

PES ISGT Conference, Singapore  
02 November 2022

Keynote Speech

# Challenges and Opportunities of Decarbonization in the Global Electric Power Sector

**Prof. Saifur Rahman**

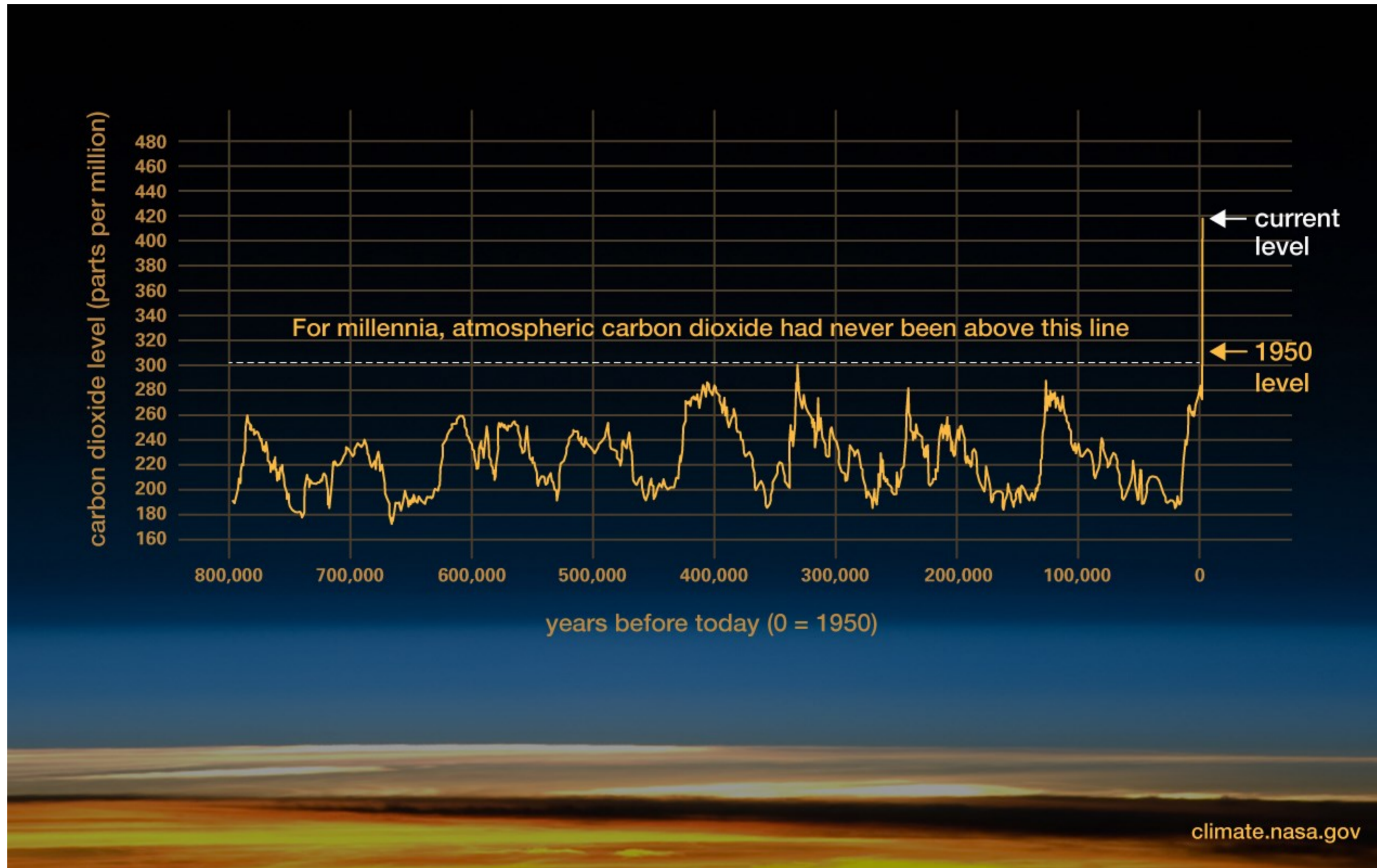
2022 IEEE  
President-elect



Director, Virginia  
Tech Advanced  
Research Inst., USA

What is Carbonization ?

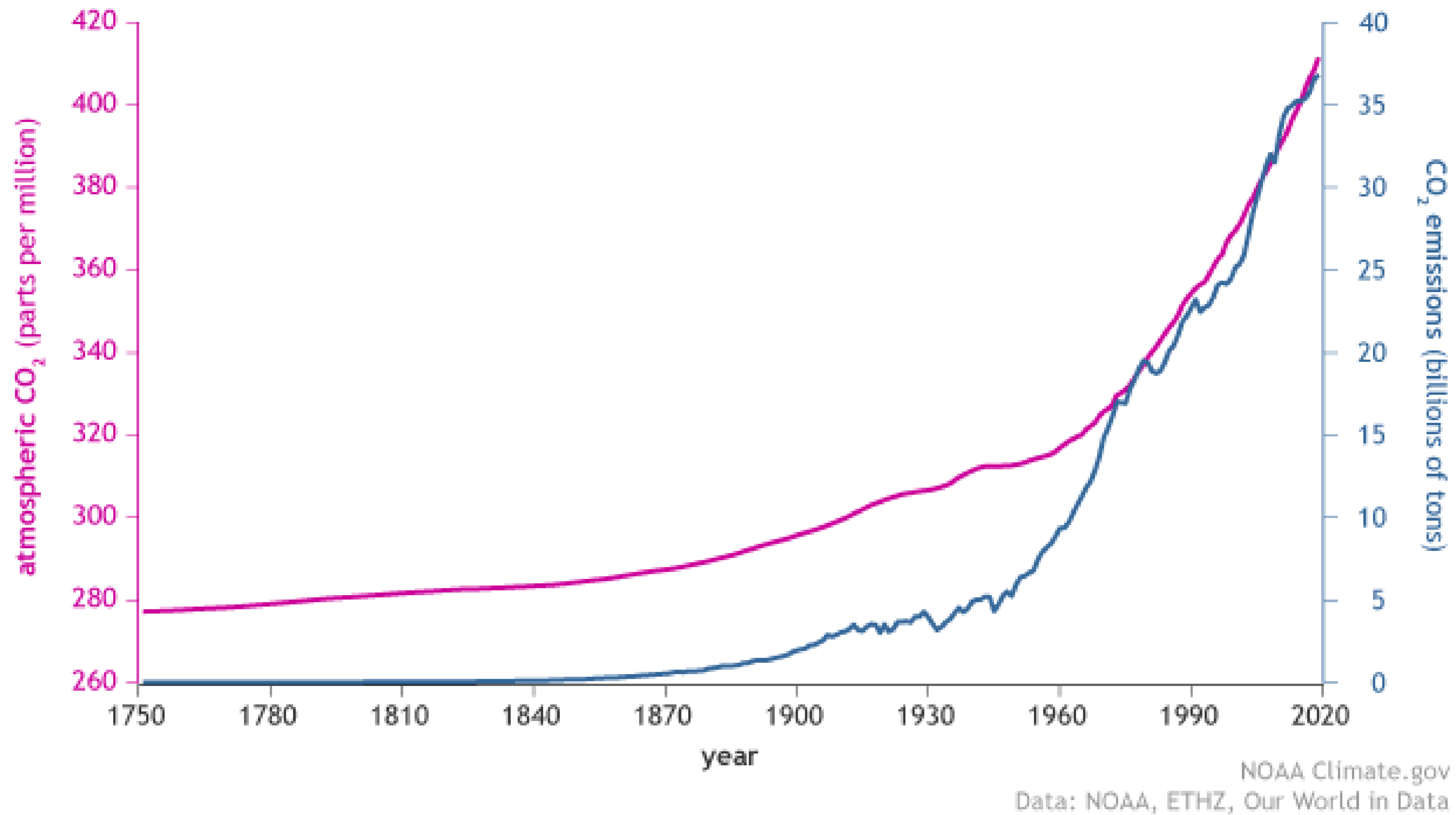




Source: NASA

[https://climate.nasa.gov/climate\\_resources/24/graphic-the-relentless-rise-of-carbon-dioxide/](https://climate.nasa.gov/climate_resources/24/graphic-the-relentless-rise-of-carbon-dioxide/)

## CO<sub>2</sub> in the atmosphere and annual emissions (1750-2019)



Source: State of the Planet

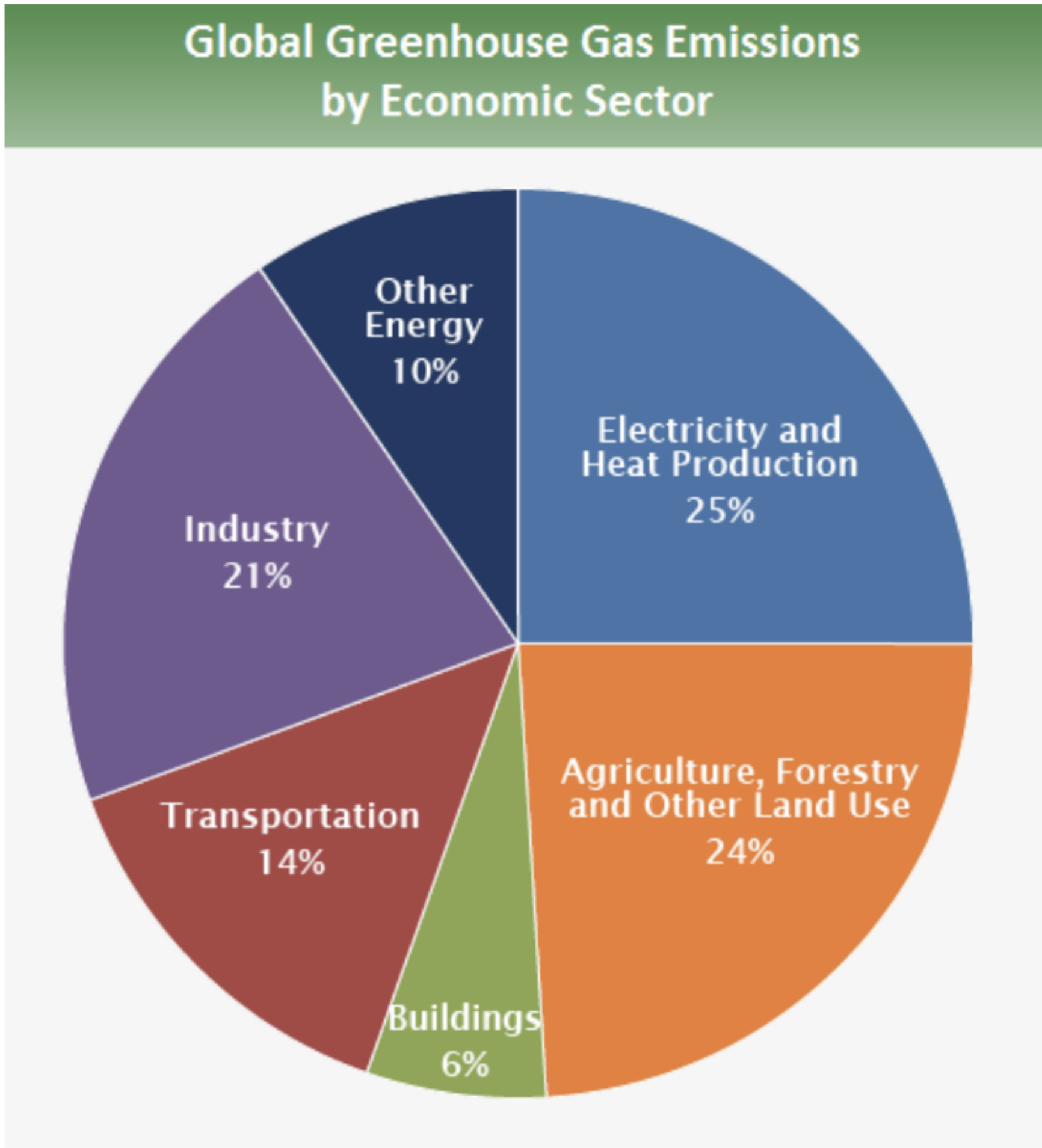
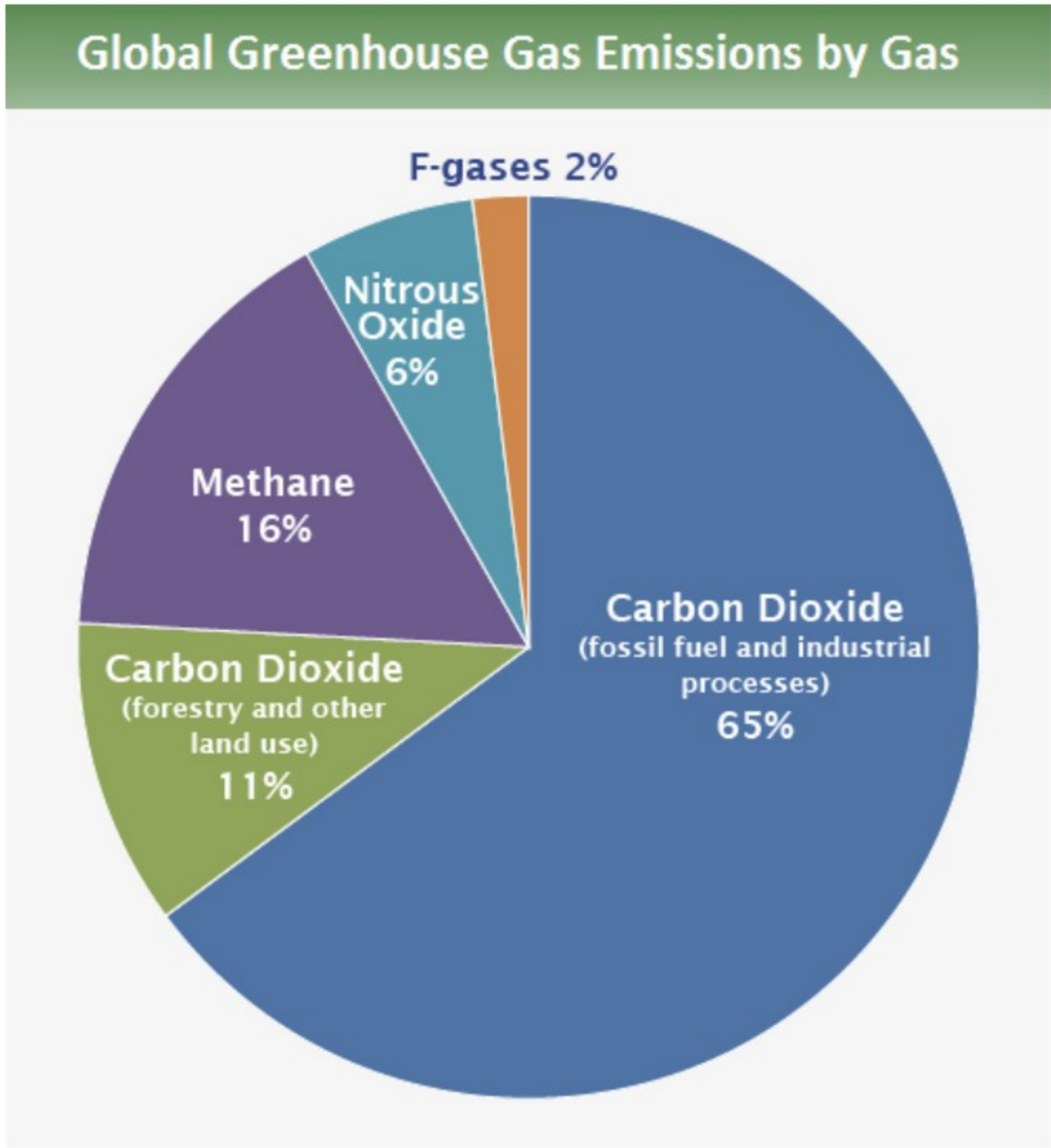
<https://news.climate.columbia.edu/2021/02/25/carbon-dioxide-cause-global-warming/>



