AABEA Thematic Lecture
09 September 2022

A Portfolio of Technology Solutions to Achieve Global Decarbonization

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IEEE President-elect 2022

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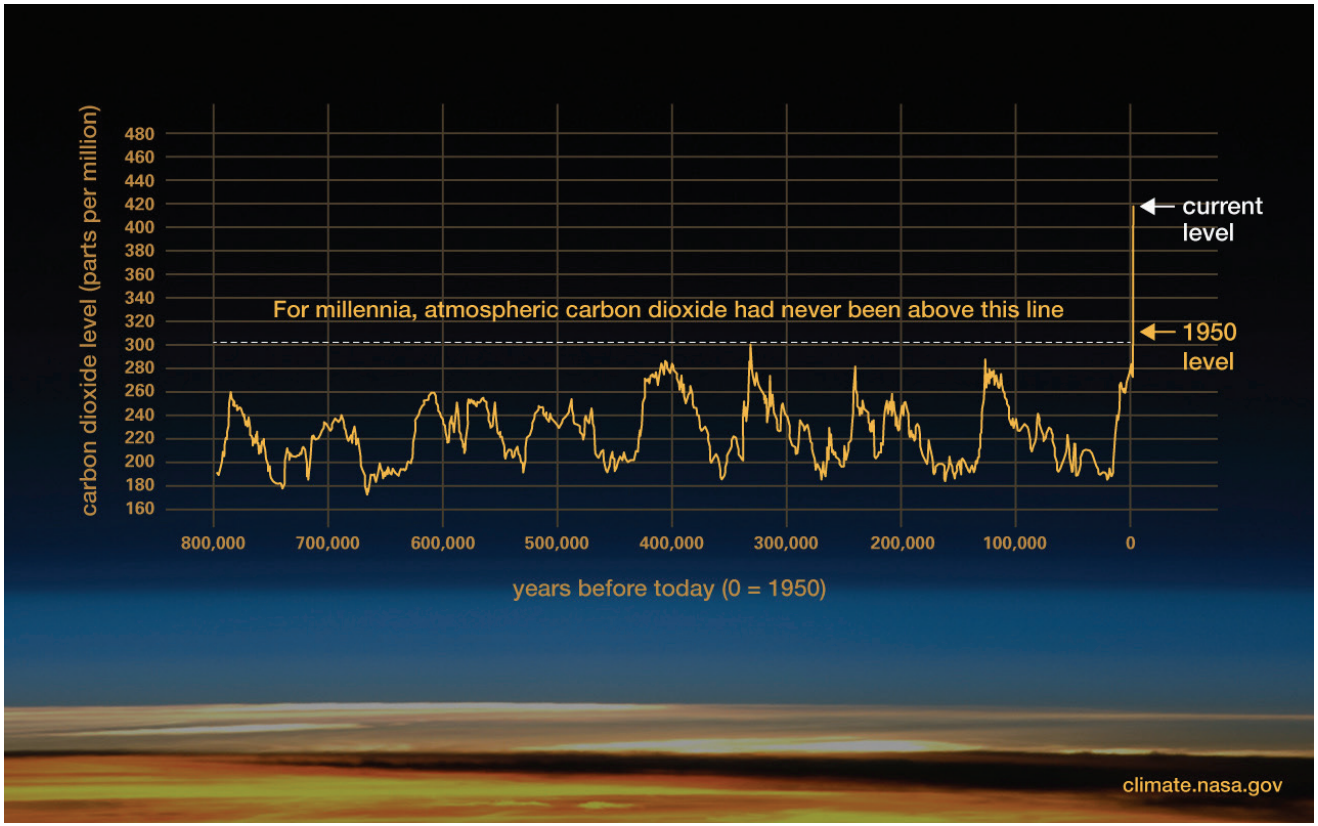
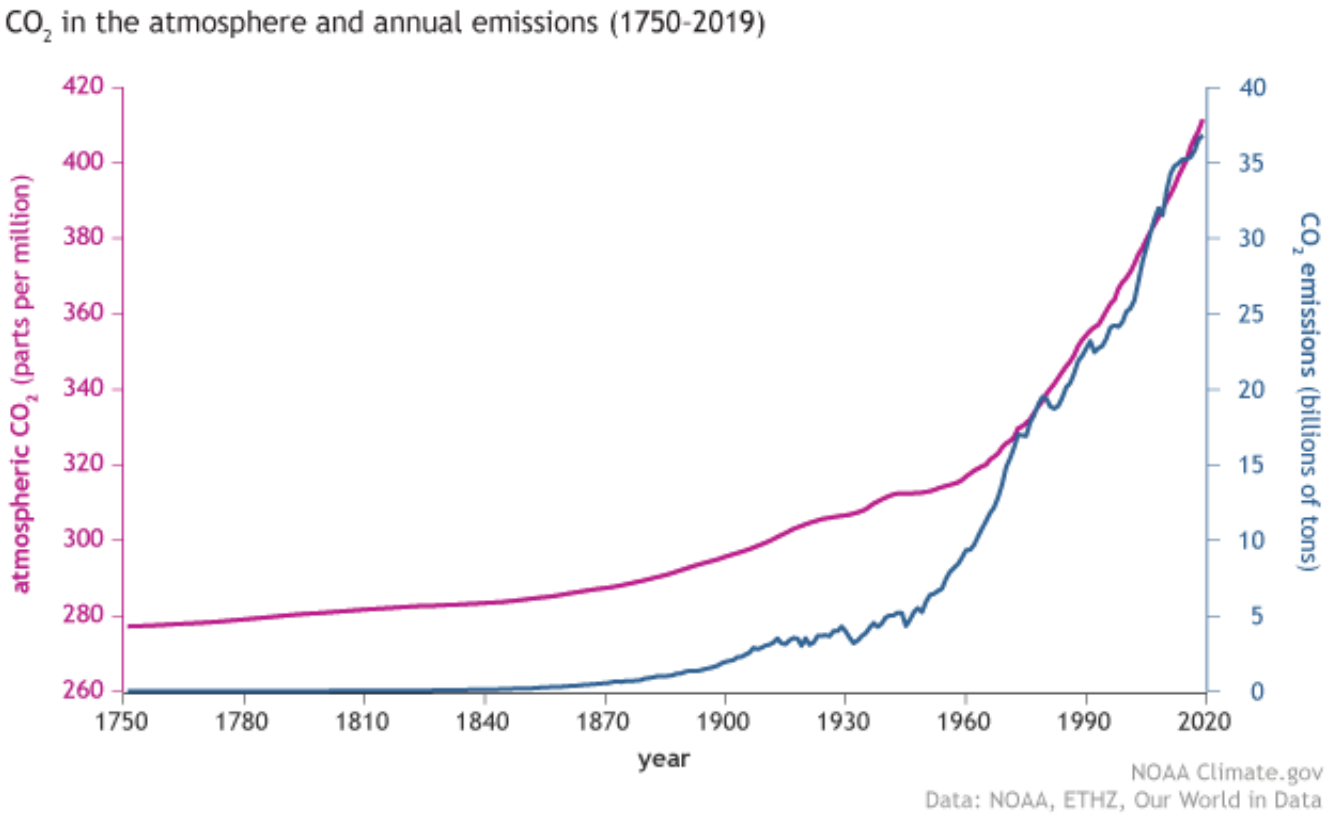
What is Carbonization



Source: NASA
https://climate.nasa.gov/climate_resources/24/graphic-the-relentless-rise-of-carbon-dioxide/

