FACTSHEET

CO_2: Carbon dioxide

Prepared by Dr Laylla Rkiouak

Carbon dioxide (commonly referred to as CO_2) is a colourless and odourless gas. Over the past few years, CO_2 has increasingly been referred to as a 'problematic gas'. Why has this fairly unreactive gas, which exists at room temperature and pressure, gotten itself such a bad reputation? [1]

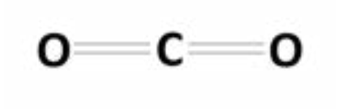

Figure: Carbon dioxide's molecular composition

In 1958, Charles David Keeling performed the first experiment involving atmospheric CO_2 at the Mauna Lao Observatory in Hawaii.[2] The records of his experiments have allowed us to chart the increase of the atmospheric concentration of carbon dioxide, which has risen from 315 parts per million (ppm) in 1958 to 397 ppm in September 2015. [2]

What Keeling's experiments tell us is that the linear growth rate of carbon dioxide has more than doubled in the last forty years.[3]

Where does CO_2 come from?

There are various generating and consuming CO_2 processes on the planet.

CO_2 occurs naturally in the earth's lithosphere, hydrosphere, and atmosphere, and a natural balance exists between processes by which it is produced and used up. Mechanisms that produce carbon dioxide include combustion of carbonaceous material, respiration of plants and animals, decay of organic material, and industrial processes while the ones that remove carbon dioxide from the air are photosynthesis, weathering of rocks, and chemosynthesis by certain bacteria. The interrelationships of these generating and consuming processes are very intricate, as each operates at a different rate.[4]

Anthropogenic (Human induced) emissions have significantly altered the quantity of gaseous carbon dioxide in the air with the combustion of fossil fuels. This has contributed to the increased atmospheric concentration of CO_2 from its preindustrial level of 278 ppm to 397 ppm in September 2015.[5]

What is the lifetime of CO_2 in the atmposhere

An atmospheric lifetime is the length of time that a gas spends in the atmosphere before disintegrating. The complexity of the processes of atmospheric CO_2 removal and production have led to an uncertain interpretation of its atmospheric lifetime. This has been highlighted by the Intergovernmental Panel on Climate Change (IPCC), which has reported various values for the atmospheric lifetime of CO_2 Their measurements have ranged from 30 to 95[6] years for the linear CO_2 uptake kinetics, to thousands of years for non-linear carbon dioxide uptake kinetics.[7] The IPCC's fifth report[8] does not clearly state the atmospheric lifetime of CO_2 due to these complexities. However, according to David Archer, one of the world's foremost greenhouse gas experts,[9] carbon dioxide currently lives for more than thousands of years in the atmosphere.

Why is CO_2 a problem?

The increase in the level of atmospheric CO_2 causes an increase in the earth's temperature through the mechanism commonly referred to as the 'greenhouse effect'. The 'greenhouse effect' is the process by which radiation from the planet's atmosphere warms the planet's surface. This process is accelerated when there are active gases, such as CO_2 in the atmosphere. The gases that contribute to this process are commonly referred to as 'greenhouse gases', or GHGs. The ultimate effect of this temperature rise is radical changes in the climate system. This process is what the world community now calls climate change.

Climate change is defined as a change in the state of the climate that can be identified by change in the mean and/or the variability of its properties and that persist for an extended period, decades or longer. The results of climate change — be it due to natural and/or anthropogenic drivers — are ubiquitous.[10] The increase in global average air and ocean temperatures, widespread melting of glaciers and icecaps, and the rising global average sea level are just a few of the consequences. According to the IPCC Plenary XXVII report,[11] most of the observed increases in global average temperatures are very likely due to the observed increase in anthropogenic GHG concentrations in the atmosphere.

It should be noted that a cocktail of different GHGs, not only carbon dioxide, contribute to climate change. Methane, nitrous and fluorinated gases[12] are also key contributors to the process. However, CO_2 remains the major anthropogenic GHG, accounting for 76 percent of total anthropogenic GHG emissions in 2010. Of the total GHG amount in 2010, 16 percent comes from CH4, 6.2 percent from N2O, and 2.0 percent from fluorinated gases.

