PROJ0016-1
BIG DATA PROJECT

Will EU achieves its goals of CO_2 reduction by 2030?

MILESTONE 1 - Context & Roadmap

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1 Why does it matter to study CO_2 emissions?

1.1 What are greenhouse gases and greenhouse effect?

Greenhouse gases (GHGs) are gases able to absorb energy contained in thermal infrared radiations. Those radiations come directly from the sun but also from the Earth's surface, atmosphere and clouds.
In turn, energy trapped within GHGs is emitted through thermal infrared radiations. A part of which is radiated back towards Earth, warming low altitude atmosphere. The rest is leaving to outer space. This phenomenon is the so called greenhouse effect (GHE) [1].

GHGs are naturally present in atmosphere, oceans, glaciers, etc. and participate in balancing total energy in the Earth's system and generating weather as we know it.
They are also massively trapped in materials used by humankind as fuels to produce energy, known as fossil fuels.

GHGs are defined by two important factors:

- Lifetime:
  Measure how long the gas will stay in the atmoshere before being removed by natural process.
- Global warming potential:
  Measure of the radiative effect of each unit of gas over a specified period of time, expressed relative to the radiative effect of carbon dioxide (CO2).

According to factors defined above, the 3 main GHGs are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) [2].

1.2 What are effects of raising GHG concentration?

Since its formation, 4.5 billion years ago, the Earth has undergone many climate changes. However those changes mostly resulted from astronomic parameters evolution such as Earth's orbital eccentricity, obliquity and precession [3] and long-term cycles of GHGs. A graph of CO2 emissions' fluctuations is accessible in figure 1.

Since industrial revolution, GHGs emissions exploded in several regions of the world trough an intensive use of fossil fuels. Thus breaking equilibrium of GHGs concentrations in natural reservoirs (oceans, forests, etc.) [4].

This leads to many uncertainties about environment, public health and economy [5] as GHGs are subject to complex dynamics. As it is, impacts on GHGs concentration levels are very chaotic and hard to predict due to positive and/or negative feedback loops depending on many parameters and interacting with each others at different time and spacial scales. [6]

1.3 Which scope to our analysis ?

Why Europe?

Europe is one of the international leader in emissions of GHGs. Indeed, Europe is the third biggest CO_2 emitters in the world behind USA and China.

On figure 2 , it can be observed that GHG emissions are significantly decreasing since the nineties. In order to compare non-CO_2 GHG and CO_2 emissions, the concept of CO_2 equivalent is used. Indeed, the CO_2 equivalent is the quantity of CO_2 that would lead to the same greenhouse effect over a period of 100 years.

Why narrow down research to CO_2 emissions?

Main GHGs are CO_2, CH_4, N_20 and F-gases. 77,6% of the GHG emissions in 2015 were CO_2. For future analyses, only the emissions of CO_2 should be considered in order to limit the scope of data analysis. Even it should be possible to analyse GHG emissions thanks to the concepts of CO_2 equivalent. [7]

Figure 3 presents the non-CO_2 GHG and CO_2 emissions in functions of the main activity sectors in Europe. It can be observed that almost 90% of the non-CO_2 GHG are emitted by the other[1] sector. While, for the CO_2, this sector takes part in only 10% of these emissions. Knowing the ratio of CO_2 emissions on GHG, it can be concluded that non-CO_2 and CO_2 emissions are not produced by the same type of sectors. For future analyses, these sectors may not be taken into account due their low participation in GHG emissions.

Figure 4 shows, in a descending order, the largest emitting countries of CO_2 in Europe for the year 2018. The pixelated bar quantifies the emissions of CO_2 per capita. It can be seen that Germany is the biggest CO2-emitting of European country while Malta is the smallest one.

From Germany to Romania, those ten countries represent 81% of the total European CO_2 emissions. Knowing the low impact of some countries on greenhouse effect, for future analyses, only a subset of the 28 countries will be taken into account.

However, countries such as Luxembourg or Estonia have the highest per capita CO_2 emissions and could be subject to an analyse.

2 Overview of in place policies to reduce CO_2 emissions.

The first package of measures set by the EU to prevent climate change was adopted on 2008 and the targets are for 2020. The first goals set for this purpose were the following [8]:

- A 20 % cut in greenhouse gas emissions (compared to 1990).
- Reach 20 % of EU energy from renewables.
- 20 % improvement in energy efficiency.

As our project focuses on the cut of CO2 emissions, the first point will be the one getting most of our attention, even if energy efficiency and proportion of renewables also play a important role in CO2 emissions reduction. Nowadays, EU has reached and even outperformed the 2020 goals as EU GHG emissions were down by 22 % compared to 1990 in 2017 [9].