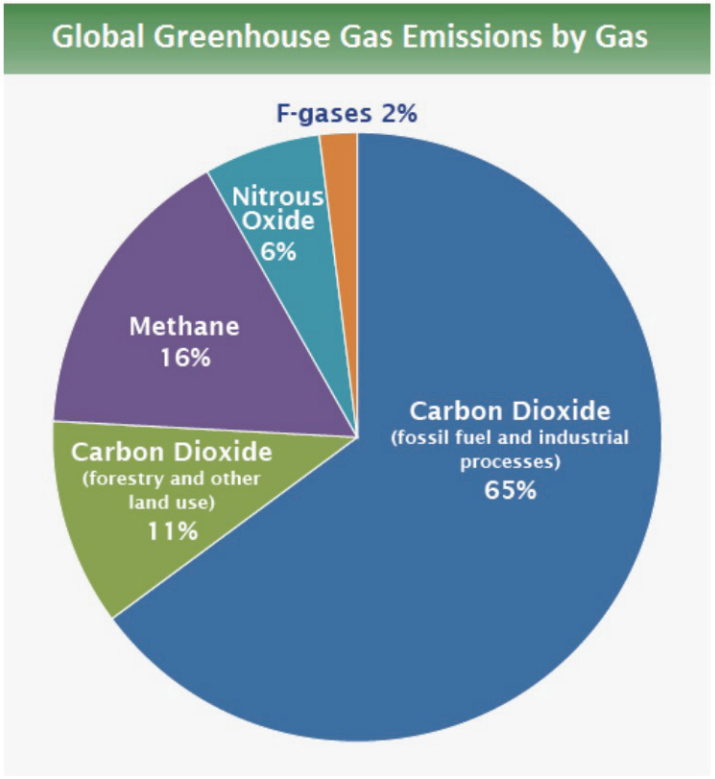


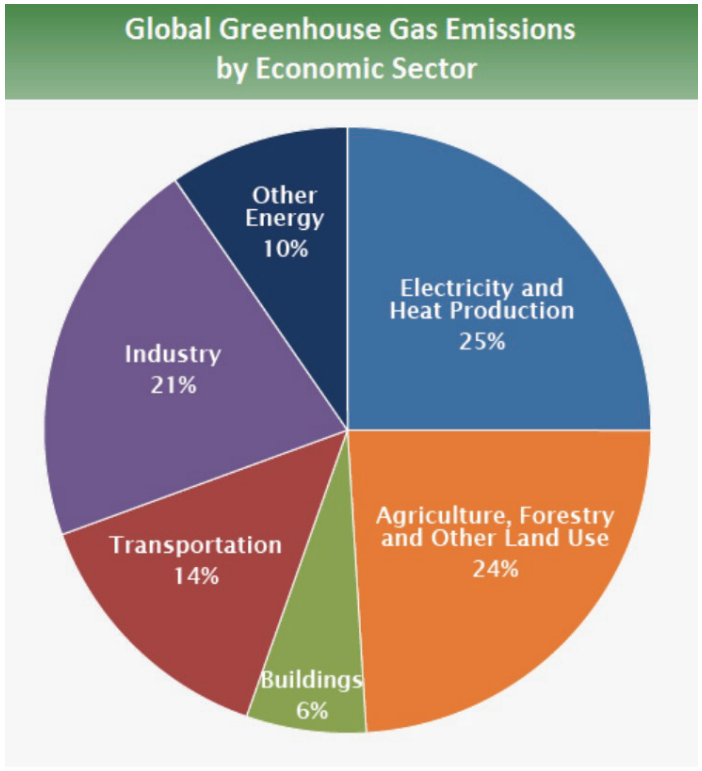
Source: State of the Planet
https://news.climate.columbia.edu/2021/02/25/carbon-dioxide-cause-global-warming/

Global CO_2 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_2 Emissions in 2021
https://www.iea.org/reports/global-energy-review-co2-emissions-in-2021-2

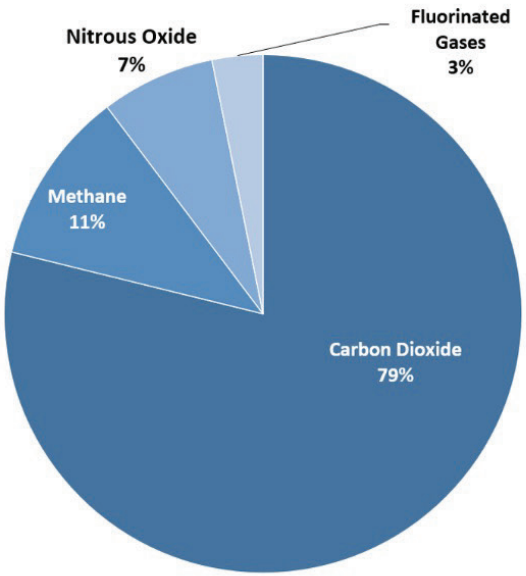




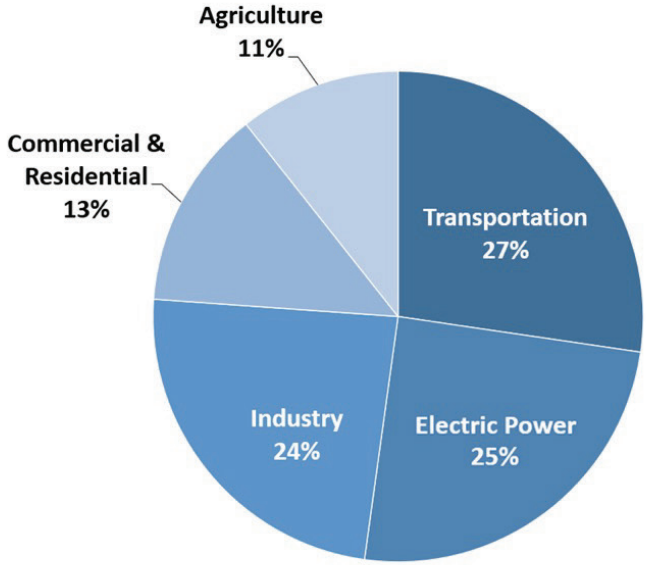
Source: IPCC (2014)

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

Overview of U.S. Greenhouse Gas Emissions in 2020



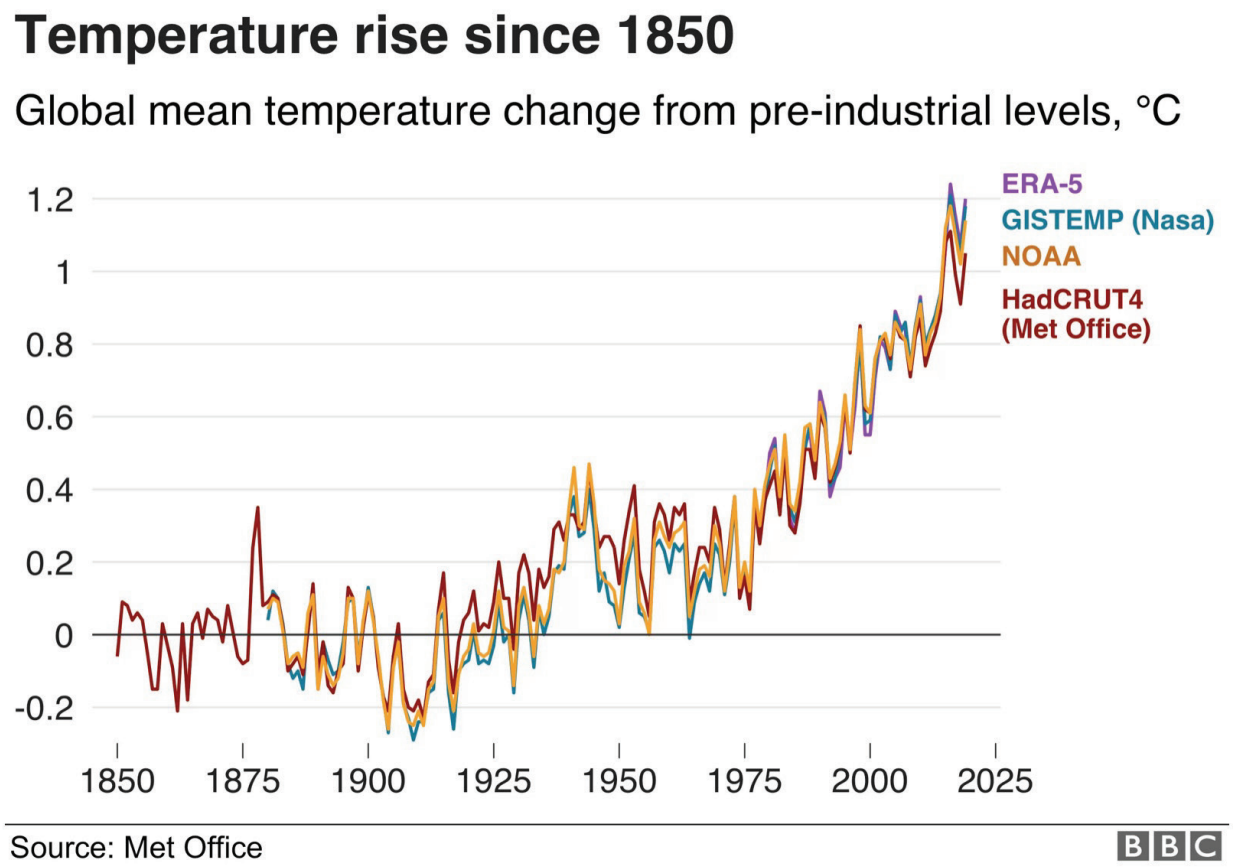
Sources of U.S. Greenhouse Gas Emissions in 2020



