WORLD'S LARGEST LESSON

WAME
World Access to Modern Energy

photo by Marco Garofalo

Subjects	Duration	Age
Geography, Social Sciences, Maths	2-4 lessons	14-16 years of age

7 AFFORDABLE AND CLEAN ENERGY

ENERGY AND CLIMATE CHANGE
Lesson Plan

"We cannot solve our problems with the same thinking we used when we created them."
Albert Einstein

Learning outcomes

- Students will learn about the causes and impacts of climate change
- Students will understand the link between SDG7 and SDG13
- Students will learn to distinguish between human and naturally induced Greenhouse Gas emissions (GHG)
- Students will identify which regions of the world emit the most greenhouse gasses today and over the past couple of centuries
- Students will learn about the solutions available to address human induced GHG emissions
- Students will learn to read and analyse graphs of various forms
- Students will start thinking about the importance of knowing and identifying reliable sources of data

Preparation

- Read the lesson plan and tips thoroughly

Materials

- Print handouts
- Access to the internet/computers/tablets for students

Acknowledgement

With special thanks to Pia Løvengreen Alessi, WAME Project Coordinator

Note on language terms for educators

Absorption: reduction of GHG concentration (i.e. CO2) by vegetation which during photosynthesis captures CO2 and releases O2, or by the ocean. Yearly absorption is opposite to yearly emission. If absorption is smaller than emission, we have an increase in concentration.

Adaptation: actions to reduce the vulnerability of natural, biological and social systems, to increase their resilience, and to support the people and the ecosystem to adapt to a certain level of climate change which is happening and can only be partially mitigated by a reduction of GHG.

Carbon: a widely distributed element that forms organic compounds in combination with hydrogen, oxygen, etc., and that occurs in a pure state as diamond and graphite, and in an impure state as charcoal. In such expressions as *carbon emissions, carbon storage, carbon tax*, we use "carbon" as an abbreviation for carbon dioxide

Carbon dioxide (CO2): a colourless, odourless, incombustible gas, CO_2, present in the atmosphere and formed during respiration, usually obtained from wood, coal, or natural gas by combustion, from carbohydrates by fermentation. The main component in GHG emissions

Climate: the general weather conditions usually found in a particular place

Climate change: changes in the world's climate, in particular the trend towards higher global average temperature, regional changes in precipitation, more frequent extreme weather events. It is the result of human activity mostly by combustion of fossil fuel (coal, gas, oil) and deforestation which increases the concentration of carbon dioxide and other gases in the atmosphere thus increasing its greenhouse effect.

Correlation: a connection or relationship between two or more facts, numbers, etc.

Cycles: a series of events that are regularly repeated in the same order.

Ecosystem: all the living things in an area and the way they affect each other and the environment

Efficiency: the ability to accomplish something with the least waste of time, effort, and cost

Environment: the air, water, and land in or on which people, animals, and plants live

Global warming: is the global dynamic behind climate change, an increase in the earth's average atmospheric temperature that causes among others things, the melting of ice, rising sea levels, an increase of deserts and of ocean acidity, changes in vegetation and in ocean streams, recurrence of extreme weather conditions.

Greenhouse effect: a natural atmospheric heating phenomenon which allows life on earth; solar radiation enters inward through the earth's atmosphere but is partially transmitted outward, owing to the absorption effect of GHG in the atmosphere. Climate change is caused by an increase of the greenhouse effect of the atmosphere caused by human activity consisting in the combustion of fossil fuels and destruction of forests.

Tip: Use Appendix D to ease understanding if needed

Greenhouse Gas (GHG): any of the gases whose absorption of solar radiation is responsible for the greenhouse effect, including carbon dioxide, methane, ozone, and the fluorocarbons.

Greenhouse gas concentration: the amount of GHGs in air, usually measured in parts per million by volume (ppmv or simply ppm).

Greenhouse gas emissions: the emission into the earth's atmosphere of carbon dioxide or other GHGs that contribute to the greenhouse effect. World or country emissions are measured in billions of metric tons (gigatons) per year (Gt/y). Per capita emissions are measured in metric tons per year (t/y)

Mitigation: all actions that reduce net carbon emission by decreasing the use of fossil fuel or increase the absorption capacity of ecosystems or technologies.

Sustainability*:* economic development is sustainable when it meets the needs of the present without compromising the ability of future generations to meet their own needs. Use of natural resources is sustainable when resources are not depleted but re-generated as far as possible, and waste is minimized. The same notion applies to energy systems: energy should be made available and used without damaging the environment and without producing GHG emissions that alter the natural level of carbon concentration in the atmosphere.

STEP 1 What are your main concerns about Climate Change?

Take a minute to think about Albert Einstein's quote.

