50 MOST IMPORTANT TOPICS

PART - I

Methane

- Methane (CH_4) is the **second most important greenhouse gas.**
- Methane is **more potent than CO_2** because the radiative forcing produced per molecule is greater.
- The emission of methane is a big concern as it is a greenhouse gas having **25-28 times more harmful effects than carbon dioxide.**

Methane

- However, methane exists in far lower concentrations than CO_2 in the atmosphere.
- Methane also has a considerably shorter residence time in the atmosphere than CO_2 (the residence time for CH_4 is roughly 10 years, compared with hundreds of years for CO_2).
- Methane is also a dangerous air pollutant and affects air quality.

Methane

- Approximately 17% of the current world greenhouse gas emissions are attributed to it.
- It is also held accountable for at least 25 to 30 percent of the temperature increase from pre-industrial times.
- Methane is mostly a sectoral gas, unlike carbon dioxide, and there are only a few emission sources.
- Thus, it is feasible to reduce methane emissions without significantly harming the economy.

Methane Global Tracker Report

- The International Energy Agency has released the annual Methane Global Tracker Report.
- According to the report, fossil fuel companies emitted 120 million metric tonnes of methane into the atmosphere in 2022.
- The report also points to the inaction of these companies in restricting methane emissions.

Methane Global Tracker Report

- As per the report - 75 per cent of methane emissions from the energy sector can be reduced with the help of cheap and readily available technology.
- The implementation of such measures would cost less than three per cent of the net income received by the oil and gas industry in 2022.

Global Methane Assessment: 2030 Baseline Report

- It was released by Climate and Clean Air Coalition (CCAC) and United Nations Environment Programme (UNEP).
- It was launched at Climate and Clean Air Ministerial Meeting at 27th Conference of Parties (COP27) to United Nations Framework Convention on Climate Change (UNFCCC).
- Examines baseline projections of methane emissions over the coming decade and implications for the Global Methane Pledge (GMP) target.
- The amount of Methane in the atmosphere is 260% of pre-industrial levels.
- Methane emissions can rise 5-13 per cent above 2020 levels by 2030.
- Human-driven methane emissions are responsible for nearly 45% of current net warming.
- 2021 saw the largest annual increase recorded.

Global Methane Hub

- CCAC partner since 2023.
- The Global Methane Hub, a philanthropic fund to support methane mitigation, has raised $70 million to support critical research on reducing methane emissions from enteric fermentation — the largest single source of methane emissions from agriculture.

Climate and Clean Air Coalition

- The Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants was launched by the United Nations Environment Programme (UNEP) and six countries — Bangladesh, Canada, Ghana, Mexico, Sweden, and the United States — on 16 February 2012.
- The program is managed by the United Nations Environmental Programme through a Secretariat in Paris, France.
- The CCAC aims to catalyze rapid reductions in short-lived climate pollutants to protect human health, agriculture and the environment.

Climate and Clean Air Coalition

- The Coalition's initial focus is on methane, black carbon, and HFCs.
- The coalition has 53 country partners and 17 International Governmental Organizations and 45 Non-governmental organization partners.
- India is not a partner country however The Energy and Resources Institute (TERI) is a partner NGO since 2015

Global Methane Pledge

- The pledge was first announced in September 2021 by the US and EU and is essentially an agreement to reduce global methane emissions.
- Launched at the UN COP26 climate conference in Glasgow.
- One of the central aims of this agreement is to cut down methane emissions by up to 30 per cent from 2020 levels by the year 2030.
- China, Russia and India have not signed up.
- At CoP27, 150 nations joined the pledge.

International Methane Emissions Observatory (IMEO)

- According to a report by IMEO, cutting methane emissions is the fastest way to tackle climate change in the short-term.
- An initiative by UNEP, launched in 2021, with support from European Commission.
- It will help to catalyse the reduction of methane emissions, starting with the fossil fuel sector.
- It is the core implementing partner of the Global Methane Pledge.

Global Methane Initiative

- GMI is a voluntary Government and an informal international partnership having members from 45 countries.
- The forum has been created to achieve a global reduction in anthropogenic methane emission through a partnership among developed and developing countries having economies in transition.
- India has been a member since the inception of GMI.

MARS

At the 27th Conference of Parties (COP27) to the United Nations Framework Convention on Climate Change in Sharm El-Sheikh, Egypt, the Methane Alert and Response System (MARS) was unveiled.

About MARS

- MARS is the global system capable of transparently connecting methane detection to notification processes.
- It is the first of its kind.
- It has been set up as part of the UNEP International Methane Emissions Observatory (IMEO) strategy.

EMIT Mission

- EMIT was developed at NASA's Jet Propulsion Laboratory and launched on July 14, 2022.
- The instrument observes Earth from outside the International Space Station.
- Methane 'Super-Emitters' were mapped by NASA's Earth Surface Mineral Dust Source Investigation (EMIT).
- EMIT mission helped to identify more than 50 super-emitters of methane gas in central Asia, west Asia and southwestern United States.
- Super-emitters are facilities, equipment, and other infrastructure, typically in the fossil-fuel, waste, or agriculture sectors, that emit methane at high rates.

Biomethanation

- Biomethanation is anaerobic digestion of organic materials which is converted into biogas.
- Anaerobic digestion (AD) is a bacterial fermentation process that operates without free oxygen and results in a biogas containing mostly methane (~60%), carbon dioxide (~40%) and other gases.
- Biomethanation has dual benefits - It gives biogas as well as manure as the end product.

Biomethanation

- The biogas generated from Biomethanation process can be burned directly in a gas boiler/burner to produce heat for thermal application industries and cooking or burnt in a gas engine to produce electricity.
- Alternatively, the biogas can be cleaned to remove the carbon dioxide and other substances, to produce BioCNG.
- This can be injected into the national gas grid to be used in the same way as natural gas, or used as a vehicle fuel.

