French National
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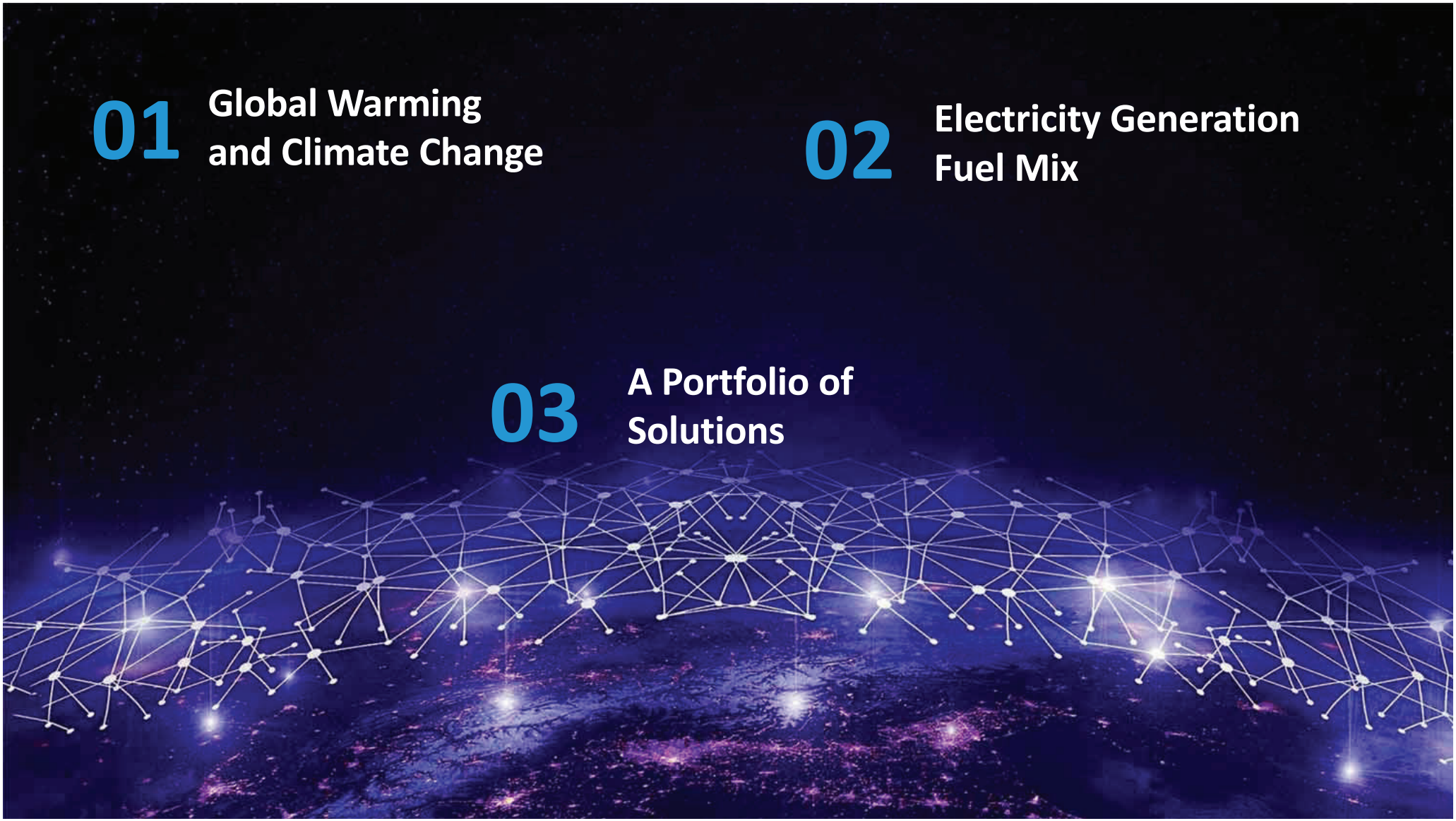
Director, Virginia Tech Advanced Research Inst., USA

Invited Talk

Global Electric Power Sector: Engaging with Environmental Issues

12 April 2022

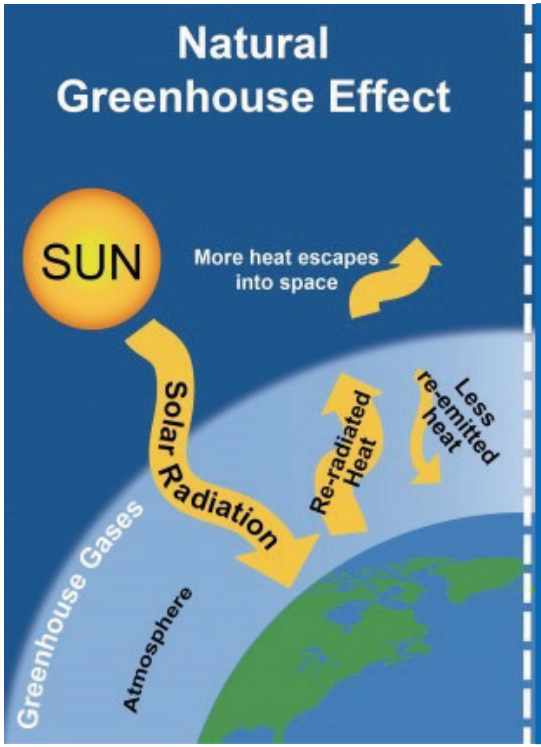

01 Global Warming and Climate Change
02 Electricity Generation Fuel Mix
03 A Portfolio of Solutions

Weather vs Climate

"***Climate*** is what you expect, ***weather*** is what you get".