Ask the students to raise their main concerns about climate change. Pick up on their concerns, group them under the following main headings: ocean, weather, food and health. Ask them if they think their peers in other parts of the world might have other main concerns and ask them to explain why.

After the discussion conclude by watching: https://www.youtube.com/watch?v=G4H1N_yXBiA

Where useful, project or distribute **appendix A** and **B** and discuss the possible consequences of climate change.

Tip: Climate change, not weather change, is causing the world to getting warmer. It will continue to get warmer as long as we continue to emit GHG into the atmosphere. This warming has dramatic consequences for life on this planet including our oceans, weather, food production and our health. Make sure to differentiate between human activities that causes climate change (CO2) and those that have a negative environmental effect such as local pollution (NO2, Sox, PMI) which represent a direct impact on health.

STEP 2 What causes global warming: increasing concentration of greenhouse gases in the atmosphere

Activity 2.1 The carbon cycle and the greenhouse effect

Start off by watching: https://www.youtube.com/watch?v=E8Y6L5TI_94
In smaller groups, list the sources of GHG emission and differentiate between human induced and naturally induced sources of GHG emissions.

Tip: The amount of CO2 produced by natural sources is completely offset by natural carbon sinks (absorption) and has been so for thousands of years. Before the influence of humans, carbon dioxide levels were quite steady because of this natural balance.

Activity 2.2 Measuring the main sources of GHG emission

Determining the exact amount of GHG emission and linking it to a specific source is a difficult task which many scientists have been working on for a long time and continue to work on today. It is important to know with detail where the emissions come from so that we can address the main sources of emissions properly.

B.1 Project or distribute **Appendix C** and **D** to identify the main sources of GHG emissions. Identify the human activities that are the main contributors to GHG emissions. Differentiate between the activities that **emit** GHG such as combustion and those that reduce **absorption** such as deforestation and discuss how these are different in nature.

B.2 Distribute/project and discuss **Appendix E** and identify the sectors in the world that are the greatest emitters of CO2 today. Discuss which subcategories of each sector you think contributes most to the given sector in your country (electricity & heat, transport, buildings, industry).

STEP 3 Who is the "TOP" emitter? What if we all emitted as much as the "TOP" emitter?

The industrial revolution has given humanity an unprecedented quality of life and has doubled life expectancy in many places. But all these advances have come with a global cost that we are only truly acknowledging today, that of increased GHG emissions and climate change. Who is to blame? Should we stop human development? How do we curb emissions in the future?

Split the class into smaller groups and ask them to solve the activities below:

Activity 3.1

A. Compare the annual emissions by China, India, Italy, UK and the United States of America in total annual emissions and in emissions per annum per capita in 1910, 1950, 1990, 2016. What accounts for the differences you obtain in the two graphs? Which are the two nations that emits most CO2?

B. If we decided that all nations would have to contribute to a "climate fund" equivalent to the CO2 they have emitted so far, which countries would end up paying most to the fund?

Use the following links or refer to APPENDIX F, G, and H

Annual CO2 emission 1751 – 2016
https://ourworldindata.org/grapher/annual-co2-emissions-per-country?time=1751..2016

CO2 emissions per capita 1800-2016
https://ourworldindata.org/grapher/annual-co2-emissions-per-country?time=1751..2016

Cumulative CO2 emissions 1751-2016
https://ourworldindata.org/grapher/cumulative-co-emissions

Activity 3.2

In smaller groups identify:

A. The year in which China first emitted more CO2 than the EU28

B. In 2015 Africa emitted 1.32 GT, find the year in which the USA emitted 1.32 GT

C. In 2010 did Africa emit more or less CO2 than international aviation and maritime transport?

Which results surprised you the most? Present the results of your discussion to your classmates.

Use the following link or refer to APPENDIX I

Annual CO2 emission by region
https://ourworldindata.org/grapher/annual-co-emissions-by-region

Tip: Inform the students about the importance of knowing that the source of your data is reliable, and make sure they understand exactly what the data is telling.

STEP 4 Global versus Local - what is the right approach? Top-down?

Climate change is a global problem with a local impact and needs to be addressed as such. Getting global political consensus is not an easy task as all national leaders are guided by their national priorities. However, significant progress has been made on a Global scale in relation to addressing climate change, the main achievements include:
The **United Nations Framework Convention on Climate Change** (UNFCCC) is an international environmental treaty created in 1994 with the aim to:

"*stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system*".

The parties of the treaty meet once a year at the Conference of Parties (COP) to assess progress in dealing with climate change. In 2019, there were 198 Parties (countries) that are members of the UNFCCC. The Convention states that Parties should act to protect the climate system on the basis of "**common but differentiated responsibilities**", and that developed country Parties should "**take the lead**" in addressing climate change while developing countries (referred to as Annex I Parties) should aim at stabilizing their greenhouse gas emissions.

