

CBCS PG: Elective Paper-Environmental  
Science M. Sc., Semester-IV

Definitions of mitigation and  
present overview of emissions  
levels and mitigation targets per  
country

# Climate Change

- Composition of the Earth's atmosphere plays a major role in establishing surface temperature and climate of the earth.
- The earth's temperature is maintained by a balance between
  - heating from Solar Radiation by the sun and
  - cooling from infra-red radiation emitted by the earth's surface.

- Movement of these radiation occurs through the atmosphere.
  - Solar radiation (visible sunlight) readily penetrates the atmosphere to warm the earth.
  - Infra-red radiation (invisible) on the other hand is trapped by Greenhouse Gases (GHGs) which acts as blankets in the atmosphere to keep the heat in.

# GHG

- CO<sub>2</sub> which was balanced by its uptake by plants during photosynthesis is now increasing due to:
  - Extraction and burning of fossil fuels (petroleum, coal, oil and gas)
  - Destruction of tropical forest for energy, timber and other land uses.

- CH<sub>4</sub> is increasing by 1% per year as a result of anaerobic fermentation of organic matter due to
  - Changing agricultural practices
  - Waste disposals and
  - Mining
- N<sub>2</sub>O is increasing by 0.3% mainly from agriculture and biomass burning
- CFCs are increasing due to production of aerosol propellants, refrigerants and insulators.

# Climate Change History

- Historical Emissions since 1880 has resulted in rise in global temperature by 0.85°C.
- Historical carbon space occupied by various countries in 2009 (1850 as base year):
  - USA: 29%
  - Other Developed countries: 45%
  - China: 10%
  - Other Emerging Economies: 9%
  - India: 3%
- India, even though not a part of problem, wants to be part of solution.

# Emissions gap report

- United Nations Environment Programme (UNEP) published Emissions Gap Report.
- It provides the latest assessment of scientific studies on current and estimated future greenhouse gas (GHG) emissions.
- Difference between “where we are likely to be and where we need to be” has become known as the ‘emissions gap’.

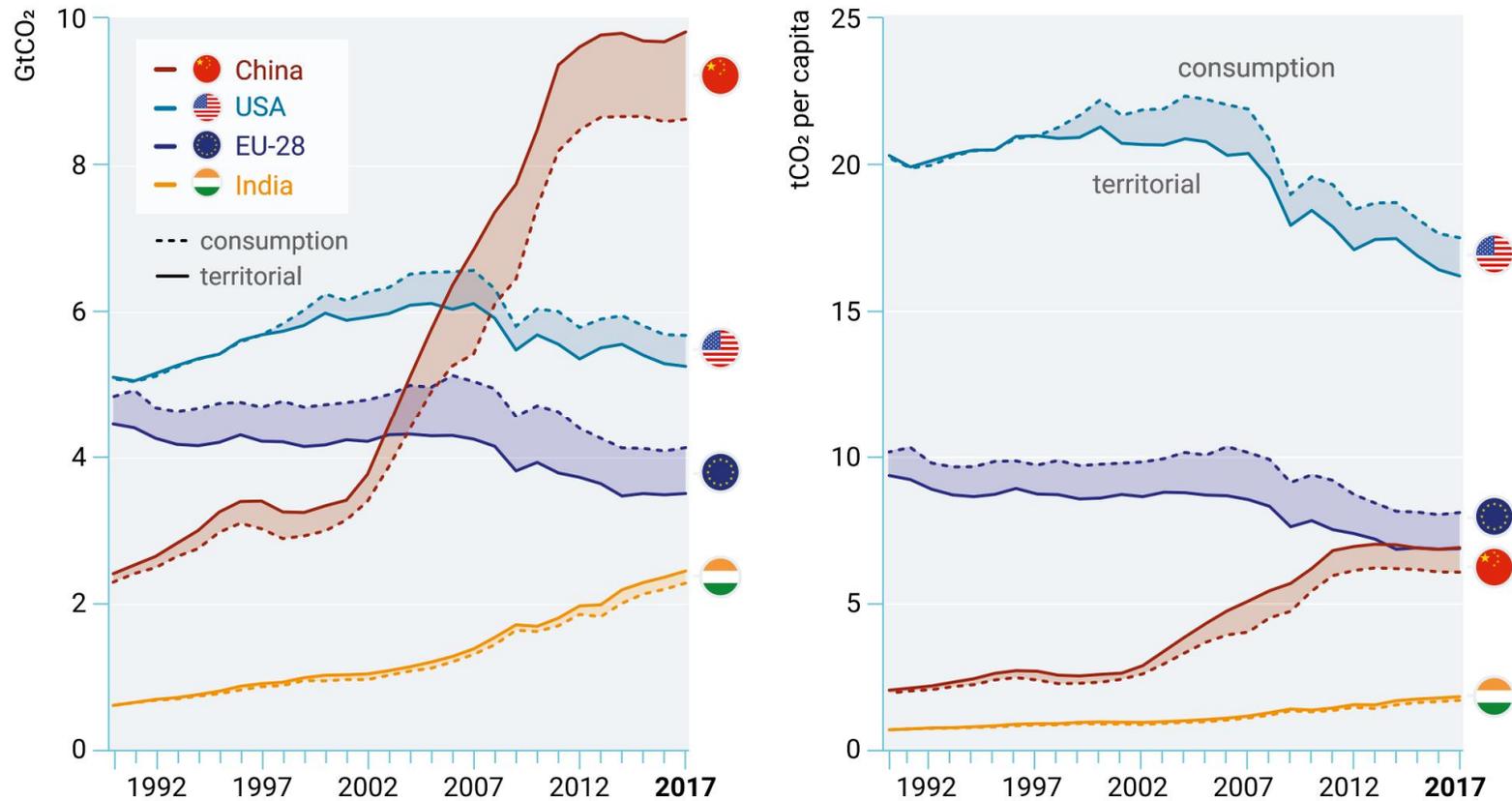
# Emission Standards

- Emission standards are the legal requirements governing air pollutants released into the atmosphere.
- Emission standards set quantitative limits on the permissible amount of specific air pollutants that may be released from specific sources over specific timeframes.
- They are generally designed to achieve air quality standards and to protect human life.

