IEEE ICEPE Conference, Dhaka, Bangladesh
26 November 2022

Keynote Speech

Causes and Effects of Carbonization on the Climate: Decarbonization Opportunities in the Electric Power Sector

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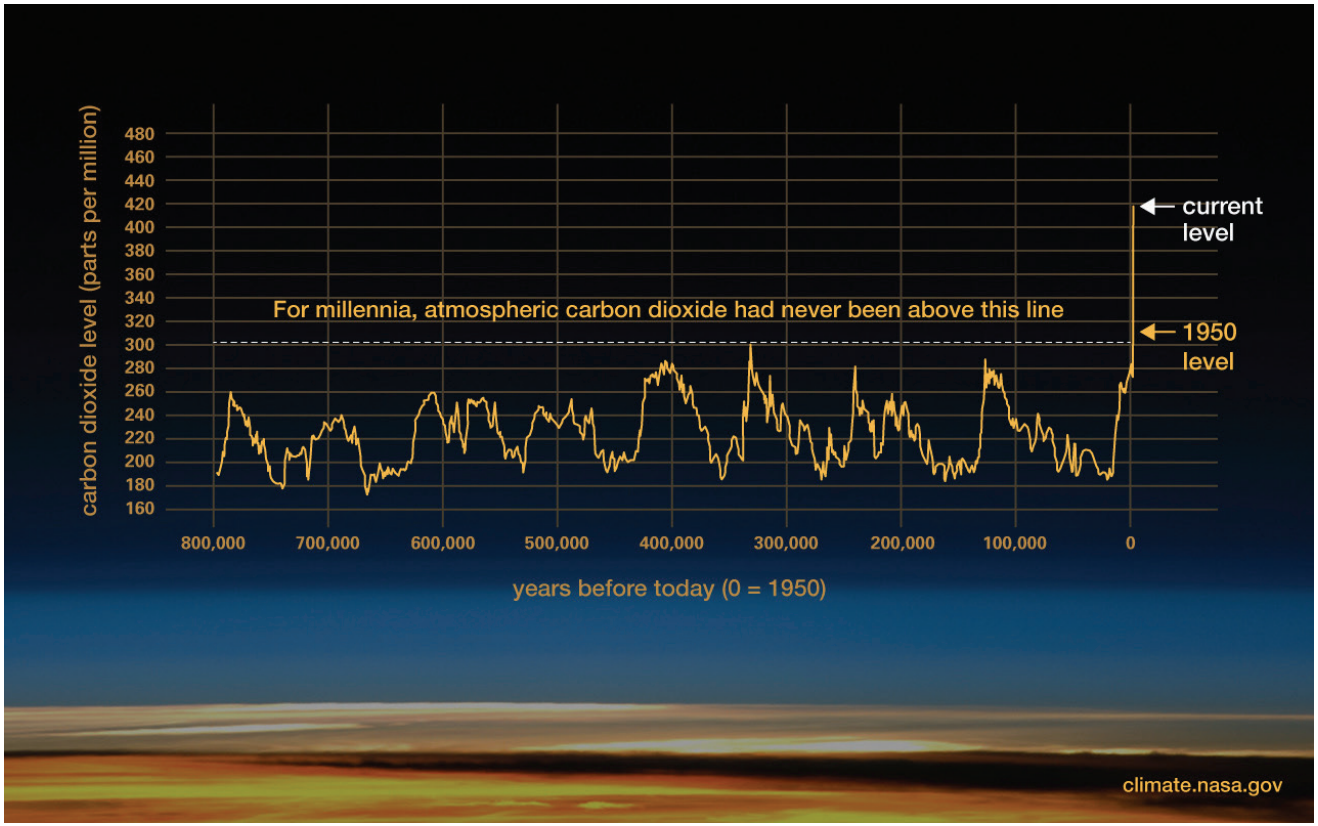
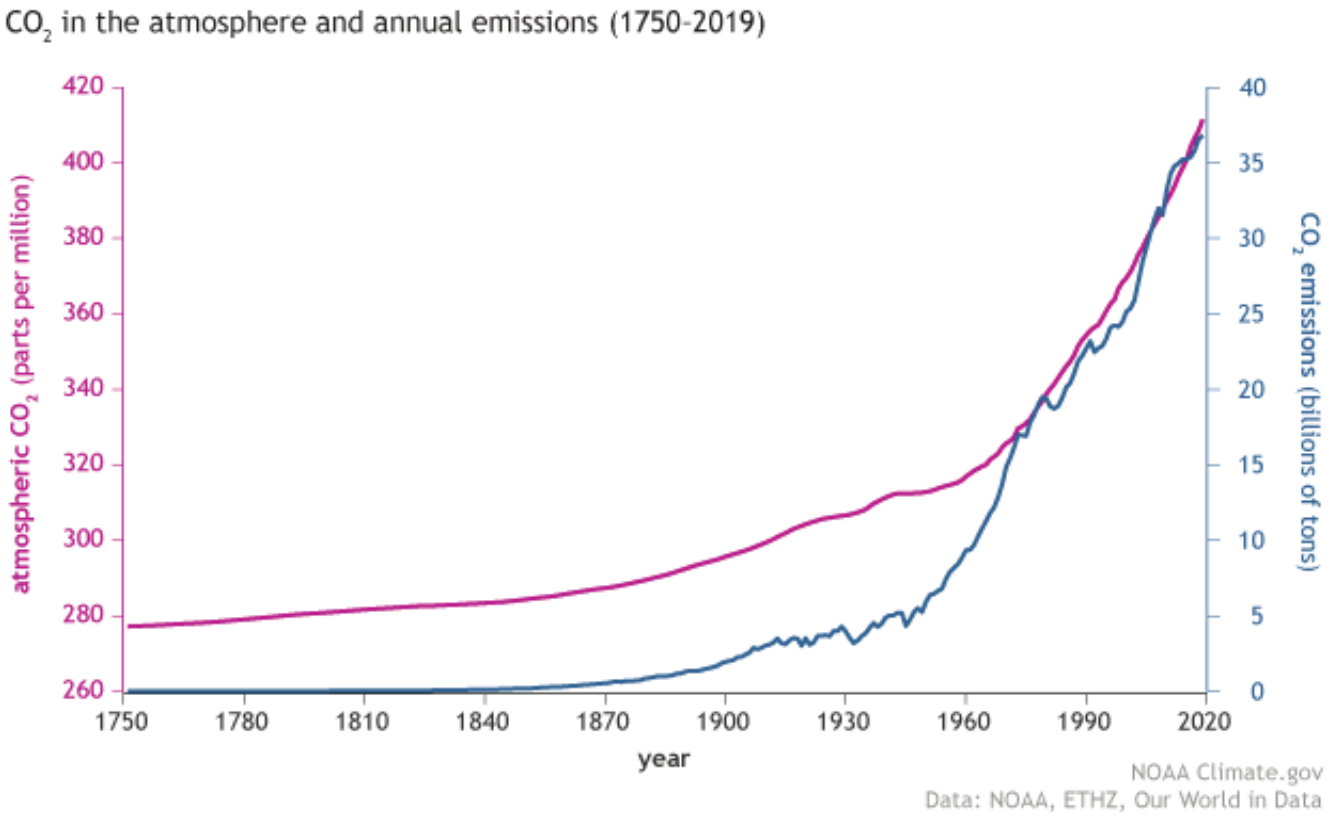
2022 IEEE President-elect