# Global CO<sub>2</sub> Emissions Due to Fossil Fuels in 2021

Coal	15.3 billion tons
Nat. Gas	7.5 billion tons
Oil	10.7 billion tons

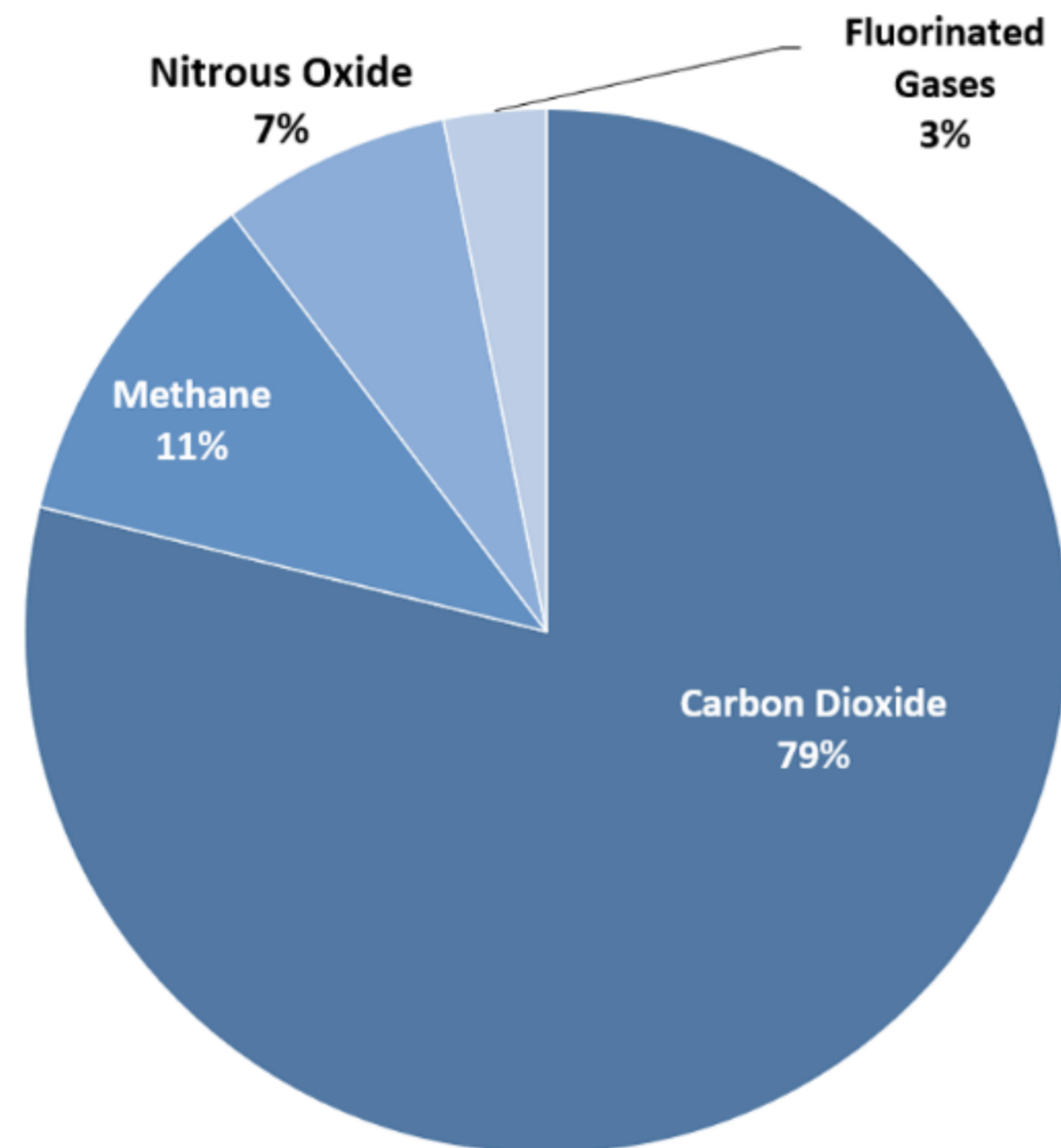
Source: IEA Global Energy Review: CO<sub>2</sub> Emissions in 2021  
<https://www.iea.org/reports/global-energy-review-co2-emissions-in-2021-2>



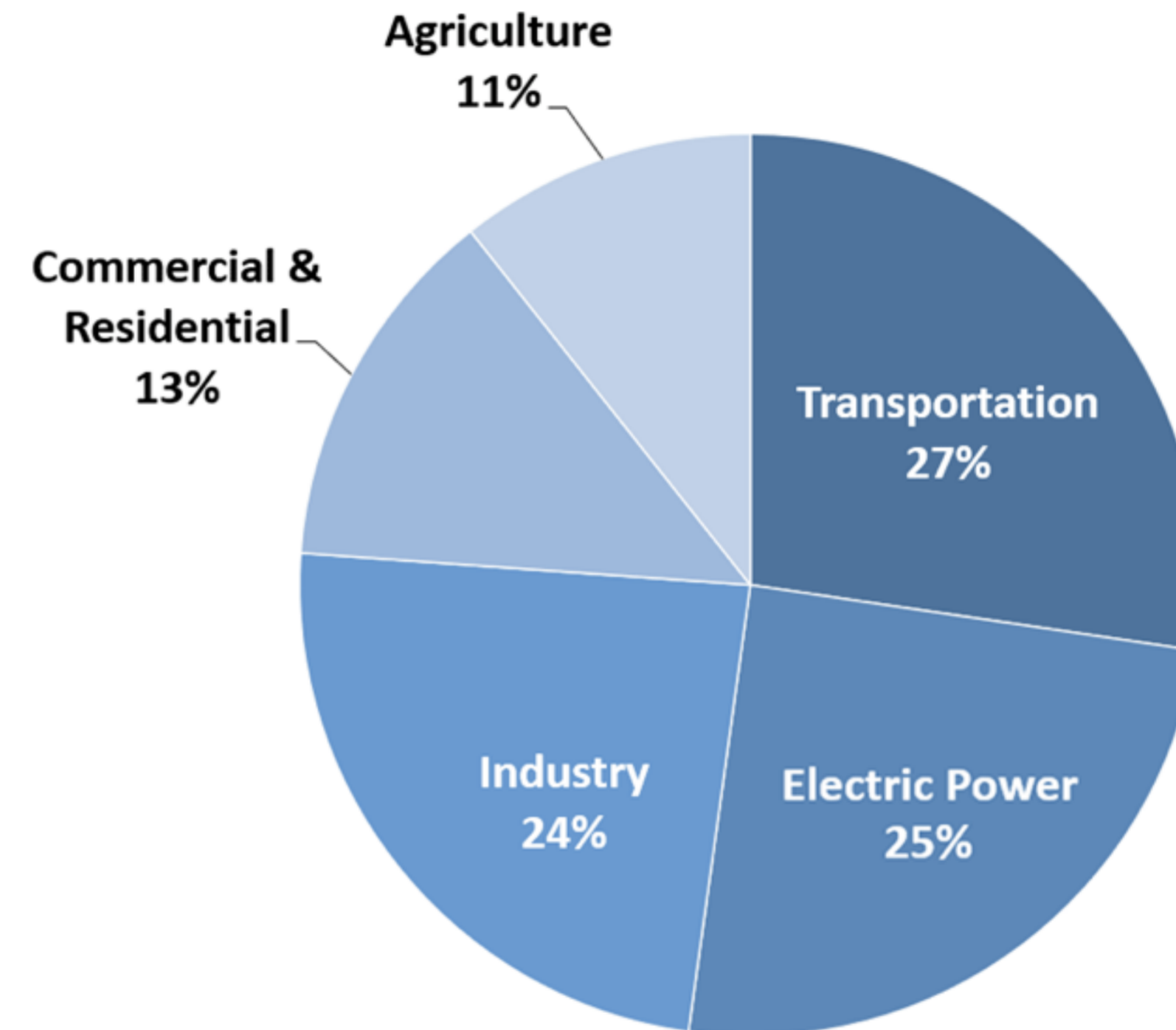
Source: [IPCC \(2014\)](https://www.ipcc.ch/)