Note: All emission estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2020*

https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks

Impacts of Carbonization



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

Flooding in Pakistan

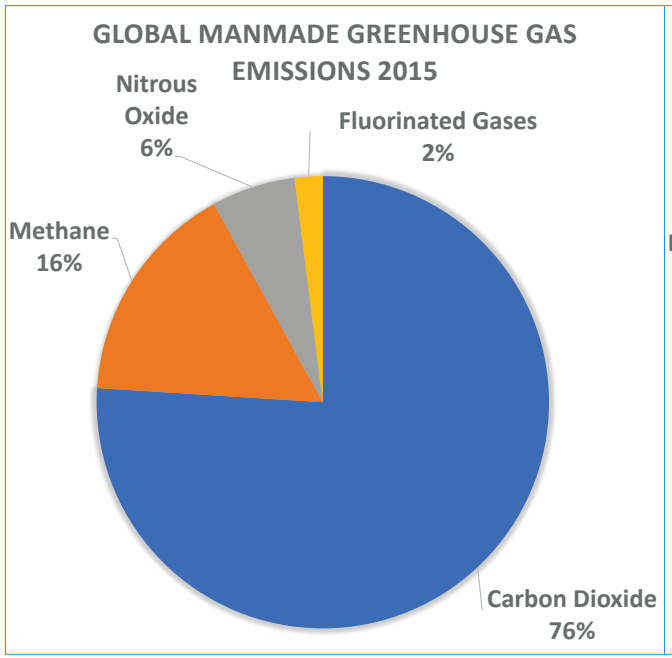

Source: Stringer/Reuters


Source: AP

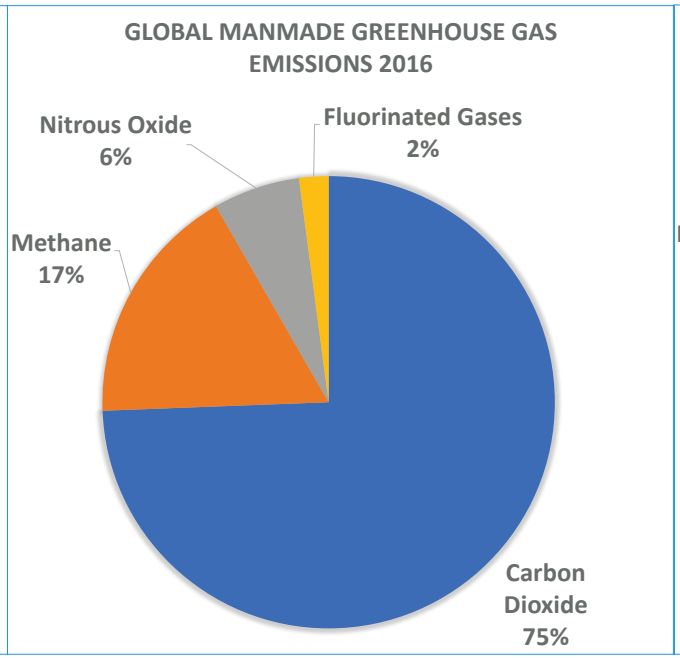

Source: Bloomberg

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

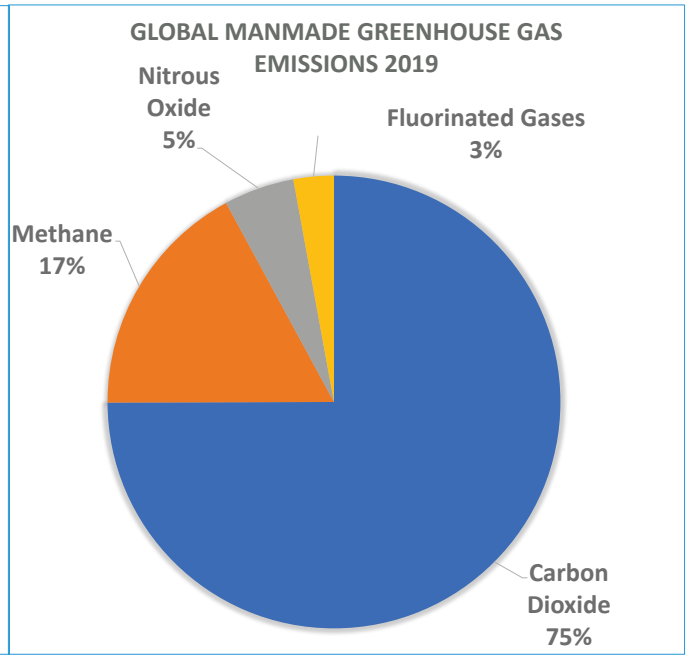
Fluorinated Gases include: HFC. PFC and SF6



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

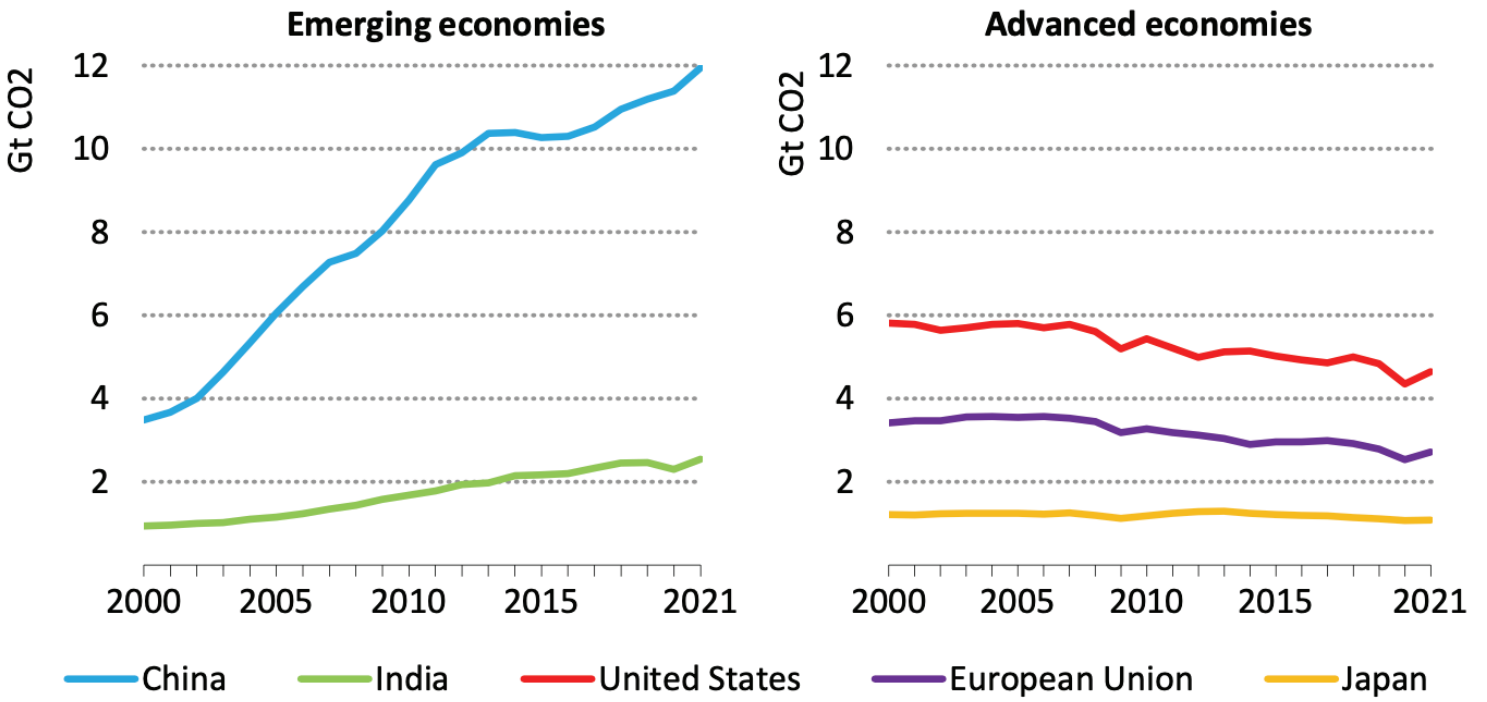


Source: https://ourworldindata.org/greenhouse-gas-emissions#annual-greenhouse-gas-emissions-how-much-do-we-emit-each-year



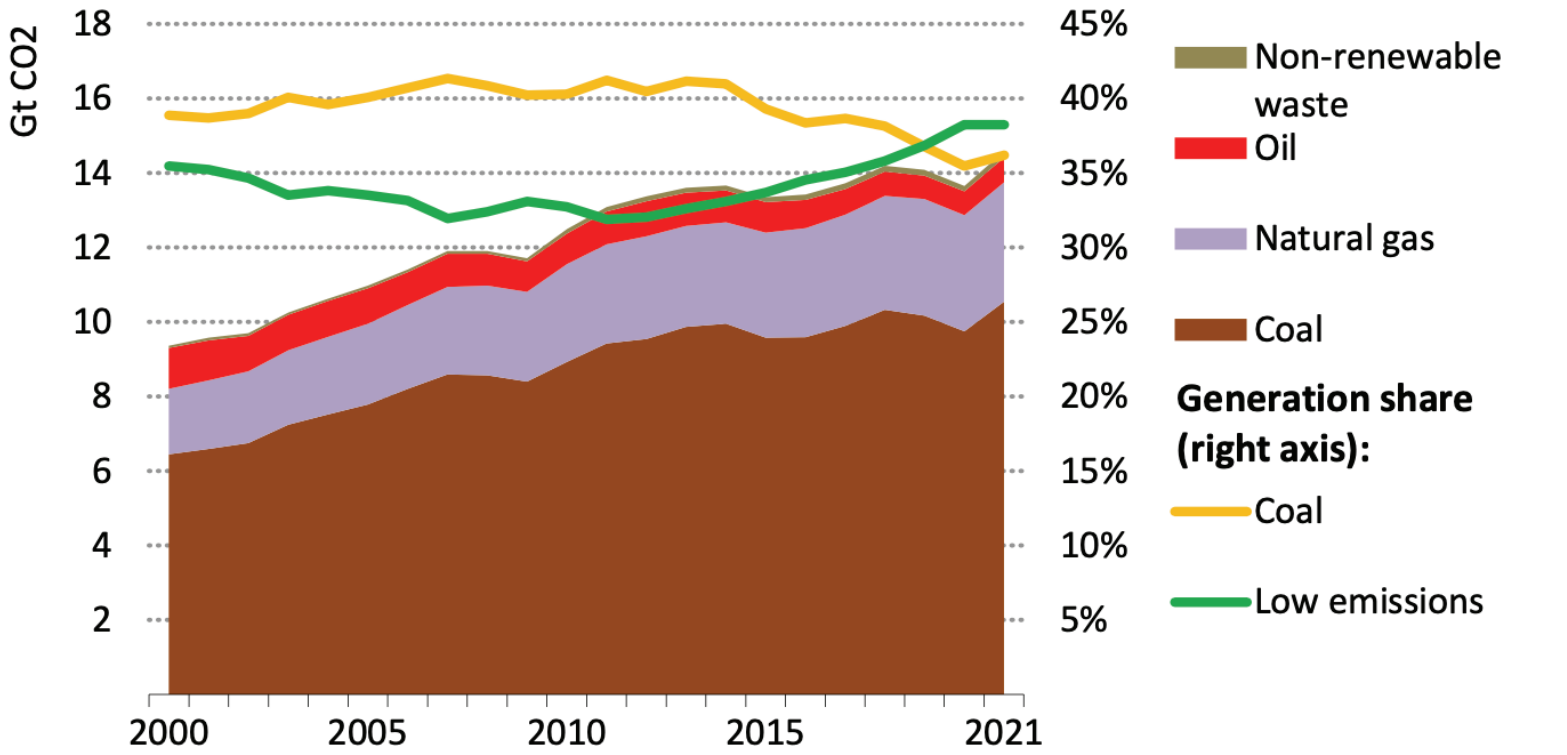
Source: UNEP Emissions Gap Report 2020 https://www.unep.org/emissions-gap-report-2020