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/

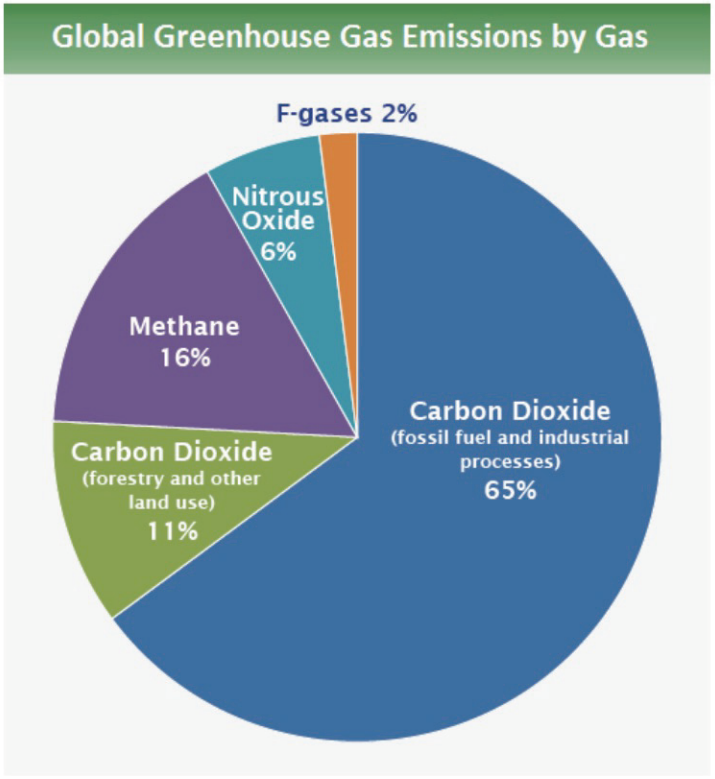


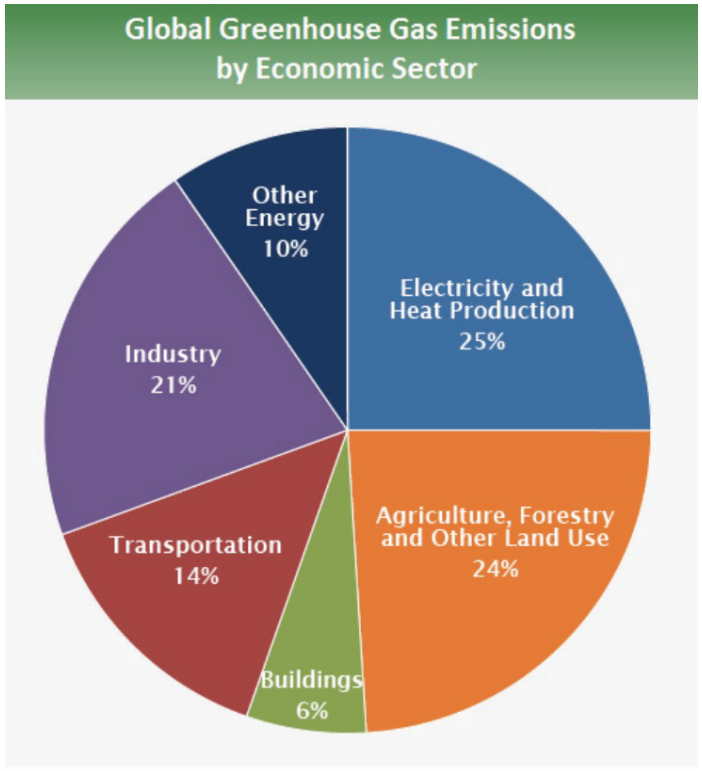
Source: State of the Planet
https://news.climate.columbia.edu/2021/02/25/carbon-dioxide-cause-global-warming/

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: CO2 Emissions in 2021
https://www.iea.org/reports/global-energy-review-co2-emissions-in-2021-2

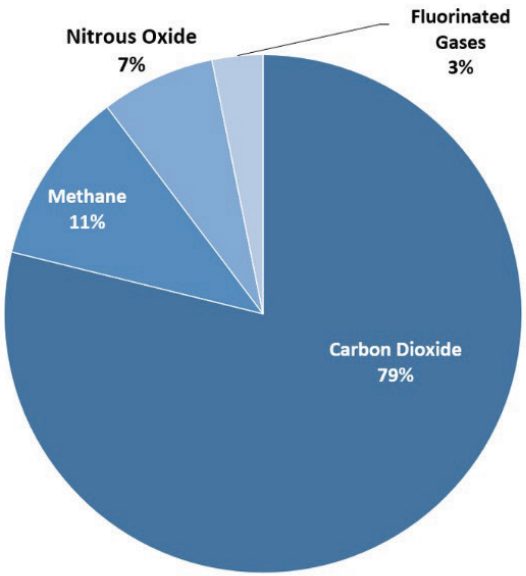




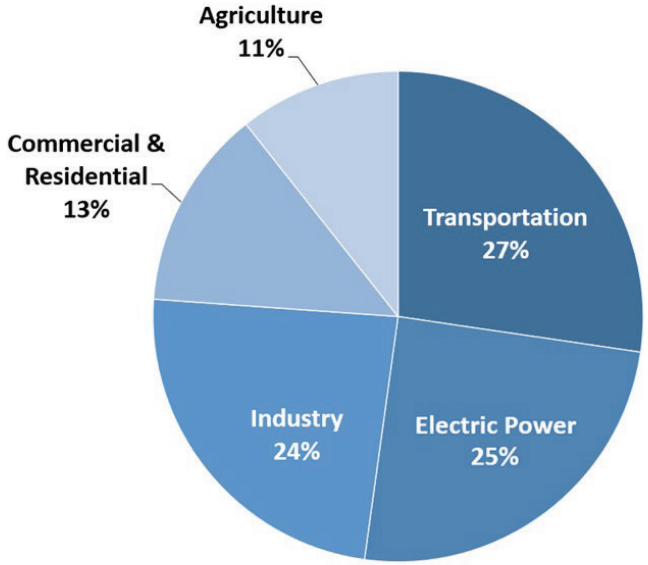
Source: IPCC (2014)