500 New Waste to Wealth Plants

- In budget 2023, 500 new 'waste to wealth' plants under the GOBARdhan (Galvanising Organic Bio-Agro Resources Dhan) scheme to promote a circular economy.
- These will include 200 compressed biogas (CBG) plants, including 75 plants in urban areas, and 300 community or cluster-based plants at a total investment of Rs 10,000 crore.

In the budget, a central excise duty exemption has also been provided to CBG that's blended with natural gas.

Cow dung to Compressed Biogas Project

- HPCL commenced its Cowdung to Compressed Biogas Project at Sanchore, Rajasthan.
- Biogas – Methane + Carbon dioxide
- It will be used as an automotive fuel.
- Waste to Energy

SATAT Initiative

- To boost availability of affordable and clean transport fuels, a MoU was signed between MoPNG and leading oil & gas marketing companies & technology providers to establish Compressed Bio-Gas CBG) plants across India under the Sustainable Alternative Towards Affordable Transportation (SATAT) initiative.
- Government of India, under the SATAT initiatives envisages setting up of 5000 CBG plants by 2023-24 with production target of 15 MMT, facilitating the creation of *new employment opportunities and enhancing farmers' income* towards further invigorating the rural economy.

Coal Bed Methane

- It is an unconventional form of natural gas found in coal deposits or coal seams.
- It is formed during the process of coalification, transformation of plant material into coal.
- The term refers to methane absorbed into the solid matrix of the coal.
- It is called 'sweet gas' because of its lack of hydrogen sulfide.
- India has the fifth-largest coal reserves in the world, and CBM has been looked at as a clean alternative fuel with significant prospects.

Coal Bed Methane

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- India has the fifth-largest coal reserves in the world, and CBM has been looked at as a clean alternative fuel with significant prospects.
- Uses include -
- Power generation, as compressed natural gas (CNG) auto fuel,
- Feedstock for fertilisers
- Industrial uses such as in cement production, rolling mills, steel plants, and
- Methanol production.

Shale Gas

- Unlike conventional hydrocarbons that can be extracted from permeable rocks easily, shale gas is trapped under low permeable rocks.
- The extraction requires the creation of fractures in oil and gas-rich shale to release hydrocarbons through a process called hydraulic fracking/fracturing.
- Russia and the US are among the largest shale oil producers.
- Shale is a compressed fine-grained type of sedimentary rock.

Harit Dhara

- Harit Dhara is is an anti-methanogenic feed supplement prepared from the natural phyto-sources.
- The Harit Dhara developed by the Indian Council of Agricultural Research, through the comprehensive research over a decade.
- It is found very effective in reducing the enteric methane emission upto 17% to 20% when incorporated in the livestock feed.

Rumin8

- Microsoft co-founder Bill Gates has invested in an Australian climate technology start-up that aims to curtail the methane emissions of cow burps.
- The start-up, Rumin8, has received funding worth $12 million from Breakthrough Energy Ventures, which Gates created in 2015.
- Rumin8 is developing a variety of dietary supplements to feed to cows in a bid to reduce the amount of methane they emit into the atmosphere.
- The supplement includes red seaweed, which is believed to drastically cut methane output in cows.

Syngas

- It is a mixture of carbon monoxide, hydrogen and other hydrocarbons, is produced by partial combustion of biomass, that is, combustion with an amount of oxygen that is not sufficient to convert the biomass completely to carbon dioxide and water.
- It can be used to produce methanol, DME and hydrogen, or converted via the Fischer-Tropsch process to produce a diesel substitute, or a mixture of alcohols that can be blended into gasoline.

Coal Gasification

- Coal gasification is a process in which coal is partially oxidised with air, oxygen, steam or carbon dioxide to form a syngas.
- In-situ gasification of coal or Underground Coal Gasification (UCG) is the technique of converting coal into gas while it is still in the seam and then extracting it through wells.
- The Ministry of Coal has prepared a National Mission document to achieve 100 MT (Million Tonnes) Coal Gasification by 2030.

Uses

- In a gasification process, coal can be converted into syngas which can be used in sponge iron making and it can further be utilised to make steel.
- It is primarily used for electricity generation, to produce chemical feedstocks.
- The hydrogen obtained from coal gasification can be used for various purposes such as making ammonia, and powering a Hydrogen Economy.
-

Methanol Economy

- BHEL developed India's first pilot plant at Hyderabad using indigenous technology to convert high ash coal to methanol.
- It uses fluidised bed gasification technology to first produce synthesis (syngas) gas from coal and then convert it into methanol with 99% purity.
- It is a part of the Clean Energy Research Initiative from NITI Aayog and is funded by the Department of Science and Technology.

Methanol Economy

- Methanol is a clean burning drop in fuel which can replace both petrol & diesel in transportation & LPG, Wood, Kerosene in cooking fuel.
- It can also replace diesel in Railways, Marine Sector, Gensets, Power Generation and Methanol based reformers could be the ideal complement to Hybrid and Electric Mobility.
- Methanol Economy is the "Bridge" to the dream of a complete "Hydrogen based fuel systems".
- Methanol burns efficiently in all internal combustion engines, produces no particulate matter , no soot , almost nil SOX and NOX emissions (NEAR ZERO POLLUTION).
- To adopt Methanol as a transport fuel, requires minimal infrastructure modifications and capital both in vehicles and in terminal and distribution infrastructure.
- Slightly lower in energy content.

Methanol Economy

- The gaseous version of Methanol – DME can blended with LPG and can be excellent substitute for diesel in Large buses and trucks.
- Bureau of Indian Standards has notified 20% DME blending with LPG.
- NITI Aayog has drawn out a comprehensive plan to replace 20% of crude imports from Methanol alone.
- Adopting Methanol in this scale would bring down pollution in the country by more than 40% and not to forget the benefits from import substitution.

Methanol Economy

- The Namrup-based Assam Petrochemicals Limited (APL) rolled out the country's first methanol-based cooking fuel project- 'Green and Clean Fuel Pilot Project on Methanol Cooking Stove'.
- This is seen as India's first step towards realising the concept of "methanol economy".
- The project has been promoted by NITI Aayog.