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



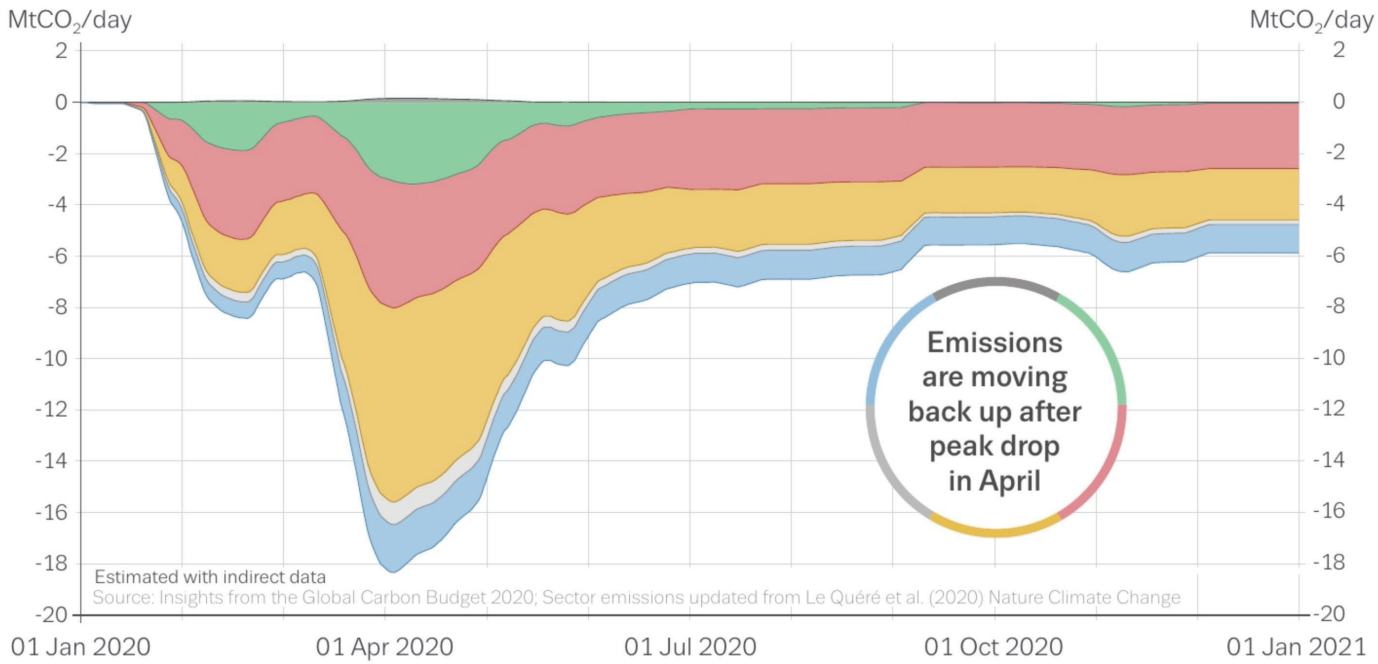
Source: IEA Global Energy Review: CO2 Emissions in 2021
https://www.iea.org/reports/global-energy-review-co2-emissions-in-2021-2

CO2 emissions from electricity and heat production by fuel, and share by fuel, 2000-2021



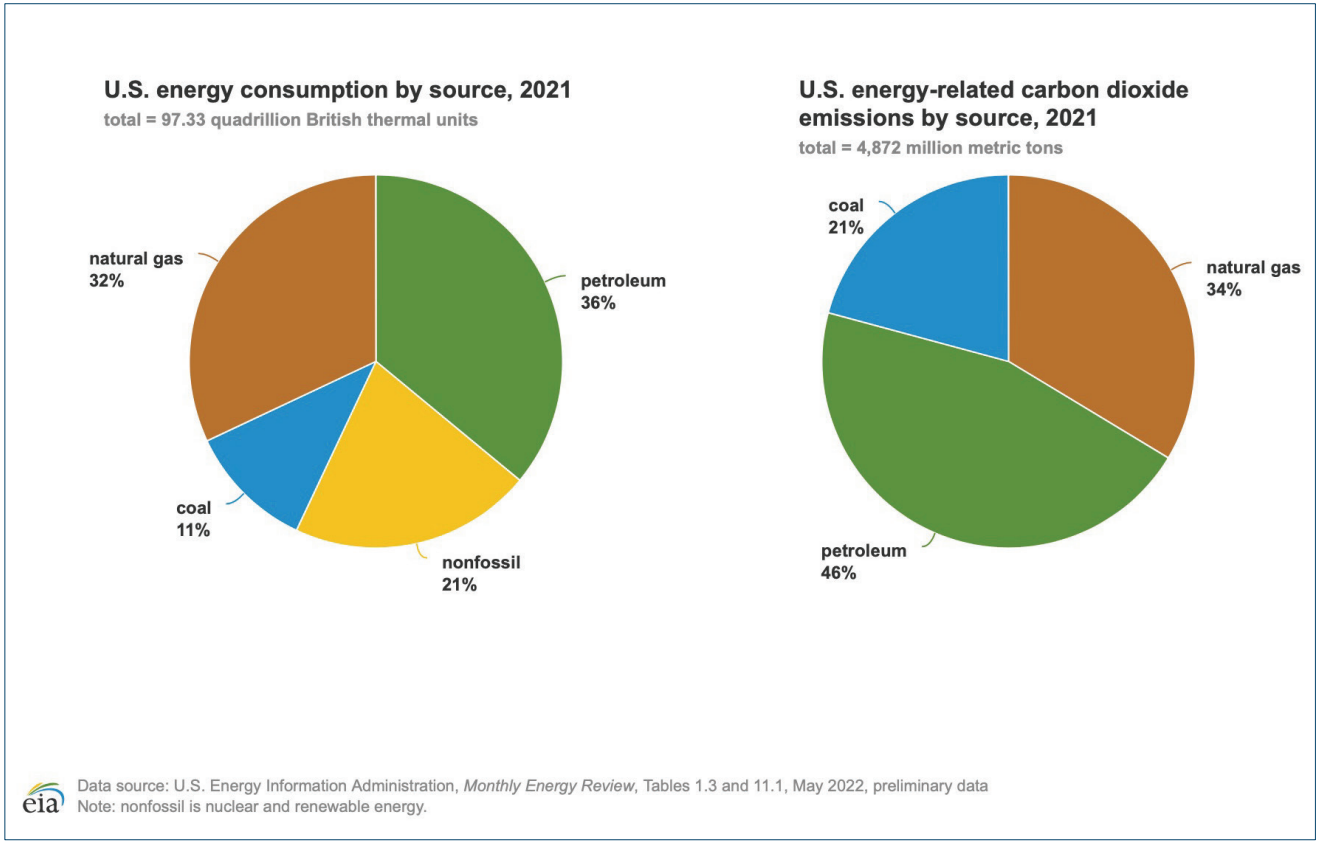
Source: IEA Global Energy Review: CO2 Emissions in 2021
https://www.iea.org/reports/global-energy-review-co2-emissions-in-2021-2

Emissions from road transport cause the largest share of the global 2020 decrease