The **1997 COP in Kyoto**, Japan, resulted in the adoption of the Kyoto Protocol which established the first legally binding obligations to reduce their greenhouse gas emissions for the period 2008 - 2012, later amended to include the period from 2013-2020. The Kyoto Protocol applies to the six greenhouse gases listed in Annex A: Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulphur hexafluoride (SF6).
The Protocol continues the principle of **common but differentiated responsibilities** as it acknowledges that individual countries have different capabilities in combating climate change, owing to different economic development.

The **2015 COP in Paris**, France, resulted in the adoption of the Paris Agreement, with the long-term goal of keeping the increase in average global temperatures well below 2°C above pre-industrial levels; and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change. The Paris Agreement governs emissions reductions from 2020 on, through **non-legally binding commitments of all COP countries in Nationally Determined Contributions (NDCs)**, which allows each country, whether developed or developing, to ensure the measures they commit to are nationally appropriate.

For further information on the International agreements go to: https://unfccc.int/resource/bigpicture/

In smaller groups discuss:

- why is it difficult to implement policies on climate change?
- whether you think it is reasonable to have "a common but differentiated" approach to addressing climate change
- dentify any policy, rule or behavior that we are following which you think comes from climate change policy
- identify commitments which you think your country should commit to in the future

Share your conclusions/ideas with your class.

Tip: We have observed how some nations have emitted and continue to emit more than other nations and we know that most developed countries have a high per capita emission relative to developing countries. Key to the discussion is, therefore, whether the principle of "a common but differentiated approach" is fair or not.

STEP 5 Positive and forward-thinking approaches to combat climate change

Activity 5.1

Watch: https://www.youtube.com/watch?v=RnvCbquYelM (TEDed)

In smaller groups, discuss how to reduce the dependence on fossil fuels to generate electricity and heat, transportation, and to power industry and buildings. Do the solutions for emerging economies differ from developed economies? Present the results of your discussion to your classmates.

Write their suggestions on the board and group them into:

1. Energy efficiency
2. Renewable energy
3. Electrification

Awareness, innovation and modern technology are key to all three solutions.

Tip: you may introduce adaptation here and explain that the effects of climate change are already present and irreversible in some places where is it no longer possible to mitigate climate change but necessary to adapt to climate change.

Activity 5.2 Activate local actions right now

Now the students have a good idea of the main sources of GHG emissions and need to take action. Climate change is a global problem that needs local action. Open the discussion on how everyone can help reduce GHG emissions (bottom-up solution). We all need food, clothes and transport. We like our homes not to be too cold or too warm, and once in a while would like to go on a holiday. Discuss how we could all help reduce GHG emissions.

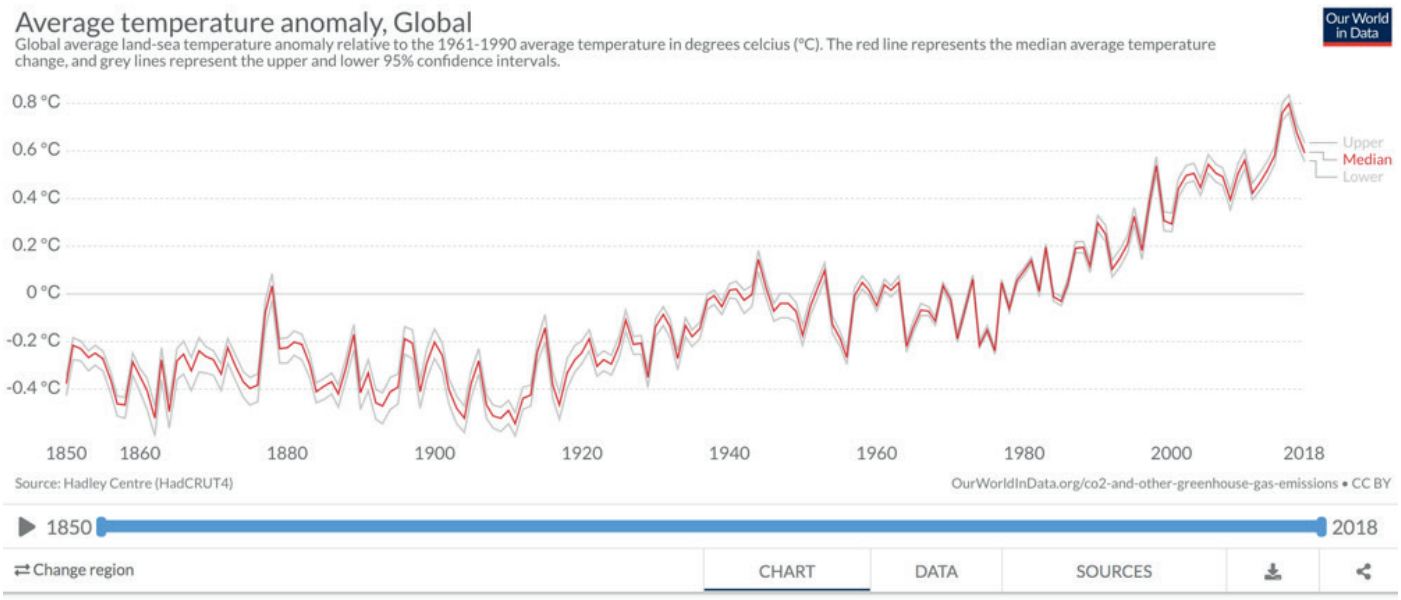
Ideas include:

- Choose alternative methods of transportation or carpool
- Turn off/reduce use of lights, cooling, heating, electronics, water heating
- Keep doors and windows closed to keep the house cool/warm, use blinds where useful
- Engage in activities that don't require electricity like reading or playing outside
- Offset your GHG emission by planting a tree or growing a vegetable garden and compost
- Reduce, reuse, and recycle all plastic, metal, glass, clothes, furniture, ink cartridges and pens, and buy refills where possible (soaps, pens)
- Use and waste less water, paper, food
- Buy locally produced products and avoid excessive packaging
- Eat less meat and other products with a high CO2 footprint due to production or transportation

Tip: This step could be extended to a project which each student needs to, for example, calculate the family's carbon footprint and take action together, redesign used clothing, start a vegetable garden or raise awareness about climate change among peers by using social media, writing an article in the school newspaper or other activities.

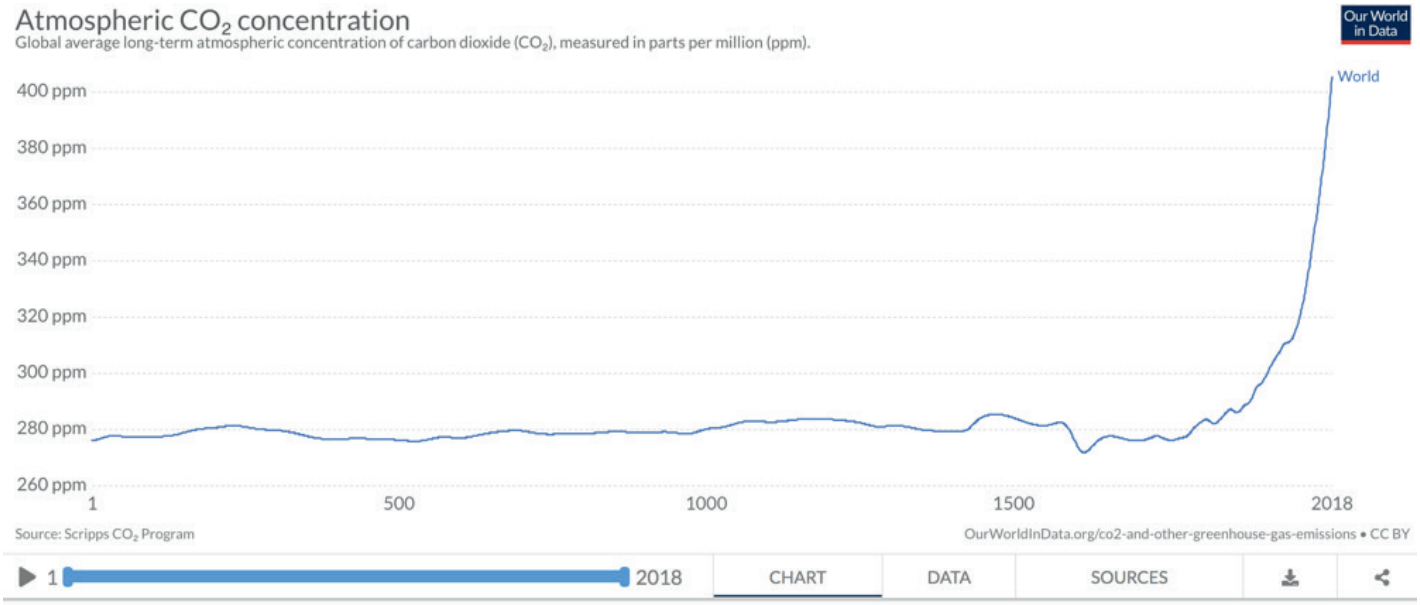
APPENDIX

APPENDIX A Average temperature anomaly



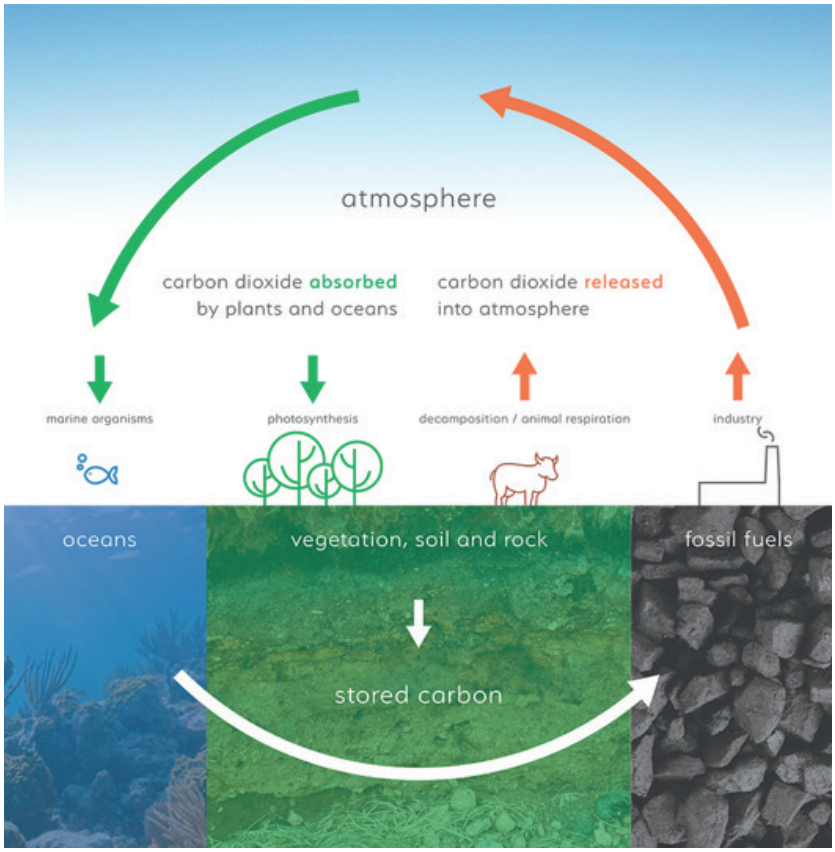
Source: Met Office Hadley Centre

APPENDIX B Atmospheric CO2 concentration



Source: Macfarling Meure, C. et al., 2006: Law Dome CO2, CH4 and N2O ice core records extended to 2000 years BP. Geophysical Research Letters, 33.

APPENDIX C The carbon cycle – nature's way of recycling carbon



Source: Forest products commission, Western Australia

There is a fixed amount of carbon on the earth and it cycles between the biosphere, ocean and atmosphere in a process of either being stored or released.
The natural balance has been upset by human activity, population growth, deforestation and the burning of fossil fuels. Now more carbon is being released than stored and it is a key cause of climate change.