# Rise GHG emission

- GHG emissions continue to rise, despite scientific warnings and political commitments.
- GHG emissions have risen at a rate of 1.5% per year in the last decade, stabilizing only briefly between 2014 and 2016.
- Total GHG emissions, including from land-use change, reached a record high of 55.3 GtCO<sub>2</sub> e in 2018.
  - Land use change is a process by which human activities transform the natural landscape, referring to how land has been used, usually emphasizing the functional role of land for economic activities.
- Fossil CO<sub>2</sub> emissions from energy use and industry, which dominate total GHG emissions, grew 2.0 per cent in 2018, reaching a record 37.5 GtCO<sub>2</sub> per year.

# CO2 emission



CO2 emissions allocated to the point of emissions (territorial) and the point of consumption, for absolute emissions (left) and per capita (right)

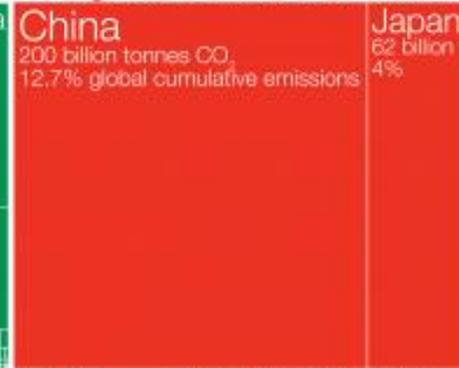
# Who has contributed most to global CO<sub>2</sub> emissions?

Cumulative carbon dioxide (CO<sub>2</sub>) emissions over the period from 1751 to 2017. Figures are based on production-based emissions which measure CO<sub>2</sub> produced domestically from fossil fuel combustion and cement, and do not correct for emissions embedded in trade (i.e. consumption-based). Emissions from international travel are not included.

**North America**  
457 billion tonnes CO<sub>2</sub>  
29% global cumulative emissions



**Asia**  
457 billion tonnes CO<sub>2</sub>  
29% global cumulative emissions



**EU-28**  
353 billion tonnes CO<sub>2</sub>  
22% global cumulative emissions



**Russia**  
101 billion tonnes  
6% global emissions



**India**  
48 billion t  
3%



**Europe**  
514 billion tonnes CO<sub>2</sub>  
33% global cumulative emissions



**Africa** 43 billion tonnes CO<sub>2</sub> 3% global emissions  
**South America** 40 billion tonnes CO<sub>2</sub> 3% global emissions



**Oceania**  
20 billion tonnes CO<sub>2</sub>  
1.2% global emissions

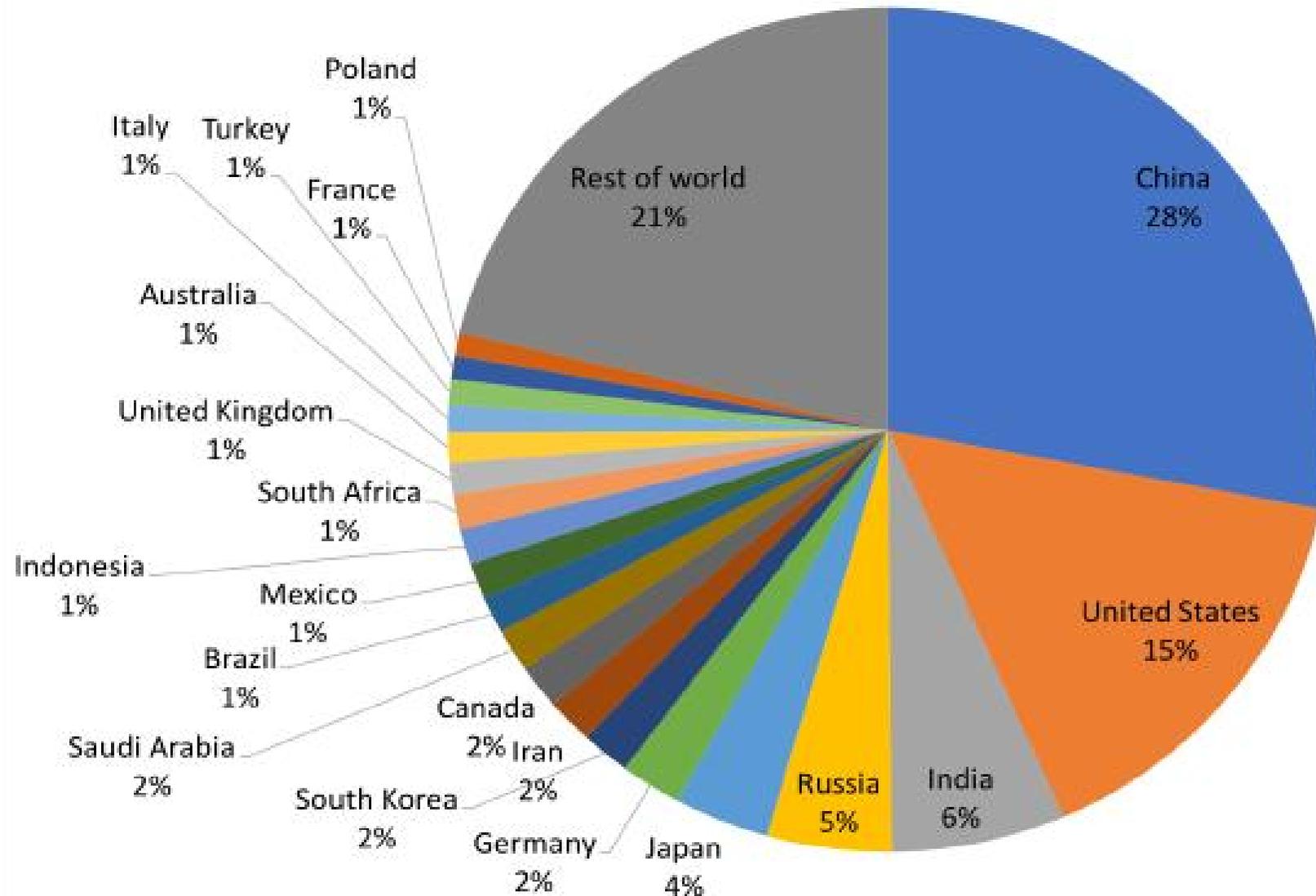


Figures for the 28 countries in the European Union have been grouped as the "EU-28" since international targets and negotiations are typically set as a collaborative target between EU countries. Values may not sum to 100% due to rounding.