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

Overview of U.S. Greenhouse Gas Emissions in 2020



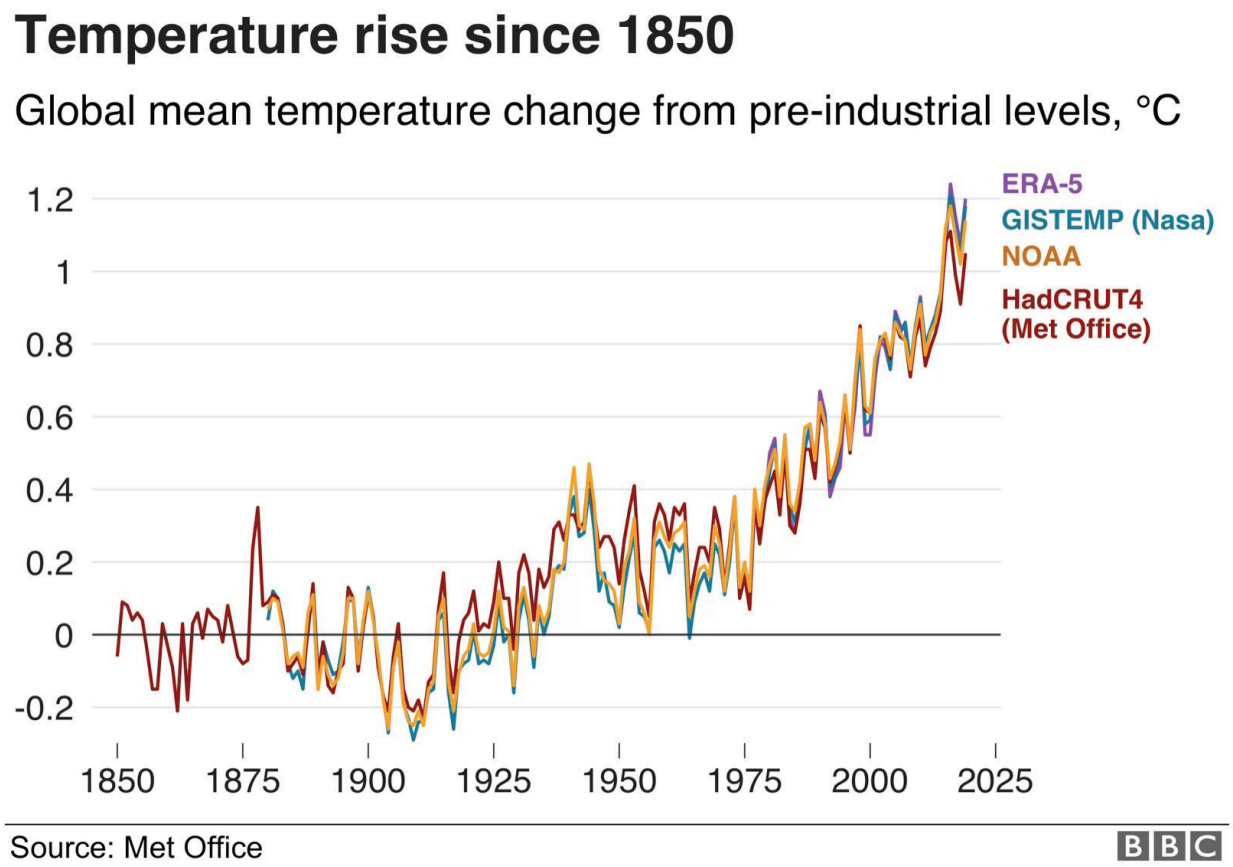
Sources of U.S. Greenhouse Gas Emissions in 2020



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

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

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

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

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. -

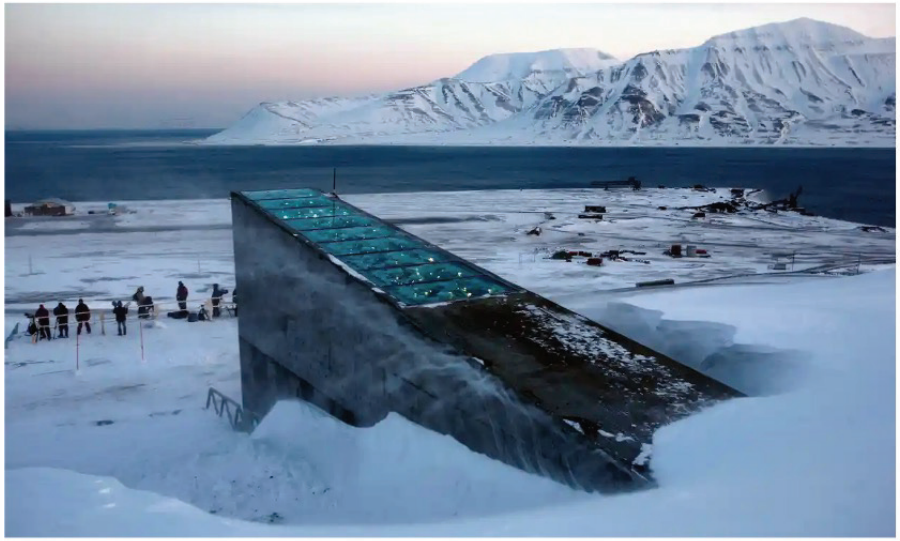
2008 China Snowstorm

Glacier Comparison Mer de Glace in France, 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

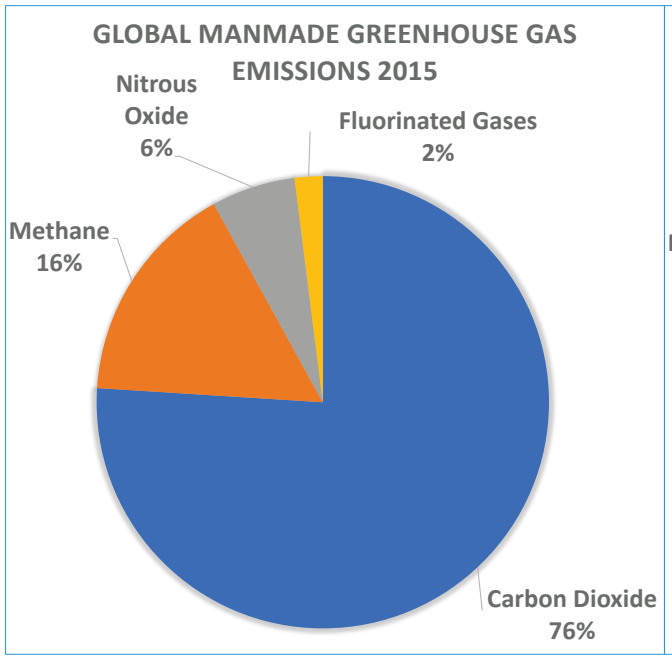
Source: The Guardian, May2017

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

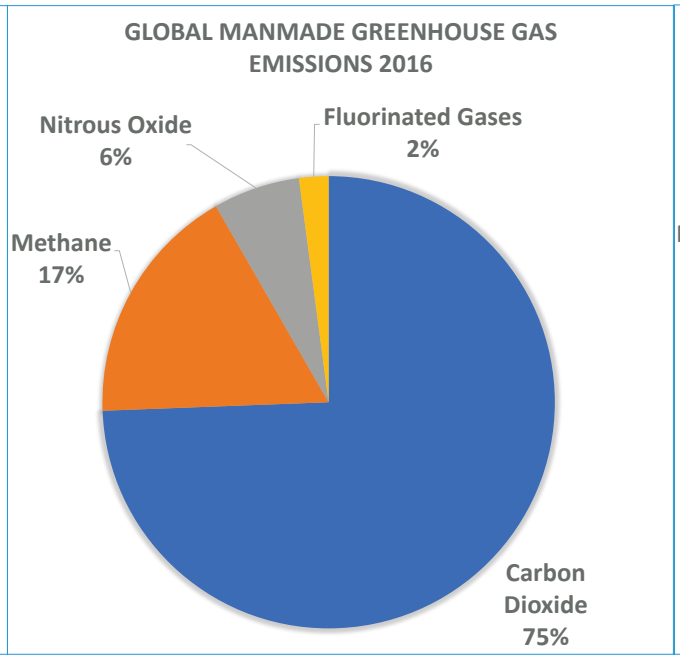
Svalbard Global Seed Vault Protects ...
nationalgeographic.com