Effect of COVID-19 restrictions on emissions

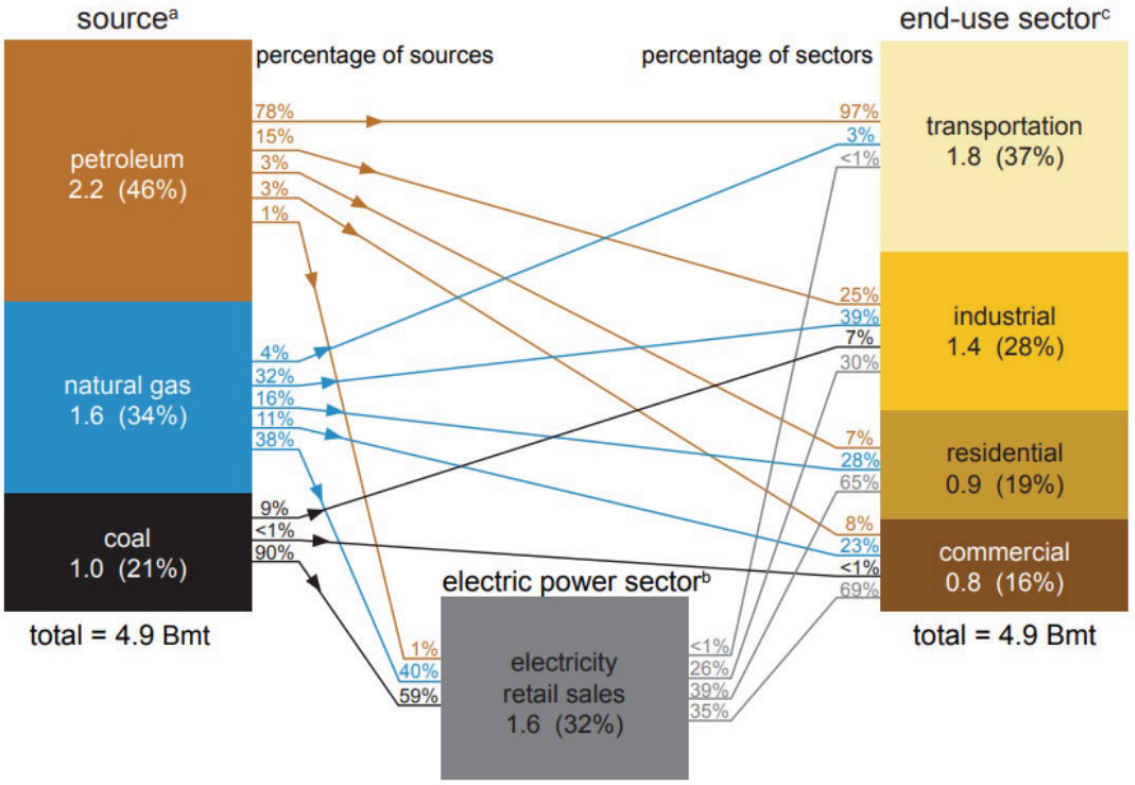
- **Residential**
- **Power**
- **Industry**
  Early data from CarbonMonitor suggest emissions from industry now exceed 2019 levels, pushed up by other factors
- **Surface transport**
  Emissions from road transport were still below their 2019 levels by the end of the year
- **Public**
- **Aviation**
  Emissions from aviation were cut by the most (by 75%) and were still below 2019 levels. This had a smaller effect than emissions from surface transport because aviation accounts for only 2.8% of global emissions



https://www.eia.gov/energyexplained/energy-and-the-environment/where-greenhouse-gases-come-from.php

U.S. CO_2 emissions from energy consumption by source and sector, 2021

billion metric tons (Bmt) of carbon dioxide (CO_2)

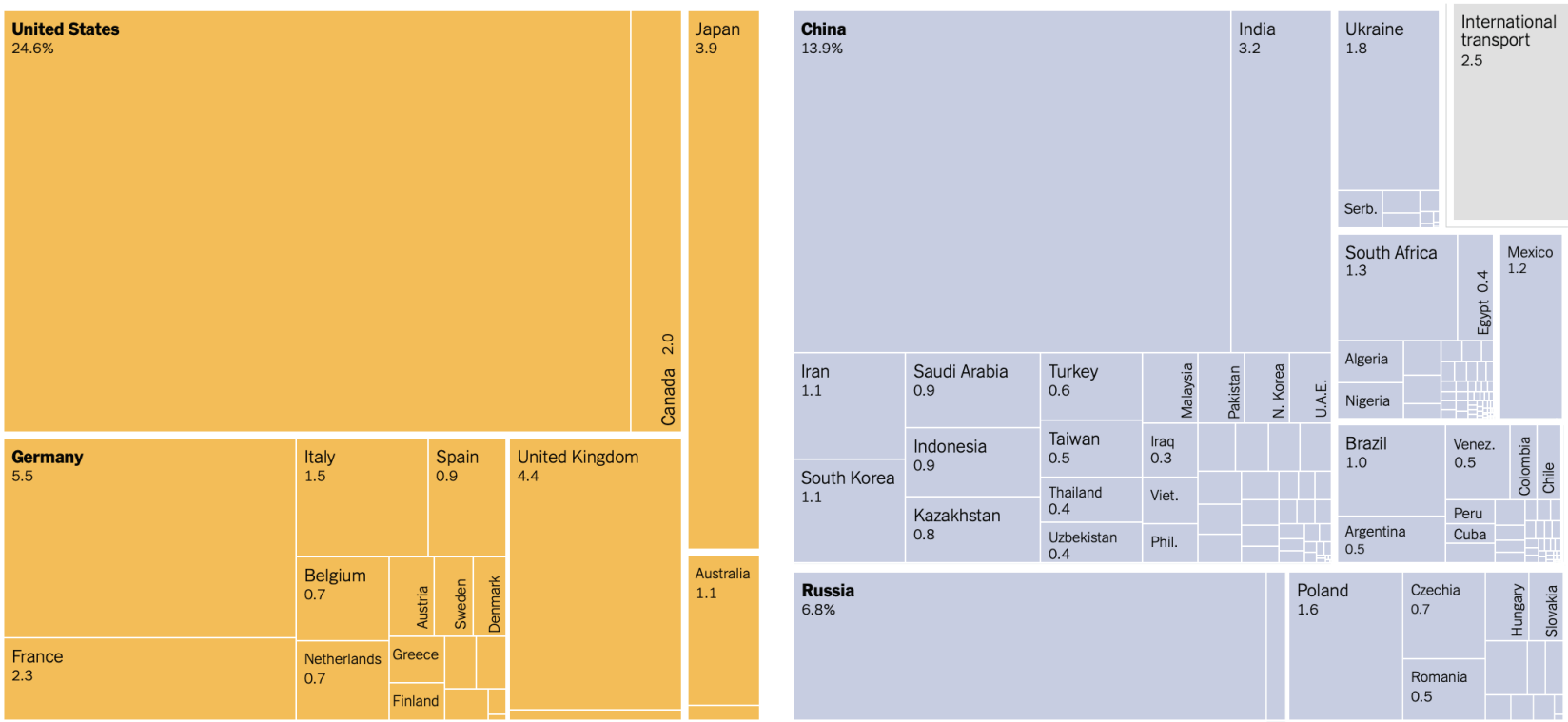


Source: https://www.eia.gov/energyexplained/energy-and-the-environment/where-greenhouse-gases-come-from.php

Who Has The Most Historical Responsibility for Climate Change

23 rich, developed countries are responsible for half of all historical CO_2 emissions.

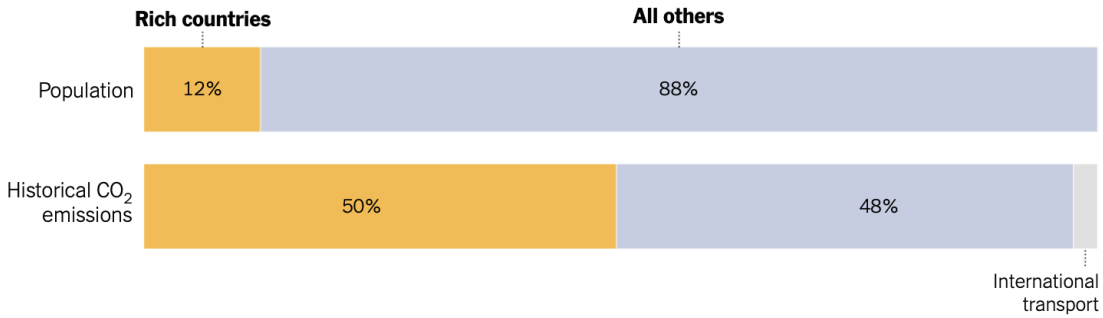
More than 150 countries are responsible for the other half.



Source: The New York Times article "Who Has The Most Historical Responsibility for Climate Change?" by 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.