Data source: Calculated by Our World in Data based on data from the Global Carbon Project (GCP) and Carbon Dioxide Analysis Center (CDIAC). This is a visualization from OurWorldinData.org, where you find data and research on how the world is changing.

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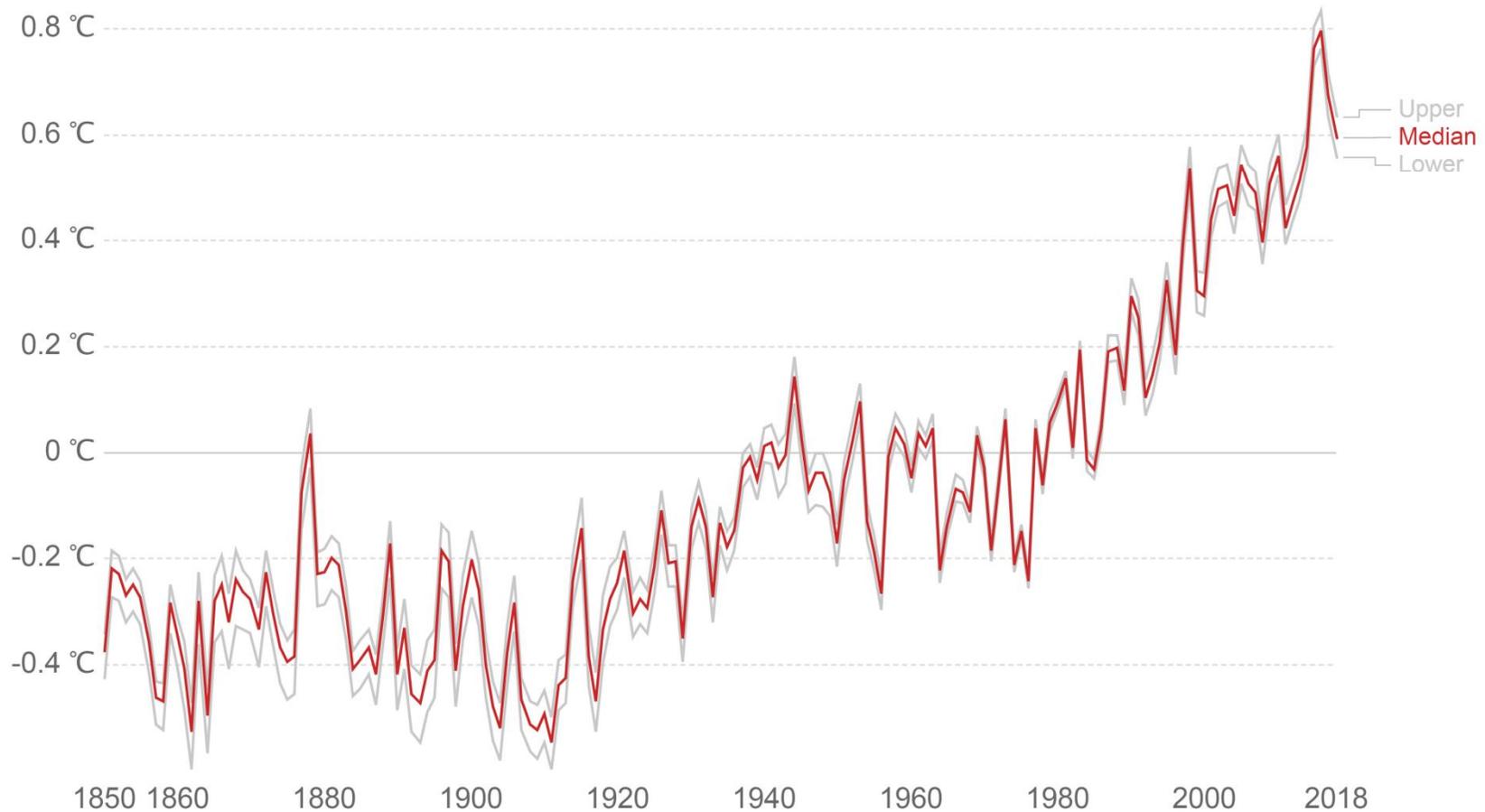
# Share of Global CO<sub>2</sub> emission from fuel combustion (2015)



# Average temperature anomaly, Global



Global average land-sea temperature anomaly relative to the 1961-1990 average temperature in degrees celsius (°C). The red line represents the median average temperature change, and grey lines represent the upper and lower 95% confidence intervals.