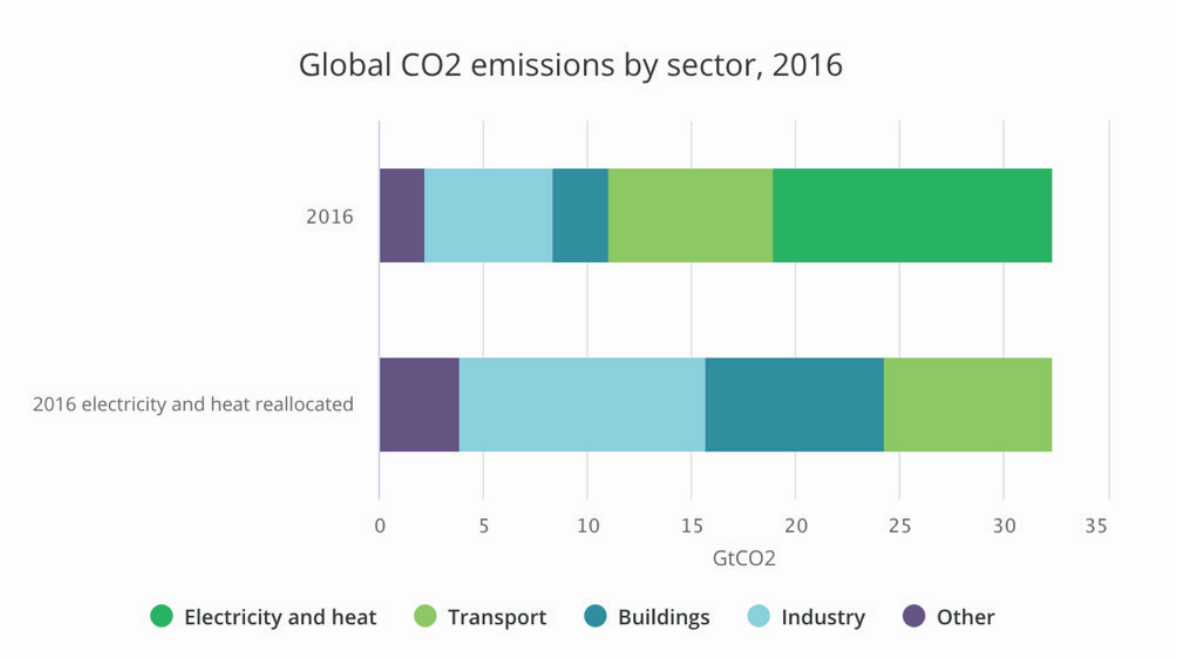
APPENDIX D The Global Carbon Cycle

According to the IPCC, nature **emits** vastly more carbon dioxide and greenhouse gasses than human activities, however, nature also **absorbs** vastly more carbon dioxide and greenhouse gasses than human activities. This is why, absent of human activity in the industrial era, global greenhouse gas levels were fairly stable.
Human activity has not only unleashed a large amount of stored carbon that would not have otherwise naturally been released (e.g., the burning of fossil fuels for energy). It has also reduced nature's ability to absorb GHG (e.g., deforestation). Although the IPCC estimates the human activity output of today to be around 49 gigatons of CO_2[1], is relatively small compared to the approximate 750 gigatons moving through the carbon cycle each year, it adds up because the land and ocean cannot absorb all the extra CO_2. About 40% of this additional CO_2 is absorbed by nature's largest carbon sink, the ocean, which has been steadily acidifying as a result of having to absorb more carbon than the natural balance. The rest of the additional CO_2 remains in the atmosphere, and as a consequence, atmospheric CO_2 is at its highest level in 15 to 20 million years. Because human activities do not reabsorb the carbon released the way that nature does - to the contrary, human activities are gradually eroding nature's ability to take greenhouse gases out of the atmosphere - it is by far the largest contributor to the overall increase in concentrations of greenhouse gases in the last few centuries. The fact is that while human industrial activities represent only a small fraction of the total amount of carbon released, it has been enough to upset the entirety of the carbon cycle.

