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Editorial

Economic development is closely linked with urbanizations. Cities are hubs of production, consumption, and waste generation. As cities grow, so does their ecological footprint; they consume more and more natural resources to meet the rising demand for food, water, energy, and goods and services. With ever increasing demands arises the release of many Green House Gases (GHG).

Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are the principal greenhouse gases emitted to the atmosphere from the burning of fossil fuels to produce heat and power for buildings. Electricity consumption in these buildings is majorly responsible for these greenhouse gases (GHG), with the remainder resulting from burning natural gas and petroleum products. Carbon Dioxide is the major greenhouse gas emissions from our vehicles, from heating our homes and businesses, and from other activities in our lives. It is also the leading greenhouse gas that contributes to global warming. Globally, buildings account for a significant proportion of our Carbon Dioxide (CO_2) emissions. The cradle-to-grave life cycle of the construction sector including all aspects of the design, construction, use and demolition of buildings and infrastructure, beyond simple occupancy itself are leading contributors to carbon footprints.

Index

Contents

Glossary

- **Carbon Dioxide Equivalent**—Emissions of greenhouse gases are typically expressed in a common metric so that their impacts can be directly compared, as some gases are more potent and have a higher global warming potential than others. The international standard of practice is to express greenhouse gases in carbon dioxide equivalents.
- **Global Warming Potential (GWP)**—is a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming. It is a relative scale that compares the gas in question to that of the same mass of carbon dioxide (CO_2) whose GWP is, by convention, equal to 1.
- **Kyoto Protocol—**is a protocol to the United Nations Framework Convention on Climate Change aimed at fighting global warming. Signatories to this protocol commit themselves to a reduction of the four main greenhouse gases; carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, and two groups of gases; hydro fluorocarbons and per fluorocarbons.
- **Emission Factors** -An emission factor is a commonly used tool to estimate emissions based on the consumption of basic inputs such as energy, fuel or fertilizers. Emissions factors enable conversion from inputs to CO_2 equivalents and are widely used in estimating emission liability in emissions trading scheme.
- **Greenhouse gas emissions factor (kgCO_2-e/kWh, or kgCO_2-e/MJ):** Greenhouse gas emissions factors quantify the amount of greenhouse gas (in terms of carbon dioxide equivalent) which will be emitted into the atmosphere, as a result of using one unit of energy, i.e. the amount of greenhouse gas emitted due to using one kilowatt hour of electricity or one mega joule of gas, coal or bio-fuel.
- **Scope 1, 2 & 3 Emissions**: Scope 1 emissions are 'direct' greenhouse gas emissions (due to activities within an organization's boundary). Scopes 2 and 3 are 'indirect' greenhouse gas emissions (due to activities outside of an organization's boundary). The Scope 1 emissions that are calculated by the GHG Emission Calculator include the direct emissions which occur due to the combustion of fuel on-site, such as the combustion of gas in a building's hot water boiler or cogeneration system. Scope 2 emissions are those which result from the generation of electricity used by the building. Scope 3 emissions include the indirect emissions that result from the processing and transportation of fuels used within the building.
- **Net generation**: Net generation data is generally not measured at unit level. Two distinct approaches were applied to estimate net generation. (i) In cases where all units of a station fall into the build margin or where all units of a station have the same installed capacity, the auxiliary consumption (in % of gross generation) of the units was assumed to be equal to that of the respective station. (ii) In all other cases, standard values for auxiliary consumption adopted by CEA were applied.

What is Carbon Footprint?

According to the Kyoto protocol, there are six main greenhouse gases with the potential to cause climate change, each with a different global warming potential. For simplicity of reporting, the warming effect of CO_2 has been assigned a value of one and the global warming potential of the other greenhouse gases are used to convert the non-carbon dioxide gases to

CO_2 equivalents (CO_2-e)

A carbon footprint is the total sum of greenhouse gas (GHG) emissions caused by an organization, event, product or person. The Carbon footprint indicates how much forest land area is needed to absorb the CO_2 that is not absorbed by the ocean.[1]

Man-made climate change, or global warming, is caused by the release of certain types of gas into the atmosphere. Carbon dioxide (CO_2), which is the primary greenhouse gas emitted through human activities. One of the main sources of CO_2 in the atmosphere is the combustion of fossil fuels (coal, oil and gas) for energy and transportation, although certain industrial processes and land-use change. But other greenhouse gas such as Methane (CH_4), for example, which is emitted mainly by agriculture, livestock farming and landfill sites, are much strong emitters than CO_2.[2] Even more potent but emitted in smaller quantities are nitrous oxide (N_2O), which is about 300 times more potent than carbon dioxide and released mainly from industrial processes and farming, and refrigerant gases, which are typically several thousand times more potent than CO_2. Every time we burn fossil fuels such as gas, coal or oil, carbon dioxide is released into the atmosphere. In a natural carbon cycle, carbon dioxide is re-absorbed by plants and trees.[3]

A **carbon footprint** considers all six of the Kyoto Protocol greenhouse gases: Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydro-fluorocarbons (HFCs), Per-fluorocarbons (PFCs) and Sulphur hexafluoride (SF_6).