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

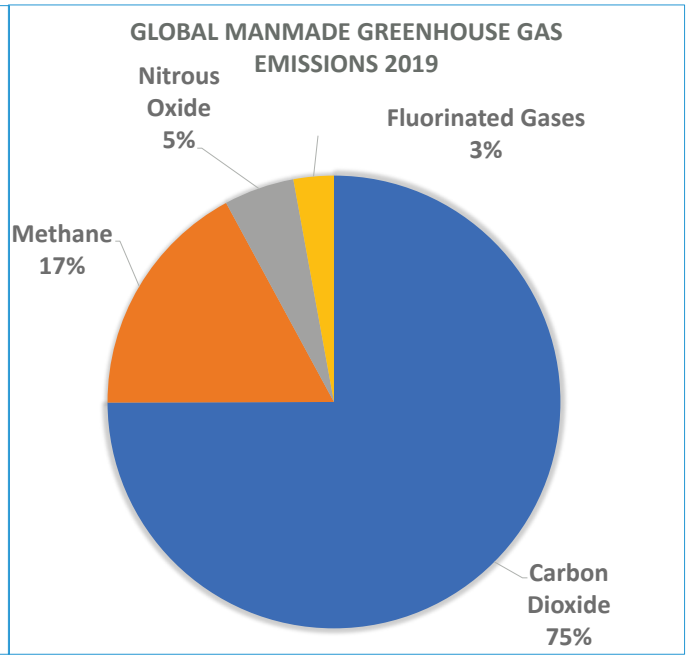
Fluorinated Gases include: HFC. PFC and SF6



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

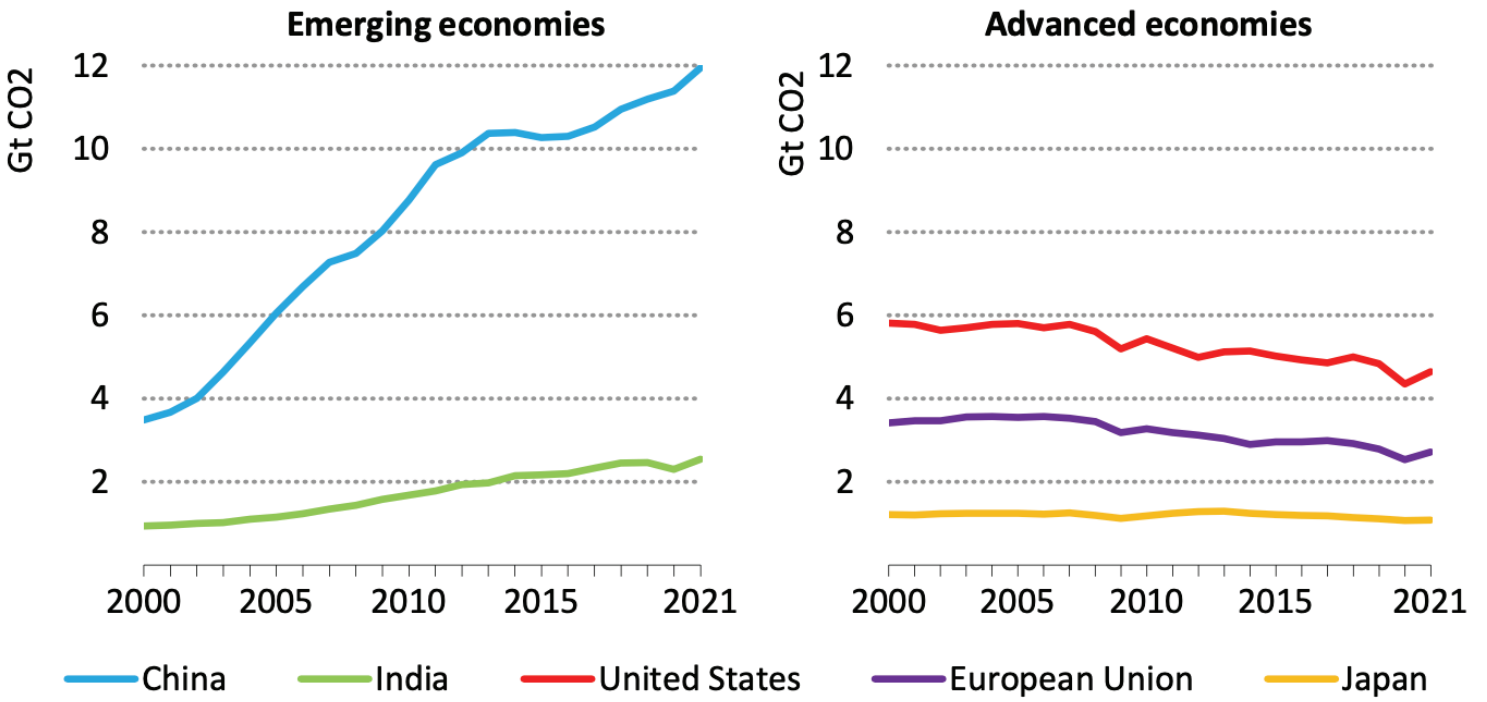


Source: https://ourworldindata.org/greenhouse-gas-emissions#annual-greenhouse-gas-emissions-how-much-do-we-emit-each-year