<https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data>

## Overview of U.S. Greenhouse Gas Emissions in 2020



## Sources of U.S. Greenhouse Gas Emissions in 2020



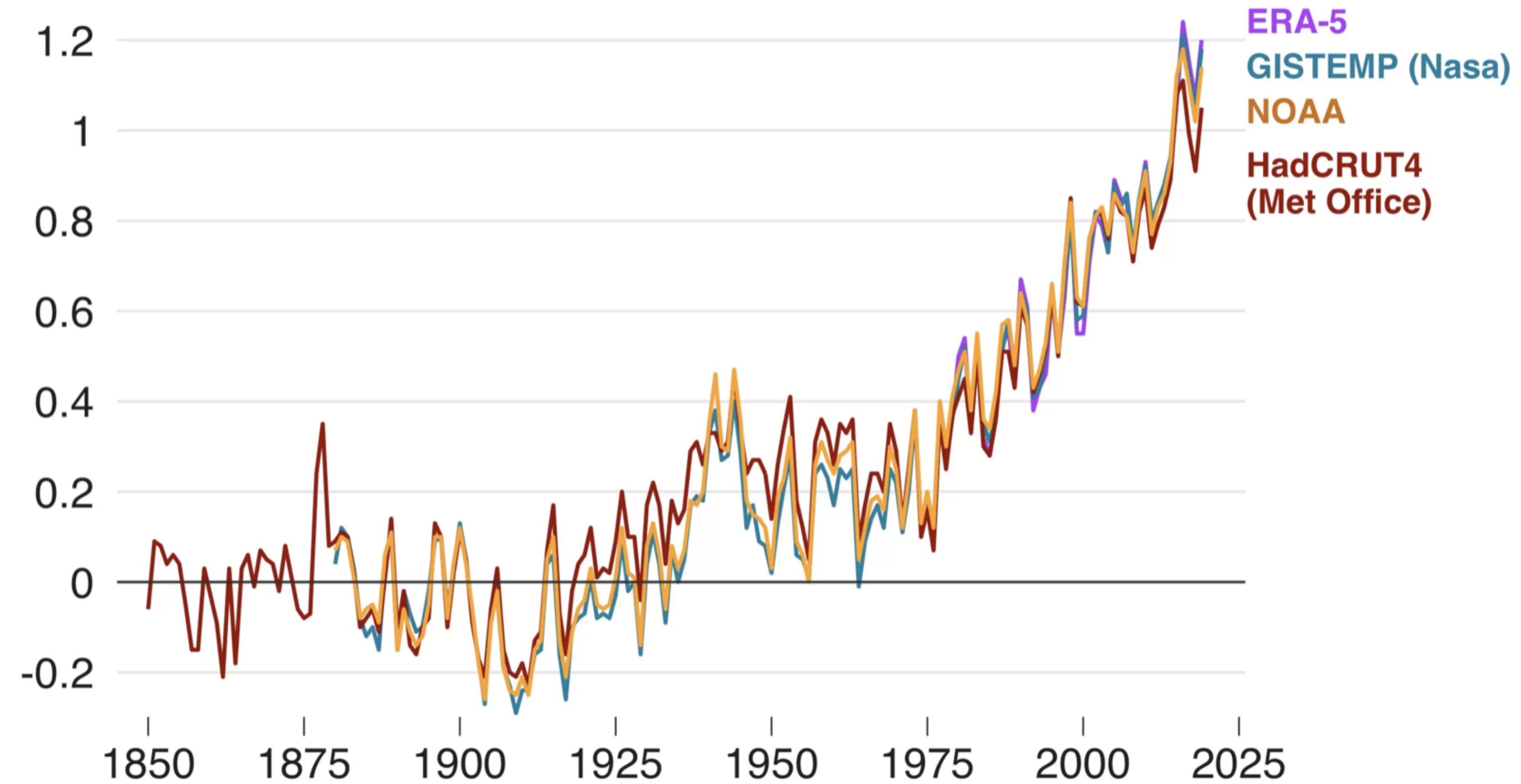
Note: All emission estimates from the [Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2020](#)



# Impacts of Carbonization

# Temperature rise since 1850

Global mean temperature change from pre-industrial levels, °C



Source: Met Office



Source: <https://www.bbc.com/news/science-environment-51111176>

Temperature rise of 1.5 – 2.0 °C = Point of No Return



Source: Craig Dearden-Phillips: Don't be a polar bear

<https://www.thirdsector.co.uk/craig-dearden-phillips-dont-polar-bear/management/article/1488091>



Climate Change Hits  
Poor and the Rich Alike



# Florida, China and Africa







Hurricane Isabel struck the Mid-Atlantic region of USA between Sept. 18-19, 2003.



# Flooding in Pakistan – August 2022



Source: <https://www.npr.org/sections/pictureshow/2022/08/30/1119979965/pakistan-floods-monsoon-climate>



Source: <https://www.nytimes.com/2022/09/07/briefing/climate-change-heat-waves-us-europe.html>





China







# Hurricane Sandy

New York, New Jersey 2012





# Droughts in 2022



Dry river bed in **Italy** (Po River) due to worst drought in 70 years, June 2022

<https://idsb.tmgrup.com.tr/ly/uploads/images/2022/07/08/217454.jpg>

The Jialing Riverbed at the confluence with the Yangtze River is exposed due to drought on August 18, 2022 in Chongqing, **China**.



<https://image.cnbcfm.com/>



# Wildfires in the US



July 2021 - The Dixie fire burned close to a million acres in **California's** Lassen county over three months and became the first fire to cross the Sierra Nevada. Photograph: Noah Berger/AP

Peaks glowing with thousands of spot fires on June 13, 2022 in Flagstaff, **Arizona**. Schumacher/The Republic





# Wildfires in Europe - Summer of 2022



Southwestern **France**, July 17, 2022



Central **Portugal**, July 13, 2022



Brandenburg, **Germany**, August 2022



**Greece**, July 2022



Northern **Spain**, June 2022



Central **Italy**, July 2022

**“The number of wildfires in 2022 in the EU have nearly quadrupled the 15-year average”**

[Source: CNN according to Copernicus, EU Earth observation program](#)



# Siberia: Wildfires in June 2020 and June 2021



The Greenpeace Russia team has documented forest fires in the Krasnoyarsk region.

JULIA PETRENKO / GREENPEACE



*In this June 16, 2021 photo, firefighters work at the scene of forest fire near Andreyevsky village outside Tyumen, western Siberia, Russia. -*

Copyright AP Photo/Maksim Slutsky, File



# 2008 China Snowstorm





# Glacier Comparison Mer de Glace in France, 2012



Glacier Mer de Glace 1910



Glacier Mer de Glace 2001



Glacier Mer de Glace 2006



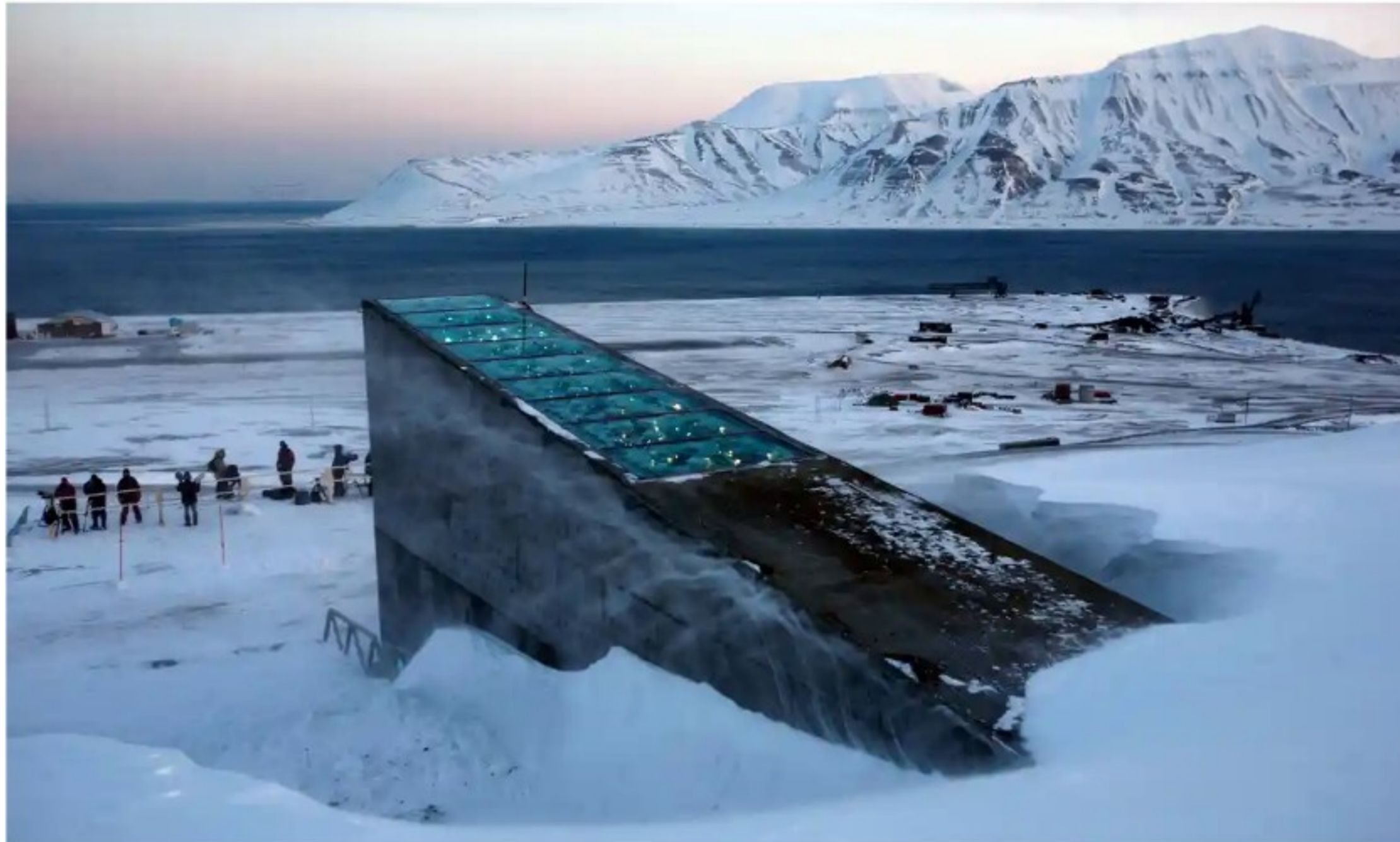
Glacier Mer de Glace 2012



# The Global Seed Vault in Svalbard, Norway

## Arctic stronghold of world's seeds flooded after permafrost melts

No seeds were lost but the ability of the rock vault to provide failsafe protection against all disasters is now threatened by climate change



📷 The Svalbard 'doomsday' seed vault was built to protect millions of food crops from climate change, wars and natural disasters. Photograph: John Mcconnico/AP

Source: [The Guardian, May2017](#)



Entrance to the Svalbard Global Seed Vault (SGSV), on the island of Spitsbergen, Norway. HEIKO JUNGE/AFP/GETTY IMAGES