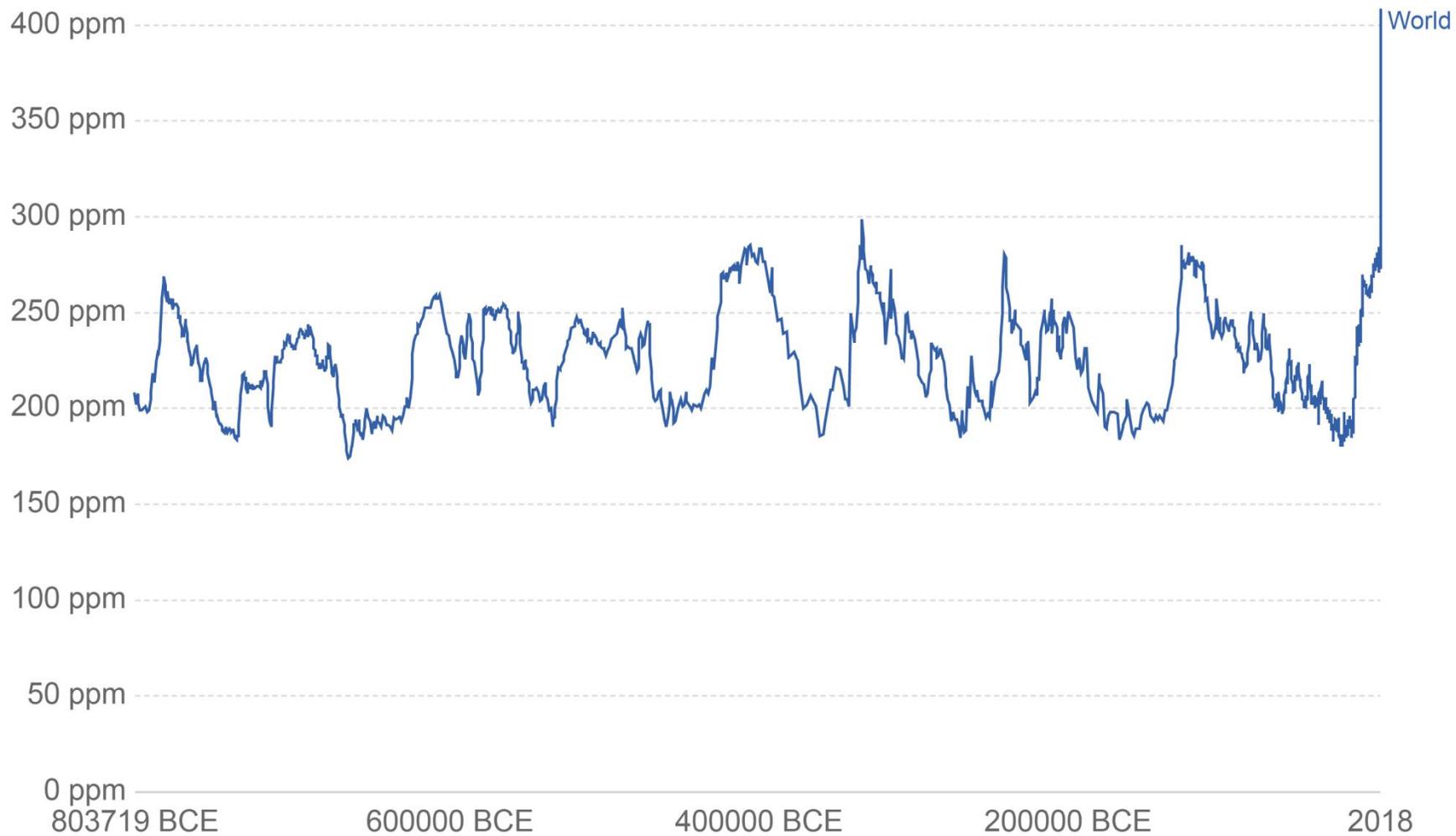


Source: Hadley Centre (HadCRUT4)

OurWorldInData.org/co2-and-other-greenhouse-gas-emissions • CC BY

# Atmospheric CO<sub>2</sub> concentration

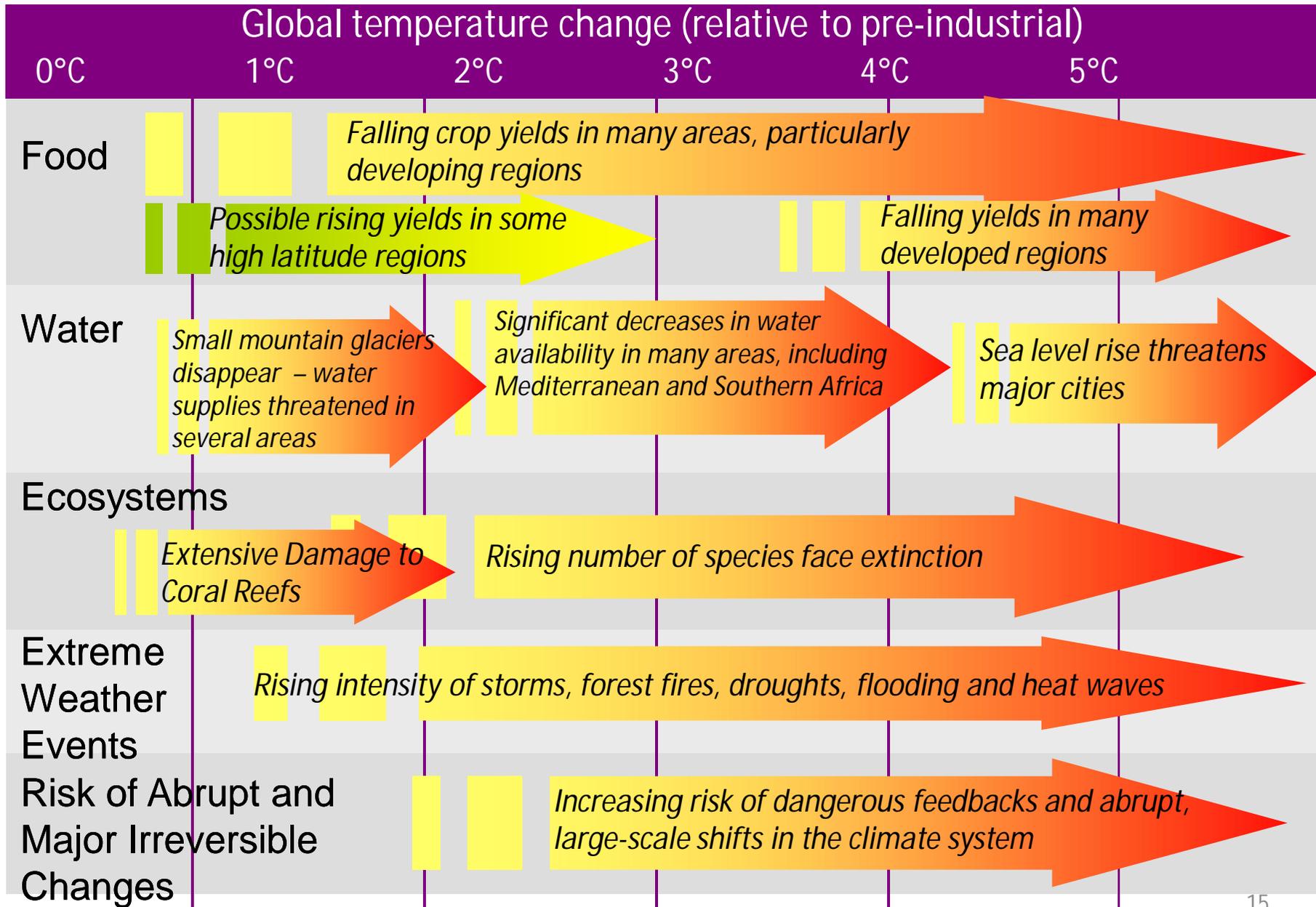
Global average long-term atmospheric concentration of carbon dioxide (CO<sub>2</sub>), measured in parts per million (ppm). Long-term trends in CO<sub>2</sub> concentrations can be measured at high-resolution using preserved air samples from ice cores.