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

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

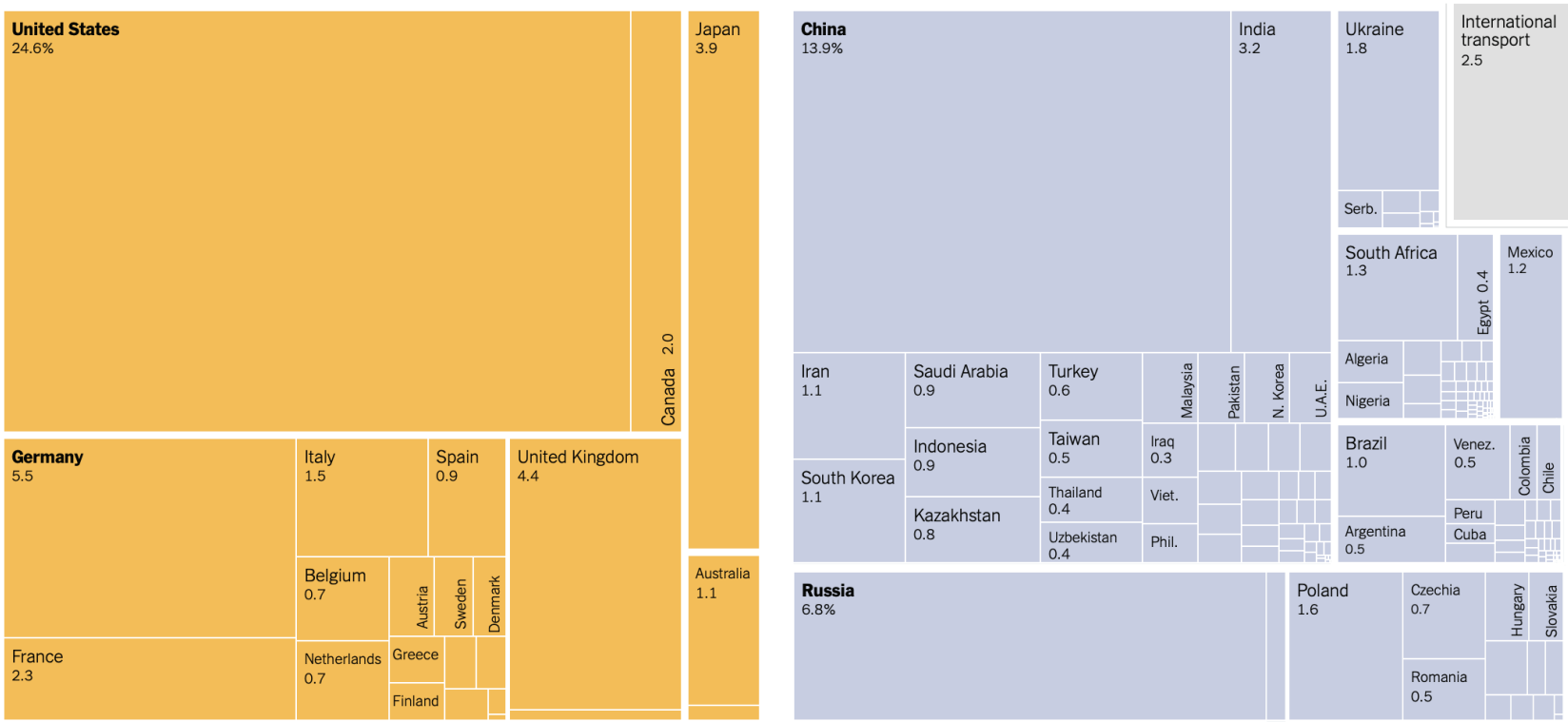


Source: IEA Global Energy Review: CO2 Emissions in 2021
https://www.iea.org/reports/global-energy-review-co2-emissions-in-2021-2

Who Has The Most Historical Responsibility for Climate Change

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

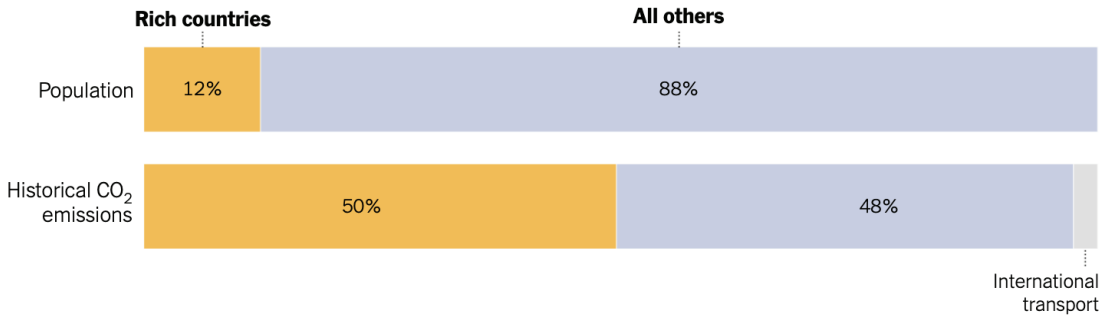
More than 150 countries are responsible for the other half.



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.



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_2 & 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_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

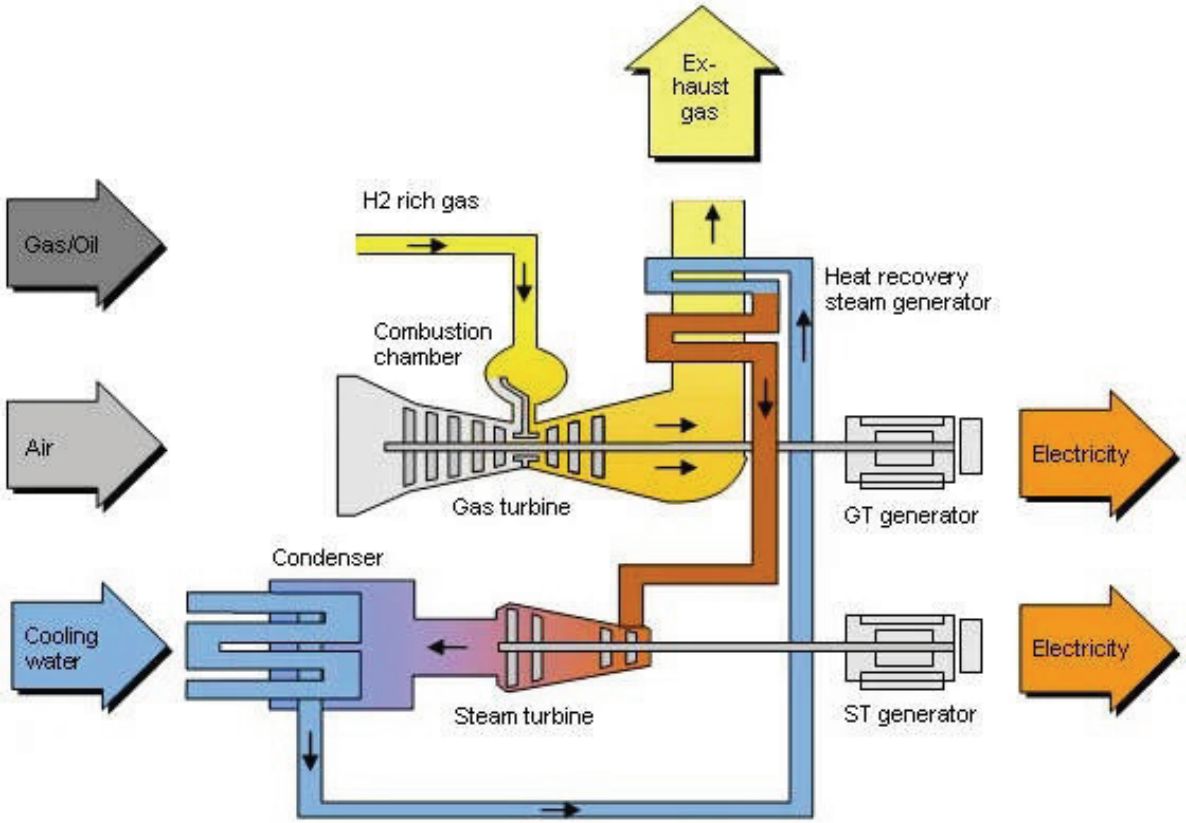
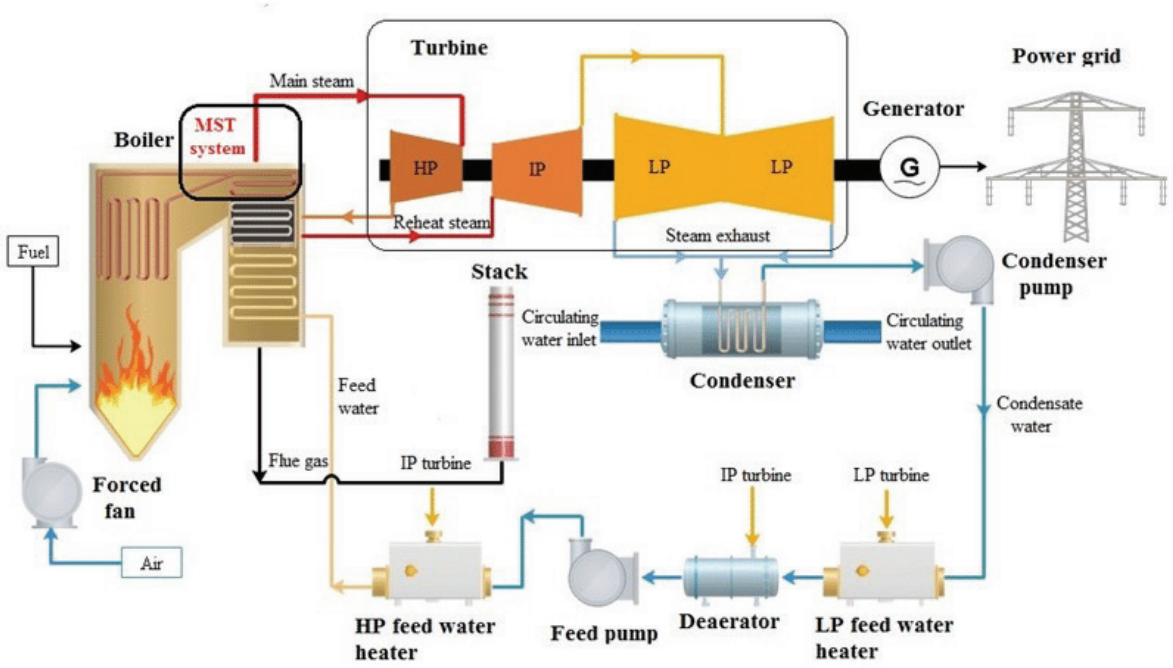