Global warming potential of different greenhouse gases covered in the Kyoto Protocol[4]

Gas	Warming Potential (Time Horizon) 20 years	Source
Carbon dioxide	1	Mainly from fossil fuel use
Methane	21	Mainly from ruminant animals and organic waste
Nitrous oxide	310	Mainly from agriculture
Hydro fluorocarbons	140 to 11,700	Mainly from refrigerants
Per fluorocarbons	9,200 to 6,500	From aluminum production
Sulphur hexafluoride	23,900	Mainly from the electricity industry

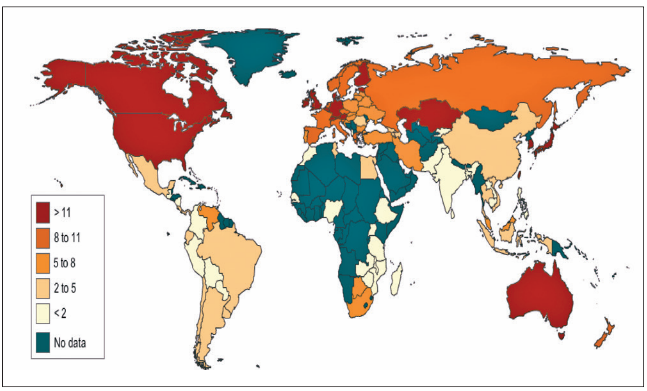


Fig 1: Tons per Capita CO_2 emission Worldwide[5]

According “The Global Carbon Budget 2014” shows that global CO_2 emission from burning fossil fuel and cement production also grew 2.3 % to a record high of 36 billion tonnes CO_2 in 2013. The largest emitters were China, the USA, the EU and India, together accounting for 58 % of the global emissions in 2013. Emissions are projected to increase by a further 2.5 % are projected to rise by 2.5 per cent in 2014 - % above 1990 levels, the reference year for the Kyoto Protocol. In 2013, the ocean and land carbon sinks respectively removed 27% and 23% of total CO_2 **(fossil fuel and land use change), leaving 50% of emissions into the atmosphere**.

India’s CO_2 emissions grew by 5.1 per cent in 2013, China’s grew by 4.2 per cent and the US’s grew by 2.9 per cent, according to the update.[6]

Carbon dioxide (CO_2) emissions from fossil fuel burning and cement production increased by 2.3% in 2013, with a total of 9.9±0.5 GtC (36 Gt CO_2) emitted to the atmosphere.[7]

Globally Buildings account for 30% to 40% of total world’s final energy & demand. More than 60% of global final building energy use in 2005 comes from the 4 priority GBPN regions (China, Europe, India and the United States). According to IPCC Report, Greenhouse gas (GHG) emissions from the buildings sectors have more than doubled since 1970 to reach 9.18Gt Co eq in 2010.[8]

As per report of International Energy Agency (2013), most of GHG emissions 6.02 Gt are CO emissions from electricity use in buildings. In 2010 building accounted for 32% (24% for residential and % for commercial) of total global final energy use it being one of the largest end-use sectors worldwide.

Space heating represented 32–34% of the global final energy consumption in both the residential and the commercial building sub sectors. In commercial buildings lighting and in residential building cooking and water heating are significant contributor to energy consumption. [9]

Annual per capita final energy use of Residential and Commercial buildings for eleven regions 1990 and 2010