Robert A. Heinlein

The Greenhouse Effect



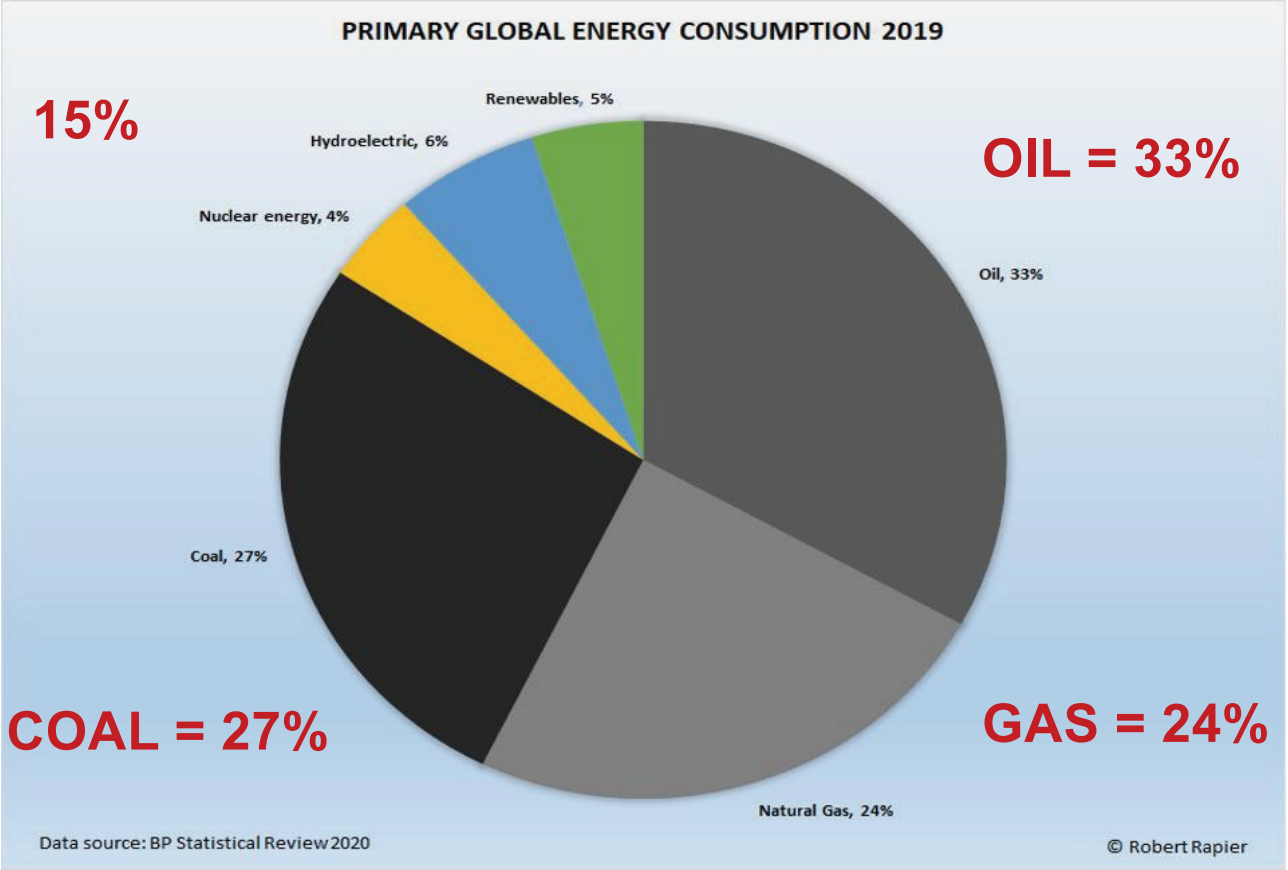
- Greenhouse gases (GHGs)naturally occur in Earth's atmosphere
- Without GHGs the average global temperature would be around 30ºC lower than it is today.
- Human activity is increasing concentration of GHGs

Global Warming vs Climate change

Global warming – the long term trend of raising average global temperature.

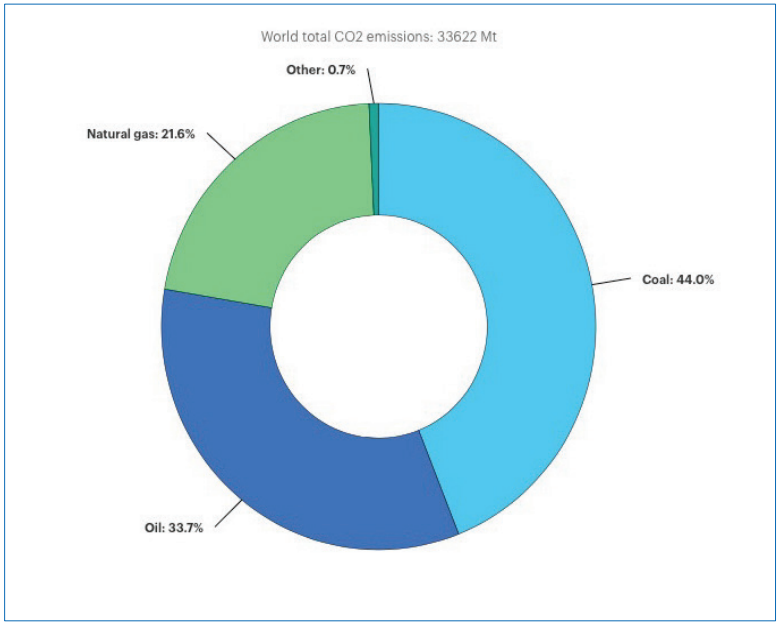
Climate change - changes in the global climate, resulting from the increasing average global temperature; e.g. changes in precipitation patterns, increased prevalence of droughts, heat waves, and other extreme weather.