1 IPCC, AR5

APPENDIX E Global CO2 emission by sector, 2016

Electricity and heat generation were the largest source of emissions in 2016, accounting for 42% of the global total.
When allocating emissions from electricity to consuming sectors, industry was the largest emitter followed by buildings - whose share increased from 8% to 27% due to their strong reliance on electricity - and then transport.
As electricity and heat are not referring to a specific sector, the lower bar chart reallocates the CO2 emissions of electricity and heat to the sector in which it is actually used.



Source: IEA

The IEA identifies four main sectors of energy consumption:

Buildings: The buildings sector includes energy used in residential, commercial and institutional buildings, and non-specified other. Building energy use includes space heating and cooling, water heating, lighting, appliances and cooking equipment.

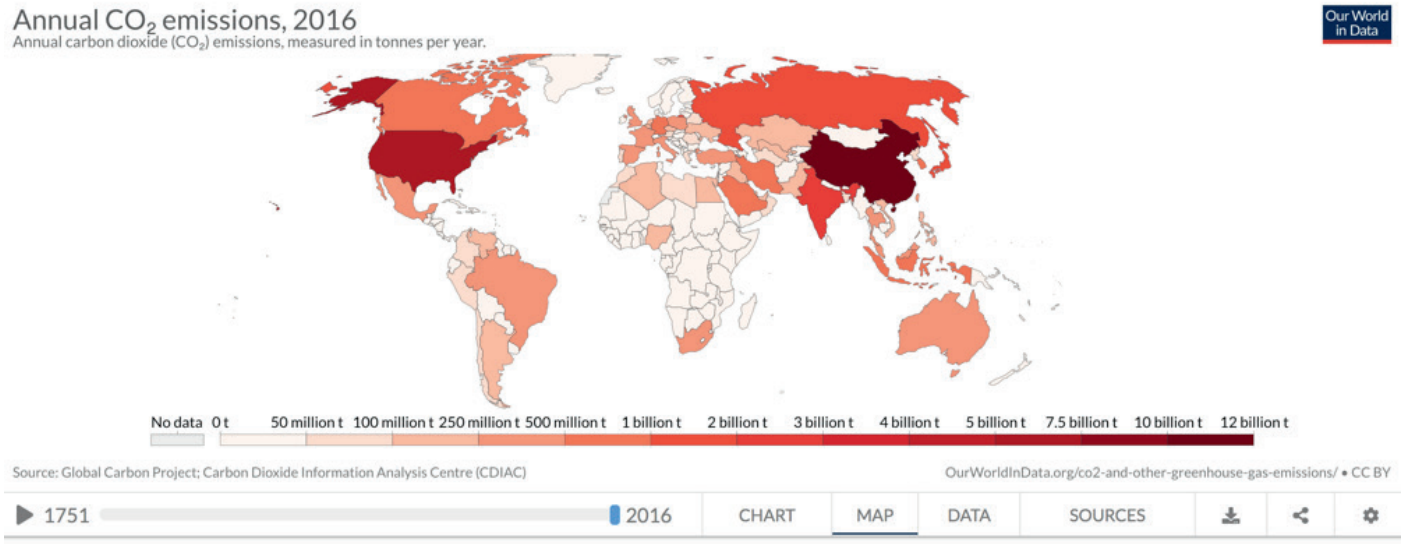
Industry: Includes fuel used within the manufacturing and construction industries. Key industry branches include iron and steel, chemical and petrochemical, cement, and pulp and paper. Use by industries for the transformation of energy into another form or for the production of fuels is excluded and reported separately under other energy sectors. Consumption of fuels for the transport of goods is reported as part of the transport sector.