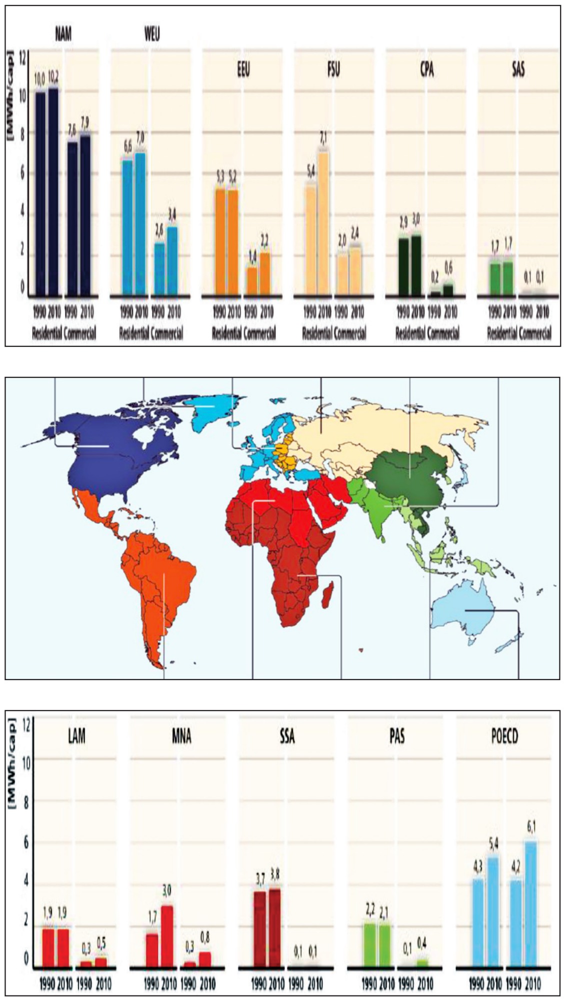
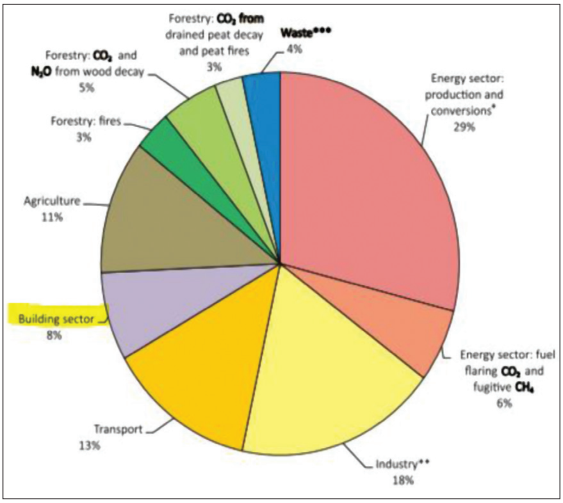


Fig 2 Source: IPCC Working Group III – Mitigation of Climate Change -Chapter 9 Buildings

Shares of sources of global reenhouse gas emissions in 2010 by main sector



CO_2e using GWP values as used for UNFCCC/ Kyoto Protocol reporting

Fig3: Source: JRC/PBL (2012) (EDGAR 4.2 FT2010)

Many buildings are susceptible to changes taking place in climate and which influences energy demand and its profile. The uncertainty of climate changes such as precipitation extremes could increase construction delays and thus costs. The changing patterns of extreme weather events imply more rebuilding and repair work. The severity of heat waves has implications for building design, potentially implying the need to move away from current architectural designs towards different approaches for new builds. Elevated temperatures will drive changes in climate related energy demand. Extreme warm and cold climates, will lead to excessive energy demand, principally for air conditioning, heaters and transport etc.

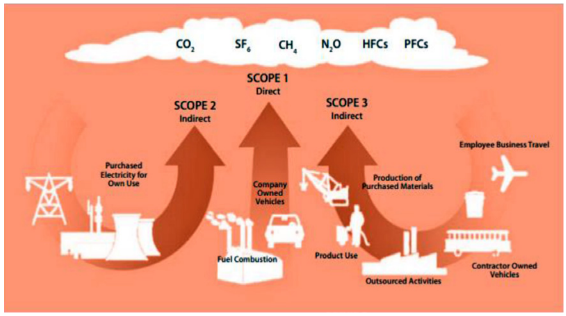


Fig 4: Scope of GHG Emissions

The key emission factors released during production of material and construction phase;

- Vegetation clearing;
- Building construction;
- Road construction;
- Computer and telecommunication systems;
- Fuel use – mobile vehicles (litres);

Onsite vehicles;

- ✓ Supply vehicles
- ✓ Blasting;
- ✓ Personnel transport – air
- ✓ Personnel transport – road

- Fuel use – stationary combustion;
  - ✓ Diesel generators
  - ✓ Boilers
  - ✓ Electricity consumption
- Waste;
  - ✓ Landfill
  - ✓ Compost
  - ✓ Incinerated
  - ✓ Recycled
  - ✓ Explosive

Direct on-site Emissions result from sources within the boundaries of the building or building operation site under study that can be quantified by the reporting entity, including stationary combustion emissions, process emissions.

Direct emissions are typically produced from the following types of activities:

- Stationary combustion emission from generation of on-site electricity, cooling, heat or steam
- Fugitive emissions from intentional or unintentional releases [10]

Indirect Emissions are a consequence of the activities that occur outside the building site, for example activities at a community power plant for providing the energy consumed on-building-site. The **Other Indirect Emissions** may include the upstream and downstream emissions related raw material extraction of metals, transport activities during life cycle stages of a building, reuse, recycling and waste disposal processes. [11]

Life cycle of a Building

The energy consumption during the operational phase of a building depends on a wide range of interrelated factors, such as climate and location; level of demand, supply, and source of energy; function and use of building; building design and construction materials; and the level of income and behavior of its occupants. Biomass constitutes the largest portion of the total fuel mix use in by the building sector.