Methanol Economy

- Methanol Economy Research Programme, by Department of Science and Technology, for production of Methanol from various sources including Indian coal and CO2 from thermal plants, steel plants etc.
- A notification for M-15, M-85, M-100 blends has been issued by the Ministry of Road, Transport and Highways.
- Test standards and plans for the M-15 blend are being evolved in consultation with the Indian Oil Corporation Limited, Automotive Research Association of India and Society of Indian Automobile Manufacturers.
- Railway is working towards blending methanol in the range of 5-20% through direct fuel injection in locomotives.

Green Coal

- Green coal, also known as bio-coal, is considered a sustainable alternative to polluting conventional coal as it combines agricultural residue and MSW.
- Green coal has been drawing attention due to its ability to replace coal for energy and, thus, mitigate the amount of CO2 from coal combustion.
- It is claimed that replacing a kilogram of coal with the same quantity of green coal can mitigate two kg of CO2.

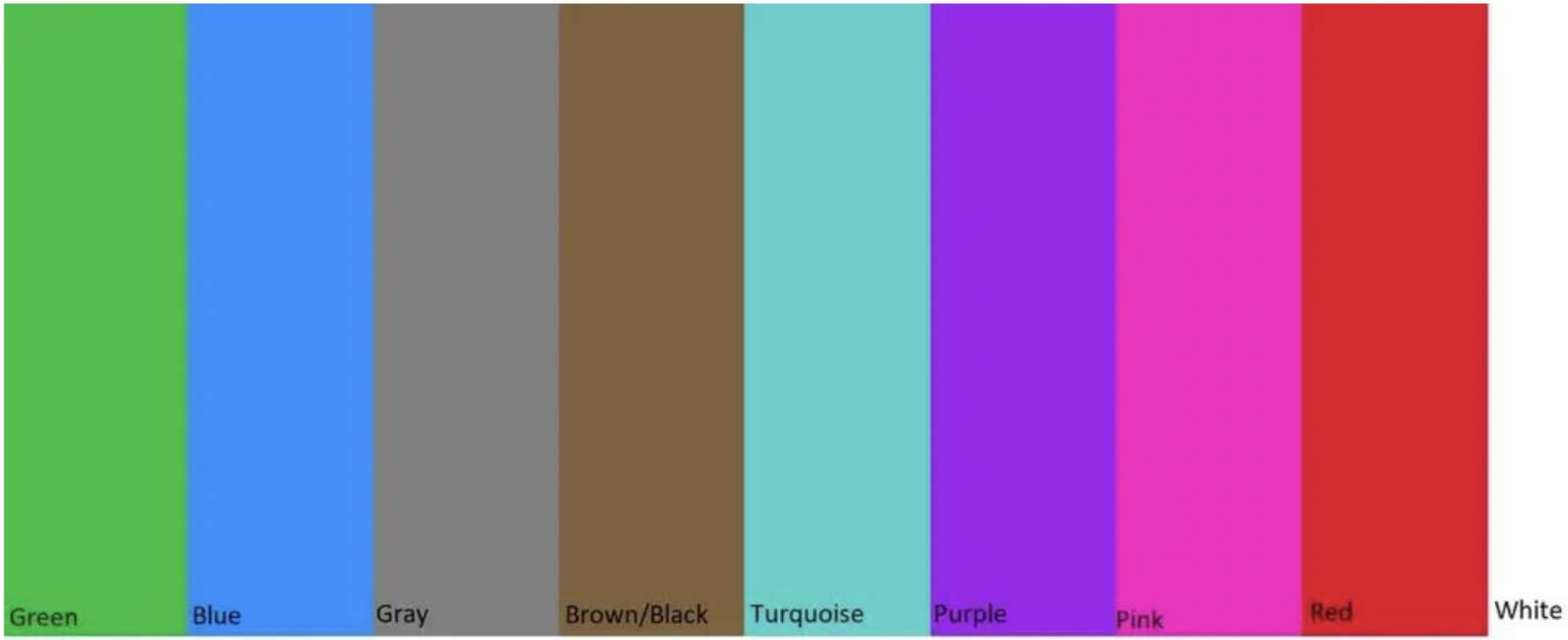
Green Coal

- Green coal production from MSW involves segregation, mixing and heating processes.
- The process begins with converting raw waste into refuse-derived fuel(fuel produced from various types of waste)
- This is followed by the thermal treatment of the waste at a temperature of 200-300°C inside a 'charcoal reactor', resulting in the formation of a solid fuel with properties similar to normal coal.

Green Coal

- The reaction inside the reactor is claimed to be relatively simple and cost-effective since the process does not require any additives or hazardous processes.
- The charcoal produced is further cleaned using a sieve.
- The purified charcoal is then mixed with exact proportions of binder and water in a mixer.
- The mixture is then fed into a pelletising machine, which produces the ultimate product, 'Green Coal'.

Hydrogen Color Codes



H2 Bulletin www.h2bulletin.com

Hydrogen Color Codes

- Hydrogen itself is a colourless gas but there are around nine colour codes to identify hydrogen.
- The colours codes of hydrogen refer to the source or the process used to make hydrogen.
- These codes are: *green, blue, grey, brown or black, turquoise, purple, pink, red and white.*

Hydrogen Color Codes

- **Green hydrogen** is produced through water electrolysis process by employing **renewable electricity.** The reason it is called green is that there is **no CO_2 emission** during the production process. Water electrolysis is a process which uses electricity to decompose water into hydrogen gas and oxygen.
- **Blue hydrogen** is sourced from fossil fuel. However, the CO_2 is captured and stored underground (**carbon sequestration**). As no CO_2 is emitted, so the blue hydrogen production process is categorised as carbon neutral.

Hydrogen Color Codes

- **Gray hydrogen** is produced from fossil fuel and commonly uses **steam methane reforming (SMR)** method. During this process, CO2 is produced and eventually released to the atmosphere.
- **Black or brown hydrogen** is produced from coal. The black and brown colours refer to the type bituminous (black) and lignite (brown) coal. The **gasification of coal** is a method used to produce hydrogen. However, it is a very polluting process, and CO2 and carbon monoxide are produced as by-products and released to the atmosphere.