Transport: Fuels and electricity used in the transport of goods or persons within the national territory irrespective of the economic sector within which the activity occurs. This includes fuel and electricity delivered to vehicles using public roads or for use in rail vehicles; fuel delivered to vessels for domestic navigation; fuel delivered to aircraft for domestic aviation; and energy consumed in the delivery of fuels through pipelines. Fuel delivered to international marine and aviation bunkers is presented only at the global level and is excluded from the transport sector at the domestic level.

Electricity generation and heat: Defined as the total amount of electricity generated by power only or combined heat and power plants including types required for own-use. This is also referred to as gross generation. Heat refers to a wide range of end-uses, including space and water heating, and cooking in buildings, desalination and process applications in industry. It does not include cooling applications.

APPENDIX F Annual CO2 emission 1751 – 2016

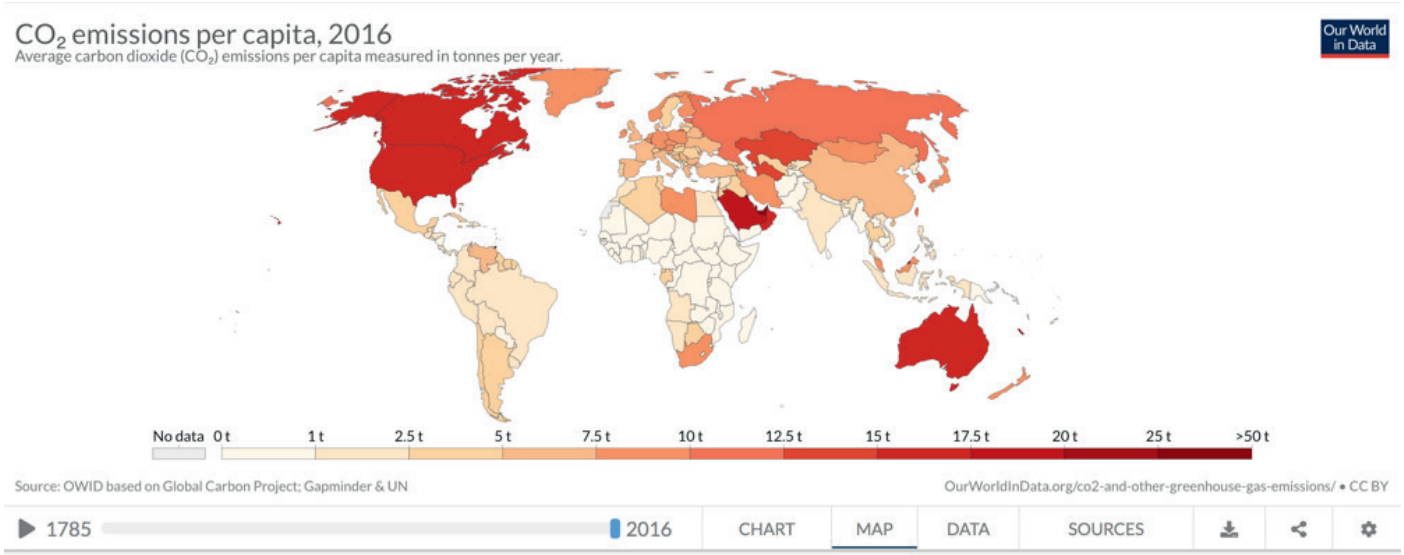
https://ourworldindata.org/grapher/annual-co2-emissions-per-country?time=1751..2016



Source: Le Quéré et al. (2017). Global Carbon Project.