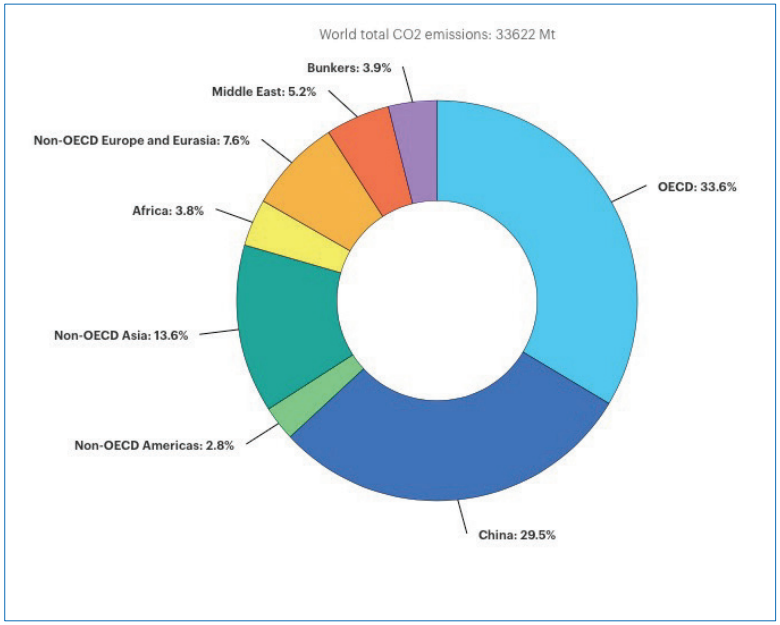
GLOBAL ENERGY CONSUMPTION 2019



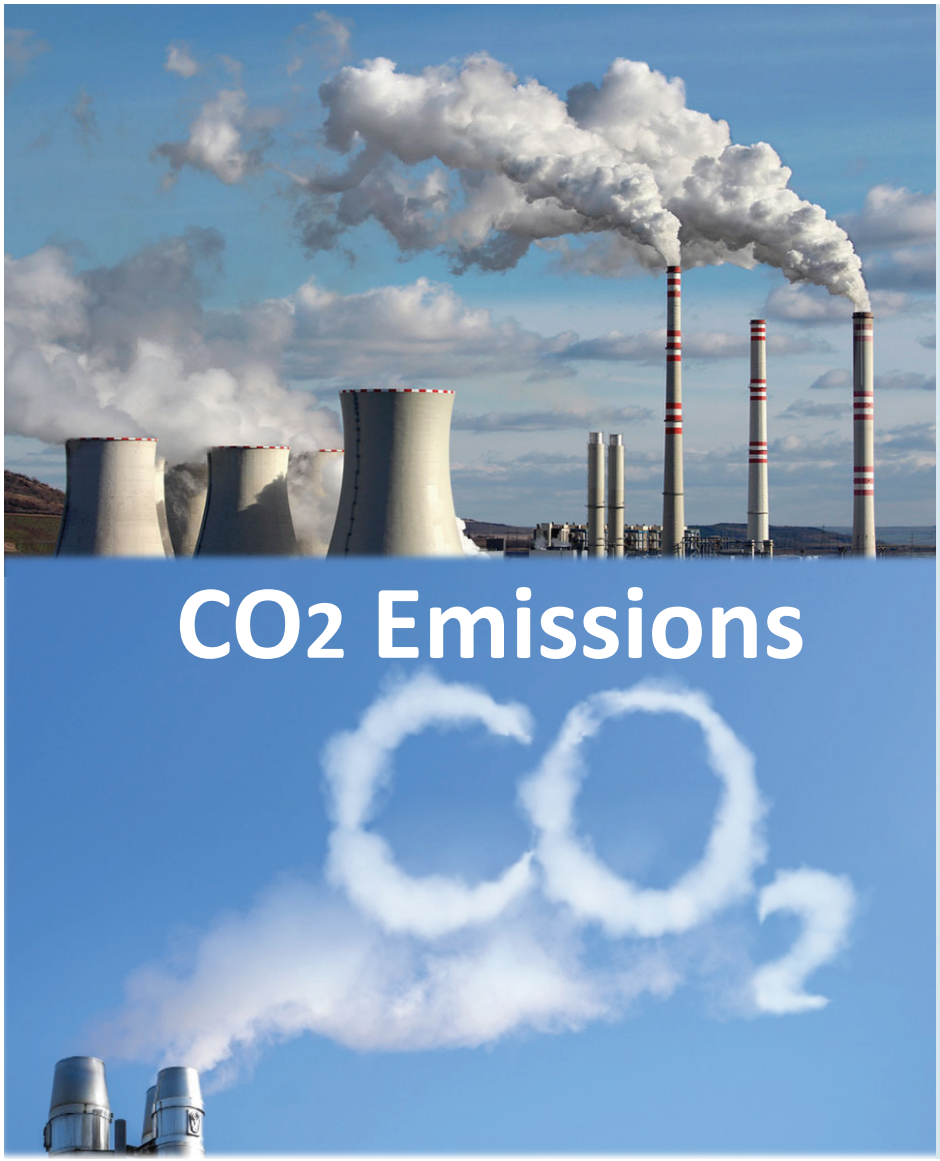
Needs To Reduce Emissions by 45% by 2030 & Net Zero by 2050 for 1.5C rise

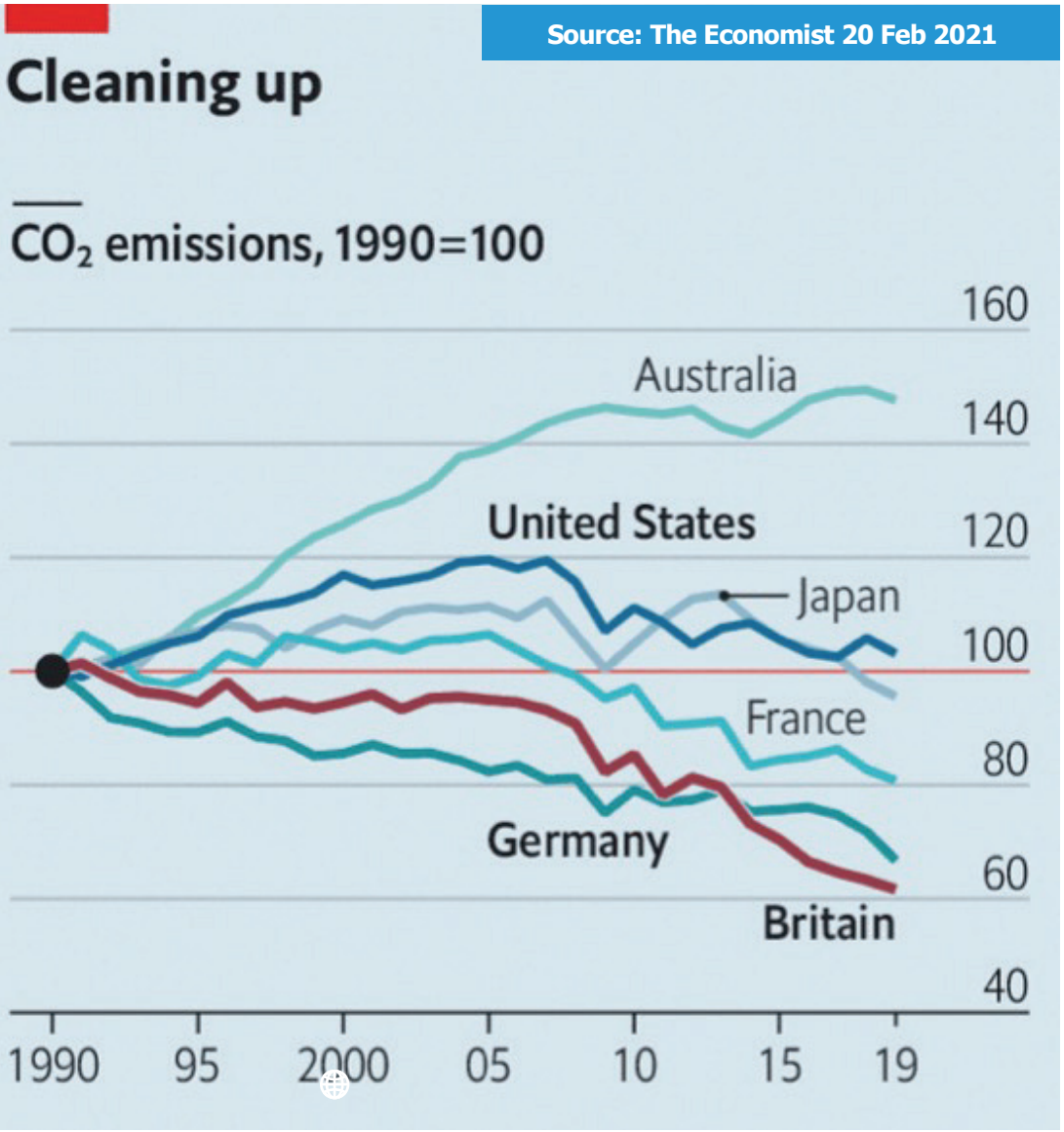
CO_2 Emissions from Fuel Combustion by Source and Regions 2019 (33,622 Mt CO_2)