Hydrogen Color Codes

- **Purple hydrogen** is made though using nuclear power and heat through combined chemo thermal electrolysis splitting of water.
- **Pink hydrogen** is generated through electrolysis of water by using electricity from a nuclear power plant.
- **Red hydrogen** is produced through the high-temperature catalytic splitting of water using nuclear power thermal as an energy source.

Hydrogen Color Codes

- **Turquoise hydrogen** can be extracted by using the thermal splitting of methane via methane pyrolysis.The process, though at the experimental stage, **remove the carbon in a solid form instead of CO_2 gas.**
- **White hydrogen** refers to naturally occurring hydrogen, geological hydrogen found in underground deposits and created through fracking.

National Green Hydrogen Mission

Figure VII.9: Salient Features of the National Green Hydrogen Mission

Likely Outcomes by 2030	• Green hydrogen production capacity of at least 5 MMT (Million Metric Tonne) per annum. • Cumulative reduction in fossil fuel imports over ₹1 lakh crore and creation of over 6 lakh jobs. • Renewable energy capacity addition of about 125 GW and abatement of nearly 50 MMT of annual GHG emissions.
Interventions	• Financial incentive targeting domestic manufacturing of electrolysers and production of Green Hydrogen. • Regions capable of supporting large scale production and/or utilisation of Hydrogen to be developed as Green Hydrogen Hubs.
Policy Framework	•Development of an enabling policy framework to support establishment of Green Hydrogen ecosystem. • Robust Standards and Regulations framework. • Public-private partnership framework for R&D. • Skill development programme

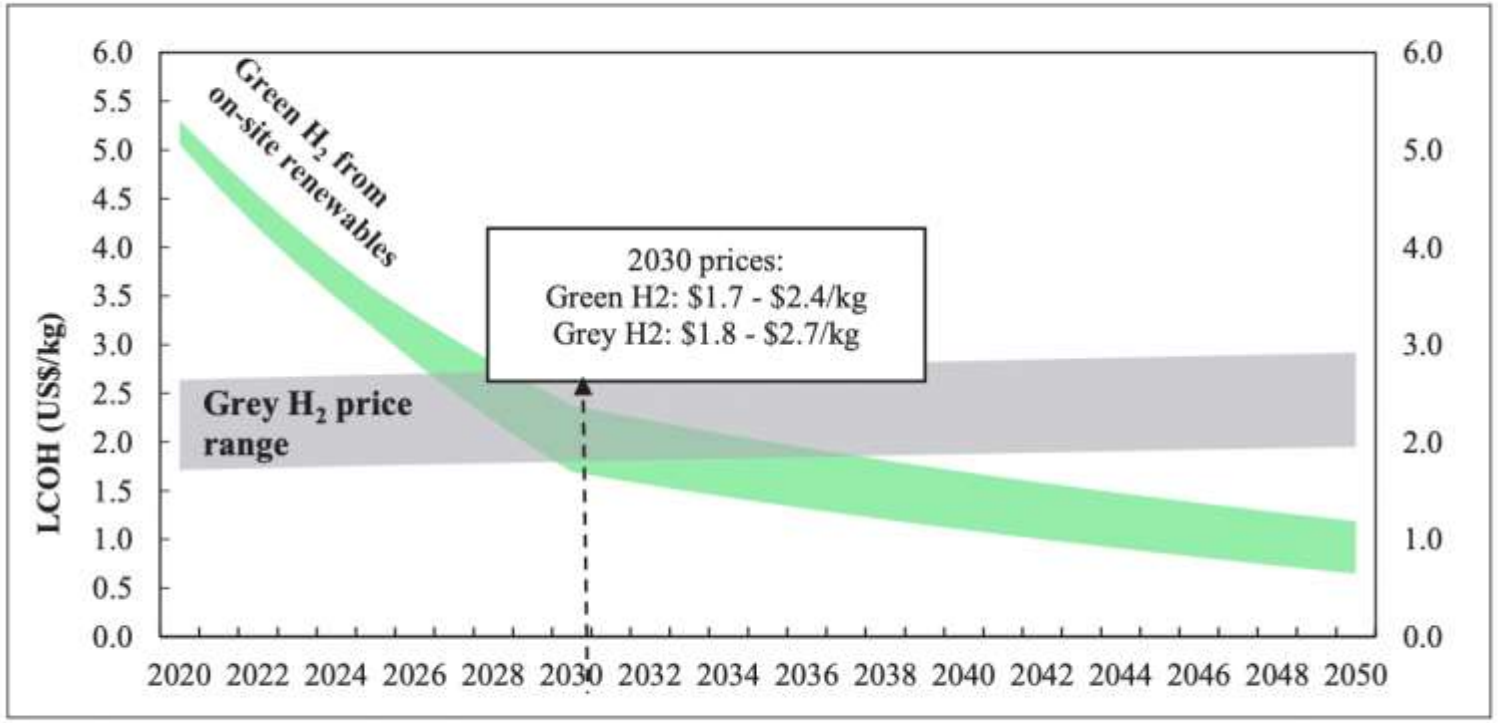
Source: Ministry of New & Renewable Energy

Levelised Cost of Hydrogen

- The Levelised Cost of Hydrogen (LCOH) is a variable that indicates how much it costs to produce 1 kg of Green Hydrogen, taking into account the estimated costs of the investment required and the cost of operating the assets involved in its production.