Source: EPICA Dome C CO<sub>2</sub> record (2015) & NOAA (2018)

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# Projected impacts of climate change



# What is mitigation?

- Climate Change mitigation is the **actions we can take to reduce the emissions of greenhouse gases,**
- The summary findings of emission gap report are bleak (cold and miserable, not good anyway).
- Countries collectively failed to stop the growth in global GHG emissions.
- So deeper and faster cuts are now required.

# Mitigation Measures

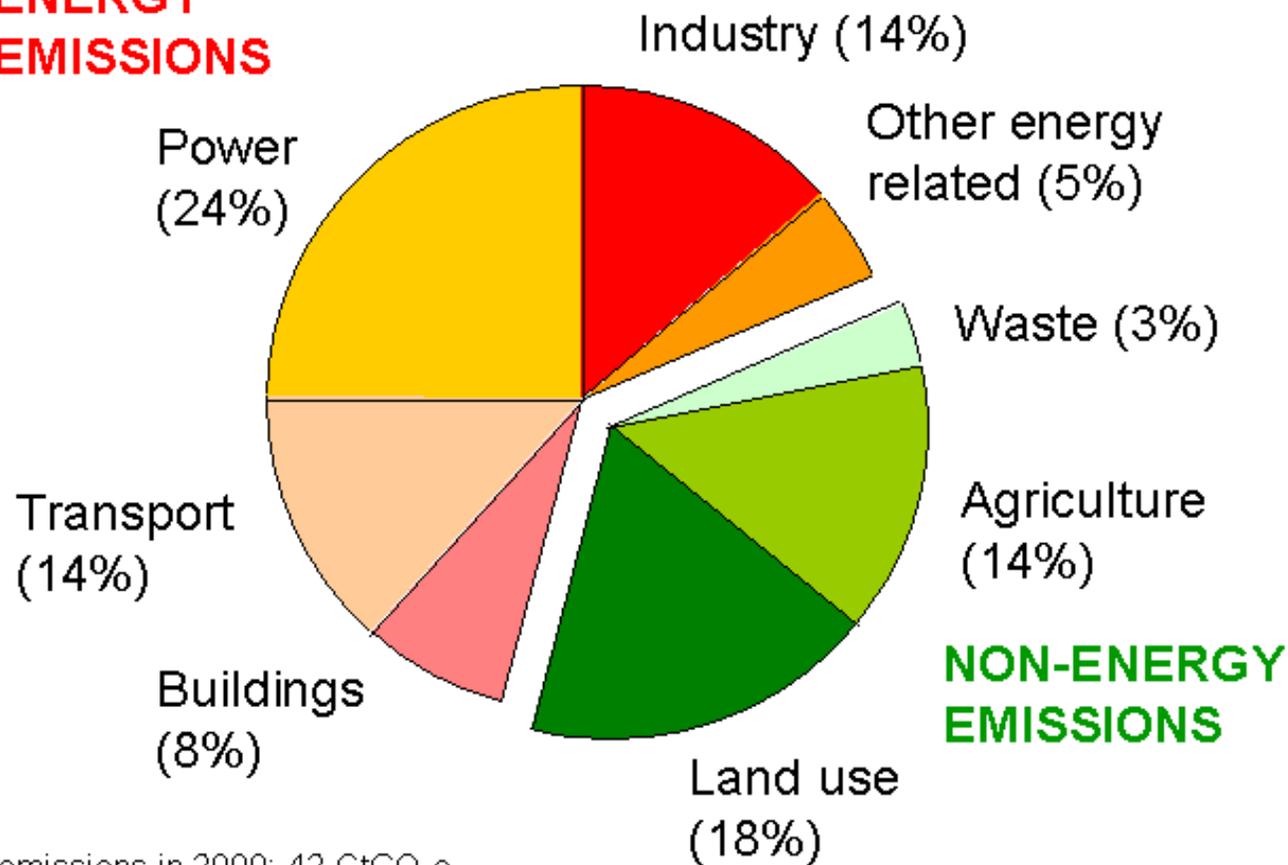
- A. Reduction of activities which releases GHGs.
- B. New alternatives: technologies, behaviors, sources of energy.
- C. Sequestration (capture): forests, soil, ocean, and underground

# How can we reduce carbon emissions?

- We could reduce (mitigate) carbon emissions in the following areas.
  - Transportation
  - Heating and Cooling Buildings
  - Industry Carbon Output
  - Electricity Use

# Reducing emissions requires action across many sectors

## ENERGY EMISSIONS



Total emissions in 2000: 42 GtCO<sub>2</sub>e.

# Mitigation Strategy #1: Transportation Efficiency



1. A car that gets 30 mpg releases 1 ton of carbon into the air for every 10,000 miles of driving
2. Fuel efficient cars get more miles per gallon (mpg)
3. Increasing the fuel efficiency of cars will reduce the amount of CO<sub>2</sub> emitted into the atmosphere

# Mitigation Strategy #2: Transport Conservation



1. With more cars on the road, the amount of CO<sub>2</sub> emitted steadily increases.
2. Reducing the time and number of cars on the road will reduce emissions.
3. Increasing the use of public transportation would reduce the amount of individual driving time.