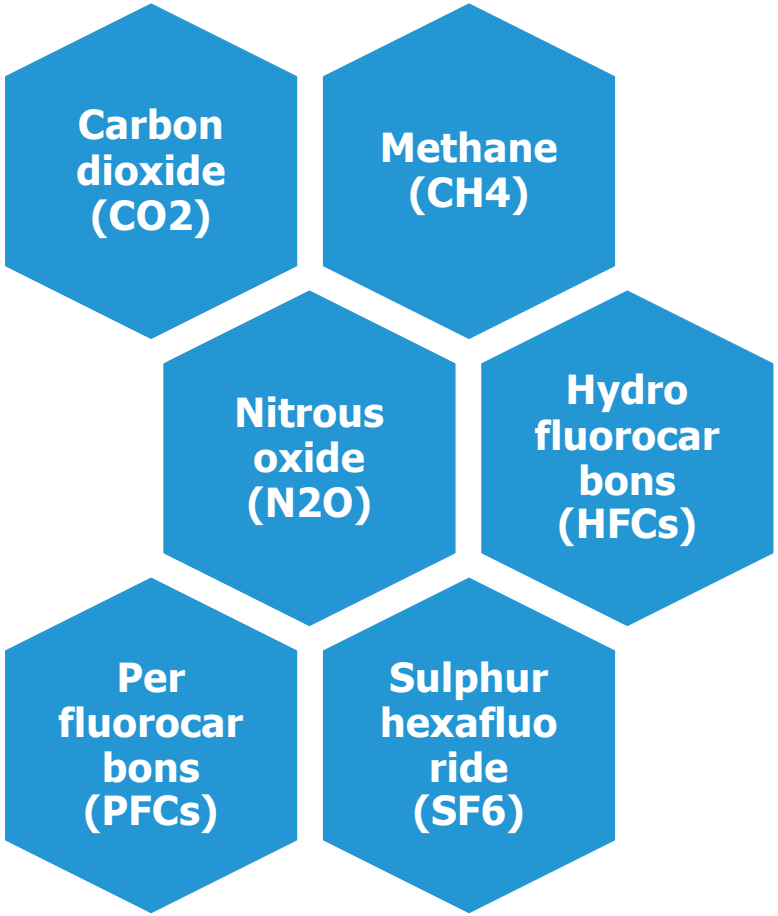


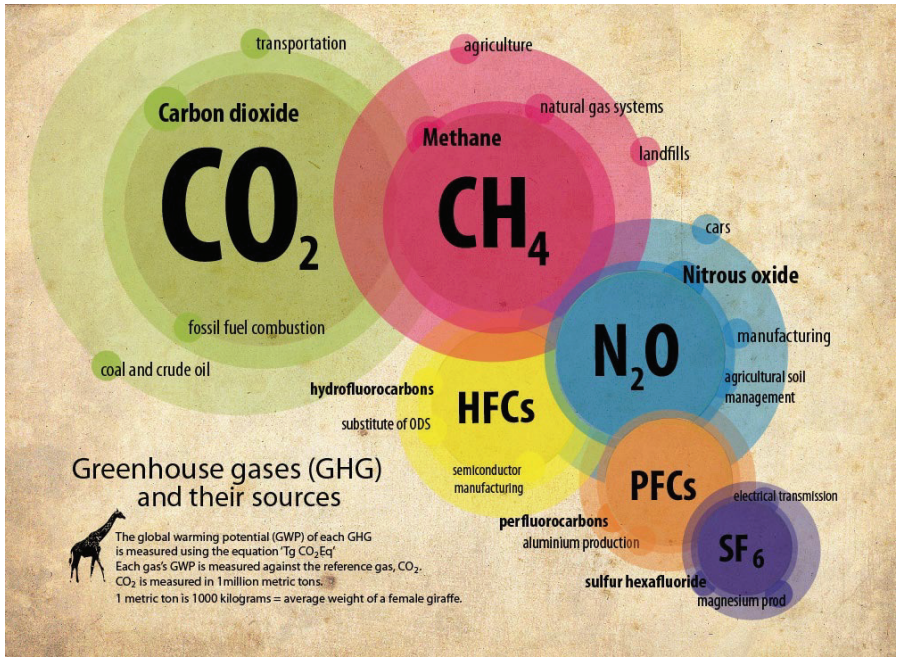
Source: IEA, Share of world CO2 emissions from fuel combustion, 2019, IEA, Paris Key World Energy Statistics 2021
https://www.iea.org/data-and-statistics/charts/share-of-world-co2-emissions-from-fuel-combustion-by-region-2019


CO2 Emissions


Source: The Economist 20 Feb 2021
Cleaning up
CO2 emissions, 1990=100
160
140
120
100
80
60
40
Australia
United States
Japan
France
Germany
Britain
1990
95
2000
05
10
15
19

Six Greenhouse Gases



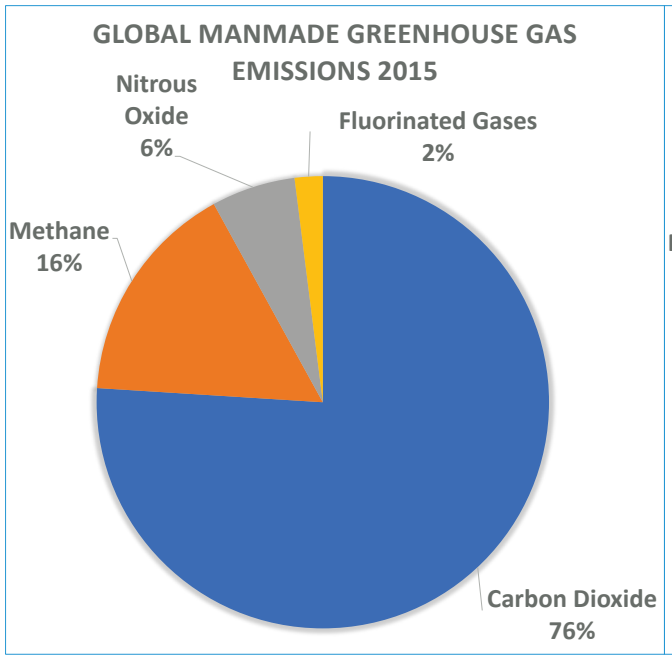


1997 CO2 emissions from fossil fuels and cement production: 30.4 billion tons

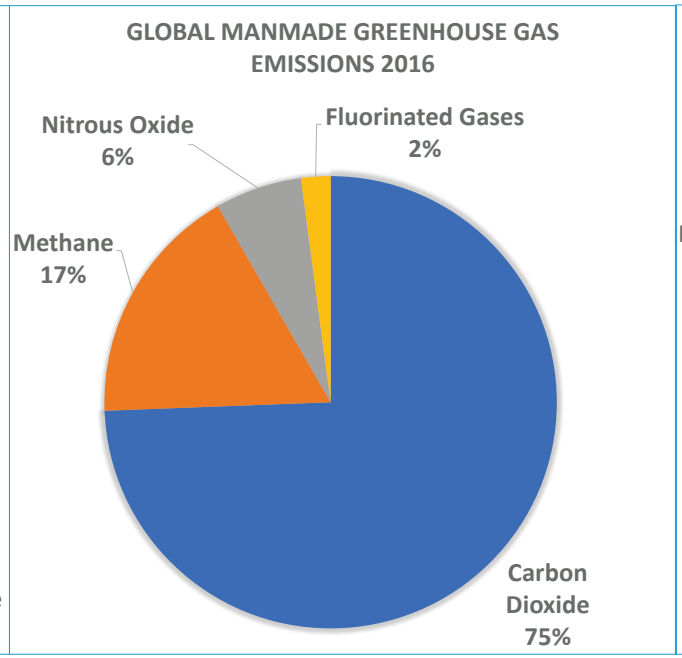
2018 CO2 emissions from fossil fuels and cement production: 41.1 billion tons