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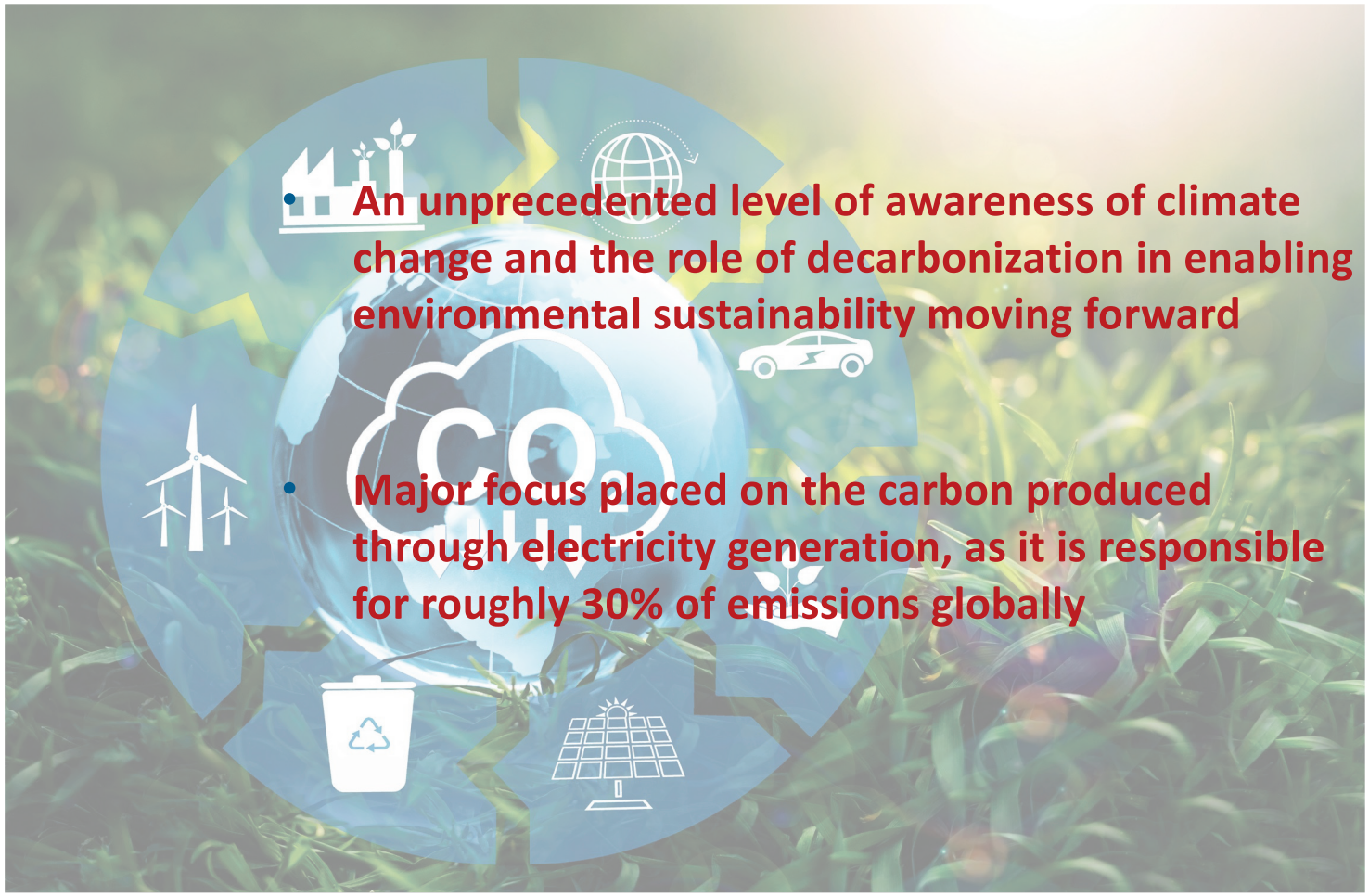

• An unprecedented level of awareness of climate change and the role of decarbonization in enabling environmental sustainability moving forward
• Major focus placed on the carbon produced through electricity generation, as it is responsible for roughly 30% of emissions globally

- 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.

A portfolio of technology solns

- Use less electricity through energy efficiency applications
- Use highly efficient fossil-fuel power plants with carbon capture and storage
- Promote and deploy more renewables
- Use hydrogen and other storage technologies to make renewable energy more useful
- Explore cross-border power transfer with neighboring countries
- Explore advanced nuclear technology such as small modular reactors (SMR)

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_2 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

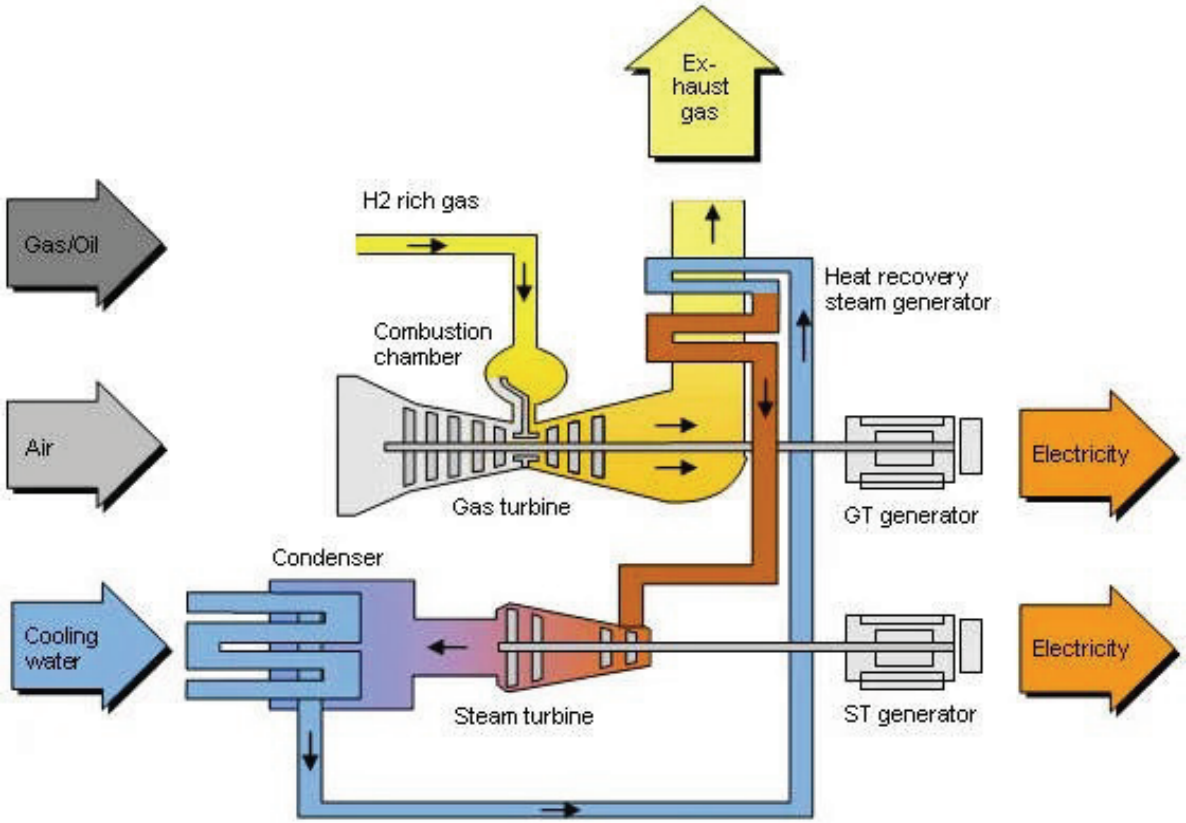
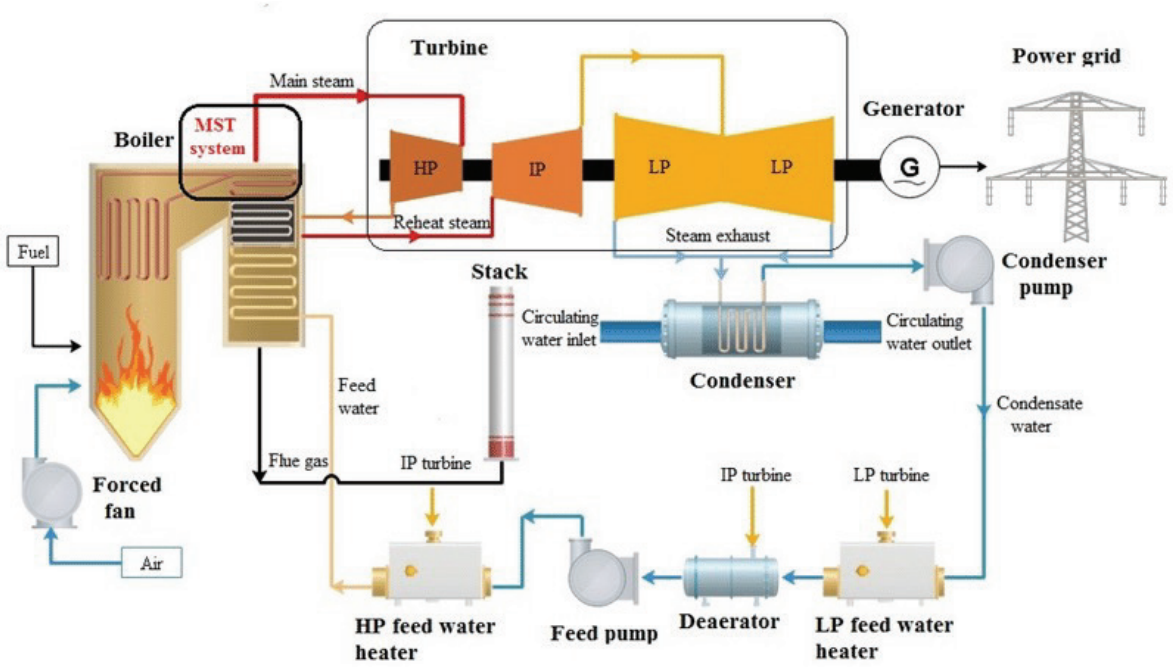