# Mitigation Strategy #3: Building Efficiency



- Providing electricity, transportation, and heat for buildings produces high levels of CO<sub>2</sub> emission.
- Reducing heating and energy use would reduce the amount of carbon released into the atmosphere.
- Insulating buildings, using alternative energy sources, and solar water heating are ways to reduce emissions.

# Mitigation Strategy #4: Efficient Electricity Production

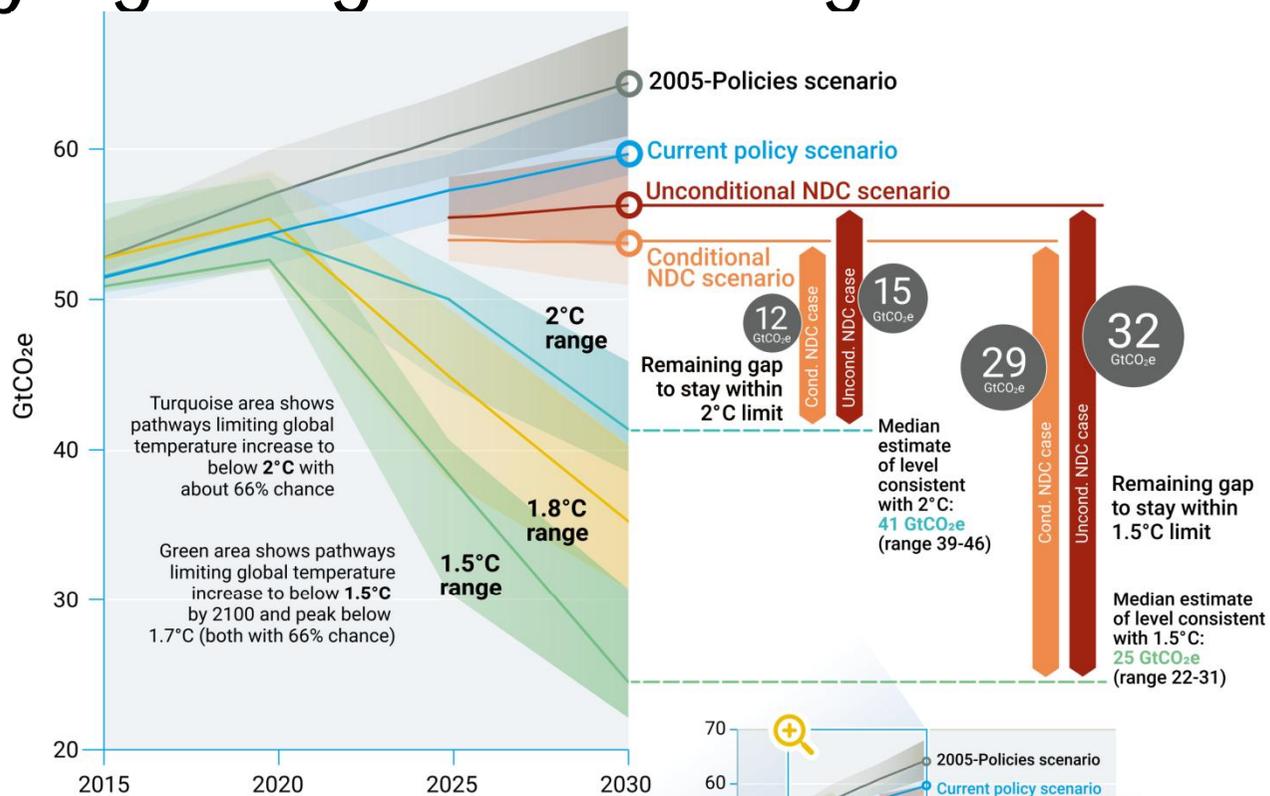


- 25% of the world's carbon emissions come from the production of electricity at coal plants.
- Since nearly 50% of electricity comes from coal combustion, improving coal plant efficiency will significantly reduce carbon emission.
- To do this requires alternative ways of using coal to produce electricity.

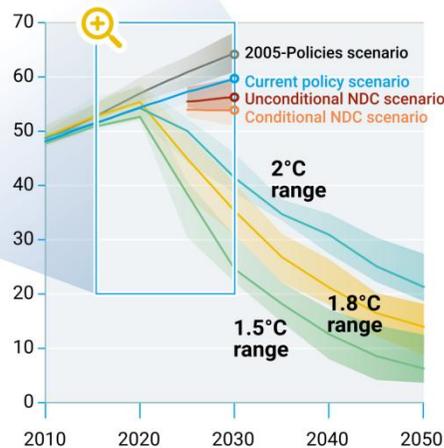
# Mitigation Targets

- The political context in 2019 has been dominated by the United Nations Secretary-General's Global Climate Action Summit brought together governments, the private sector, civil society, local authorities and international organizations.
- The aim of the Summit was
  - to stimulate action and in particular to secure countries' commitment to enhance their nationally determined contributions (NDCs) by 2020 and aim for net zero emissions by 2050.