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

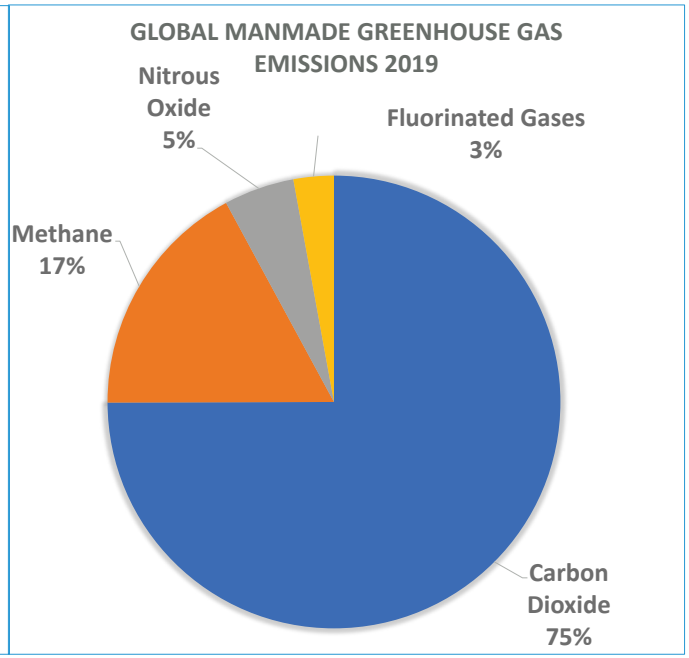
Fluorinated Gases include: HFC. PFC and SF6



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

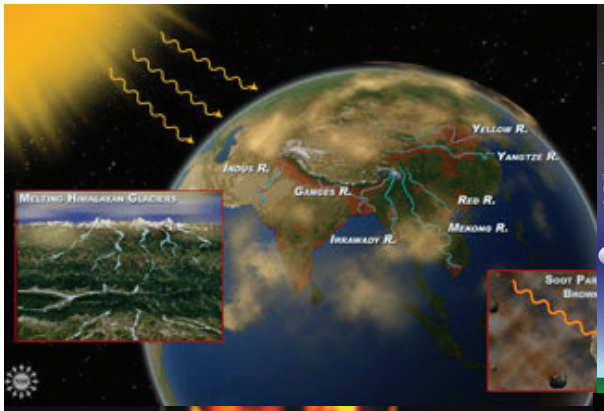


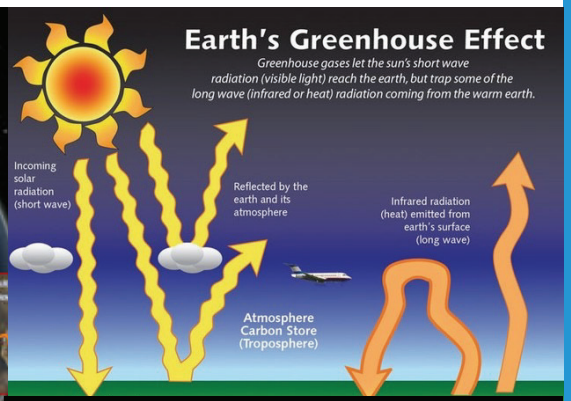
Source: https://ourworldindata.org/greenhouse-gas-emissions#annual-greenhouse-gas-emissions-how-much-do-we-emit-each-year

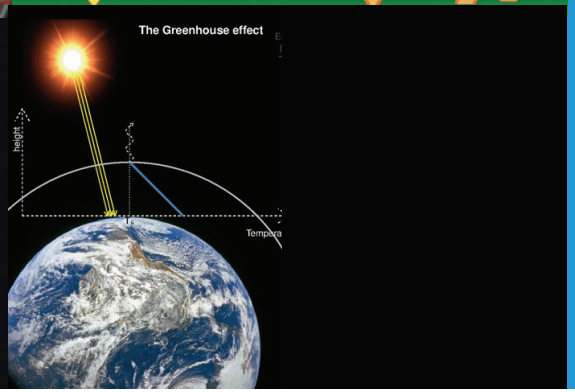


Source: UNEP Emissions Gap Report 2020 https://www.unep.org/emissions-gap-report-2020

Global Warming Potential (GWP) of Greenhouse Gases







GLOBAL WARMING

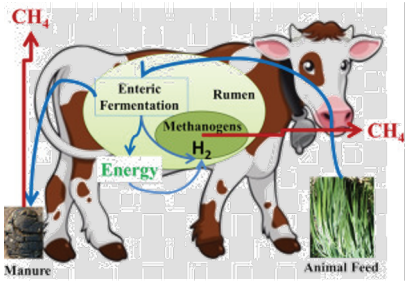
- ✓ Carbon dioxide (CO2): 1
- ✓ Methane (CH4): 28
- ✓ Nitrous oxide (N2O): 265
- ✓ Hydro fluorocarbons (HFCs): 138
- ✓ Per fluorocarbons (PFCs): 6,630
- ✓ Sulphur hexafluoride (SF6): 23,500

(over 100-year time scale)

Sources of Atmospheric Methane

Natural wetlands

Paddy rice fields



Emission from livestock production systems

Biomass burning (including forest fires)

Anaerobic decomposition of organic waste in landfills

Fossil methane emission during the exploration and transport of fossil fuels

WHAT WAS AGREED AT COP 26

US & CHINA COOPERATION

US and China agreed to work together this decade to limit global temperature rise to 1.5C including methane emissions, transition to clean energy and decarbonisation

No detail is yet available

COAL

More than 40 countries, including 23 new ones, have pledged to phase out coal including heavy coal users like Poland, Ukraine and Vietnam

Major countries to phase out coal in the 2030s - poorer countries in the 2040s

Excludes Australia, China, US & India

The COP agreement changes the wording on the Joint Declaration from countries to "phase out coal power and subsidies" to “phase down coal power and subsidies" implying a downward trend - but by how much and when?

Changes in Generation Mix in China

China will start to reduce its CO_2 emissions beginning in 2030

Year	Hydro/Solar/Wind (%)	Thermal (%)
2001	25.56	73.47
2016	33.80	63.77
2018	37.00	60.00
2030	52.00	42.00