Image courtesy of: http://www.powergeneration.siemens.com

Power Plant: Ninemile 6, Westwego, La
Owner: Entergy Louisiana
Size: 560MW combined cycle unit
Gas Turbines: GE 7FA
Fuel: Natural gas and/or Fuel oil
Built: December 2014
Cost: $655 Million

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



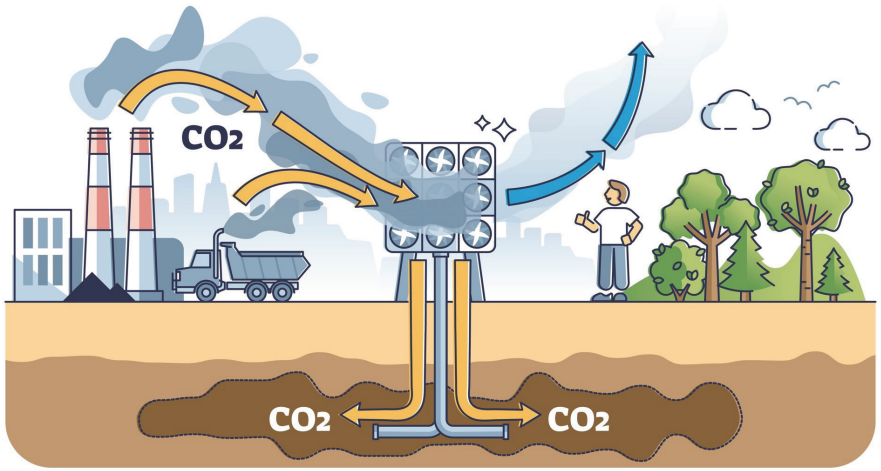
Source: https://www.researchgate.net/publication/343169041_An_Efficient_Robust_Predictive_Control_of_Main_Steam_Temperature_of_Coal-Fired_Power_Plant

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



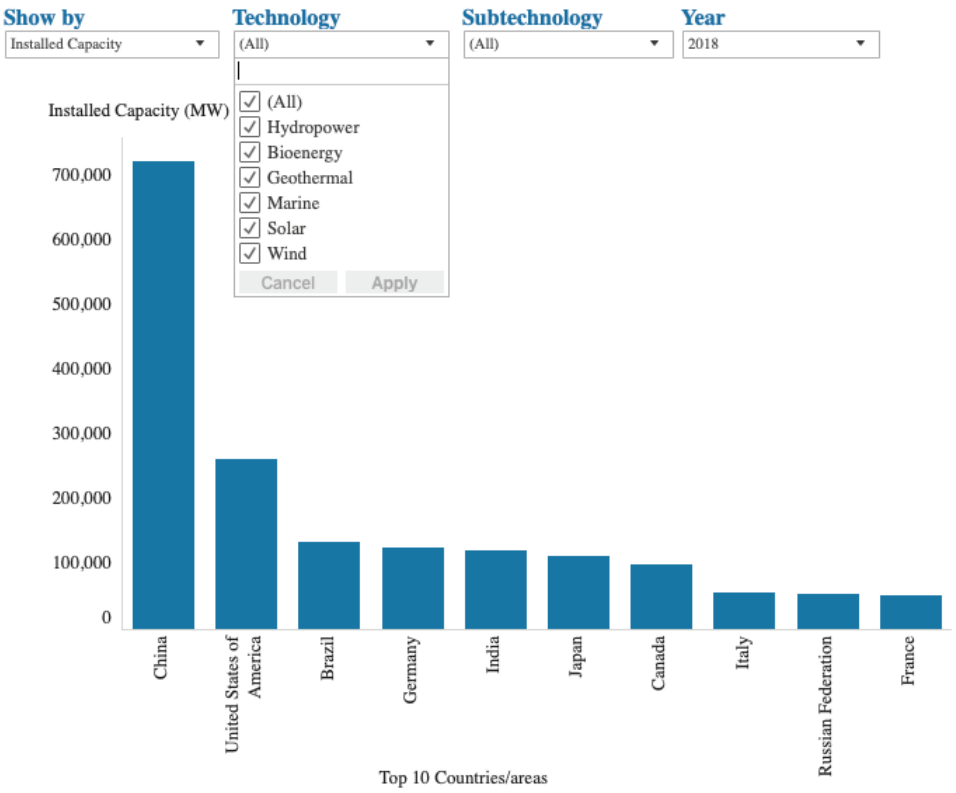
Carbon Capture and Storage (CCS)

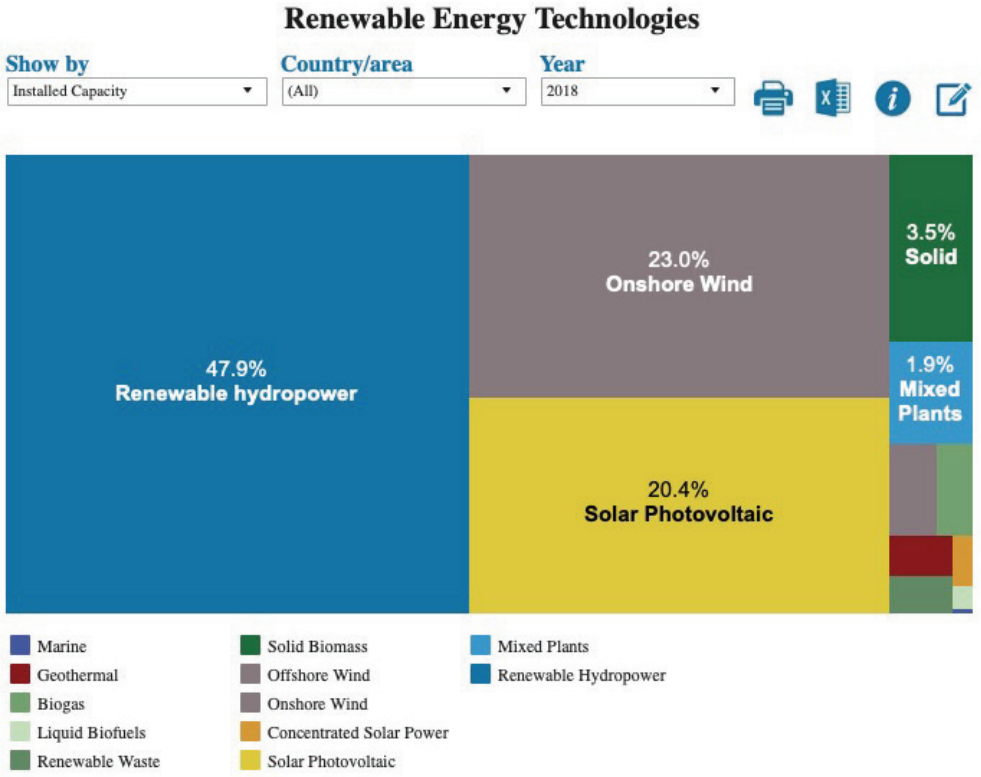
Renewable Energy Integration

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)