Image courtesy of: http://www.powergeneration.siemens.com

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



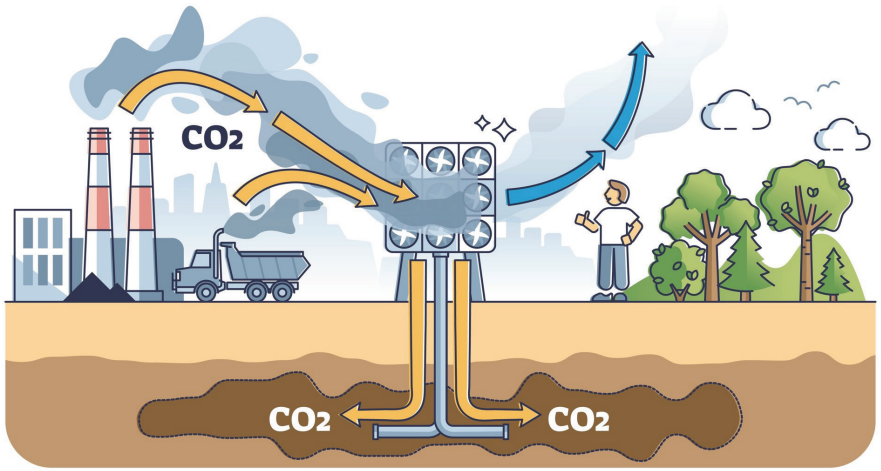
Source: https://www.researchgate.net/publication/343169041_An_Efficient_Robust_Predictive_Control_of_Main_Steam_Temperature_of_Coal-Fired_Power_Plant