APPENDIX G CO2 emission per capita 1785 - 2016

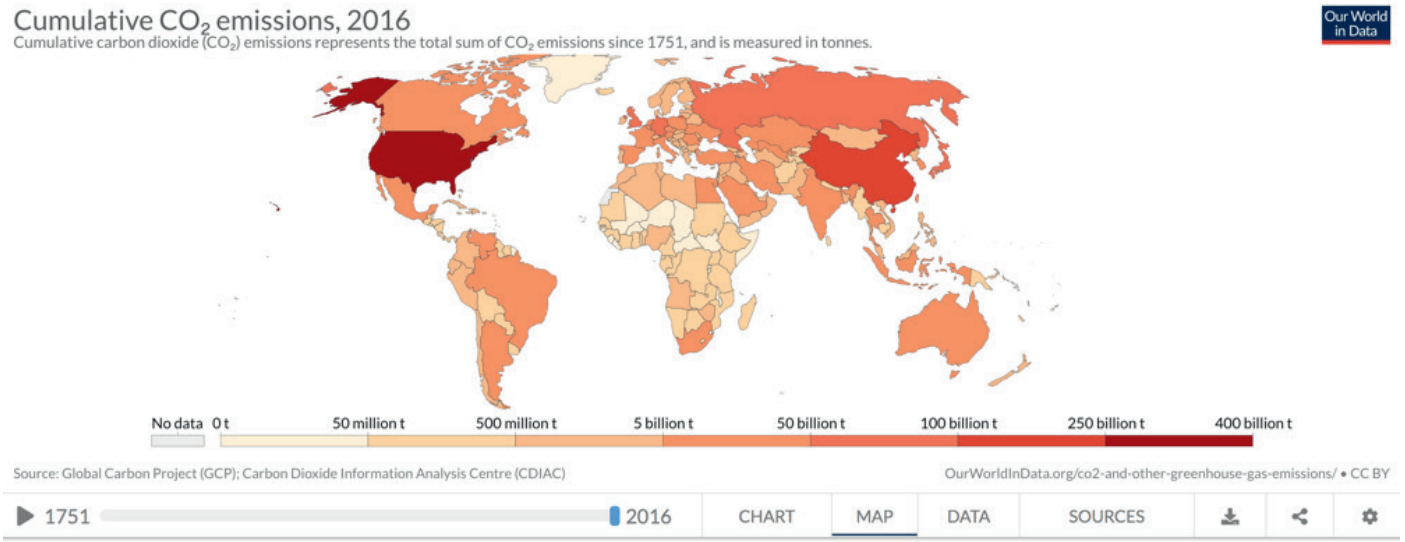
https://ourworldindata.org/grapher/annual-co2-emissions-per-country?time=1751..2016



Source: OWID based on the Global Carbon Project, Gapminder and UN population estimates

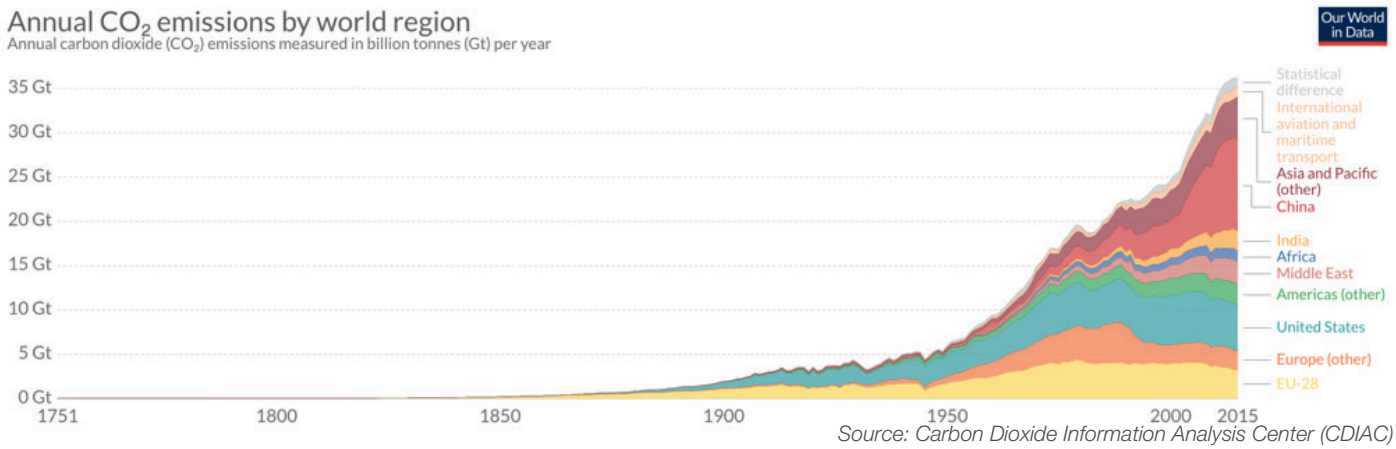
APPENDIX H Cumulative CO2 emissions 1751-2016

https://ourworldindata.org/grapher/cumulative-co-emissions



Source: Le Quéré et al. (2017). Global Carbon Project.

APPENDIX I Annual CO2 emissions by world region



Source: Carbon Dioxide Information Analysis Center (CDIAC)

Sources:
International Energy Agency: https://www.iea.org/
Our World in Data: https://ourworldindata.org/
International Panel on Climate Change (IPCC): https://www.ipcc.ch/