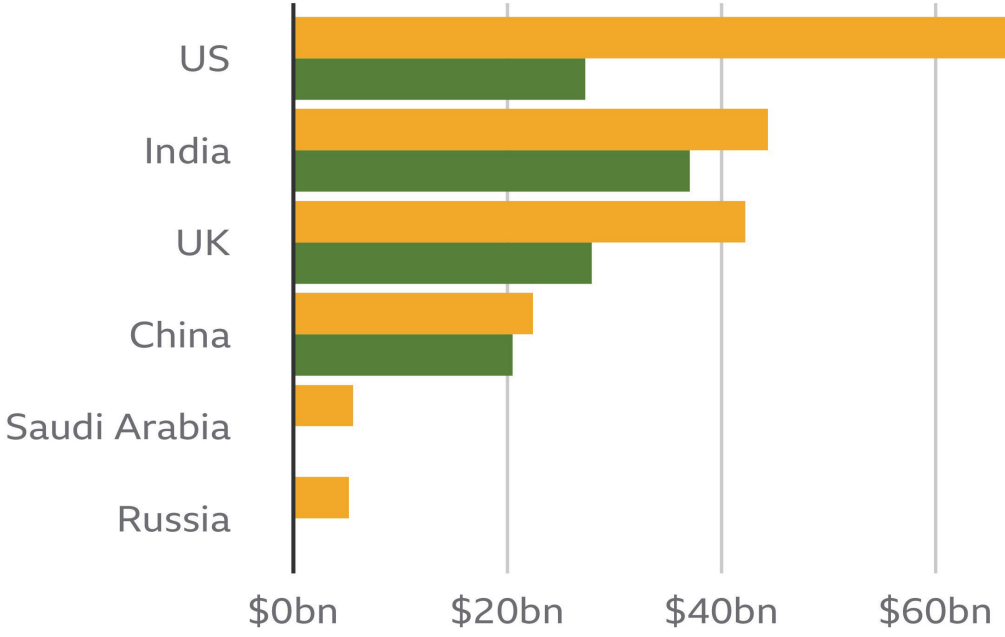
GHG Emissions Reduction/ Decarbonization Targets

Country	50% by	100% by
US	2030 (Power Sector)	2050
EU	2035 (All Sectors)	2050
China	2030 (Power Sector)	2060
India	----	2070

FOSSIL FUEL SUBSIDIES

Energy industry subsidies through new or amended policies

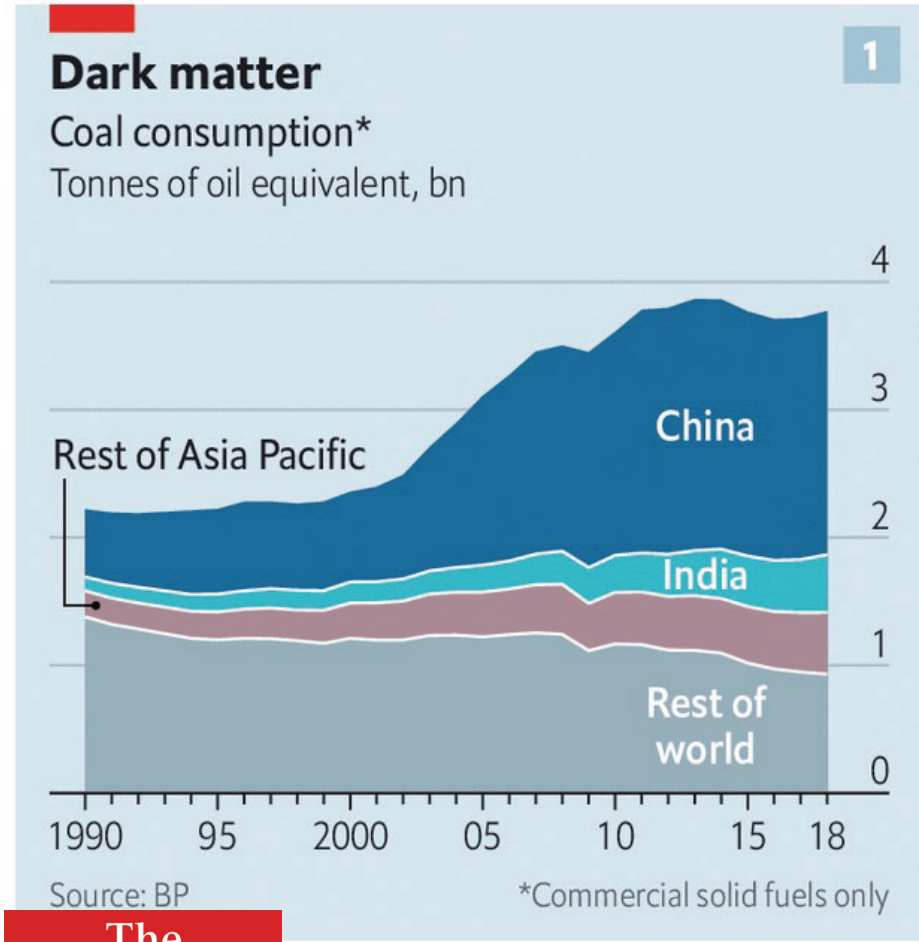
Government financial support for **fossil fuels** and **clean energy** since January 2020, selected countries



Source: Energy policy tracker

BBC

Over 75% of Global Demand for Coal Comes from Asia



01 CO_2 Emission Total Top 25 Countries (2014)

No.	Country	CO_2 (10^6 Tonnes)
1	China	9,820
2	United States	5,562
3	EU-28	3,484
4	India	2,184
5	Russia	1,622
6	Japan	1,263
7	Germany	793
8	Iran	642
9	Saudi Arabia	602
10	South Korea	587
11	Canada	576
12	Brazil	524
13	South Africa	482
14	Mexico	481
15	United Kingdom	439
16	Indonesia	417
17	Australia	394
18	Turkey	362
19	Italy	348
20	France	334
21	Poland	310
22	Thailand	280
23	Kazakhstan	279
24	Taiwan	261
25	Ukraine	258
63	Bangladesh	66

02 CO_2 Emissions Total Top 25 Countries (2019)

No.	Country	CO_2 (10^6 Tonnes)
1	China	10,175
2	United States	5,285
3	EU-28	3,287
4	India	2,616
5	Russia	1,678
6	Japan	1,107
7	Iran	780
8	Germany	702
9	Indonesia	618
10	South Korea	611
11	Saudi Arabia	582
12	Canada	577
13	South Africa	479
14	Brazil	466
15	Mexico	438
16	Australia	411
17	Turkey	405
18	United Kingdom	370
19	Italy	337
20	France	324
21	Poland	323
22	Kazakhstan	314
23	Thailand	288
24	Taiwan	263
25	Spain	253
57	Bangladesh	102

Source: Our World in Data (https://github.com/owid/co2-data)

01 CO_2 Emissions per Capita Top 25 Countries (2014)

No.	Country	CO_2 per capita (tonnes)
1	Saudi Arabia	19.47
2	United States	17.45
3	Australia	16.70
4	Canada	16.15
5	Kazakhstan	16.11
6	South Korea	11.59
7	Russia	11.21
8	Taiwan	11.12
9	Japan	9.86
10	Germany	9.73
11	South Africa	8.84
12	Iran	8.29
13	Poland	8.14
14	China	7.02
15	EU-28	6.86
16	United Kingdom	6.71
17	Italy	5.76
18	Ukraine	5.71
19	France	5.20
20	Turkey	4.68
21	Thailand	4.09
22	Mexico	4.00
23	Brazil	2.58
24	India	1.69
25	Indonesia	1.63
192	Bangladesh	0.43