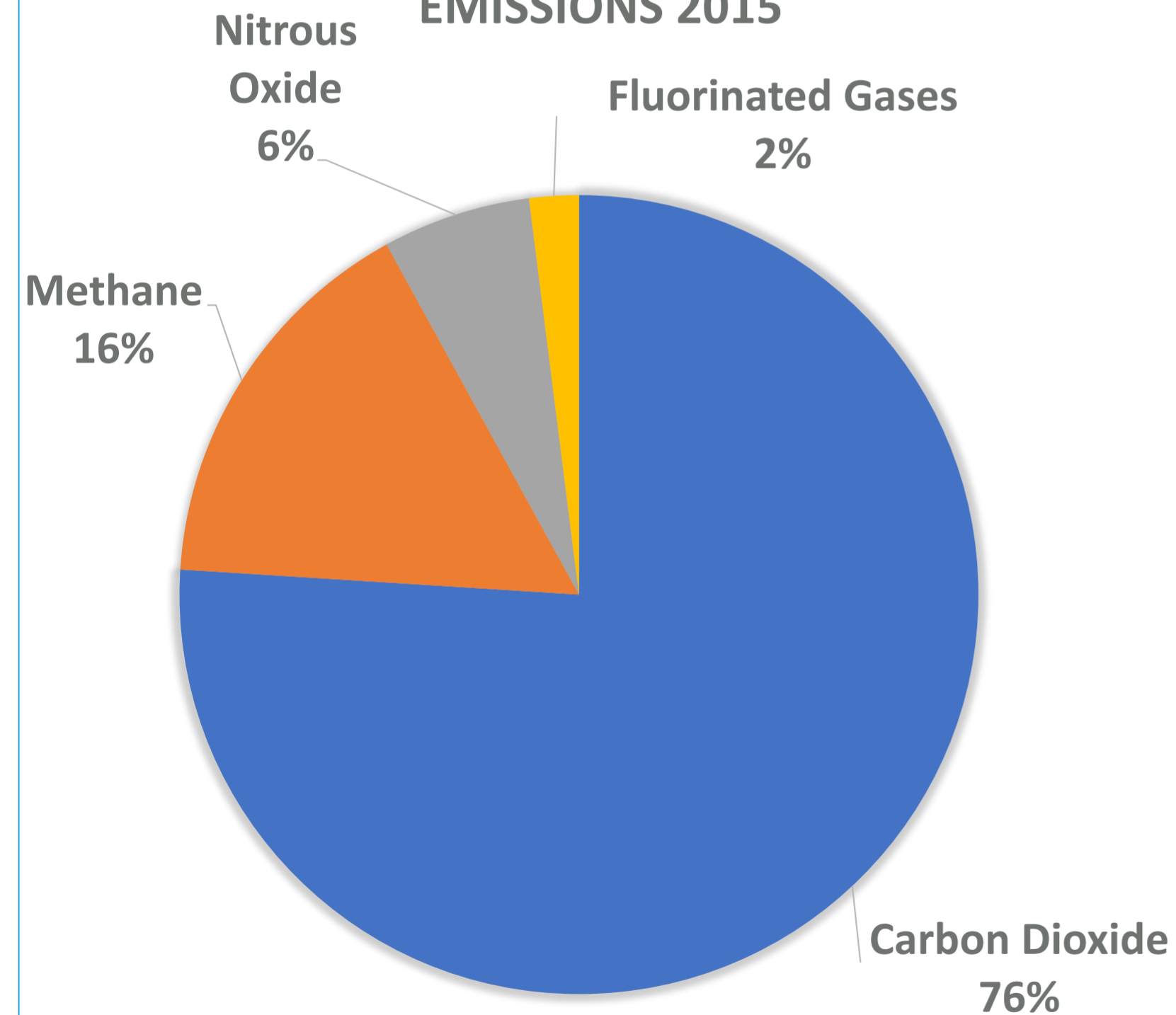
[Svalbard Global Seed Vault Protects ... nationalgeographic.com](#)



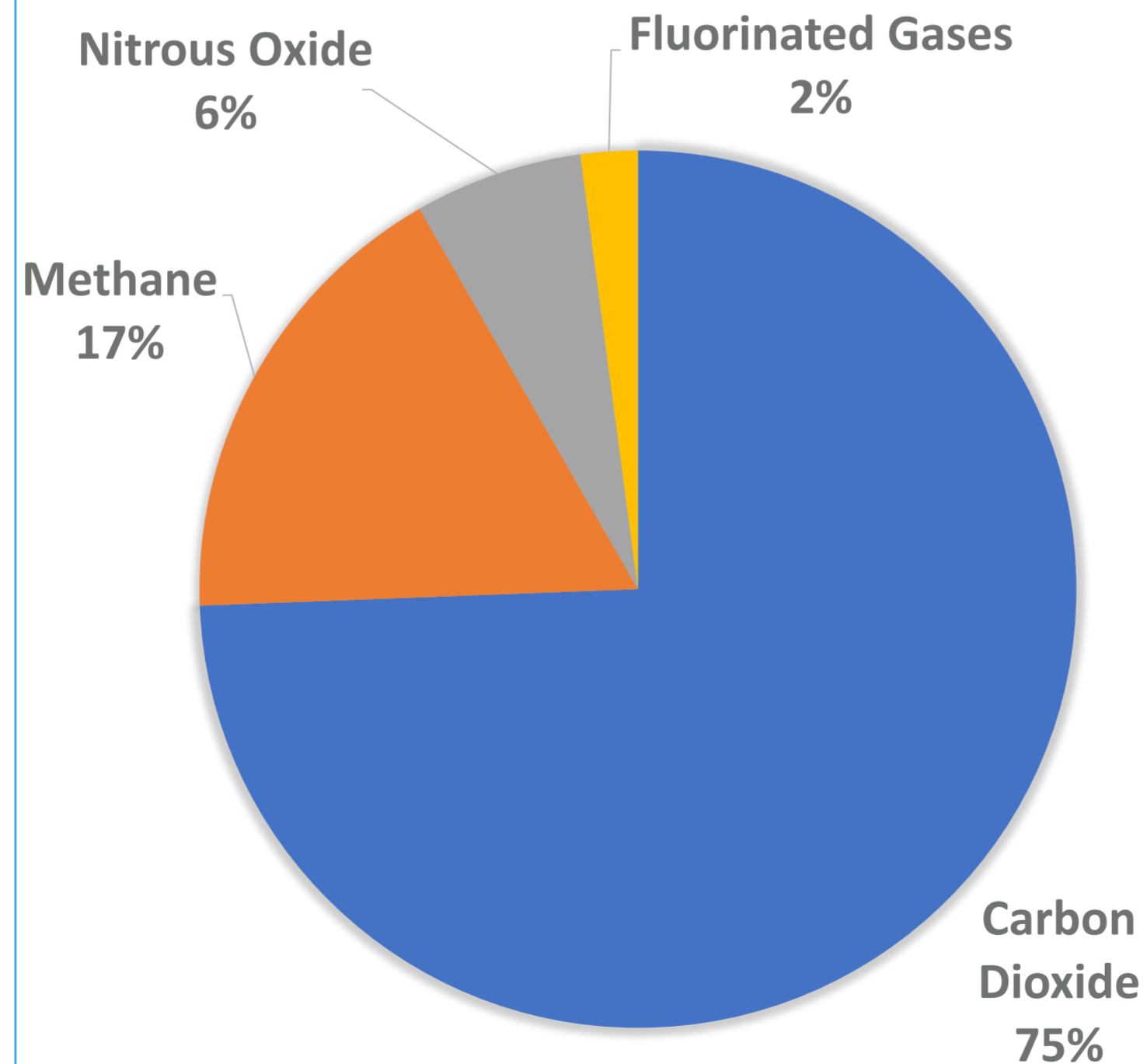
# Global Anthropogenic Greenhouse Gas Emissions by Gas 2015, 2016 & 2019

Fluorinated Gases include: HFC, PFC and SF6

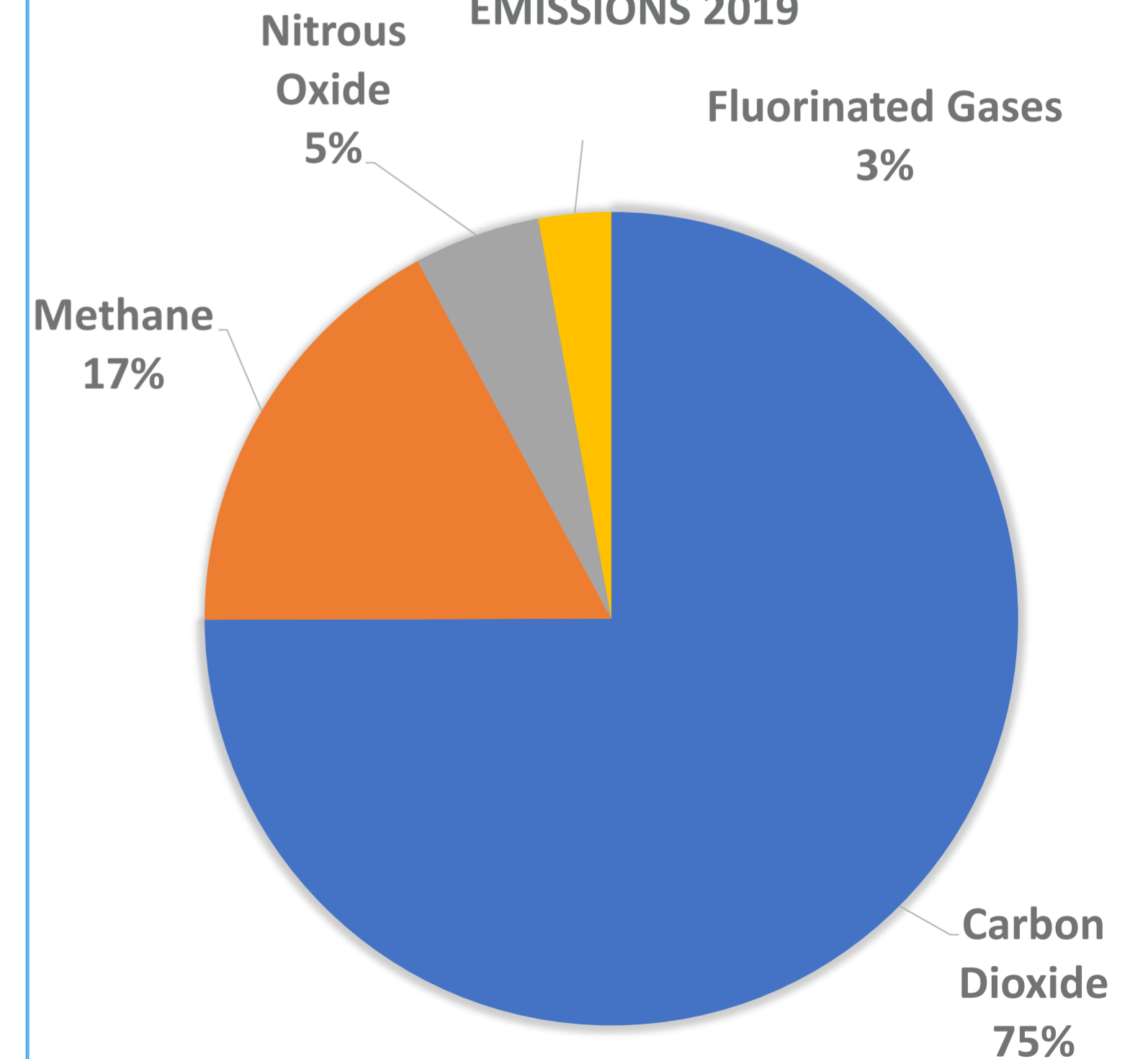
### GLOBAL MANMADE GREENHOUSE GAS EMISSIONS 2015



### GLOBAL MANMADE GREENHOUSE GAS EMISSIONS 2016



### GLOBAL MANMADE GREENHOUSE GAS EMISSIONS 2019



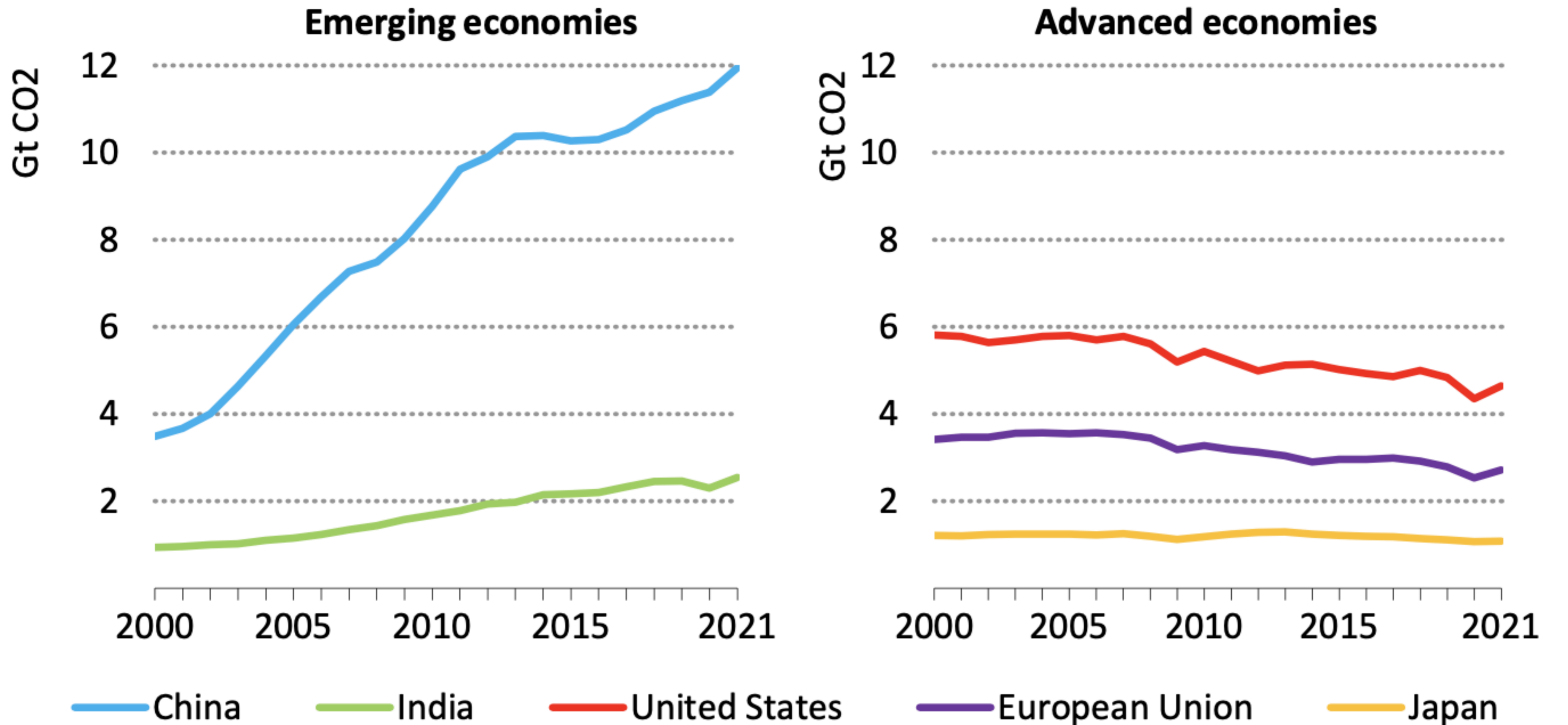
Source: <https://www.c2es.org/content/international-emissions/>

