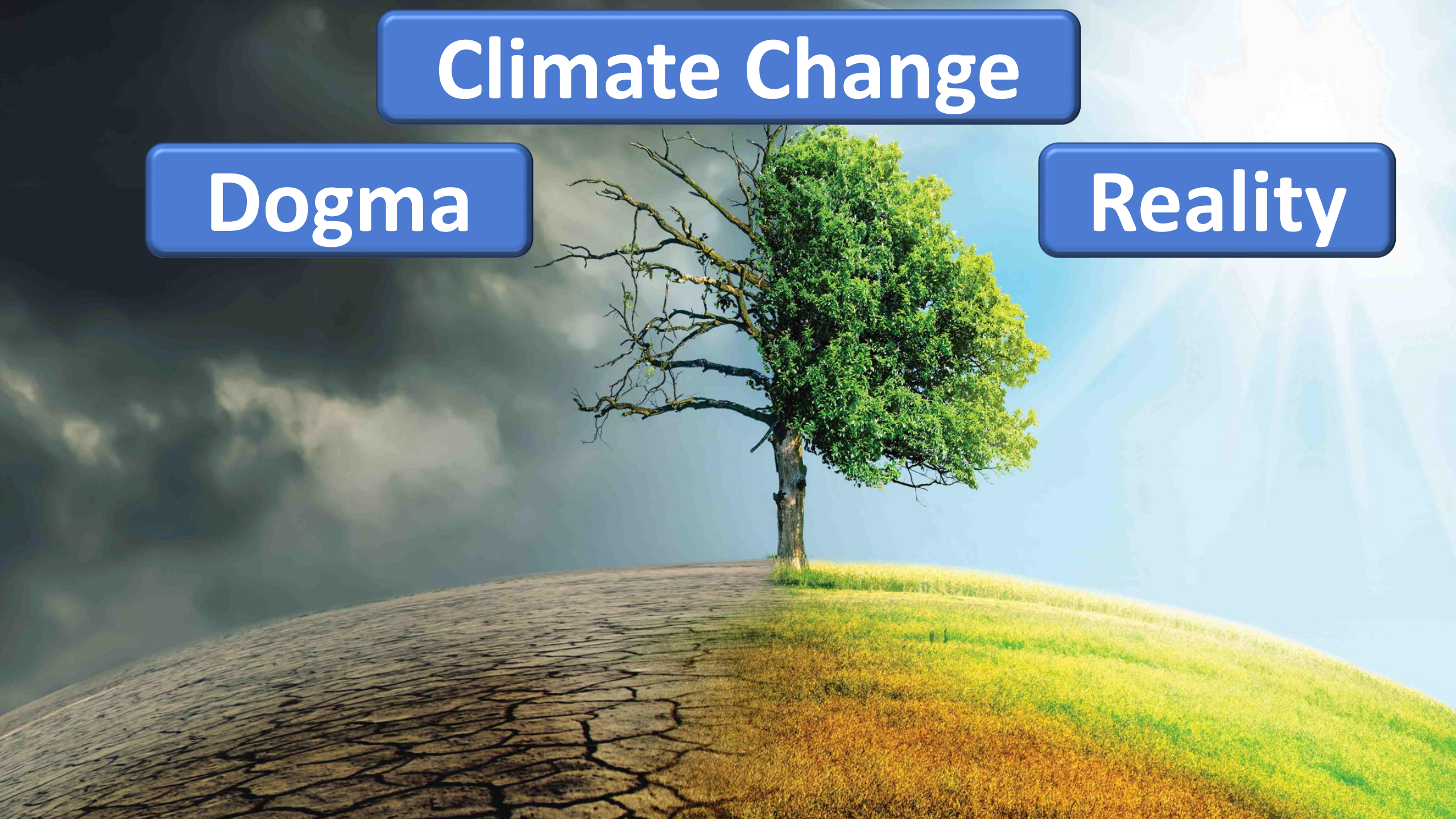
Public accepts higher cost, lower standard of living, and environmental degredation…

Adequate & secure supply of Li, Cu, Mn, Co, REs

Rapid deployment of existing technologies

Economic innovation of laboratory curiosities

…for no impact on global climate


Climate Change
Dogma
Reality

# Oil, Natural Gas, & Coal

## Dogma

## Reality

# References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- Environmental footprint at the Volkswagen Group (volkswagenag.com)
- The tough calculus of emissions and the future of EVs | TechCrunch
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- Rare Earth Permanent Magnets Supply Chain Deep Dive Assessment U.S. Department of Energy EERE Technical Report Template (energy.gov)
- Biden admin issues 20-year mining ban as it turns to foreign supply chain amid green energy push | Fox News
- The Environmentalist Assault on Civilization › American Greatness (amgreatness.com)