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Carbon Emissions: 101

What is Carbon Dioxide?

Carbon dioxide (CO2) is a potent greenhouse gas (GHG), making up the vast majority of the annual emissions in the United States and the world.

Greenhouse gases (GHG) are gases that **absorb** and **radiate heat** [3]. The Environmental Protection Agency lists **four** main greenhouse gases: **methane (CH4), nitrous oxide (N2O), fluorinated gases such as hydrofluorocarbons, and carbon dioxide (CO2).**

What Affect Does CO2 Have on the Planet?

Carbon dioxide's heat-trapping abilities have been researched since the **late 1800s** when Swedish scientist **Svante Arrhenius** first conducted experiments to examine **the relationship between industry-born carbon emissions and the atmosphere**. His research yielded results that indicated a positive correlation between the concentration of atmospheric carbon dioxide and the surface temperature of the planet. These early experiments help discover and establish the scientific basis for greenhouse gases.

The next major advancement in monitoring global temperatures came from research by **Dr. Charles Keeling** in the **early 1960s**. Dr. Keeling's work culminated in the development of **atmospheric carbon dioxide concentration curves** [1]. Prior to Dr. Keeling's work, it was believed that the earth had endured **four warming and cooling cycles**, however, the curves showed that the actual number of cycles was approximately **thirty-two** [1]. Ironically, this discovery led to a wave of concern about a coming ice age, not an increasing global temperature.

It was not until the **1980s**, as **global temperatures began to rise**, that the worry of an ice age waned. Late in the decade, however, observed global temperatures began to climb at a faster rate than historical trends. At this point, concerns about global warming started to arise and soon rose to global discussion.

The Problem with Carbon

Carbon dioxide emissions pose **significant climate risks** when emitted into the atmosphere. When emitted, carbon dioxide builds up in the earth's atmosphere, creating a layer of gas over time. The chemical makeup of greenhouse gasses like carbon dioxide is such that they are **great insulators**. That is, these gasses have the ability to absorb and trap heat emanating from the planet in our atmosphere that would otherwise pass through our atmosphere. This causes a phenomenon called the **greenhouse effect,** which greatly attributes to rising global temperatures among other issues [3].

Carbon dioxide is the **primary target for emissions reductions** due to the gas' unique properties. Though carbon dioxide is less heat-absorbent than other greenhouse gasses, there is **much more** of it in the atmosphere than other greenhouse gasses. Also, carbon dioxide can **remain** in the atmosphere **much longer** than other

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greenhouse gases. In total, carbon dioxide is estimated to be responsible for a**pproximately "two-thirds of the total energy imbalance that is causing the Earth's temperature to rise"** [3].

• The issues with carbon dioxide are **not purely atmospheric**. Concerns about the interaction between carbon dioxide emissions and the oceans also exist**.** Chemical imbalances between carbon dioxide and oceanic water cause a reaction that creates another chemical called **carbonic acid** which **raises the acidity of the seas**. A more acidic ocean has many **detrimental effects**, particularly with very sensitive ecosystems and ocean-borne species [3].

Sources of Carbon Emissions

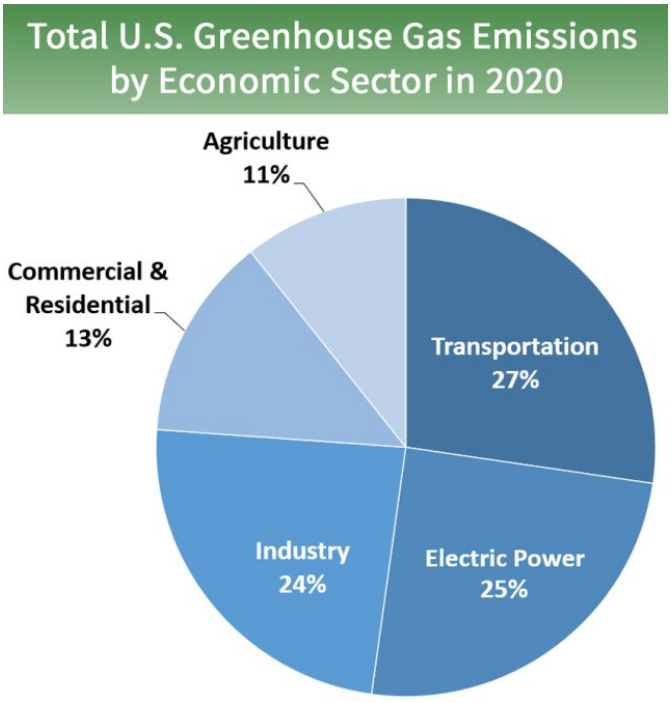
According to the **Environmental Protection Agency (EPA)**, carbon emissions come from **six key sources**: **transportation**, **electricity production**, **industry**, **commercial and residential properties**, **agriculture** and **land use, and forestry**. **12 Three** of these six primary sources of carbon emissions account for **approximately 76 percent of all carbon and greenhouse gas emissions in 2020.**

- **Transportation - 27%**
- **Electricity Generation - 25%**
- **Industry - 24%**

Direct emissions are defined by the EPA as emissions "produced by burning fuel for power or heat, through chemical reactions, and from leaks from industrial processes or equipment" [2].