Source: <https://ourworldindata.org/greenhouse-gas-emissions#annual-greenhouse-gas-emissions-how-much-do-we-emit-each-year>

Source: UNEP Emissions Gap Report 2020 <https://www.unep.org/emissions-gap-report-2020>



# CO2 emissions in selected emerging and advanced economies, 2000-2021

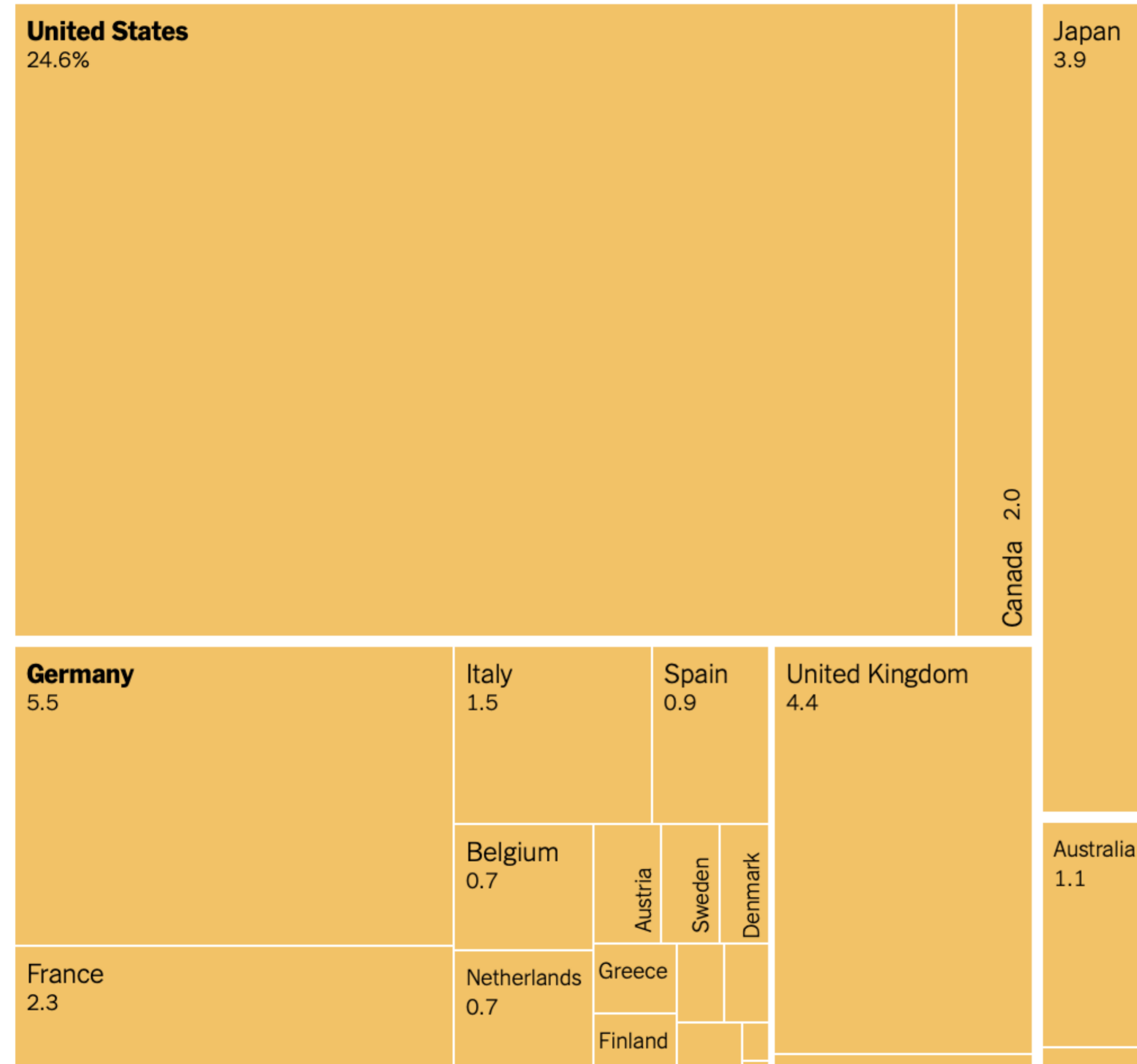


IEA. All rights reserved.

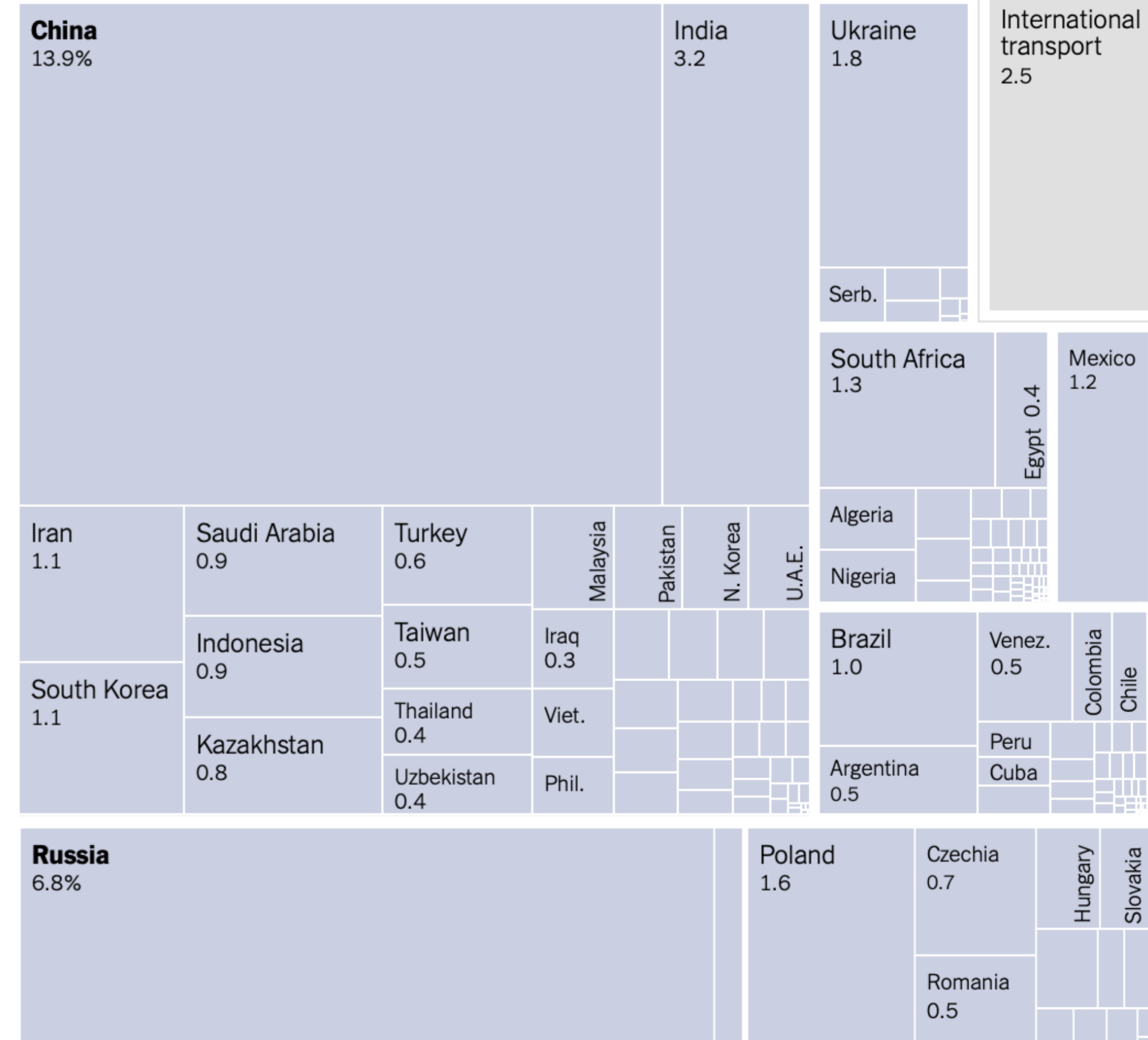


# Who Has The Most Historical Responsibility for Climate Change

**23 rich, developed countries** are responsible for half of all historical CO<sub>2</sub> emissions.



**More than 150 countries** are responsible for the other half.

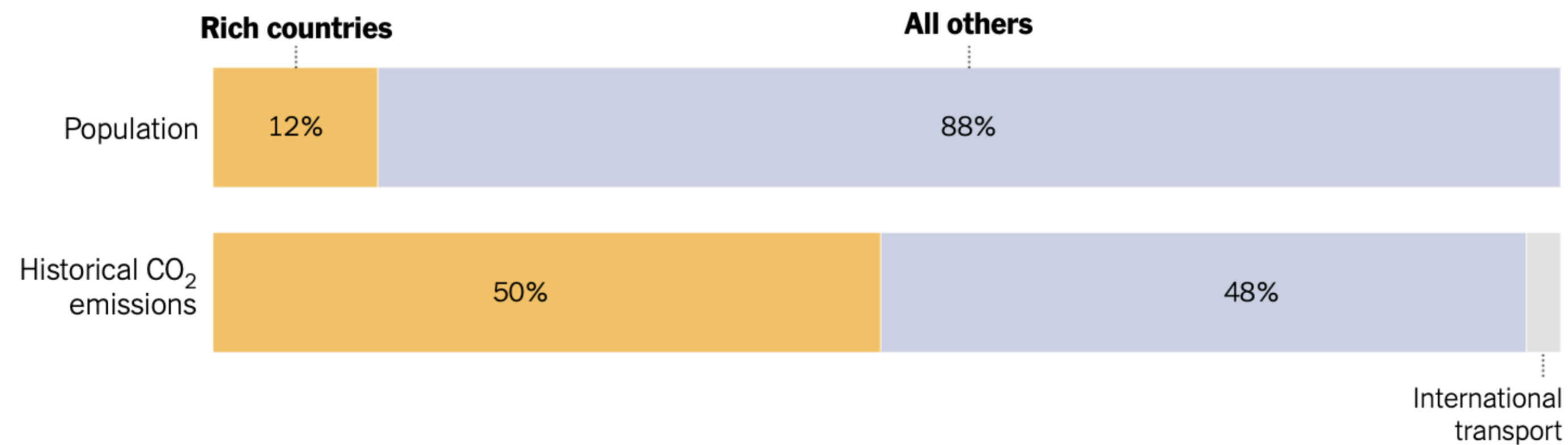


Source: The New York Times article "Who Has The Most Historical Responsibility for Climate Change?" by [Nadja Popovich](#) and [Brad Plumer](#), Nov. 12, 2021 (<https://www.nytimes.com/interactive/2021/11/12/climate/cop26-emissions-compensation.html>)




# Who Has The Most Historical Responsibility for Climate Change

Rich countries, including the United States, Canada, Japan and much of western Europe, account for just 12 percent of the global population today but are responsible for 50 percent of all the planet-warming greenhouse gases released from fossil fuels and industry over the past 170 years.