The following are the broad classification of emission arise in each stage of building [12]

Design

Overall building design can help determine the amount of lighting, heating, and cooling a building will require. CO_2 emissions will occur early from the process of design e.g. energy and transport use by architects/planners/engineers. However, the real scope for this sector to reduce CO_2 is through the impact design makes on in-use emissions, e.g. passive/active ventilation, renewable energies etc.

Material or product Manufacturing

A measure is included for CO_2 emissions associated with the domestic production of construction products/materials as well as emissions embodied in imported products/ materials.

Transportation of Raw materials and final products

CO_2 emitted from the combustion of petroleum-based products, like gasoline, in internal combustion engines, while transporting materials and people to the site.

On-site Operations

Onsite operations include direct and indirect CO_2 emissions (i.e. combustion and energy use) from on-site operations. Emissions during the construction of a building can be associated with land clearing, drilling and

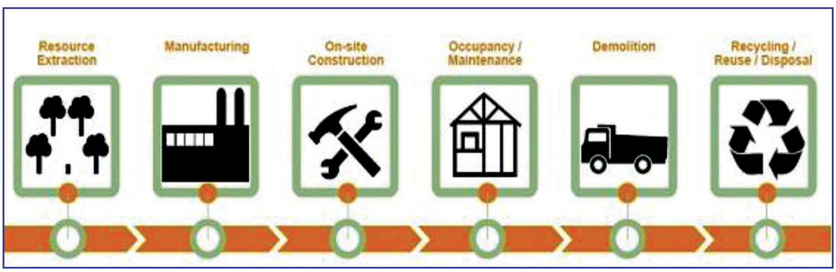


Fig 5: Life cycle stage of a building

blasting, ground excavation and dust emissions.

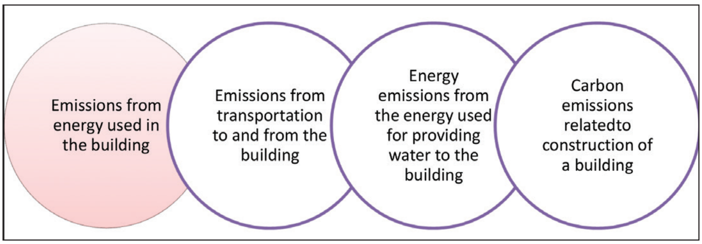
In-Use Emissions

The CO_2 emissions resulting from the behavior that takes place in buildings is included. In-Use building emissions accounts for the largest proportion, over 80%, of total CO_2 emissions. Emissions arise from energy consuming activities including heating, cooling, ventilation and lighting of the building. Utilizing efficient technologies can reduce GHG emissions by moderating energy use.

Demolish

Emission released due to direct and indirect CO_2 emissions (i.e. combustion and energy use) from demolished and waste removal, as well as the process of refurbishment.

Factors considered while calculating Carbon Footprints of a Building are;



Source: Sustainable Buildings and the Carbon Footprint-Express Tower

Types of Carbon Footprint

The main types of carbon footprint for organizations are: [13]

Organizational Carbon Footprint

Emissions from all the activities across an organization, including buildings' energy use, industrial processes and company vehicles.

Value chain Carbon Footprint

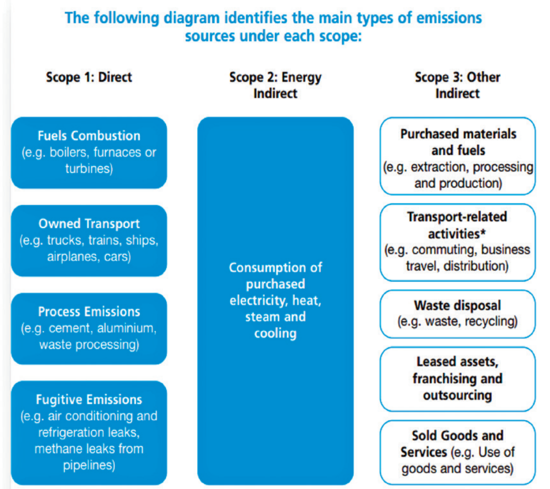
Includes emissions which are outside an organization's own operations, this represents emissions from both suppliers and consumers, including all use and end of life emissions.

Product Carbon Footprint

Emissions over the whole life of a product or service, from the extraction of raw materials and manufacturing right through to its use and final reuse, recycling or disposal.

The carbon footprint of a building is also measured by calculating the emission due to materials used in the building. The amount of recycled materials used in the building is also taken into account while measuring the carbon footprint. These measurements account for the energy expended in the creation of new materials for use in the building.

A carbon footprint can be divided into embodied carbon and operational carbon. Embodied carbon is the total carbon emissions related to construction materials and construction activities, and operational carbon denotes the emissions associated with heating and electrical consumption of a building during its operational lifespan. It accounts for 80-90% of emissions resulting from energy use mainly for heating, cooling, ventilation, lighting and appliances.