Levelised Cost of Hydrogen

Figure VII.10: Falling Levelised Cost of Hydrogen (LCOH[11]) for green hydrogen



Source: NITI Aayog

Updated NDCs

- Demonstrating higher ambition in its climate action, the Government of India submitted its updated NDC on August 26, 2022.
- The new NDC with enhanced targets translates the vision of the "Panchamrit" at the UNFCCC Conference of Parties (COP 26) in Glasgow in November 2021

Updated NDCs

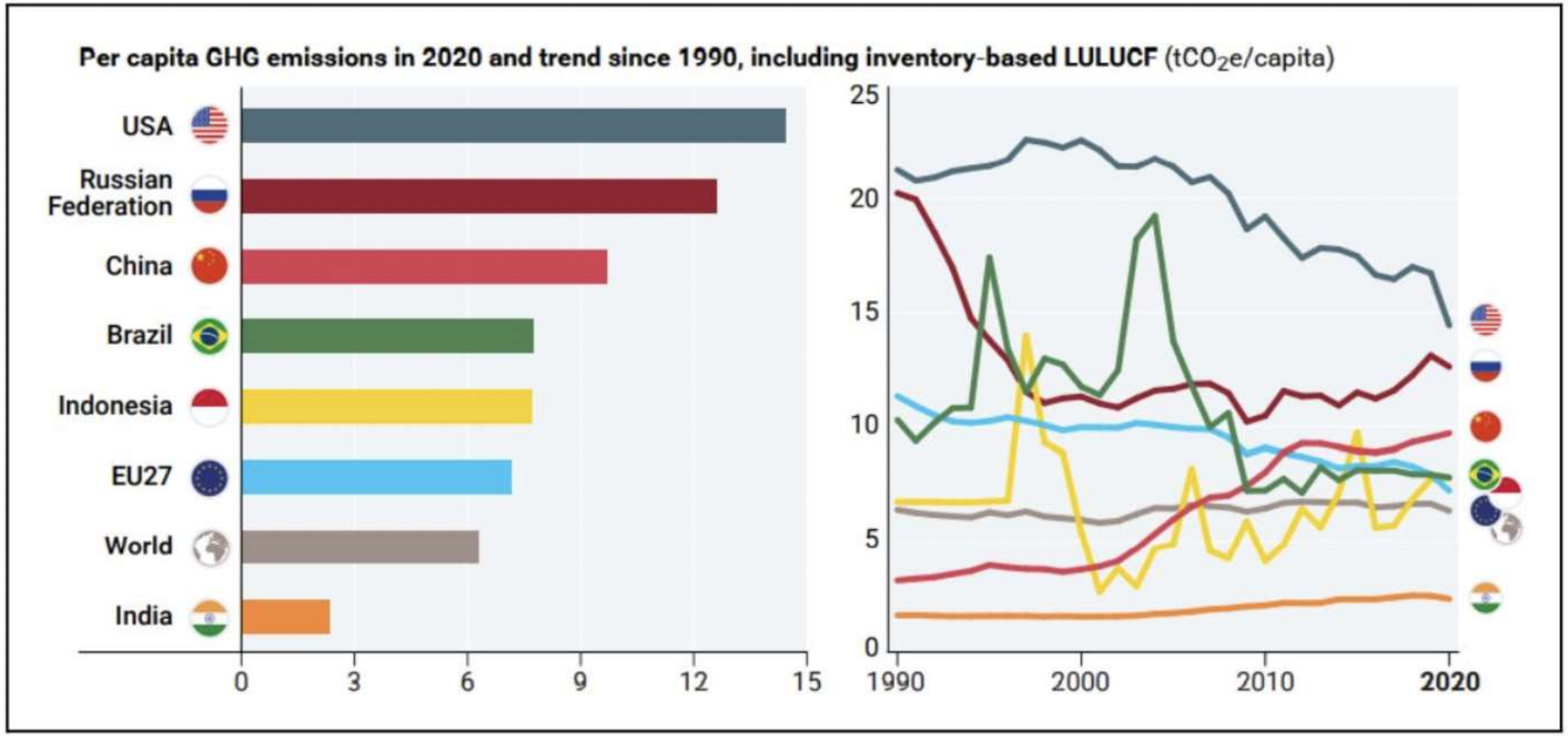
- To reduce the Emissions Intensity of its GDP by 45 per cent by 2030, from the 2005 level.
- To achieve about 50 per cent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030, with the help of the transfer of technology and low-cost international finance, including from the Green Climate Fund (GCF).
- To create an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030.

PANCHAMRITA

- At the 26th Conference of Parties (CoP26), Indian Prime Minister declared a five-fold strategy, termed as the *panchamrita*.
- These five points include:
  - India will get its non-fossil energy capacity to 500 gigawatt (GW) by 2030
  - India will meet 50 per cent of its energy requirements from renewable energy by 2030
  - India will reduce the total projected carbon emissions by one billion tonnes from now onwards till 2030
  - By 2030, India will reduce the carbon intensity of its economy by less than 45 per cent
  - So, by the year 2070, India will achieve the target of Net Zero