Source: The New York Times article "Who Has The Most Historical Responsibility for Climate Change?" by By [Nadja Popovich](#) and [Brad Plumer](#), Nov. 12, 2021 (<https://www.nytimes.com/interactive/2021/11/12/climate/cop26-emissions-compensation.html>)



- 
- **An unprecedented level of awareness of climate change and the role of decarbonization in enabling environmental sustainability moving forward**
  - **In this talk the major focus is placed on the carbon produced through electricity generation, as it is responsible for roughly 30% of emissions globally**



- 
- Navigating the tension between industrialized nations and emerging economies for global decarbonization efforts requires a diverse portfolio of solutions for low-carbon generation, storage and demand side management with advanced technology focusing on energy efficiency.
  - To more efficiently facilitate the global shift towards renewable energy adoption, the following six areas should be our priority.



# Reduce Carbon Emissions from Electricity Production



## Reduce Carbon Emissions

1. Use less electricity, energy efficiency
2. Use low carbon fossil fuel power plants
3. Use H<sub>2</sub> & other storage technologies
4. Promote more renewables
5. Accept some nuclear
6. Promote cross-border power transfer



# Customers Controlling Buildings Optimized for Savings

## Measured energy savings across deployments

**20%** HVAC Energy Savings

**25%** Lighting Energy Savings

**Occupant satisfaction:** spaces controlled by a building automation systems are more comfortable due to more consistent temperature profiles and healthier air quality through consistent monitoring of environmental factors (CO<sub>2</sub> levels, PM 2.5).





# Energy Efficiency Applications

## *Consider light bulbs*

- Provide more energy efficient applications and tools globally
- The amount of electricity required to run an LED light bulb is less than 15% of what is needed to run an incandescent light bulb producing the same amount of light
- Providing developing nations with lightbulbs that are more energy efficient can ensure that energy consumption and carbon emissions are being reduced requiring lesser investments in power generation, transmission & distribution





# Highly Efficient Fossil-fuel Power Plants

*Carbon Capture and Storage*

- Combined Cycle Gas/Steam Power Plant
- Ultra-supercritical steam power plant



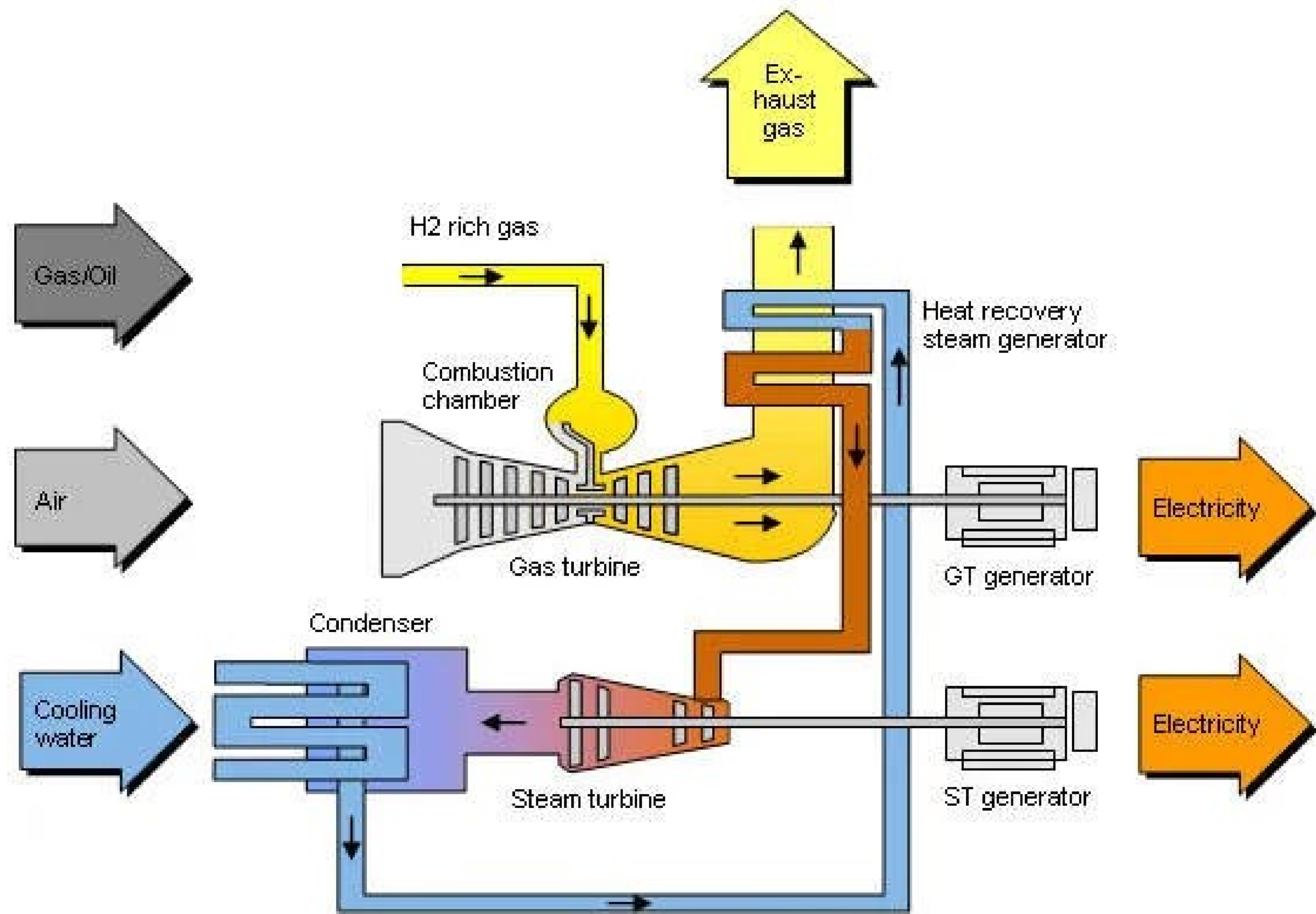
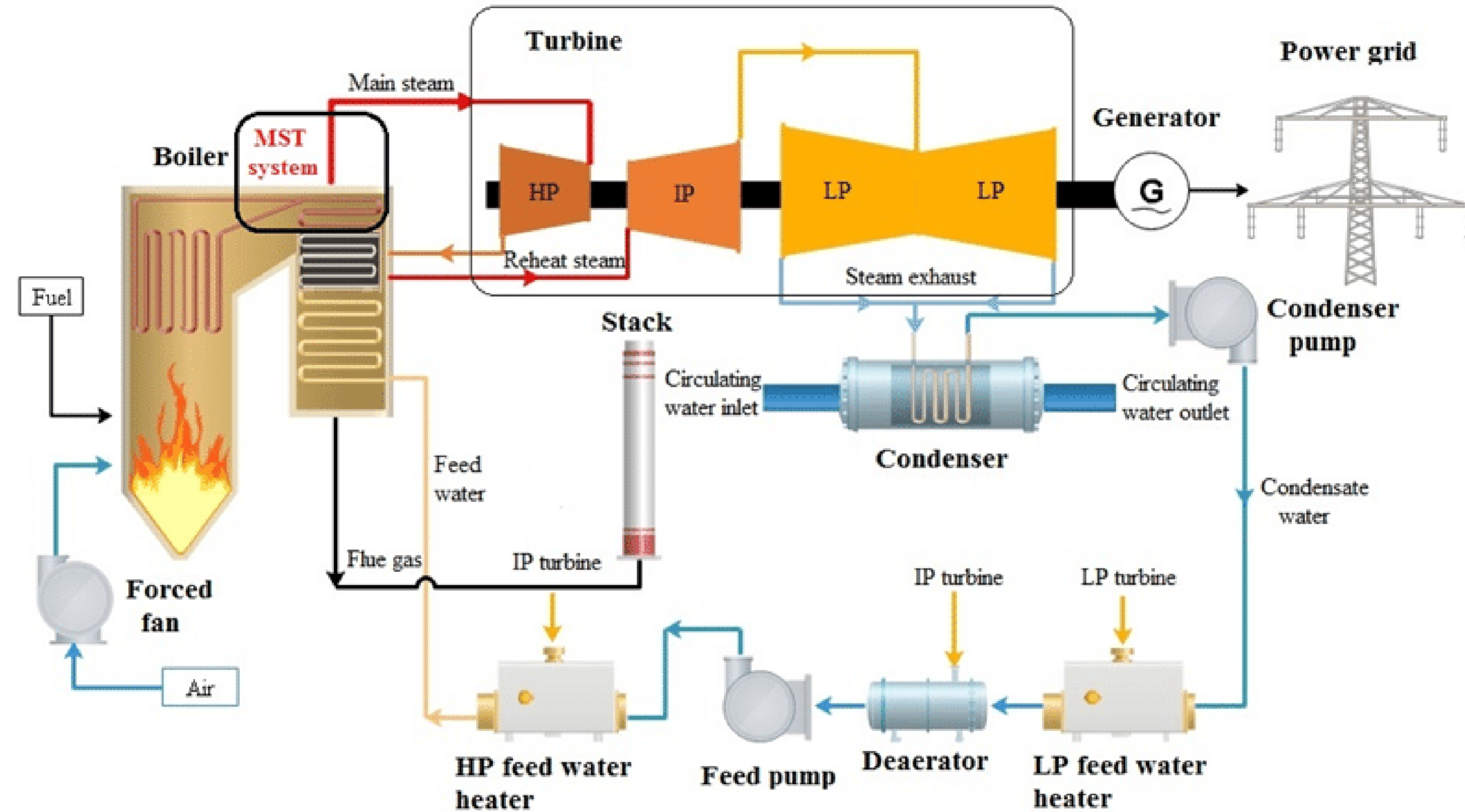


Image courtesy of: <http://www.powergeneration.siemens.com>



# Simplified layout of a 1000 MW coal-fired ultra-supercritical power plant



Source: [https://www.researchgate.net/publication/343169041\\_An\\_Efficient\\_Robust\\_Predictive\\_Control\\_of\\_Main\\_Steam\\_Temperature\\_of\\_Coal-Fired\\_Power\\_Plant](https://www.researchgate.net/publication/343169041_An_Efficient_Robust_Predictive_Control_of_Main_Steam_Temperature_of_Coal-Fired_Power_Plant)