Methodology to calculate Carbon Footprints:

Building emits direct and indirect emissions, which can be identified and carbon footprint of a building during its life stages can be calculated.

The weight of carbon dioxide equivalent ($kgCO_2e$) emitted per square meter per year = $kgCO_2e/m^2$/year (by building type and by climate region)[14]

Table representing CO_2 Emission factors[15]

CO_2 Factor (kg CO_2 per Unit)	
Natural Gas	0.05444kg CO_2 per scf
Diesel	10.21 Kg CO_2 per gallon
LPG	5.68 Kg CO_2 per gallon
Electricity	0.97 kg CO_2 per KWh
Motor Gasoline	8.78 Kg CO_2 per gallon
Blast Furnace Gas	0.02524 kg CO_2 per scf
Municipal Solid Waste	411.37 kg CO_2 per short ton
Plastics	2539 kg CO_2 per short ton

**Scf = Standard cubic feet.*

Source Common Carbon Metric & Protocol - UNEP

Know your Carbon Footprints:

Calculate CO_2 emissions from Electricity consumption [16]

CO_2 emissions (Kg of CO_2) = Input value (in KWh/Yr) X (Emission Factor) = Output value in (Kg of CO_2)

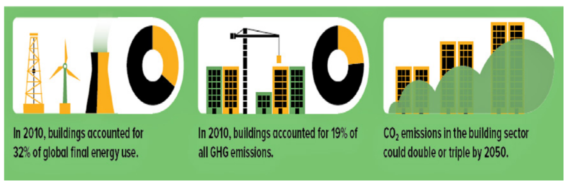
Calculate CO_2 emissions from freight transport operations [17]

CO_2 emissions (Kg of CO_2) = Transport volume by transport mode x average transport distance by transport mode x average CO_2-emission factor

Energy / fuel consumption-based approach [18]

CO_2 emission = fuel consumption (in litres) x CO_2-emission factor

Key Finding from the Intergovernmental Panel on Climate Change Fifth Assessment Report



- In 2010, the world's buildings accounted for 32% of global final energy use and 19% of all greenhouse gas (GHG) emissions. Under business-as-usual projections, use of energy in buildings globally could double or even triple by 2050. Drivers include billions of people acquiring adequate housing and access to electricity.
- Widespread implementation of best practices and technologies could see energy use in buildings stabilize or even

fall by 2050. Many mitigation options promise multiple co-benefits.

- Many barriers exist to greater uptake of energy-saving opportunities, including poor market transparency, limited access to capital and risk aversion. But know-how exists on retrofitting and how to build very low- and zero-energy buildings, often at little marginal investment cost; and there is a broad portfolio of effective policy instruments available to remove barriers to uptake.
- Buildings face major risks of damage from the projected impacts of climate change, having already experienced a big increase in extreme weather damage in recent decades. There is likely to be significant regional variation in the intensity and nature of such impacts.

Measures to reduce Carbon Footprints of a Building

Key ideas for reducing the carbon footprint of buildings are illustrated below;[19]

1 **Review the selection of raw materials:** The extraction, production and transportation of basic construction materials are both energy- and carbon-intensive, so it is critical to select suppliers of building products and materials who are actively working to manage their own carbon impacts

2 **Investigate the origin of the raw materials:** Natural stone, for example, produces minimal emissions during the production process but the transportation from the source to manufacturing site can be the largest cause of emissions, e.g. in transporting from quarries in India. In such cases, managing the transportation process is crucial to managing supply chain emissions. This contrasts with concrete where typically the carbon emissions during production are much higher than those released during transportation.

3 **Consider construction phase emissions:** Key factors contributing to construction process emissions include the multiple, temporary sites, transportation, waste arising, and heavy machinery which is common in large building projects

4 **Consider how to influence the occupancy and use of buildings and infrastructure:** These 'downstream' emissions are generated in the use phase but are greatly influenced by specifications from architects, choices made by developers and clients, and from the way the buildings are used by the people who ultimately work and live in them. The purpose and design of a building also contributes to its embodied carbon. The people using it, the use of lighting, heating, ventilation and air conditioning, and the proportions and differing insulating properties of glass, metal, concrete, brick and wood can all have a tangible impact on the carbon footprint.

News

Natural gas usage won't help curb CO_2 emission: Study

Sep 25, 2014, Times of India

NEW YORK: Increased use of natural gas will not help arrest carbon dioxide (CO_2) emission significantly because it delays the widespread construction of low-carbon energy facilities, such as solar arrays, says a US-based study.

Inexpensive gas boosts electricity consumption and hinders expansion of cleaner energy sources, such as wind and solar, the study noted.

"In our results, abundant natural gas does not significantly lower greenhouse gas emissions. This is true even if no methane leaks during production and shipping," said lead author Christine Shearer from the University of California, Irvine in the US.