02 CO_2 Emissions per Capita Top 25 Countries (2019)

No.	Country	CO_2 per capita (tonnes)
1	Saudi Arabia	16.99
2	Kazakhstan	16.92
3	Australia	16.31
4	United States	16.06
5	Canada	15.41
6	South Korea	11.93
7	Russia	11.51
8	Taiwan	11.05
9	Iran	9.40
10	Japan	8.72
11	Poland	8.52
12	Germany	8.41
13	South Africa	8.17
14	China	7.10
15	EU-28	6.41
16	Italy	5.57
17	United Kingdom	5.48
18	Spain	5.41
19	France	4.97
20	Turkey	4.86
21	Thailand	4.14
22	Mexico	3.44
23	Indonesia	2.28
24	Brazil	2.21
25	India	1.92
183	Bangladesh	0.63

Source: Our World in Data (https://github.com/owid/co2-data)

The Decarbonization Debate

- Industrialized countries want emerging countries to cut carbon emissions.
- Emerging economies want to continue using fossil fuel for electricity production
- There is a third way – Use a diverse portfolio of solutions

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

Building Automation System Optimized for Savings

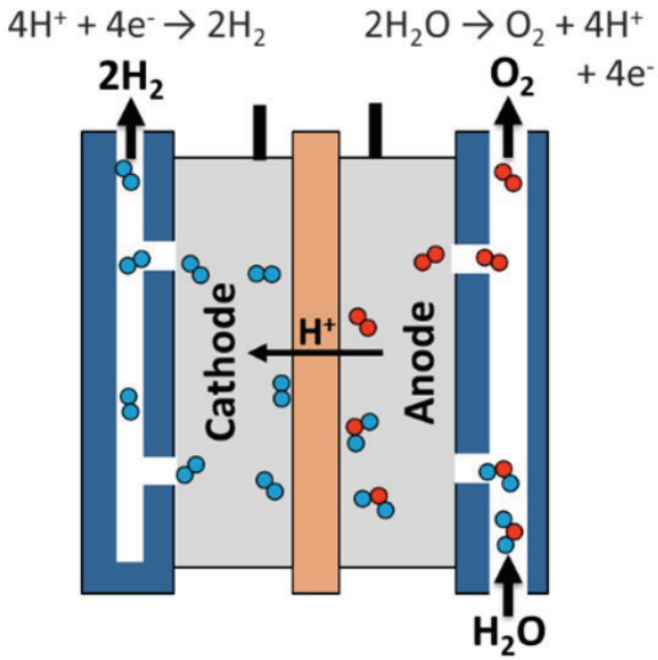
- Heating, Ventilation and central AC systems
- Lighting systems
- 20% or more energy savings
- Healthy building air quality

Hydrogen Economy

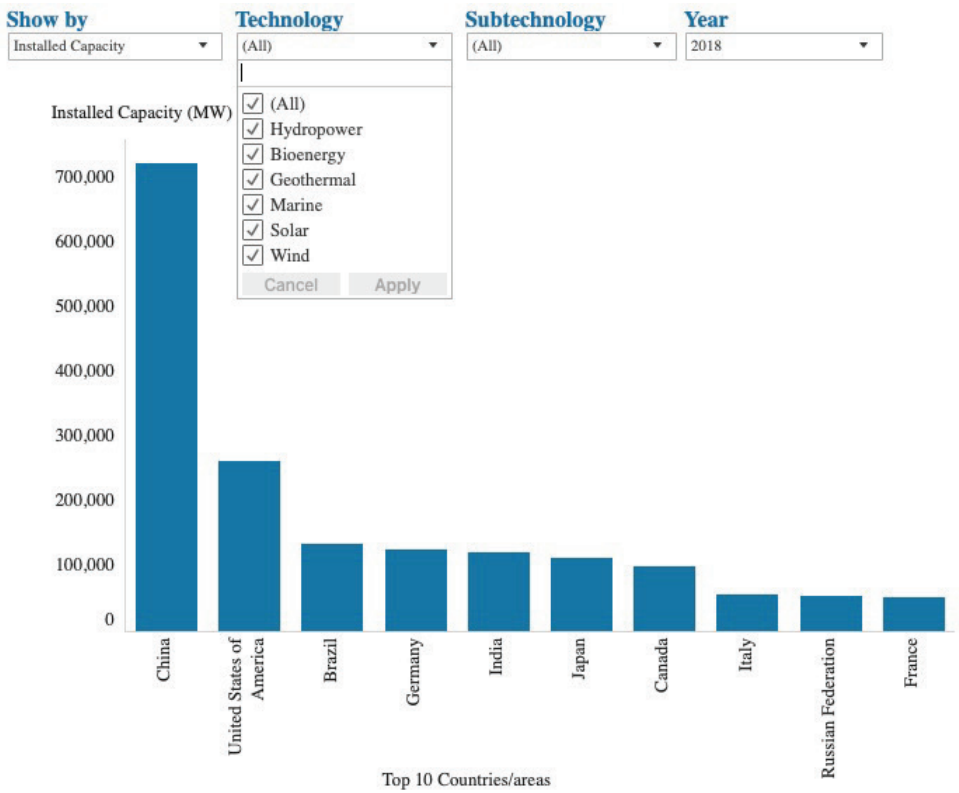
High Temperature Steam/
Natural Gas Reformation