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

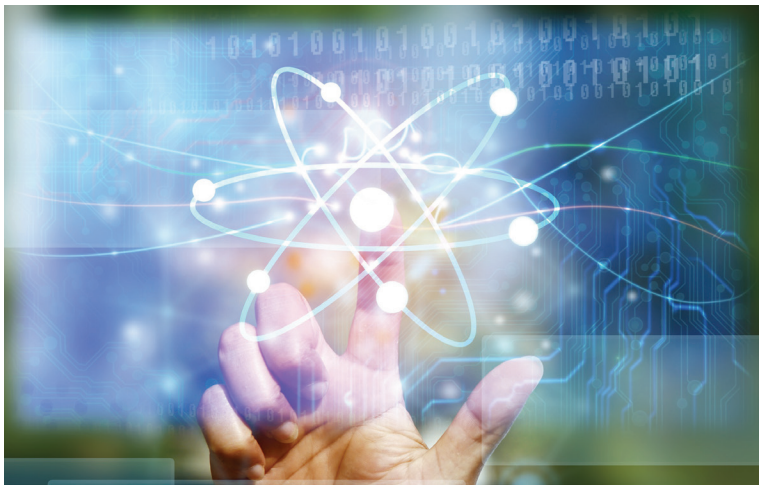
We all are impacted by climate change

- 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

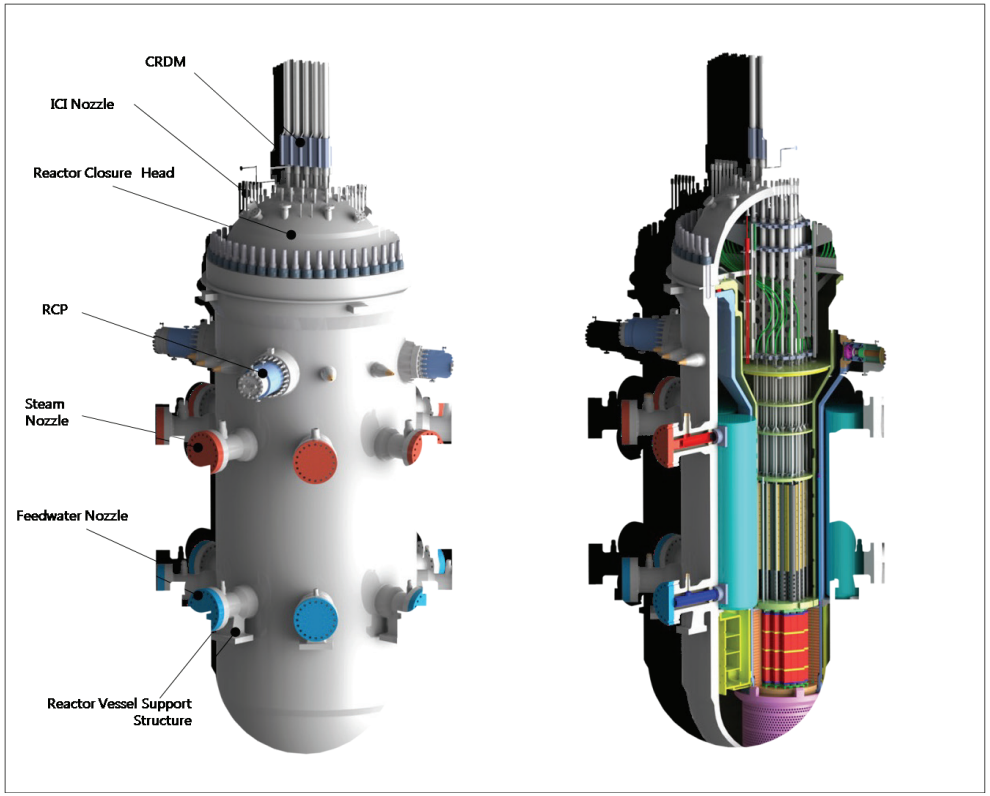
Advanced Nuclear Technologies

Diverse solutions to address climate change

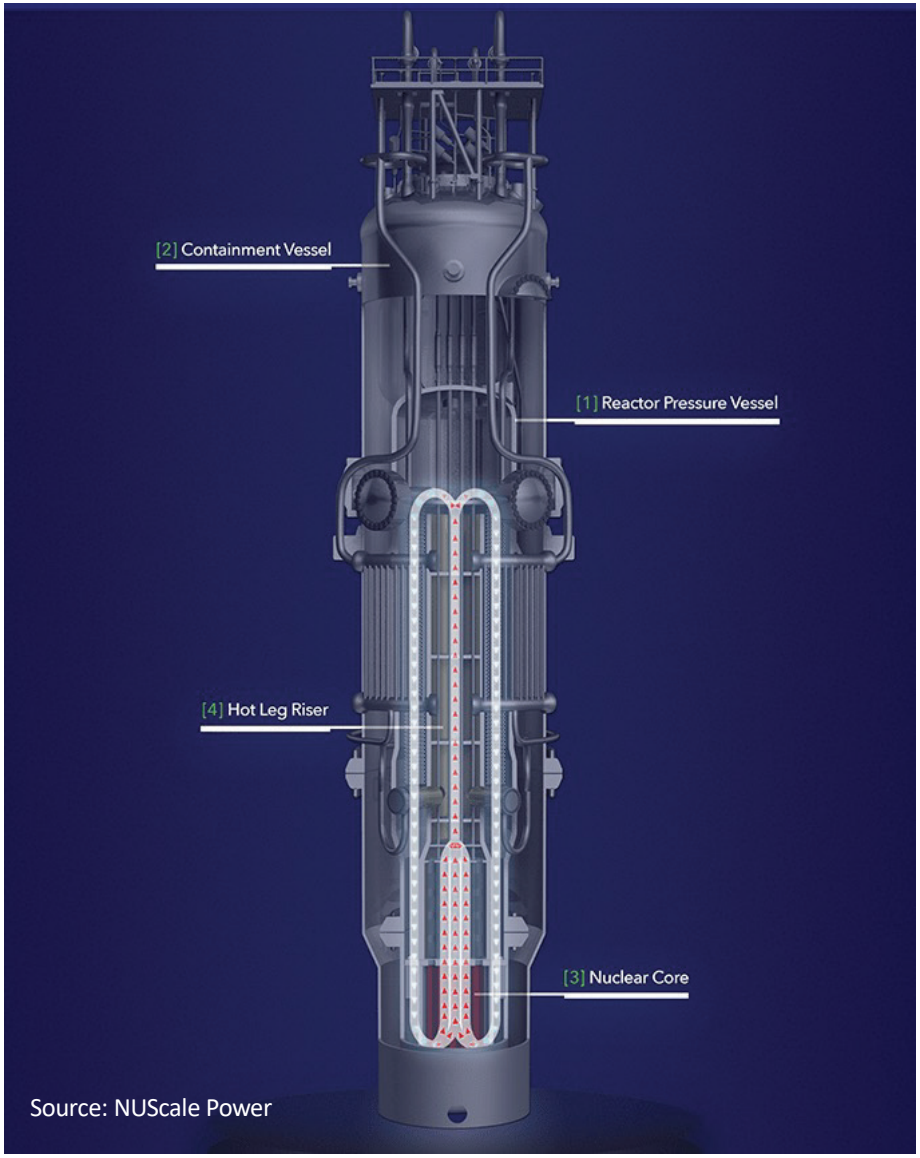
- Advanced nuclear technologies, such as small modular reactors (SMRs), can play a role
  - Smaller and can be built more quickly than more traditional nuclear reactors
- Ramping up the development of SMRs can help to produce energy when and where needed
- This energy could be integrated into existing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



Our Plan for a Clean Energy Future

Our Goals

Our Progress

2050
Net Zero
GHG Emissions

2030
50%
Reduction

2020
52%
Reduction[1]

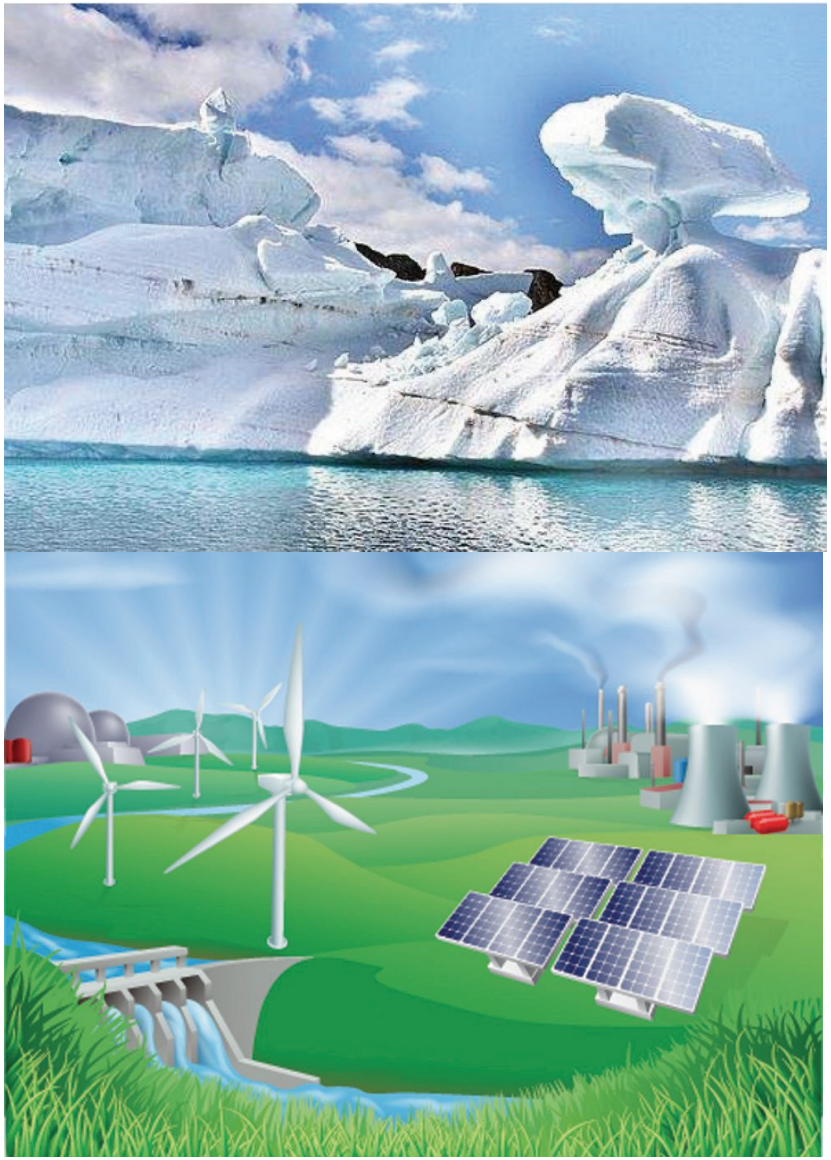
2017
36%
Reduction

2007
GHG Emission
Baseline

https://www.southerncompany.com/clean-energy/net-zero.html

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



THANK YOU!

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