# Delaying mitigation is dangerous and costly



NDC Nationally determined contributions



# Commitment percentages of Countries

- G8 Heiligendamm – global 50% by 2050 (consistent with stabilisation around 500ppm CO<sub>2</sub>e)
- US (under e.g. Obama/Clinton) - 80% from 1990 levels by 2050.
- France – 75% by 2050 (Factor 4), relative to 1990
- EU Spring Council: 60-80% by 2050 and 20-30% by 2020, relative to 1990
- Germany – 40% by 2020, relative to 1990
- India to stay below rich country average per capita

The Group of Eight

G8



US of America



United Kingdom



France



Germany



Italy



Japan



Russia



Canada

# Transition options

## 1. Renewable energy

**Table ES.3.** Summary of five energy transition options

Option	Major components	Instruments	Co-benefits	Annual GHG emissions reduction potential of renewables, electrification, energy efficiency and other measures by 2050
<b>Renewable energy electricity expansion</b>	<ul style="list-style-type: none"> <li>• Plan for large shares of variable renewable energy</li> <li>• Electricity becomes the main energy source by 2050, supplying at least 50 per cent of total final energy consumption (TFEC)</li> <li>• Share of renewable energy in electricity up to 85 per cent by 2050</li> <li>• Transition</li> </ul>	<ul style="list-style-type: none"> <li>• Flexibility measures to take on larger shares of variable renewable energy</li> <li>• Support for deployment of distributed energy</li> <li>• Innovative measures: cost reflective tariff structures, targeted subsidies, reverse auctions, net metering</li> </ul>	<ul style="list-style-type: none"> <li>• Greater efficiency in end-use energy demand</li> <li>• Health benefits</li> <li>• Energy access and security</li> <li>• Employment</li> </ul>	<ul style="list-style-type: none"> <li>• Power sector: 8.1 GtCO<sub>2</sub></li> <li>• Building sector: 2.1 GtCO<sub>2</sub></li> <li>• District heat and others: 1.9 GtCO<sub>2</sub></li> </ul>

## 2. Coal phase out

**Table ES.3.** Summary of five energy transition options

Option	Major components	Instruments	Co-benefits	Annual GHG emissions reduction potential of renewables, electrification, energy efficiency and other measures by 2050
<b>Coal phase-out</b>	<ul style="list-style-type: none"> <li>• Plan and implement phase-out of coal</li> <li>• Coal to renewable energy transition</li> <li>• Expand carbon capture usage and storage systems</li> <li>• Improve system-wide efficiency</li> </ul>	<ul style="list-style-type: none"> <li>• Regional support programmes</li> <li>• Tax breaks, subsidies</li> <li>• Carbon pricing</li> <li>• Moratorium policies</li> <li>• De-risking of clean energy investments</li> <li>• Relocation of coal workers (mines and power plants)</li> </ul>	<ul style="list-style-type: none"> <li>• Lower health hazards (air, water, land pollution)</li> <li>• Future skills and job creation</li> </ul>	Share of the power emissions reduction from a coal phase-out: 4 GtCO <sub>2</sub> (range: 3.6– 4.4 GtCO <sub>2</sub> ), with 1 GtCO <sub>2</sub> from the OECD and 3 GtCO <sub>2</sub> from the rest of the world

# 3. Decarbonise transport

**Table ES.3.** Summary of five energy transition options

Option	Major components	Instruments	Co-benefits	Annual GHG emissions reduction potential of renewables, electrification, energy efficiency and other measures by 2050
<b>Decarbonize transport</b>	<ul style="list-style-type: none"> <li>• Reduce energy for transport</li> <li>• Electrify transport</li> <li>• Fuels substitution (bioenergy, hydrogen)</li> <li>• Modal shift</li> </ul>	<ul style="list-style-type: none"> <li>• Pathways for non-motorized transport</li> <li>• Standards for vehicle emissions</li> <li>• Establishing of charging stations</li> <li>• Eliminating of fossil-fuel subsidies</li> <li>• Investments in public transport</li> </ul>	<ul style="list-style-type: none"> <li>• Increased public health from more physical activity, less air pollution</li> <li>• Energy security</li> <li>• Reduced fuel spending</li> <li>• Less congestion</li> </ul>	Electrification of transport: 6.1 GtCO <sub>2</sub>

## 4. Decarbonise industry and 5. avoid future emission

Table ES.3. Summary of five energy transition options

Option	Major components	Instruments	Co-benefits	Annual GHG emissions reduction potential of renewables, electrification, energy efficiency and other measures by 2050
<b>Decarbonize industry</b>	<ul style="list-style-type: none"> <li>• Demand reduction (circular economy, modal shifts and logistics)</li> <li>• Electrify heat processes</li> <li>• Improve energy efficiency</li> <li>• Direct use of biomass/ biofuels</li> </ul>	<ul style="list-style-type: none"> <li>• Carbon pricing</li> <li>• Standards and regulations, especially on materials demand reduction</li> </ul>	<ul style="list-style-type: none"> <li>• Energy security</li> <li>• Savings and competitiveness</li> </ul>	<ul style="list-style-type: none"> <li>• Industry: 4.8 GtCO<sub>2</sub></li> </ul>
<b>Avoid future emissions and energy access</b>	<ul style="list-style-type: none"> <li>• Link energy access with emission reductions for 3.5 billion energy-poor people</li> </ul>	<ul style="list-style-type: none"> <li>• Fit and auctions</li> <li>• Standards and regulations</li> <li>• Targeted subsidies</li> <li>• Support for entrepreneurs</li> </ul>	<ul style="list-style-type: none"> <li>• Better access</li> <li>• Meet basic needs and SDGs</li> </ul>	<ul style="list-style-type: none"> <li>• N/A</li> </ul>

# India: GHG Emission

- The total net Greenhouse Gas (GHG) emissions from India in 2007 were 1727.71 million tons of CO<sub>2</sub> equivalent (eq) of which –
  - CO<sub>2</sub> emissions were 1221.76 million tons
  - CH<sub>4</sub> emissions were 20.56 million tons
  - N<sub>2</sub>O emissions were 0.24 million tons
- GHG emissions from **Energy**, Industry, Agriculture, and waste sectors constituted **58%**, 22%, 17% and 3% of the net CO<sub>2</sub> eq emissions respectively.

- Energy sector emitted 1100.06 MtCO<sub>2</sub> eq, of which 719.31 MtCO<sub>2</sub> eq were emitted from electricity generation and 142.04 MtCO<sub>2</sub> eq from the transport sector.
- Industry sector emitted 412.55 MtCO<sub>2</sub> eq.
- LULUCF (Land Use Land Use Change & Forestry) sector was a net sink. It sequestered 177.03 million tons of CO<sub>2</sub> .