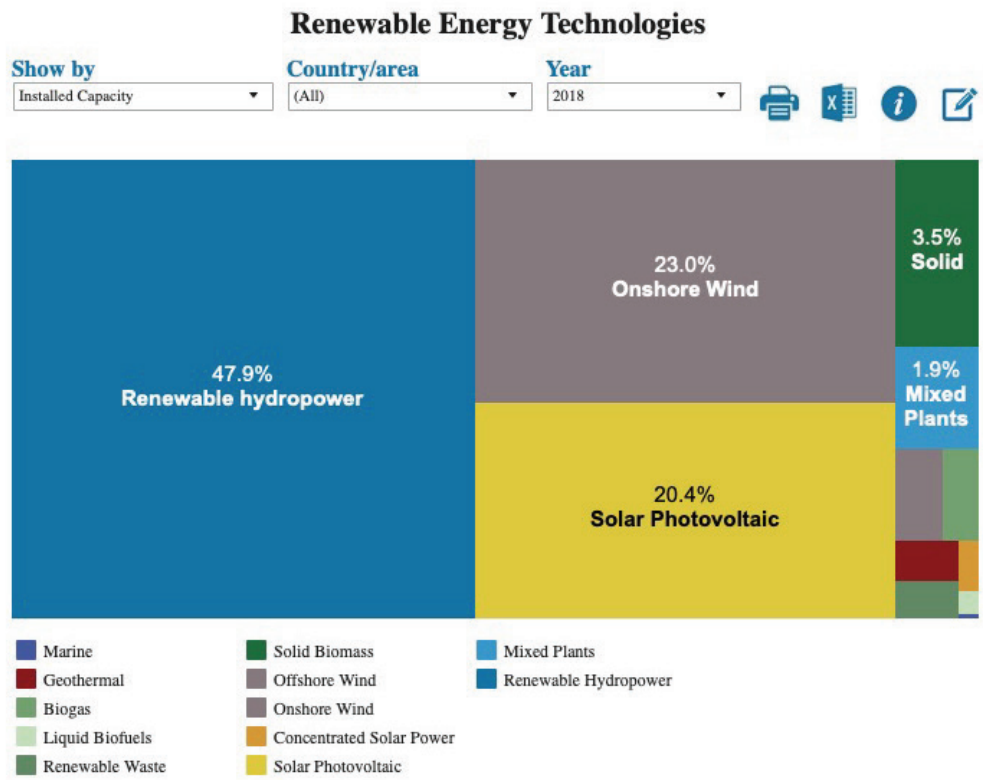
$CH_4 + H_2O = H_2 + CO + CO_2$

Electrolysis



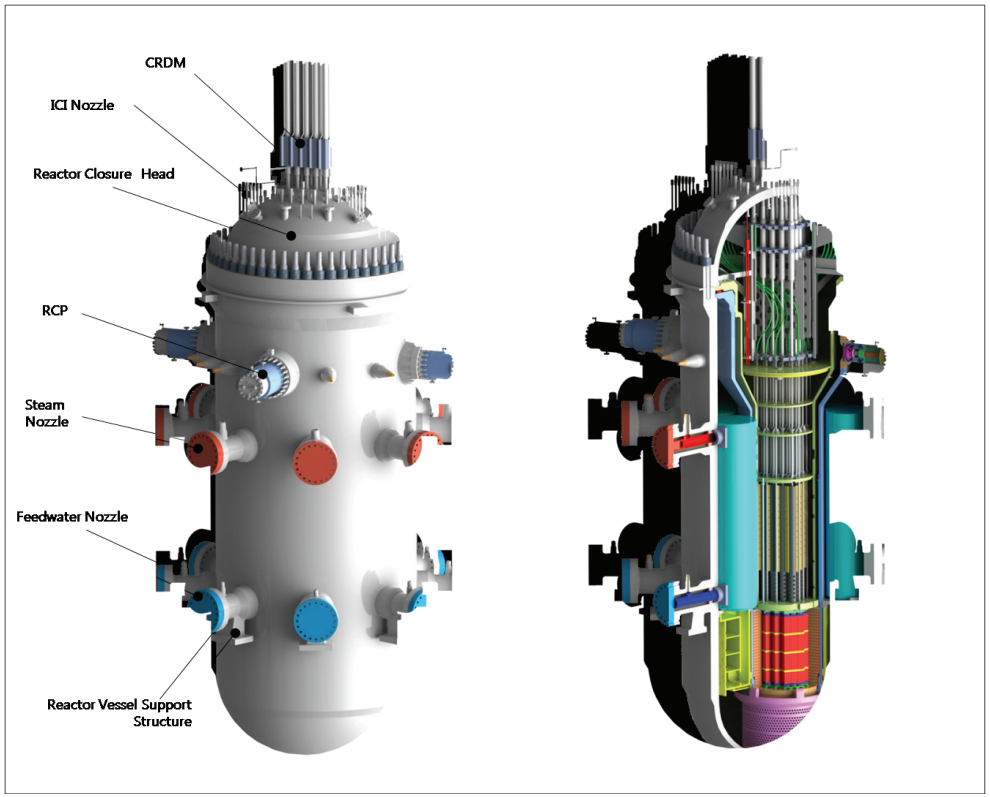
Total Installed Renewable Energy Capacity Top Ten Countries (2018)



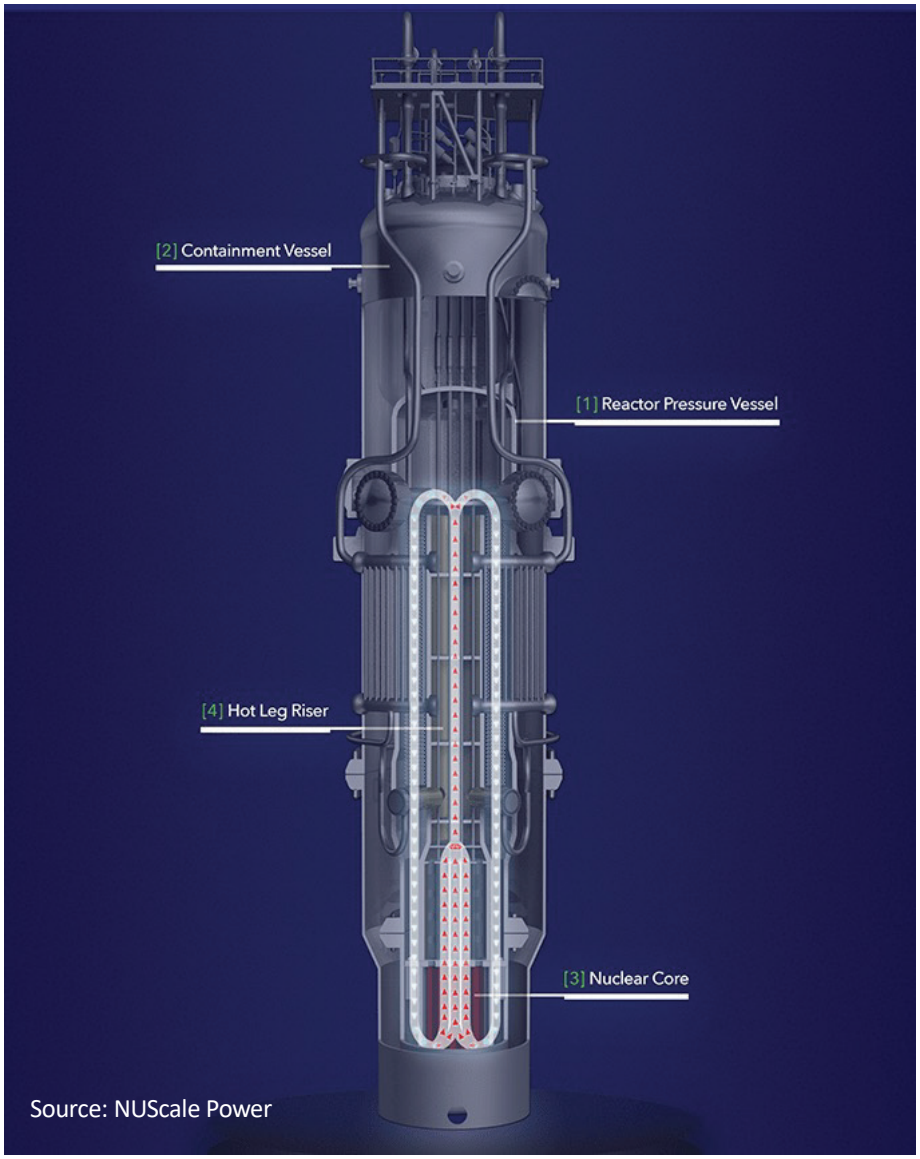


Source: International Renewable Energy Agency IRENA
https://www.irena.org/Statistics/

Small Modular Reactors (SMR)



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



Source: NUScale Power

IEEE Response to Climate Change

Committee to Coordinate IEEE's Response to Climate Change (CCIRCC)

Provides a platform for presenting alternatives –

Participation from IEEE technical committees involved in power engineering (including renewables and nuclear), energy departments in national governments, CIGRE (the French version of IEEE), national engineering societies and central electricity authorities in several countries, and vendors.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