Previous studies have focused on the risk of natural gas — composed primarily of methane — leaking into the atmosphere from wells and pipelines.

Analysing a range of climate policies, the researchers found that high gas usage could actually boost cumulative emissions between 2013 and 2055 by five percent — and, at most, trim them by nine percent.

"Natural gas has been presented as a bridge to a low-carbon future, but what we see is that it is actually a major detour. We find that the only effective paths to reducing greenhouse gases are a regulatory cap or a carbon tax," Shearer added.

Greater use of gas is a poor strategy for clearing the atmosphere, the researchers concluded.

"Cutting greenhouse gas emissions by burning natural gas is like dieting by eating reduced-fat cookies," said Steven Davis, assistant professor at UC Irvine and the study's principal investigator.

"It may be better than eating full-fat cookies, but if you really want to lose weight, you probably need to avoid cookies altogether," Davis explained.

Greenhouse gas levels rising at fastest rate since 1984

Sep 8, 2014 BBC news

A surge in atmospheric CO_2 saw levels of greenhouse gases reach record levels in 2013, according to new figures.

Concentrations of carbon dioxide in the atmosphere between 2012 and 2013 grew at their fastest rate since 1984.

The World Meteorological Organization (WMO) says that it highlights the need for a global climate treaty. But the UK's energy secretary Ed Davey said that any such agreement might not contain legally binding emissions cuts, as has been previously envisaged.

The WMO's annual Greenhouse Gas Bulletin doesn't measure emissions from power station smokestacks but instead records how much of the warming gases remain in the atmosphere after the complex interactions that take place between the air, the land and the oceans.

It could be that the biosphere is at its limit but we cannot tell that at the moment" Oksana Tarasova WMO. About half of all emissions are taken up by the seas, trees and living things.

According to the bulletin, the globally averaged amount of carbon dioxide in the atmosphere reached 396 parts per million (ppm) in 2013, an increase of almost 3ppm over the previous year.

"The Greenhouse Gas Bulletin shows that, far from falling, the concentration of carbon dioxide in the atmosphere actually increased last year at the fastest rate for nearly 30 years," said Michel Jarraud, secretary general of the WMO. "We must reverse this trend by cutting emissions of CO_2 and other greenhouse gases across the board," he said."We are running out of time."

Atmospheric CO_2 is now at 142% of the levels in 1750, before the start of the industrial revolution.

However, global average temperatures have not risen in concert with the sustained growth in CO_2, leading to many voices claiming that global warming has paused.

"The climate system is not linear, it is not straightforward. It is not necessarily reflected in the temperature in the atmosphere, but if you look at the temperature profile in the ocean, the heat is going in the oceans," said Oksana Tarasova, chief of the atmospheric research division at the WMO.

'More worrying'

The bulletin suggests that in 2013, the increase in CO_2 was due not only to increased emissions but also to a reduced carbon uptake by the Earth's biosphere.

The scientists at the WMO are puzzled by this development. That last time there was a reduction in the biosphere's ability to absorb carbon was 1998, when there was extensive burning of biomass worldwide, coupled with El Nino conditions."In 2013 there are no obvious impacts on the biosphere so it is more worrying," said Oksana Tarasova.

"We don't understand if this is temporary or if it is a permanent state, and we are a bit worried about that.""It could be that the biosphere is at its limit but we cannot tell that at the moment."The WMO data indicates that between 1990 and 2013 there was a 34% increase in the warming impact on the climate because carbon dioxide and other gases like methane and nitrous oxide survive for such a long time in the atmosphere

Emission Factors for Greenhouse Gas Inventories

Typically, greenhouse gas emissions are reported in units of carbon dioxide equivalent (CO_2e).Gases are converted to CO_2e by multiplying their global warming potential (GWP).The emission factors listed in this document have not been converted to CO_2e.To do so ,multiply the emission by the corresponding GWP listed in the table below.

Gas	100-yearGWP
CH4	25
	298

Source: Intergovernmental Panel on Change (IPCC), Fourth Assessment Report (AR4), 2007.