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

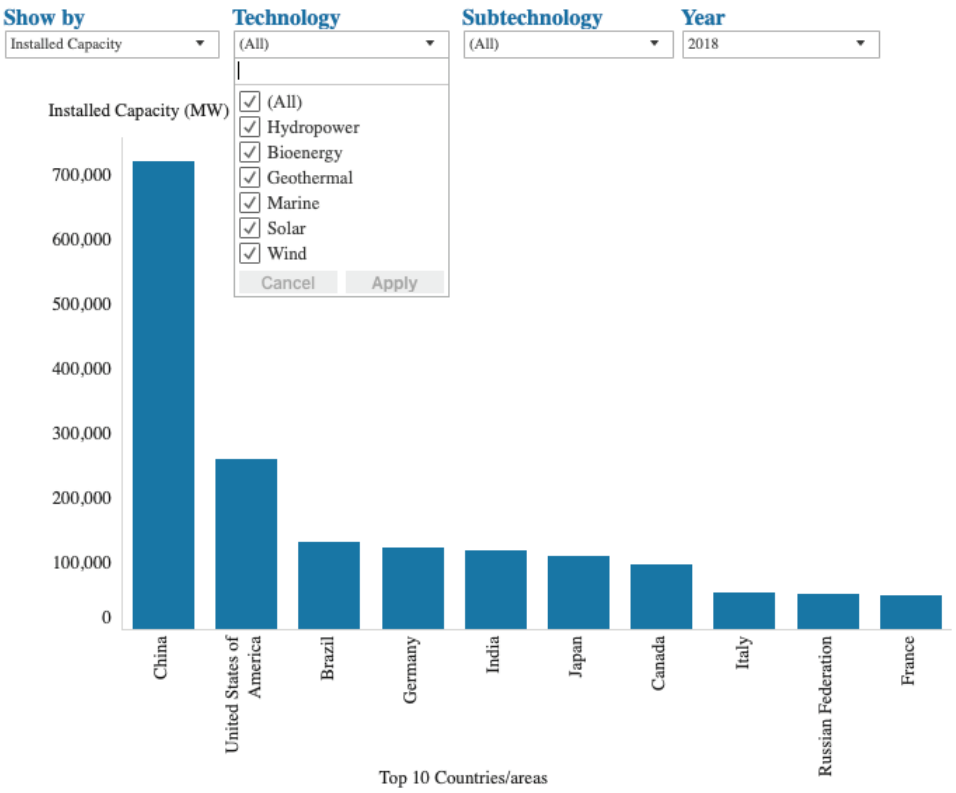


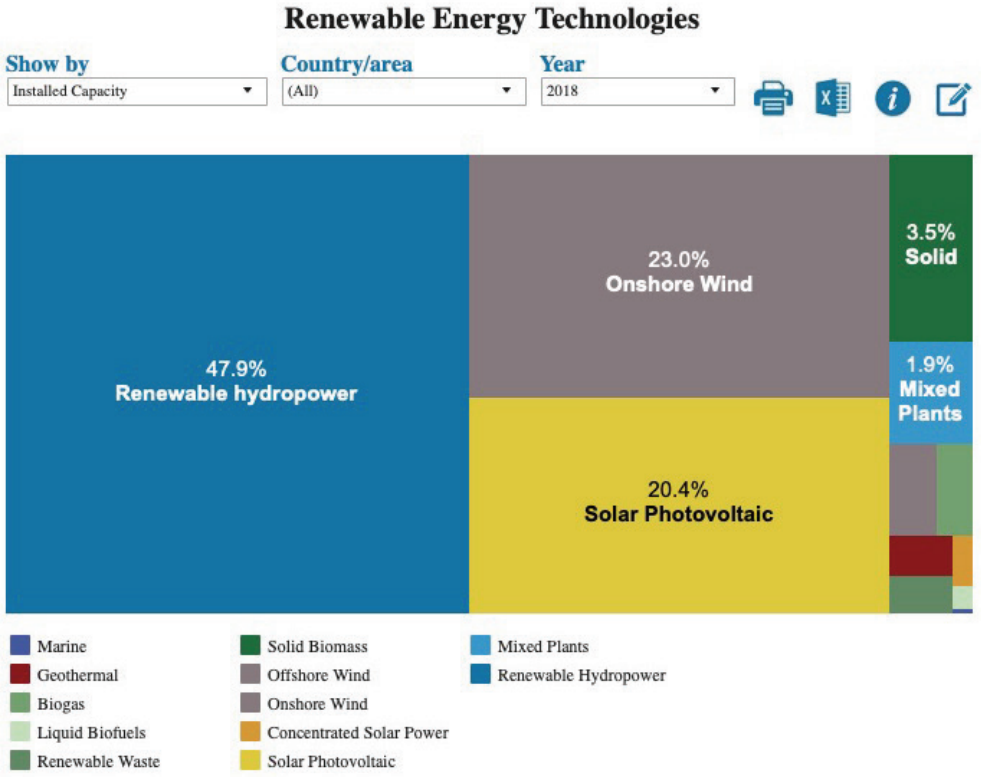
Renewable Energy Integration

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

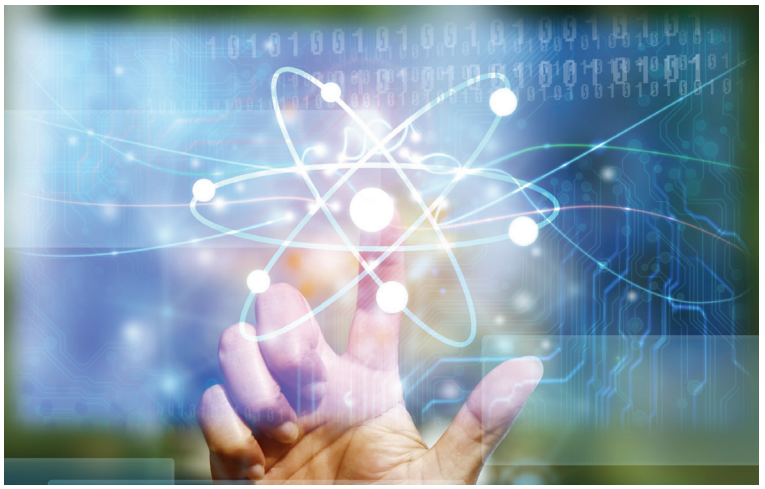
We all are impacted by climate change

- 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

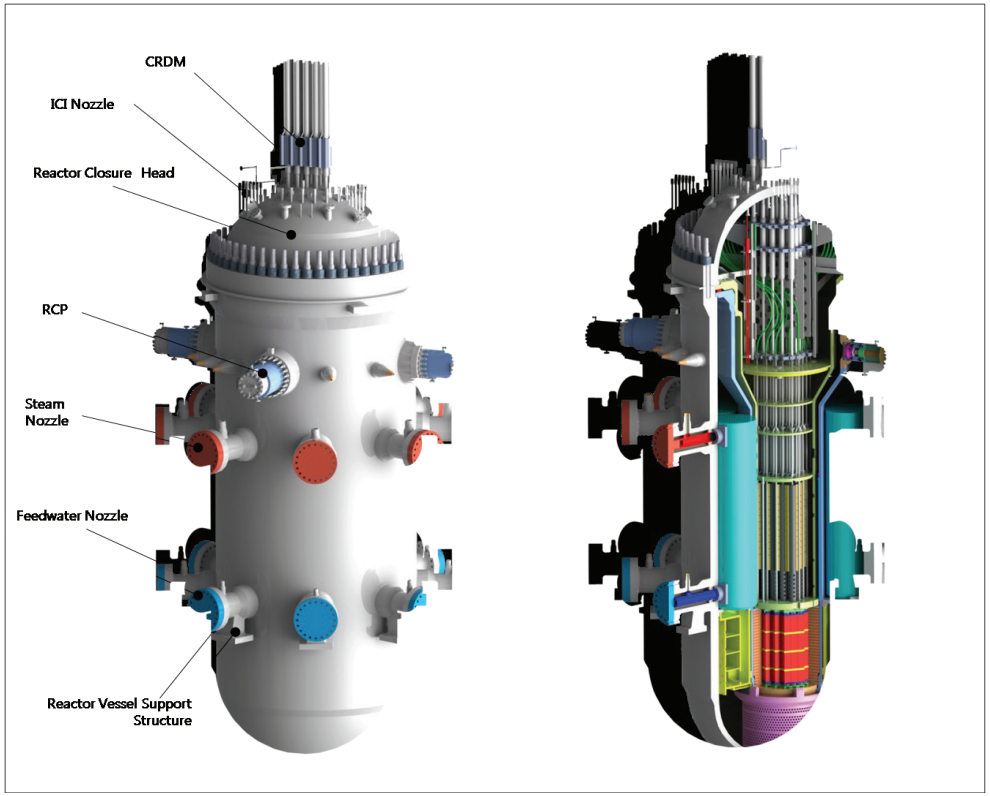
Advanced Nuclear Technologies

Diverse solutions to address climate change

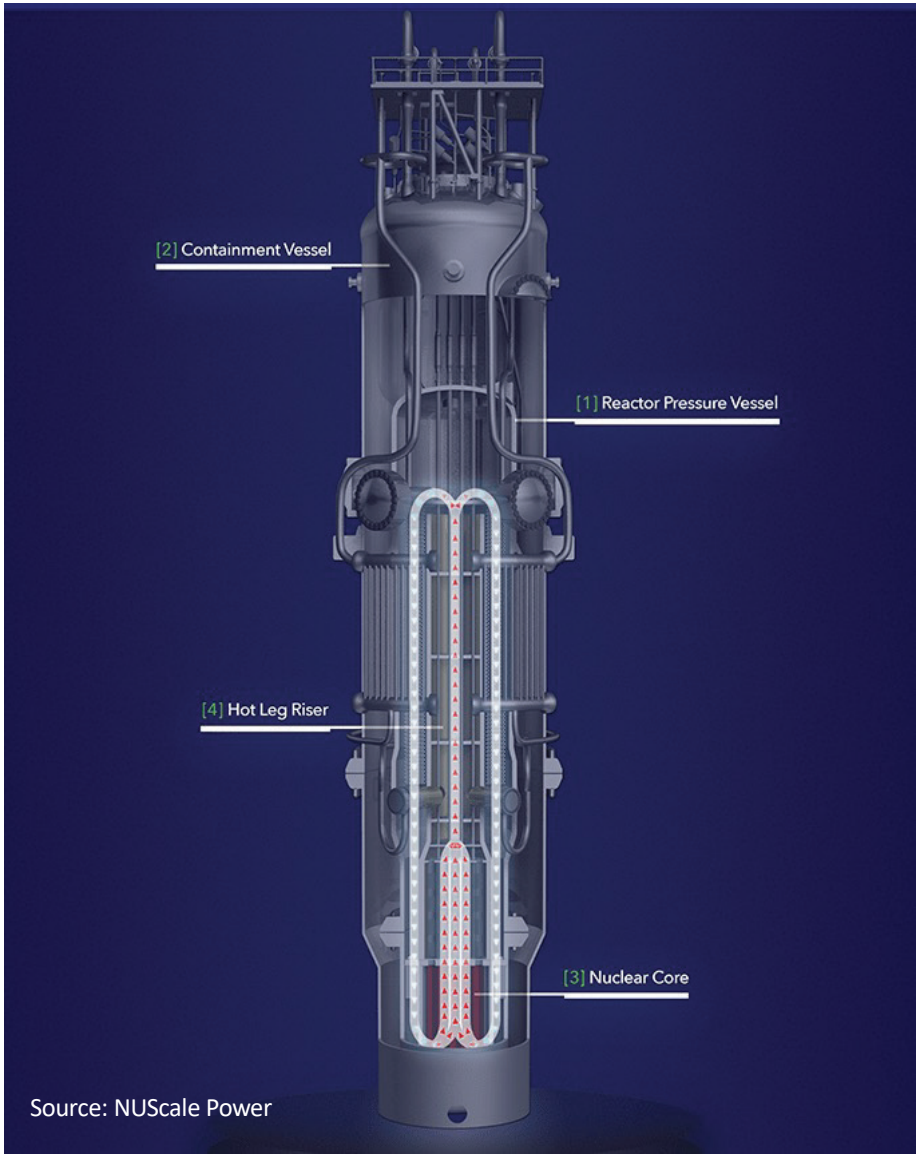
- Advanced nuclear technologies, such as small modular reactors (SMRs), can play a role
  - Smaller and can be built more quickly than more traditional nuclear reactors
- Ramping up the development of SMRs can help to produce energy when and where needed
- This energy could be integrated into existing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