# Eemshaven ultra-supercritical steam power plant, The Netherlands



Power Plant: Two units rated 800MW each

Efficiency: 46.2%

Temp: 609 deg C

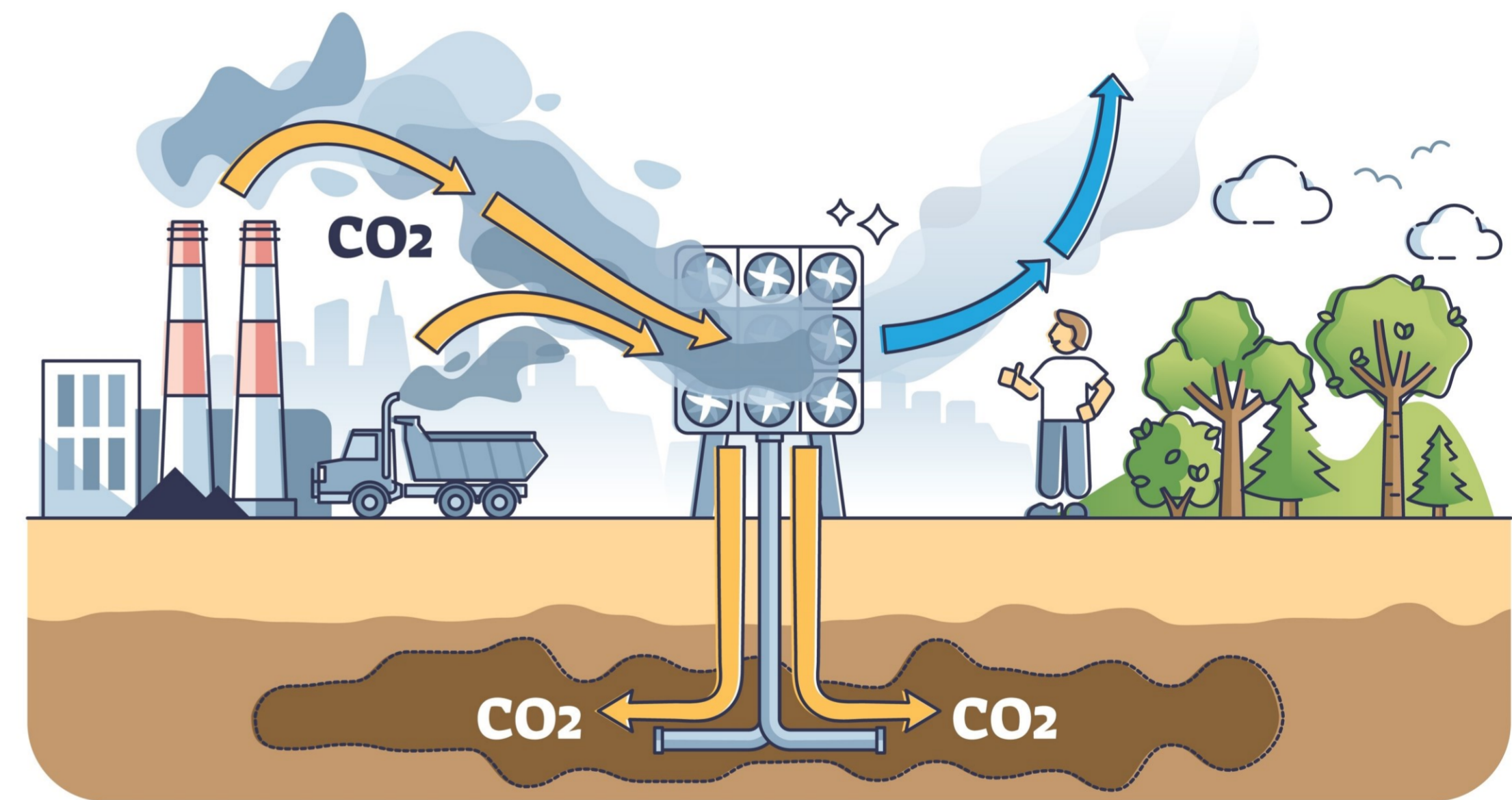
Steam Turbine: Siemens SST5-6000

Built: 2014



# Carbon Capture & Storage Systems (CCS)

- Can help ensure that emissions created during the energy generation phase will not be emitted into the atmosphere
- These technologies have the potential to significantly reduce carbon emissions in energy systems across the board





# Renewable Energy Integration

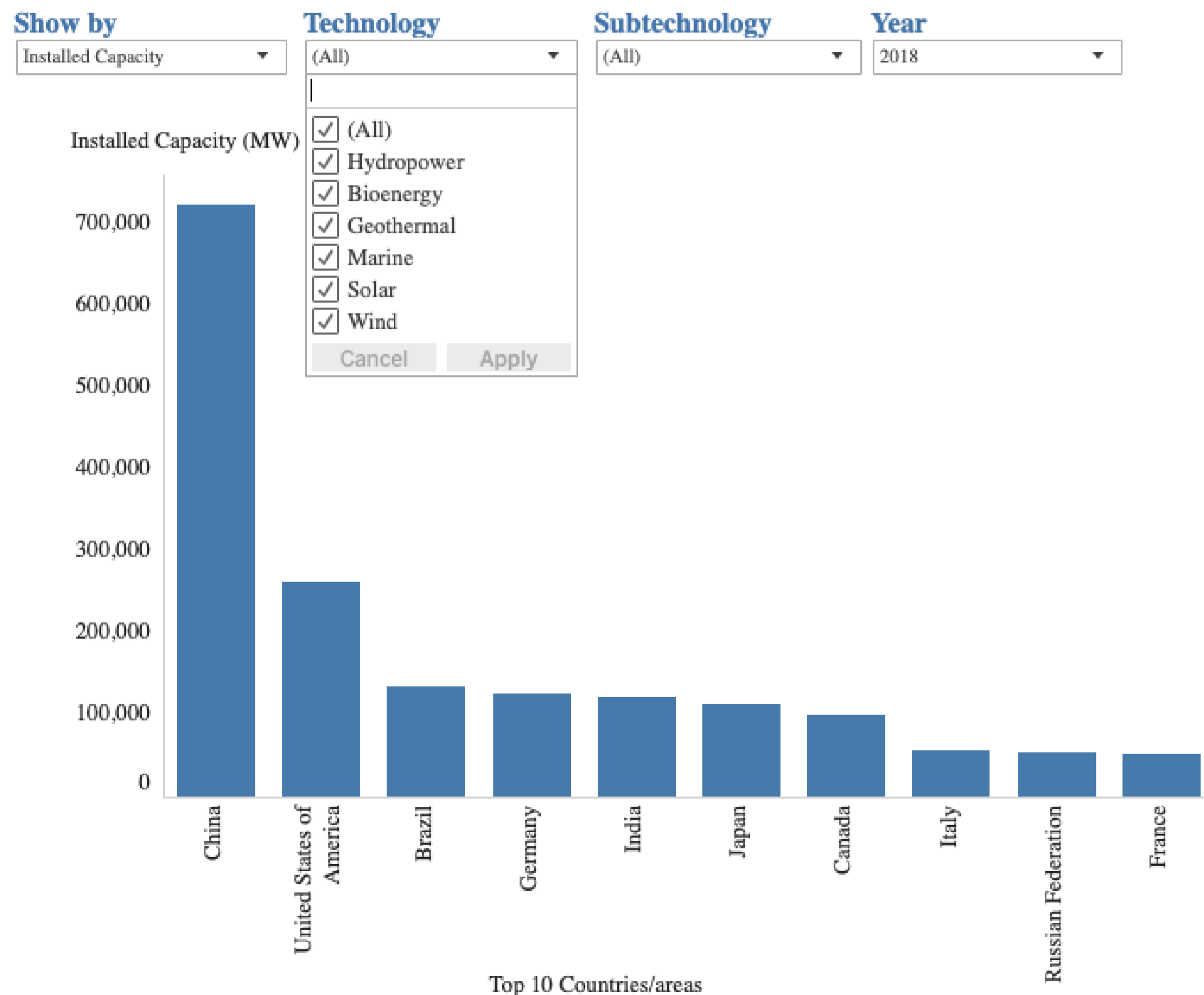
*Build more strategically from the start*

- Focus on where energy is needed most, via three core components:
  - Energy generation
  - Transmission
  - Distribution



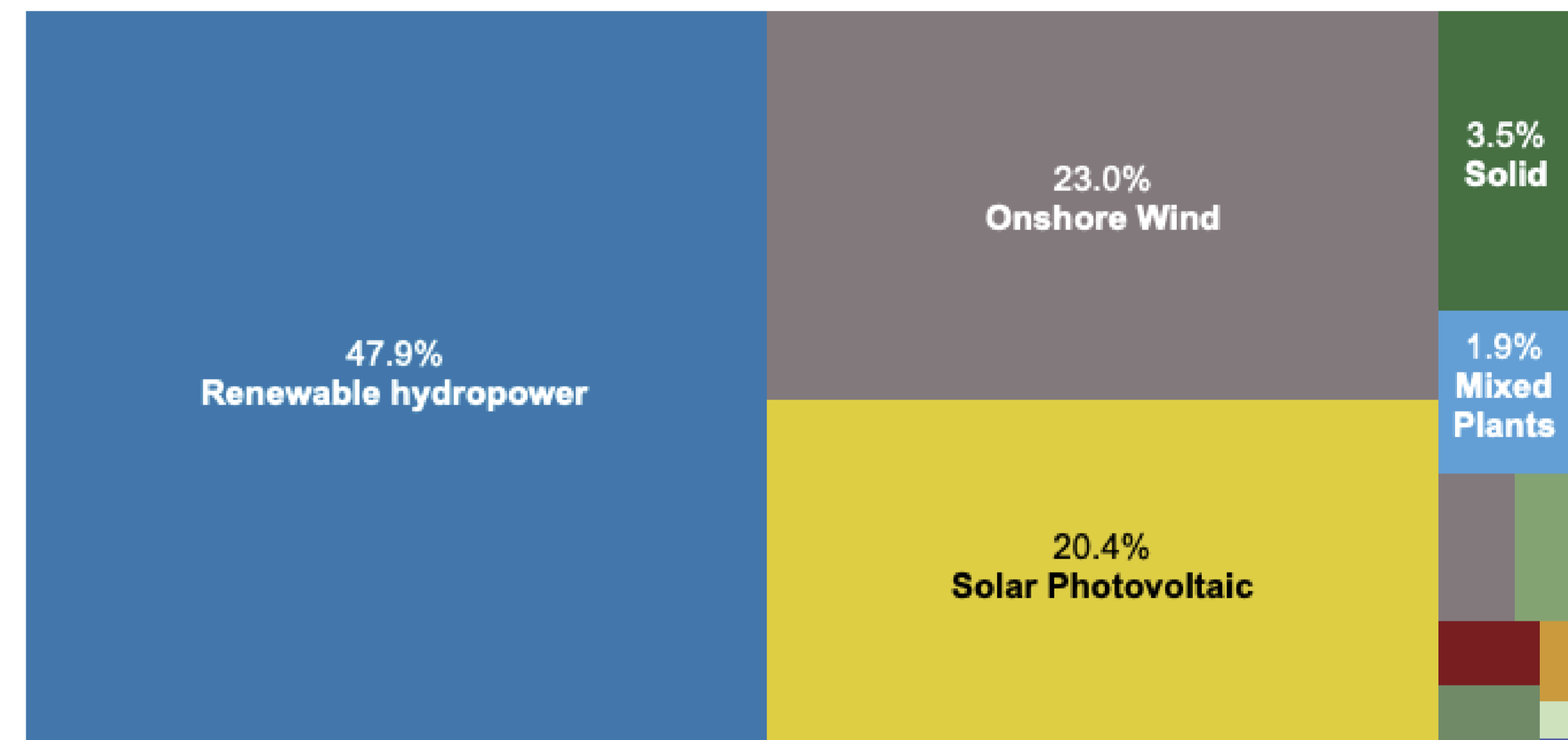


# Total Installed Renewable Energy Capacity Top Ten Countries (2018)



## Renewable Energy Technologies

**Show by** Installed Capacity | **Country/area** (All) | **Year** 2018



- Marine
- Geothermal
- Biogas
- Liquid Biofuels
- Renewable Waste
- Solid Biomass
- Offshore Wind
- Onshore Wind
- Concentrated Solar Power
- Solar Photovoltaic
- Mixed Plants
- Renewable Hydropower

  
**Source: International Renewable Energy Agency IRENA**  
<https://www.irena.org/Statistics/>



# Hydrogen and Storage Solutions

*Optimize renewable energy solutions being integrated into energy grids*



- Low-carbon hydrogen will help emerging economies to meet climate goals in and of itself
  - Provide for diverse energy portfolios
  - Improving resilience
  - Lowering costs
- Storage solutions serve as optimizers for other renewable energy solutions
  - Ensure that electricity generated during off-peak hours does not go to waste



# Cross-Border Energy Transfer

*We all are impacted by climate change*

- As we are in this fight together, our solutions should be collaborative to secure better outcomes for all countries, regardless of location
- The International Energy Agency (IEA) has identified three main modes of cross-border energy integration:
  - Bilateral
  - Multilateral
  - Unified