Carbon dioxide emissions in the WANA region

The West Asia North Africa region counts for about 6 percent of the global CO_2 emissions (see table 1 below).

The sectorial global characterization illustrates the distribution of GHG emissions in 2010. The energy sector is responsible for one third of the greenhouse gases emissions, while the industry sector is responsible for a fifth.

Sector	% GHG anthropogenic emissions
Energy	34.6
AFOLU	24
Industry	21
Transport	14
Building	6.4

Table 1: Total anthropogenic greenhouse gas (GHG) emissions (gigatonne of CO_2- equivalent per year, $GtCO_2$-eq/yr) from economic sectors in 2010

While the WANA region may contribute a large fraction of the world's oil, it produces only 6.4 percent of global CO_2 emissions. The five states with the highest carbon emission rates in the region are Qatar, Kuwait, Oman, the UAE and Bahrain.

It is interesting to note that the WANA countries share around 57 percent of global oil reserves, with, Saudi Arabia, Iran, Iraq, Kuwait, and United Arab Emirates being the major oil producers.

What's next?

The IPCC's two most recent assessments confirm that climate change is having an increased impact on societies. The WANA region is particularly threatened considering its shortage of water resources. Developing mitigation strategies to reduce or prevent emissions of carbon dioxide is essential, especially in countries of the region where the economy and energy systems are fossil fuel based.

Countries	CO_2 Emissions (metric tons per capita) 2010 (World Bank)
Algeria	3.3
Bahrain	19.3
Egypt	2.6
Iran	7.7
Iraq	3.7
Jordan	3.4
Kuwait	31.3
Lebanon	4.7
Libya	9.8
Morocco	1.6
Oman	20.4
Palestine	0.62
Qatar	40.3
Saudi Arabia	17.0
Sudan	0.31
Syria	2.87
Tunisia	2.45
Turkey	4.13
United Arab Emirates	19.85
Yemen	0.96

Table 2: States of the WANA region and their CO_2 emissions (metric tons per capita)

Dr Laylla Rkiouak

Laylla joins the WANA Institute following the completion of her PhD at the University of Cambridge. Her PhD research was part of the stratospheric particle injection for climate engineering in the UK - it investigated the surface properties of seven different particle's candidates and the ozone depletion impacts on these surfaces. Laylla also holds a Bachelor of Science in Engineering and a Master of Science in Chemical Engineering. At the WANA Institute Laylla is working with the Green Economy team to investigate the transition from a fossil fuel-driven economy to a sustainable system for the West Asia-North Africa region.

1 Keeling, "Rewards and Penalties of Monitoring the Earth."

2 US Department of Commerce, "ESRL Global Monitoring Division - Global Greenhouse Gas Reference Network."

3 Hofmann, Butler, and Tans, "A New Look at Atmospheric Carbon Dioxide."

4Topham et al., "Carbon Dioxide."

5 US Department of Commerce, "ESRL Global Monitoring Division - Global Greenhouse Gas Reference Network."

6 Archer et al., "Atmospheric Lifetime of Fossil Fuel Carbon Dioxide."

7 Inman, "Carbon Is Forever."

8 US Department of Commerce, "ESRL Global Monitoring Division - Global Greenhouse Gas Reference Network."

9 IPCC, "Fifth Assessment Report (AR5) IPCC - Intergovernmental Panel on Climate Change."

10 Archer et al., "Atmospheric Lifetime of Fossil Fuel Carbon Dioxide."

11 Houghton, Global Warming; Watson, Climate Change 2001; Solomon, Climate Change 2007 - The Physical Science Basis; IPCC, "Fifth Assessment Report (AR5) IPCC - Intergovernmental Panel on Climate Change"; Burroughs, Climate Change; The Royal Society, Geoengineering the Climate.

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