Small Modular Reactors (SMR)

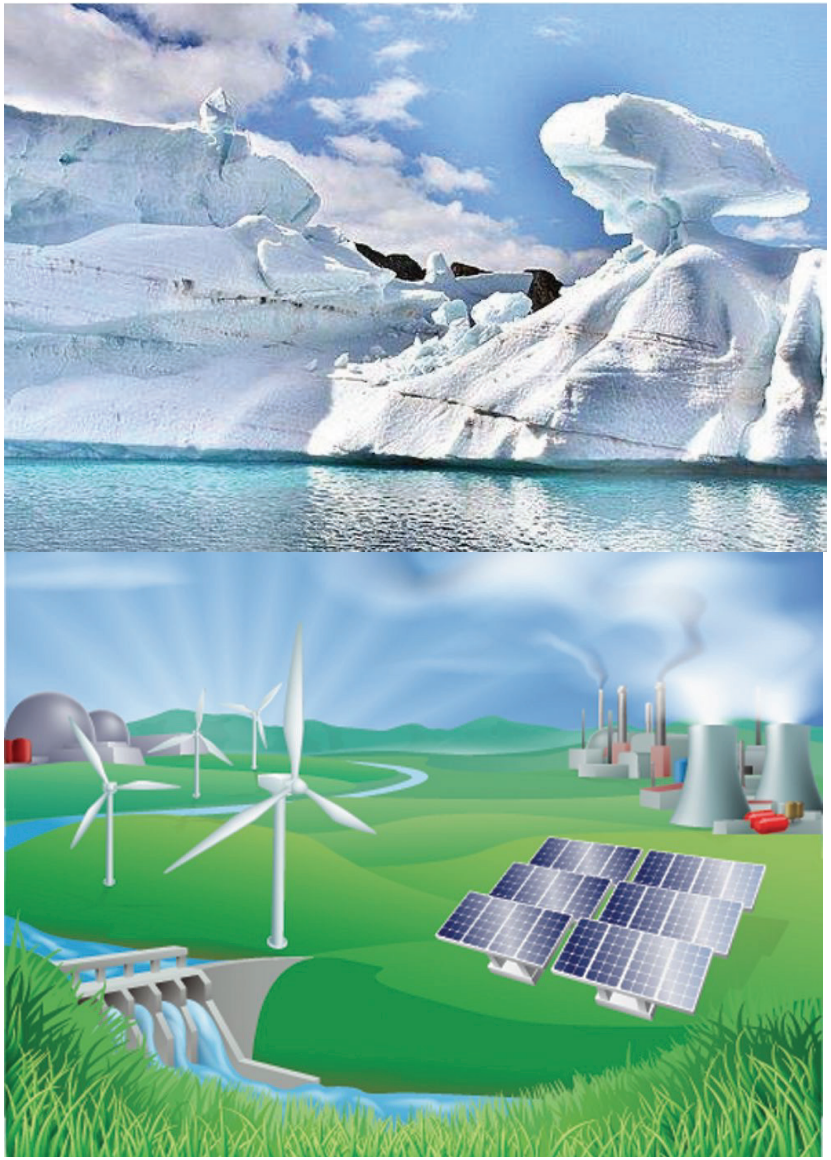


20m tall, 2.7m dia. 590 tons LWR
4.95% enrichment 50 – 60 MWe



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

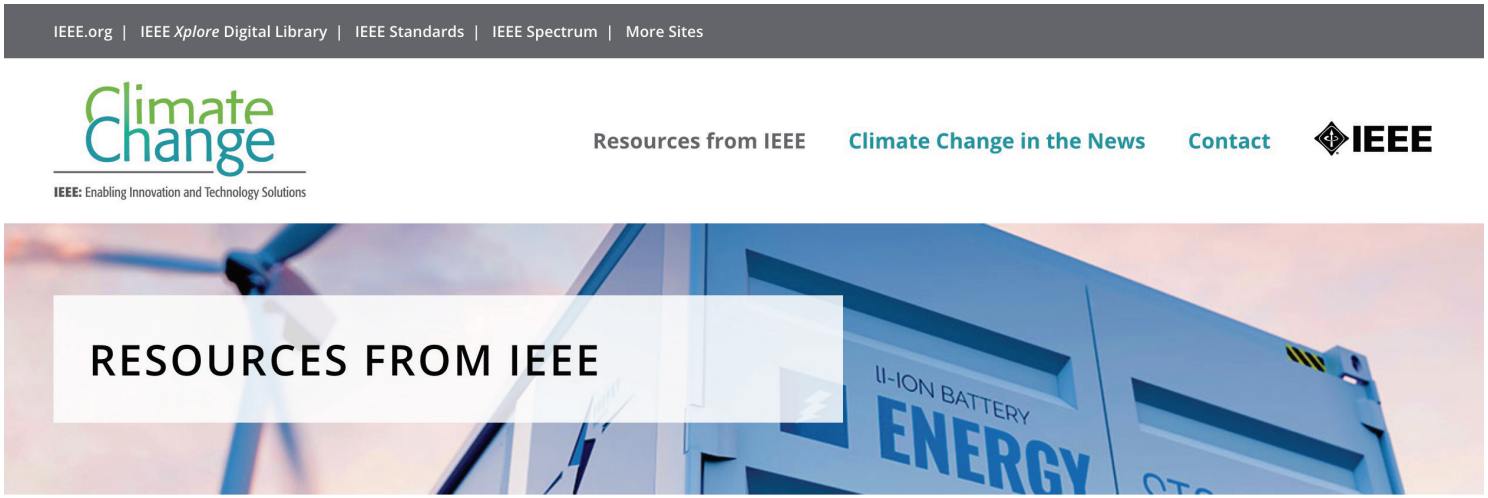


IEEE Climate Change Website

https://ieeeclimatechange.org

Email: ccircc@ieee.org

IEEE Climate Change Collection



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.

View the IEEE Climate Change Collection in IEEE *Xplore*®

THANK YOU!

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