Climate change and Environment: Preparing to face the Future

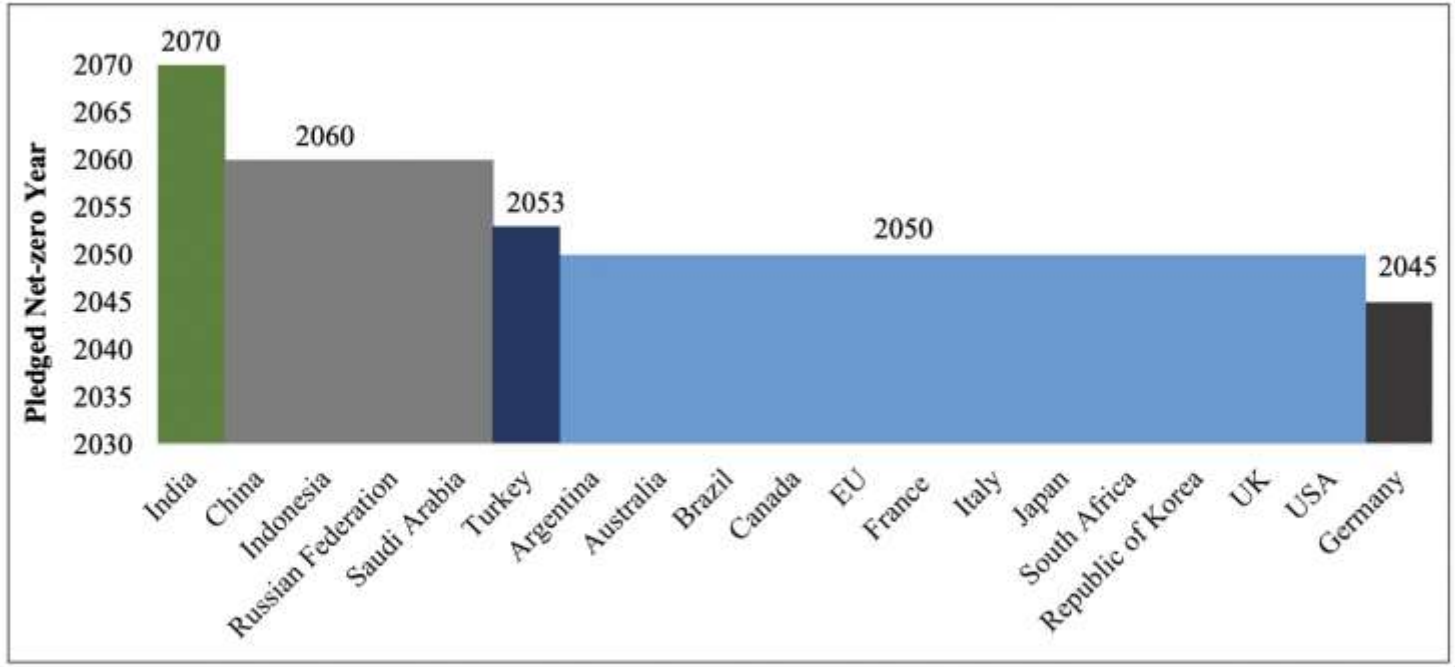
- India is one of the most vulnerable regions despite having contributed only about 4 per cent in the cumulative global emissions (for the period 1850-2019) and maintaining its per capita emission at far less than the world average.
- World average per capita GHG emissions - 6.3 tCO2e in 2020.
- India remains far below the world average at 2.4 tCO2e.



Source: Emissions Gap Report, 2022

Net Zero Pledges

Figure VII.1: Net Zero Pledges of countries (the Year pledged is on top of the bars)



Source: Emissions Gap Report 2022, UNEP

Carbon Leakage

- **Carbon leakage refers to a situation** ***where a company decides to move their production from a country with stringent policies, to a country that is more lenient,*** **leading to an increase in greenhouse gas emissions.**

Carbon Border Tax

- An import duty based on the quantity of carbon emissions produced during the production of the product in question is known as a carbon border adjustment tax.
- As a carbon tax, it reduces emissions.
- It has an impact on exports and production as a trade-related measure.
- Beginning in 2026, the European Union intends to establish a Carbon Border Adjustment Mechanism (CBAM).
- The five industries of energy, iron and steel, fertilisers, aluminium, and cement would initially be subject to the proposed import tax.
- Under Fit for 55 in 2030 package, which is EU's plan to reduce GHG emissions by at least 55% by 2030 compared to 1990 levels, in line with the European Climate Law.

Carbon Border Tax

- This will have a severe effect on the Indian industry, which has considerable export interests in the EU.
- From 2012 to 2021, the EU received close to 17% of all Indian exports; 6% of these shipments will be subject to the CBAM.
- The iron and steel industry will be most impacted, followed by aluminium, among these CBAM-involved Indian exports.
- According to BASIC, a group made up of Brazil, India, South Africa, and China, unilateral actions and discriminatory practises like carbon border fees might disrupt the market and widen the trust gap between nations.

Carbon Bombs

- It is "an oil or gas project that will result in at least a billion tonnes of CO_2 emissions over its lifetime."
- In total, around 195 such projects have been identified world over, including in the US, Russia, West Asia, Australia and India.
- According to the report, they will collectively overshoot the limit of emissions that had been agreed to in the Paris Agreement of 2015.
- The network working towards 'defusing' carbon bombs is called Leave It In the Ground Initiative (LINGO).
- Its mission is to "leave fossil fuels in the ground and learn to live without them."
- It believes the root of climate change is the burning of fossil fuels, and the 100% use of renewable energy sources is the solution.

Karakoram Anomaly

- A study investigated why glaciers in the Karakoram Range of Central-South Asia have not been as affected by Climate Change as others.
- They have attributed this phenomenon called Karakoram Anomaly to the recent revival of Western Disturbances (WDs).
- The precipitation intensity of WDs impacting Karakoram has increased by around 10% in the last two decades, which only enhances their role in sustaining the regional anomaly.
- It is termed as the stability or anomalous growth of glaciers in the central Karakoram, in contrast to the retreat of glaciers in other nearby mountainous ranges of Himalayas and other mountainous ranges of the world.

Arctic Amplification

- In recent decades, the warming in the Arctic has been much faster than in the rest of the world, a phenomenon known as Arctic amplification.
- Numerous studies report that the Arctic is warming either twice, more than twice, or even three times as fast as the globe on average.
- AKA polar amplification.
- Modelling studies show that strong Arctic amplification only occurs during the months when significant sea ice loss occurs, and that it largely disappears when the simulated ice cover is held fixed.
- Due to Ice–albedo feedback.

Triple Planetary Crisis

- The **triple planetary crisis** refers to the three main interlinked issues that humanity currently faces - **climate change, pollution and biodiversity loss.**
- Each of these issues has its **own causes and effects** and each issue needs to be resolved if we are to have a viable future on this planet.