Indirect emissions are defined by the EPA as emissions "produced by burning fossil fuels at a power plant to make electricity, which is then used by an industrial facility to power industrial buildings and machinery" [2].

- **Commercial and Residential - 13%**
- **Agriculture - 11%**
- **Land Use and Forestry - 13%**



Source: U.S. Environmental Protection Agency

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Relevant Policy

International

The Paris Agreement

Adopted in 2015, the Paris Agreement is a legally binding international agreement on climate change. Member-states are committed to limiting global warming to below 1.5 degrees Celsius compared to pre-industrial levels through various social and economic policies. As it is a legally binding agreement, member-states are liable for their own climate-related commitments, such as GHG emission reductions. The Paris Agreement has been the leading global climate change doctrine since the Kyoto Protocol of 1997.

Federal

Long-Term Strategy of the United States (LTS)

Created by the Biden Administration, the LTC sets climate-related goals, including GHG reduction targets for the nation. Relevant goals include [4]:

- Reduction in domestic GHG emissions by 50-52% from 2005 levels by 2030
- 100% pollution-free electricity by 2035
- Net-zero emission economy by 2050

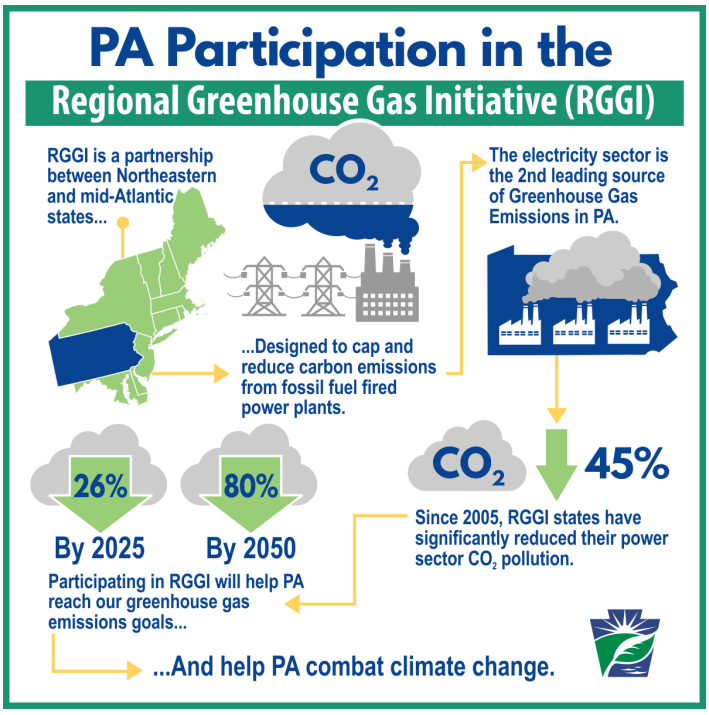
State

The Pennsylvania Climate Action Plan

Released in 2021, the Pennsylvania Climate Action plan is a comprehensive plan, which sets pathways to reach greenhouse gas reduction goals within the state [5]. The plan calls for emissions reduction goals of 26 percent by 2025, and 80 percent by 2050 from 2005 levels.

The Regional Greenhouse Gas Initiative

Pennsylvania entered the Regional Greenhouse Gas Initiative (RGGI) in 2022. RGGI is a carbon cap-and-trade program that puts a price on carbon emissions from member states' power plants. The program puts a cap on the amount of annual greenhouse gas emissions and allots plants, but allows power plants to trade their allotments.



Source: Pennsylvania DEP

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References

[1] Enzler, S. M. (2021, 12 10). History of the greenhouse effect and global warming. Retrieved from Lenntech: https://www.lenntech.com/greenhouse-effect/global-warming-history.htm

[2] Environmental Protection Agency. (n.d.). Sources of Greenhouse Gas Emissions. EPA. Retrieved February 6, 2023, from https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

[3] Lindsey, R. (2021, 12 10). Climate Change: Atmospheric Carbon Dioxide. Retrieved from Climate.gov: https://www.climate.gov/news-features/understanding-climate/climate-change-atmosphericcarbon-dioxide

[4] Executive Office of the President, The Long-Term Strategy of the United States: Pathways to Net-Zero Greenhouse Gas Emissions by 2050 (2021). Washington D.C.; United States Department of State.

[5] Pennsylvania Department of Environmental Protection, Pennsylvania Climate Action Plan (2021). Harrisburg, Pennsylvania.

[6] Pennsylvania Department of Environmental Protection. (n.d.). *RGGI Graphic* . Regional Greenhouse Gas Initiative. Retrieved May 9, 2023, from https://www.dep.pa.gov/Citizens/climate/Pages/RGGI.aspx.