# National Circumstances & Challenges

- India: 2.4% of world surface area  
17.5% of world's human population  
17.5% of world's cattle population
- Poverty: 30% of the population lives in poverty
- Housing : 20% of population without proper housing
- Electricity: 25% without electricity  
Per capita consumption 1/10<sup>th</sup> of developed world
- Drinking Water: 92 million without safe drinking water
- Human Development Index: 0.586  
Global rank of 135
- India's priority: Poverty eradication  
Sustainable growth

# Process for Developing INDC

- Multiple consultations with Ministries, Niti Aayog, State governments, Industry Associations, Civil Society Groups, Academic Institutions and Think tanks
- Consultations with members of PM Council on Climate Change
- Prime Minister level consultation with Ministers
  - Based on existing & contemplated plans, policies & programs National & State Action Plans for Climate Change lay the foundation
  - Planning ahead over a 15year frame– instead of 5 year
  - Interests of farmers and poor protected

- **Ambitious target** for renewable & electricity to all:
  - **175 GW** Renewable energy target by 2022
    - 100 GW of Solar,
    - 60 GW of Wind,
    - 10 GW of biomass and
    - 5 GW of small hydel
- ***Swachh Bharat Mission, Cleaning of rivers, Make in India, Smart Cities Mission, Housing for all***

# Current Climate Change Pledge

- Current voluntary pledge by India:
  - 20-25% reduction in Emission intensity of GDP by 2020 compared to 2005 levels
  - Achievement : 12% reduction between 2005 and 2010 (an estimate).
  - India is confident of achieving this pledge.
- UNEP Emission Gap Report 2014 recognized India as achiever of voluntary goal

# Reduce Emission Intensity of GDP

- Goal: To Reduce the emissions intensity of its GDP  
By 33 - 35% by 2030 from 2005 level.

Our national plans are ambitious and purposeful:

- Thrust on Renewable Energy
- Promotion of Clean Energy,
- Enhancing Energy Efficiency
- Climate Resilient Urban Centres
- Sustainable Green transportation Network
- Swachh Bharat Mission,
- Cleaning of rivers,
- Make in India

# Increase the share of Non-Fossil Fuel Based Electricity

Goal: To achieve 40% of electric power installed capacity from non-fossil fuel by 2030

- India running one of the largest renewable capacity expansion programs in world
- The 175 GW target by 2022 will result in abatement of 326 million tons of CO<sub>2</sub> equivalent/year.
- To include wind power, solar, hydropower, biomass, waste to energy and nuclear power.

# Increase the Share of Non-Fossil Fuel Based Electricity

- Solarization of all petrol pumps, toll plazas across country
- Ongoing scheme for development of
  - 25 Solar Parks
  - Ultra Mega Solar Power Projects
  - Canal top solar projects
  - One hundred thousand solar pumps for farmers
- India to anchor a global solar alliance

# Enhancing Forests Carbon Sink

- Goal: To Create additional carbon sink of 2.5-3 billion tonnes of CO<sub>2</sub> equivalent through additional forest and tree cover.
- Emphasis on India' s Plans to enhance its carbon sink:
  - Full implementation of Green India Mission
  - Launched Green Highways Policy: 140,000 km long "tree-line" along both sides of national highways. 1% of project cost to be earmarked for plantation
  - Plantation along Rivers: part of the Namami Gange Mission.

# Adaptation Component

- Goal:
  - To better adapt to climate change by enhancing investments in development programmes in sectors vulnerable to climate change, particularly agriculture, water resources, Himalayan region, coastal regions, health and disaster management
- High vulnerability of India to climate change impacts due to poverty & dependence of a large population on climate sensitive sectors for livelihood.

# Technology Development & Transfer

- Goal:
  - To build capacities, create domestic framework and international architecture for quick diffusion of cutting edge climate technology in India and for joint collaborative R&D for such future technologies.
- Global collaboration in R&D
- Preliminary and illustrative list of select technologies given in India' s INDC

# Sustainable Lifestyle

- Goal:

To put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation

- Extravagant lifestyles will require 5 planets
- Sustainable lifestyle will require 1 planet
- Promote “ Sustainable Lifestyles” based on needs based consumption.

# Cleaner Economic Development

- Goal:  
To adopt a climate friendly and a cleaner path than the one followed hitherto by others at corresponding level of economic development
- At comparable levels of income, India's Growth Path much more cleaner and greener & will continue to be so
- Emission Intensity of Developed countries at similar economic level as India's today was approx. 0.9 kgCO<sub>2</sub>/\$
- India's emission intensity: 0.36 kg CO<sub>2</sub>/\$ (60% less compared to developed countries)

## Recent Initiatives of the Government

- Revisiting national missions, creation of new missions and enhancing of targets etc.

### Mitigation Initiatives

- **Renewable Energy** target 175 GW & **National Solar Mission** from 20 to 100 GW
- **Kochi Airport** worlds' first airport powered by solar energy
- **Solar powered toll plazas**
- **Delhi Metro & other MRTS**
- **National Smart Grid Mission & Green Energy Corridor** for efficient transmission & distribution network

## Initiatives of the Government (contd.)

- Swachh Bharat Mission
- 100 smart cities
- Atal Mission for Rejuvenation & Urban Transformation, urban renewal of 500 cities
- Launched Green Highways Policy- develop 140,000 km long tree-line along highways
- FAME India (faster adoption and manufacturing of hybrid electric vehicles).
- Country's first passenger vehicle fuel-efficiency standards finalized
- National Air Quality Index launched.

## Initiatives of the Government (contd.)

### Adaptation Strategies

- **Paramparagat Krishi Vikas Yojana** - organic farming
- **Pradhan Mantri Krishi Sinchayee Yojana** - efficient irrigation.
- **Neeranchal** - watershed development.
- **Namami Gange**
- **National Initiative on Climate Resilient Agriculture (NICRA)**
- **Bureau for Water Use Efficiency**
- **Lifestyle & culture of sustainability**

# Initiatives of the Government

## Climate Finance Policies

- National Adaptation Fund
- Reduction in fossil fuel subsidies.
- Coal Cess increased from INR 50 to INR 200 per ton.
- Tax free infrastructure bonds introduced for renewable energy