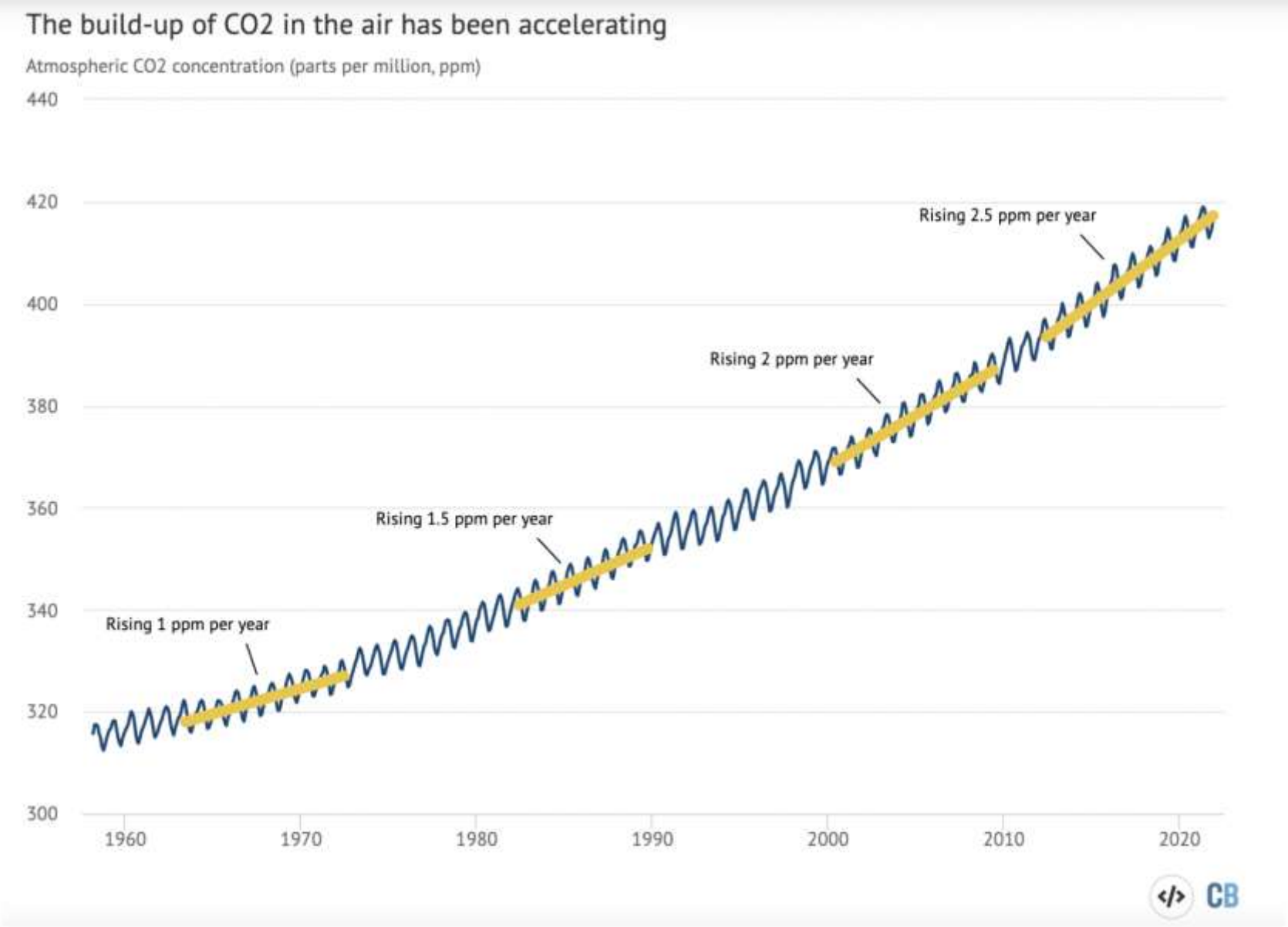
Carbon Dioxide Levels

Recently, for the first time, global concentration of carbon dioxide in the atmosphere have **crossed 415 parts per million (ppm) mark as per Mauna Loa Observatory.**

Mauna Loa Observatory (MLO) is the oldest continuous carbon dioxide (CO_2) measurement station in the world situated in Hawaii.

The observatory is part of the National Oceanic and Atmospheric Administration (NOAA) – Earth System Research Laboratory (ESRL) - Global Monitoring Division (GMD).

Keeling Curve is a graph of the **accumulation of carbon dioxide in the Earth's atmosphere** based on continuous measurements taken at the Mauna Loa Observatory.