Fuel Type	Heating Value	CO_2 Factor	CH_4 Factor	N2Factor	CO_2 Factor	CH_4 Factor	N_2 Factor	Unit
	mmBtu per short ton	$kgCO_2$ per mmBtu	gCH_4 per mm Btu	g N_2O per mm	$kgCO_2$ per short ton	gCH_4 per short ton	gN_2O per short ton	
Coal and Coke								
Anthracite Coal	25.09	103.69	11	1.6	2,602	276	40	Short tons
Bituminous Coal	24.93	93.28	11	1.6	2,325	274	40	Short tons
Sub-bituminous Coal	17.25	97.17	11	1.6	1,676	190	28	Short tons
Lignite Coal	14.21	97.72	11	1.6	1,389	156	23	Short tons
Mixed (Commercial Sector)	21.39	94.27	11	1.6	2,016	235	34	Short tons
Mixed (Electric Power Sector)	19.73	95.52	11	1.6	1,885	217	32	Short tons
Mixed (Industrial Coking)	26.28	93.90	11	1.6	2,468	289	42	Short tons
Mixed (Industrial Sector)	22.35	94.67	11	1.6	2,116	246	36	Short tons
Coal Coke	24.80	113.67	11	1.6	2,819	273	40	Short tons
Fossil Fuel-derived Fuels (Solid)								
Municipal Solid Waste	9.95	90.70	32	4.2	902	318	42	Short tons
Petroleum Coke (Solid)	30.00	102.41	32	4.2	3,072	960	126	Short tons
Plastics	38.00	75.00	32	4.2	2,850	1,216	160	Short tons
Tires	28.00	85.97	32	4.2	2,407	896	118	Short tons
Biomass Fuels (Solid)								
Agricultural Byproducts	8.25	118.17	32	4.2	975	264	35	Short tons
Peat	8.00	111.84	32	4.2	895	256	34	Short tons
Solid Byproducts	10.39	105.51	32	4.2	1,096	332	44	Short tons
Wood and Wood Residuals	17.48	93.80	7.2	3.6	1,640	126	63	Short tons
	Mm Btu per	kg CO2 per	g CH4 pe rmmBtu	g N2O pe r mmbBu	kg CO2per scf	G CH4per scf	g N2Oper scf	
Natural Gas								
Natural Gas (per scf)	0.001026	53.06	1.0	0.10	0.05444	0.00103	0.00010	scf
Fossil-derived Fuels(Gaseous)								
Blast Furnace Gas	0.000092	274.32	0.022	0.10	0.02524	0.000002	0.000009	scf
Coke Oven Gas	0.000599	46.85	0.48	0.10	0.02806	0.000288	0.000060	scf

Fuel Gas	0.001388	59.00	3.0	0.60	0.08189	0.004164	0.000833	scf
Propane Gas	0.002516	61.46	0.022	0.10	0.15463	0.000055	0.000252	scf
Biomass Fuels (Gaseous)								
Landfill Gas	0.000485	52.07	3.2	0.63	0.025254	0.001552	0.000306	scf
Other Biomass Gases	0.000655	52.07	3.2	0.63	0.034106	0.002096	0.000413	scf
	Mm B tu per gallon	kgCO 2 per Mm Btu	g CH_4 per Mm Btu	g N_2Oper Mm Btu	kgCO_2per gallon	gCH_4 per gallon	gN_2O per gallon	
Petroleum Products								
Asphalt and RoadOil	0.158	75.36	3.0	0.60	11.91	0.47	0.09	gallon
Aviation Gasoline	0.120	69.25	3.0	0.60	8.31	0.36	0.07	gallon
Butane	0.103	64.77	3.0	0.60	6.67	0.31	0.06	gallon
Butylene	0.105	68.72	3.0	0.60	7.22	0.32	0.06	gallon
Crude Oil	0.138	74.54	3.0	0.60	10.29	0.41	0.08	gallon
Distillate Fuel Oil No.1	0.139	73.25	3.0	0.60	10.18	0.42	0.08	gallon
Distillate FuelOilNo.2	0.138	73.96	3.0	0.60	10.21	0.41	0.08	gallon
Distillate Fuel Oil No.4	0.146	75.04	3.0	0.60	10.96	0.44	0.09	gallon
Ethane	0.068	59.60	3.0	0.60	4.05	0.20	0.04	gallon
Ethylene	0.058	65.96	3.0	0.60	3.83	0.17	0.03	gallon
Heavy Gas Oils	0.148	74.92	3.0	0.60	11.09	0.44	0.09	gallon
Isobutane	0.099	64.94	3.0	0.60	6.43	0.30	0.06	gallon
Isobutylene	0.103	68.86	3.0	0.60	7.09	0.31	0.06	gallon
Kerosene	0.135	75.20	3.0	0.60	10.15	0.41	0.08	gallon
Kerosene-type Jet Fuel	0.135	72.22	3.0	0.60	9.75	0.41	0.08	gallon
Liquefied Petroleum Gases(LPG)	0.092	61.71	3.0	0.60	5.68	0.28	0.06	gallon
Lubricants	0.144	74.27	3.0	0.60	10.69	0.43	0.09	gallon
Motor Gasoline	0.125	70.22	3.0	0.60	8.78	0.38	0.08	gallon
Naphtha (<401 degF)	0.125	68.02	3.0	0.60	8.50	0.38	0.08	gallon
Natural Gasoline	0.110	66.88	3.0	0.60	7.36	0.33	0.07	gallon
Other Oil (>401 degF)	0.139	76.22	3.0	0.60	10.59	0.42	0.08	gallon
Pentanes Plus	0.110	70.02	3.0	0.60	7.70	0.33	0.07	gallon
Petrochemical Feed stocks	0.125	71.02	3.0	0.60	8.88	0.38	0.08	gallon
Petroleum Coke	0.143	102.41	3.0	0.60	14.64	0.43	0.09	gallon