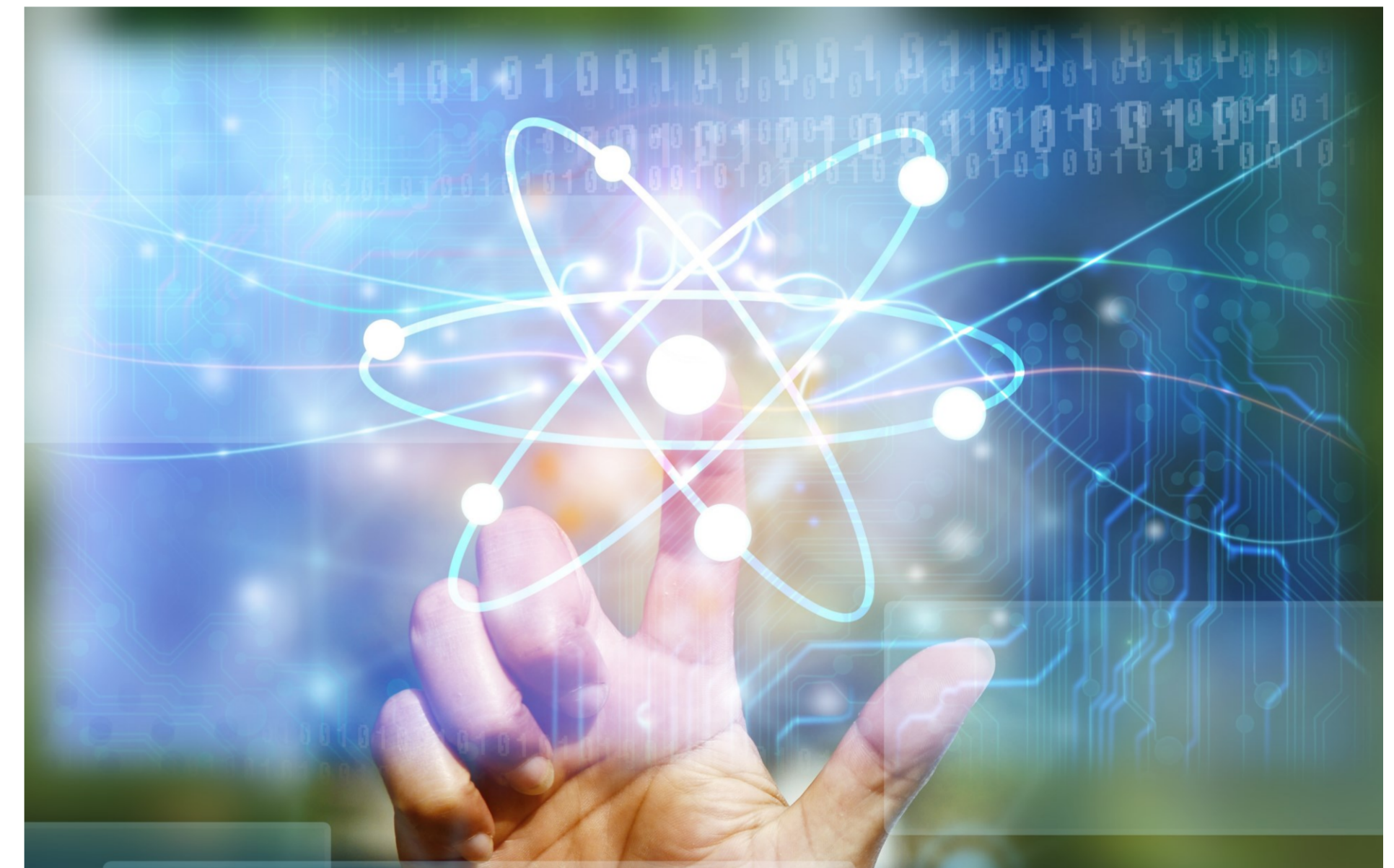




# Advanced Nuclear Technologies

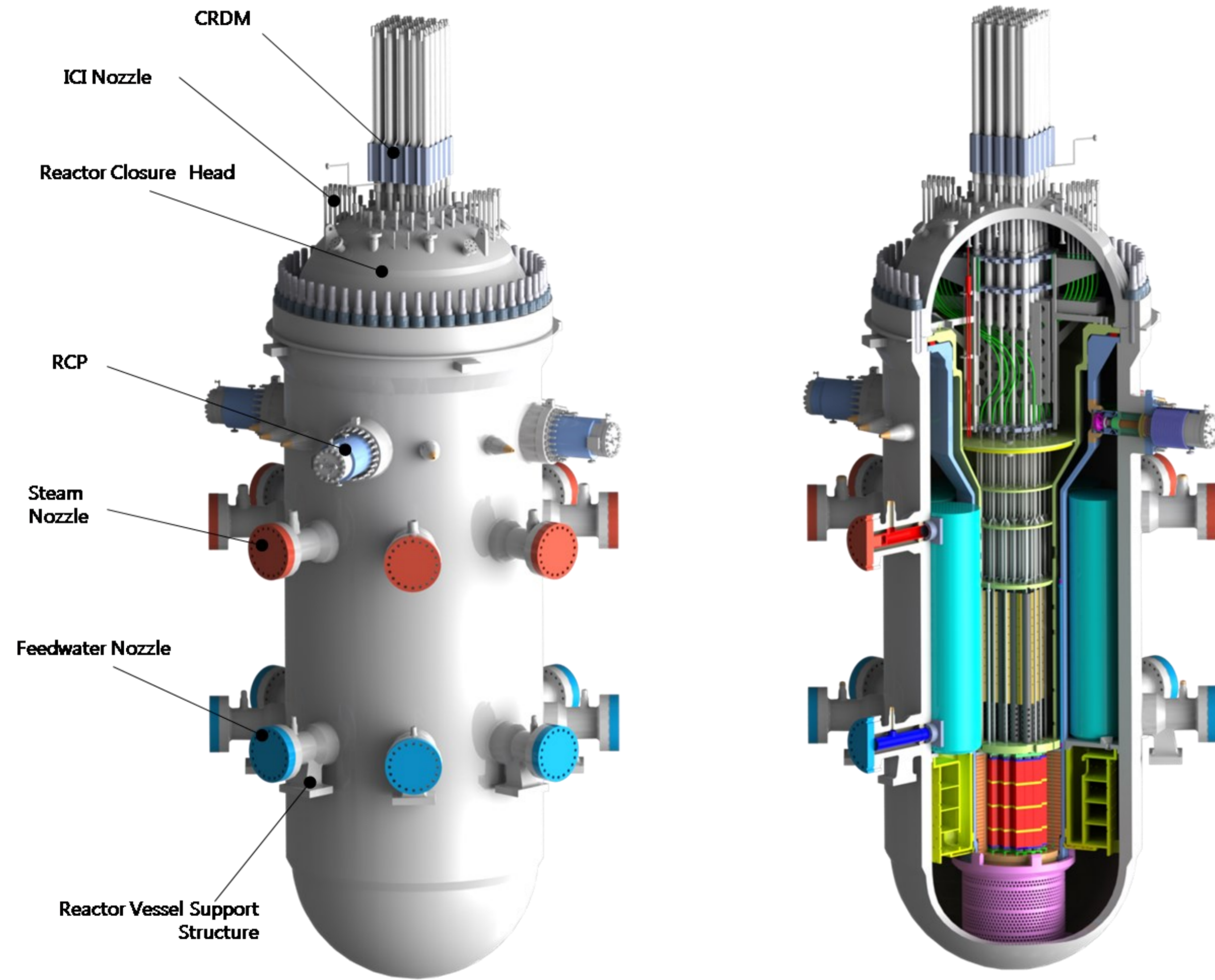
*Diverse solutions to address climate change*

- Advanced nuclear technologies, such as small modular reactors (SMRs), can play a role
  - Smaller and can be built more quickly than more traditional nuclear reactors
- Ramping up the development of SMRs can help to produce energy when and where needed
- This energy could be integrated into existing power grids
  - helping to provide improved resiliency while simultaneously reducing emissions

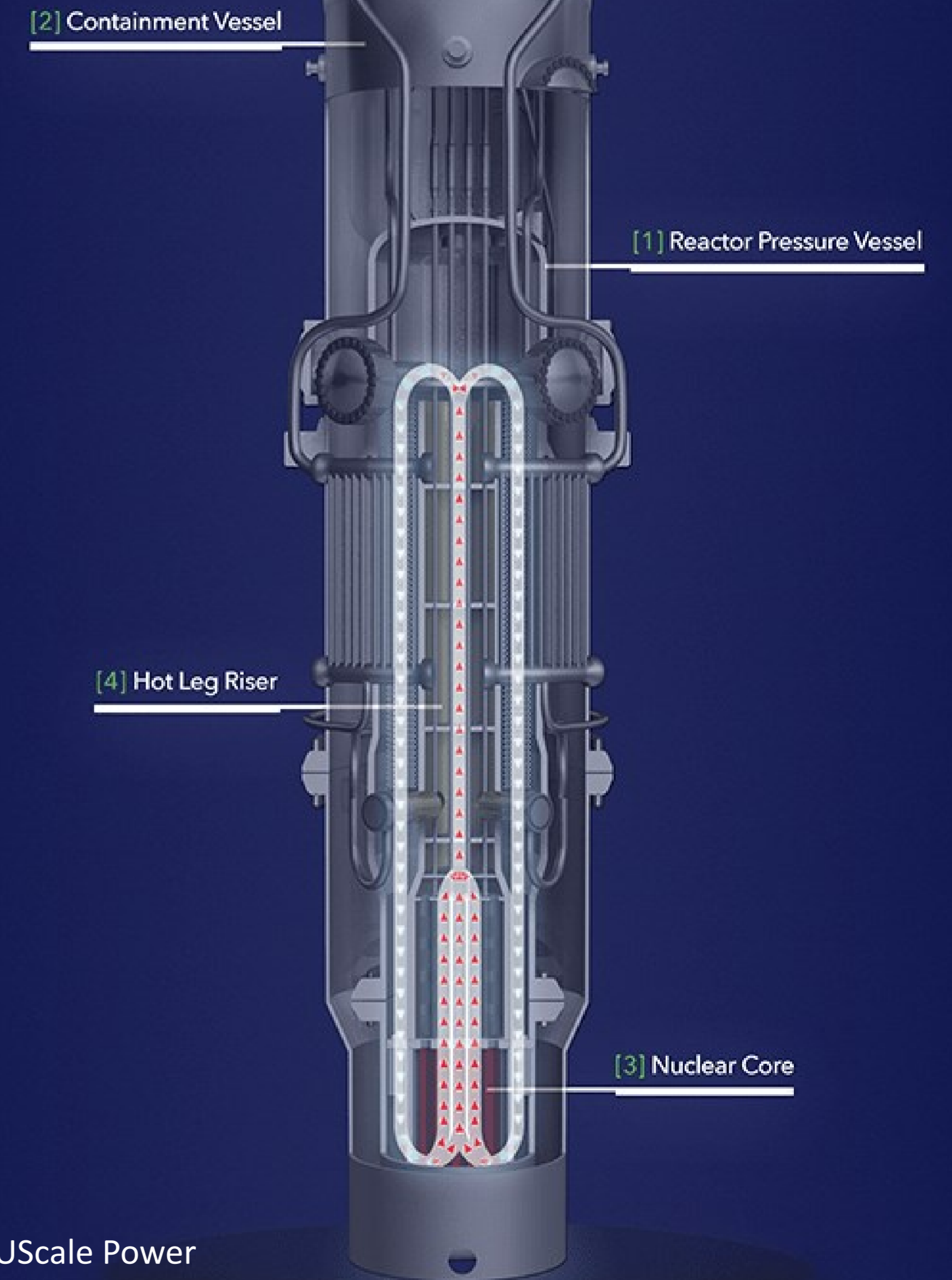




# Small Modular Reactors (SMR)



20m tall, 2.7m dia. 590 tons LWR  
4.95% enrichment 50 – 60 MWe



Source: NUScale Power



# So, What is the bottom line?

- Efforts in the electric power sector by replacing fossil fuel with renewables and nuclear will help
- But if emission from the transportation sector continues to rise, the power sector contributions will not be enough
- Large scale Electric Vehicle deployment will help, but question remains – how will the EV be powered





# IEEE Climate Change Website

<https://ieeecompatibilitychange.org>



[Resources from IEEE](#)

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Email: [ccircc@ieee.org](mailto:ccircc@ieee.org)



# IEEE Climate Change Collection

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IEEE: Enabling Innovation and Technology Solutions

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[Contact](#)

A banner image featuring a blurred background of a wind turbine on the left and a blue lithium-ion battery on the right. The battery has the text "LI-ION BATTERY" and "ENERGY" printed on it. A white semi-transparent box is overlaid on the left side of the banner, containing the text "RESOURCES FROM IEEE".

## RESOURCES FROM IEEE

As the world's largest organization of technical professionals, IEEE has both the opportunity and the responsibility to assist in organizing the response of engineers, scientists, and technical professionals across the world to address the causes, mitigate the impact, and adapt to climate change.

IEEE's scholarly publications, conference proceedings, technical standards, and other materials help foster the exchange of technical knowledge and information for the critical climate issues that our planet faces today.

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THANK  
YOU!

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