The Keeling Curve, with trends over time. Image courtesty Met Office/CarbonBrief

To limit warming to 1.5°C the CO_2 rise must slow rapidly and stop before 2050

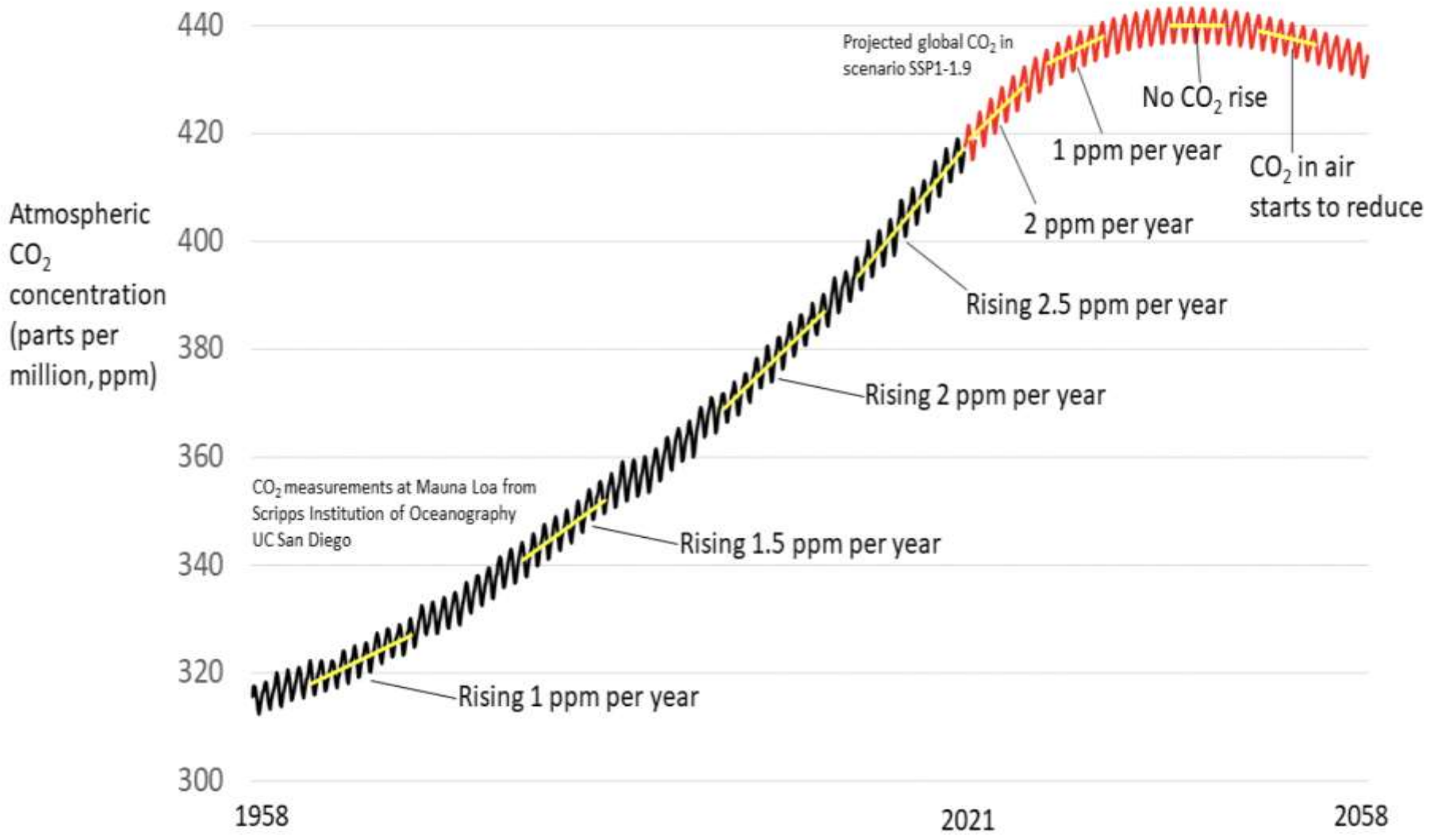


Image courtesy Richard Betts/CarbonBrief

Carbon Budget

- The AR6 showed that the world can emit only about 500 gigatonnes of carbon dioxide (GtCO2) starting January 1, 2020 for a 50 per cent chance of limiting warming to 1.5°C.
- For a 67 per cent chance of avoiding 1.5°C, the budget will come down to 400 GtCO2.
- For a 50 per cent chance of limiting temperatures to 2°C, the world can emit 1,350 GtCO2; and 1,150 GtCO2 for a 67 per cent chance.

Likelihood of limiting global warming to temperature limit	SR 15 budget starting in 2018 (In gigatonnes CO2)	AR 6 budget starting in 2020 (In gigatonnes CO2)
1.5°C – 50%	580	500
1.5°C – 67%	420	400
2°C – 50%	1,500	1,350
2°C – 67%	1,170	1,150

Carbon budgets are constructed on the premise that there is a near-linear relationship between rising global temperatures and the level of cumulative atmospheric CO2. As atmospheric CO2 rises, the temperature rises, and a looser temperature threshold like 2°C allows us to emit a higher amount of CO2 than a 1.5°C threshold.

Carbon Budget

- The AR6 estimate of the remaining carbon budget from 2020 was developed on the basis of five components:
  - Historical warming till date
  - Warming produced per tonne of CO_2, also known as transient climate response to cumulative emissions of CO_2 (TCRE); the AR6 says "each 1,000 $GtCO_2$ of cumulative CO_2 emissions is assessed to likely cause a 0.27°C to 0.63°C increase in global surface temperature with a best estimate of 0.45°C"
  - The warming that will occur once CO_2 emissions reach net-zero levels, is known as the zero-emissions commitment (ZEC)
  - Warming from non-CO_2 gases such as methane and nitrous oxide
  - Earth system feedbacks such as the thawing of permafrost that would release additional carbon, and which were not considered in methodology earlier but are now added

CO_2 equivalent

- A **carbon dioxide equivalent or CO_2 equivalent,** abbreviated as CO_2-eq is a metric measure **used to compare the emissions from various greenhouse gases** on the basis of their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming

Committed Warming

- "Committed warming," also known as "pipeline warming."
- It refers to future increases in global temperatures that will be caused by greenhouse gases that have already been emitted.
- A study of 18 Earth system models found that when emissions were cut off, some continued warming for decades to hundreds of years, while others began cooling quickly.
- Another study, published in June 2022, found a 42% chance that the world is already committed to 1.5 degrees.

Runaway Greenhouse Effect

- A runaway greenhouse effect occurs when a planet's atmosphere contains greenhouse gas in an amount sufficient to block thermal radiation from leaving the planet, preventing the planet from cooling and from having liquid water on its surface.

Tipping Points

- The climate crisis has driven the world to the brink of multiple "disastrous" tipping points, according to a major study.
- A tipping point is a critical threshold that, when crossed, leads to large and often irreversible changes in the climate system.
- It shows five dangerous tipping points may already have been passed due to the 1.1C of global heating caused by humanity to date.
- These include the collapse of Greenland's ice cap, eventually producing a huge sea level rise, the collapse of a key current in the north Atlantic, disrupting rain upon which billions of people depend for food, and an abrupt melting of carbon-rich permafrost.

Tipping Points

- At 1.5C of heating, the minimum rise now expected, four of the five tipping points move from being possible to likely, the analysis said.
- Also at 1.5C, an additional five tipping points become possible, including changes to vast northern forests and the loss of almost all mountain glaciers.
- In total, the researchers found evidence for 16 tipping points, with the final six requiring global heating of at least 2C to be triggered, according to the scientists' estimations.
- The tipping points would take effect on timescales varying from a few years to centuries.

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