Propane	0.091	62.87	3.0	0.60	5.72	0.27	0.05	gallon
Propylene	0.091	65.95	3.0	0.60	6.00	0.27	0.05	gallon
Residual Fuel Oil No. 5	0.140	72.93	3.0	0.60	10.21	0.42	0.08	gallon
Residual Fuel Oil No. 6	0.150	75.10	3.0	0.60	11.27	0.45	0.09	gallon
Special Naphtha	0.125	72.34	3.0	0.60	9.04	0.38	0.08	gallon
Still Gas	0.143	66.72	3.0	0.60	9.54	0.43	0.09	gallon
Unfinished Oils	0.139	74.54	3.0	0.60	10.36	0.42	0.08	gallon
Used Oil	0.138	74.00	3.0	0.60	10.21	0.41	0.08	gallon
Biomass Fuels (Liquid)								
Biodiesel (100%)	0.128	73.84	1.1	0.11	9.45	0.14	0.01	gallon
Ethanol (100%)	0.084	68.44	1.1	0.11	5.75	0.09	0.01	gallon
Rendered Animal Fat	0.125	71.06	1.1	0.11	8.88	0.14	0.01	gallon
Vegetable Oil	0.120	81.55	1.1	0.11	9.79	0.13	0.01	gallon
	Mm Btu per gallon	kg CO_2 per MmBtu	g CH_4 per MmBtu	g N_2O per Mm Btu				
Steam and Hot Water								
Steam and Hot Water		66.33	1.250	0.125		MmBtu		

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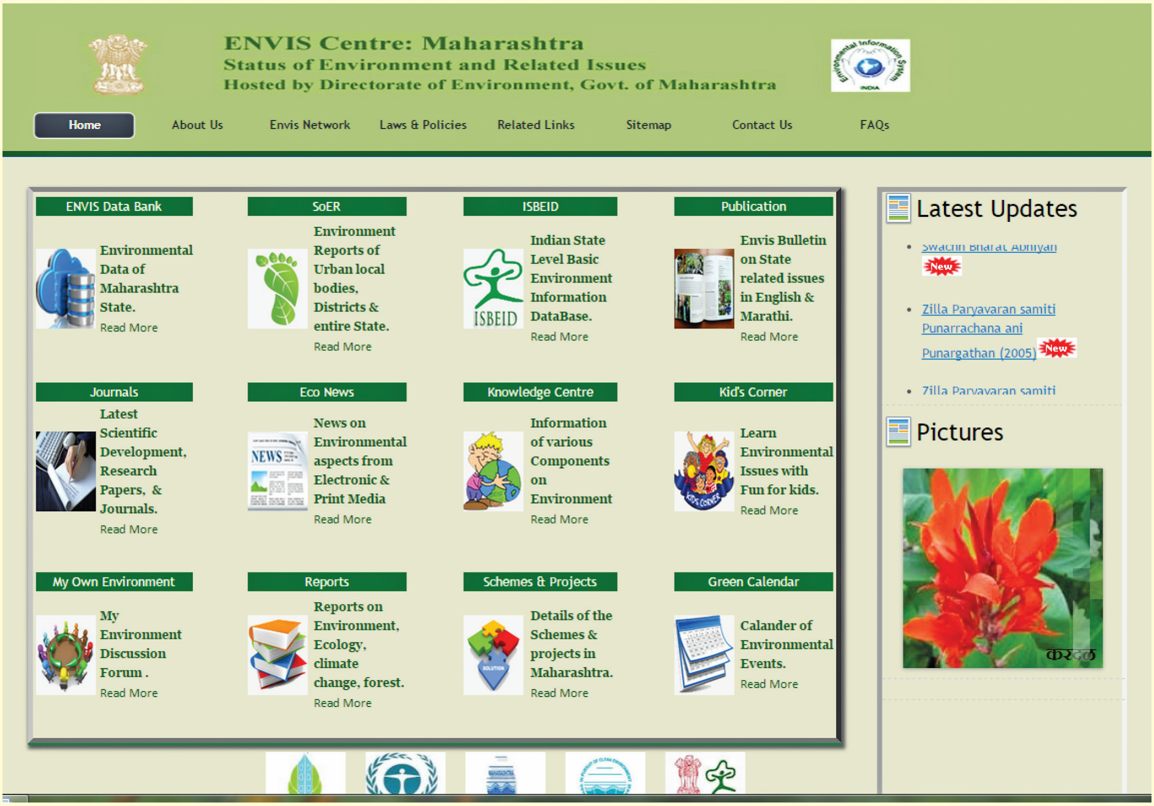

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