[1] Includes industrial process emissions (non-metallic minerals, non-ferrous metals, solvents and other product use, chemicals), indirect emissions (for N2O only), agriculture (including agricultural soils, agricultural waste burning, enteric fermentation, manure management) and waste.

Although these targets have been achieved, others objectives have been set since 2008 with deadline for 2030 and even, 2050. As 2030 deadline objectives are the closest, this project is going to lean on these. They are the following [10]:

- A 40 % cut of GHG emissions (compared to 1990).
- A 32 % share of renewable energies.
- 32.5 % improvement in energy efficiency.

In order to reach the emission aim, the different emission sectors have been divided in two groups with different goals and policies:

- ETS sectors (Emission Trading System): The Emission Trading System is already in place for 2020 plan but has been revisited for the 2030 deadline. It is composed of heavy energy-using sectors (power and heat generation, energy-intensive industry sectors, civil aviation,...) and represents 45 % of EU's GHG emissions.
  The idea is that companies within these sectors receive emission allowances which they can trade to one another as well as member states between them. Logically, the total of emission allowances for all EU is supposed to be framed by 2030 goals.
- Non-ETS sectors: It is the national emission targets that cover the non-ETS sectors (responsible for 55 % of EU total GHG emissions). These targets differ depending on the national wealth which makes the less wealthy countries allowed to have less ambitious targets.This system is called Effort Sharing Decision (ESD) [11].

Considering these different systems and the fact that the application of strict policies on one group or the other does not have the same impact on the common citizen, these two sectors have different targets. While for ETS sectors the goal is to cut down the emission by 43 % (compared to 2005), it is only by 30 % (compared to 2005) for non-ETS sectors. These measures and policies that are currently in effect will have a big impact on the future GHG emissions and so, will be among the most important factors in this project.

3 Road map sketch for the next 6 months.

This section presents a first sketch of how we could divide the work in smaller chunks to answer the research question: **"Will EU achieves its goals of CO_2 reduction by 2030?"**

1. Are there trends regarding CO_2 emissions within countries of EU?

   To simplify the study of a wide area as EU, an idea is to perform an analysis on different parameters linked to CO_2 emissions regarding each country. We could create clusters of countries sharing similitude about those variables. Then resume our study to those clusters and spot remarkable situations of particular country.

2. How to compute CO_2 emissions in a given region?

   A good point would be to check existing emission models using classic analysis with recent data gathering of CO_2 emissions. Maybe experimenting an hybrid predictive model based on both approaches (classic analysis/big data).

3. Do national/EU policies actually have an impact on CO_2 emissions?

   A first thing would be to verify if those policies are applied in countries belonging to clusters defined earlier. If it is, could we measure and predict the impacts of policy on CO_2 emissions in a region?

4. By using insights given through the different points developed above, experiment new predictive models assessing policies planned for 2030 and respond to the initial question.

Appendices

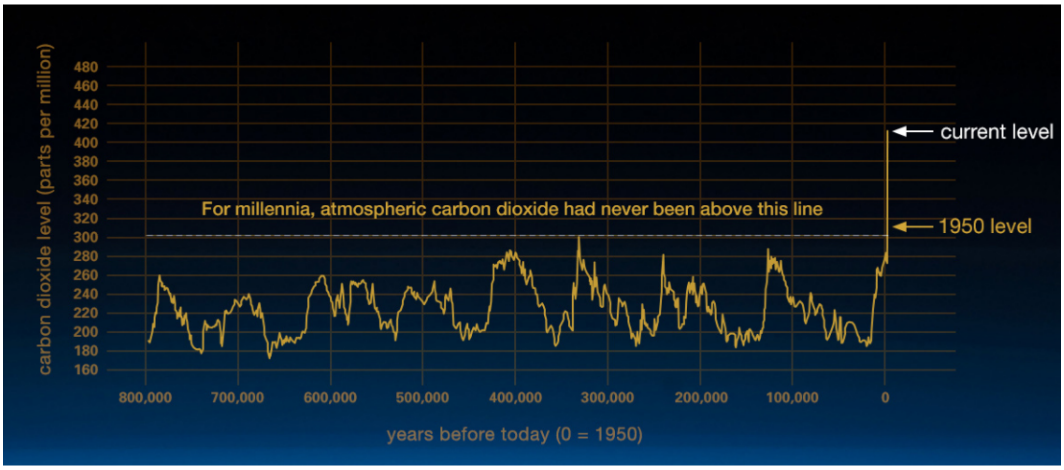

Figure 1: Level of CO_2 throughout millennia [4]

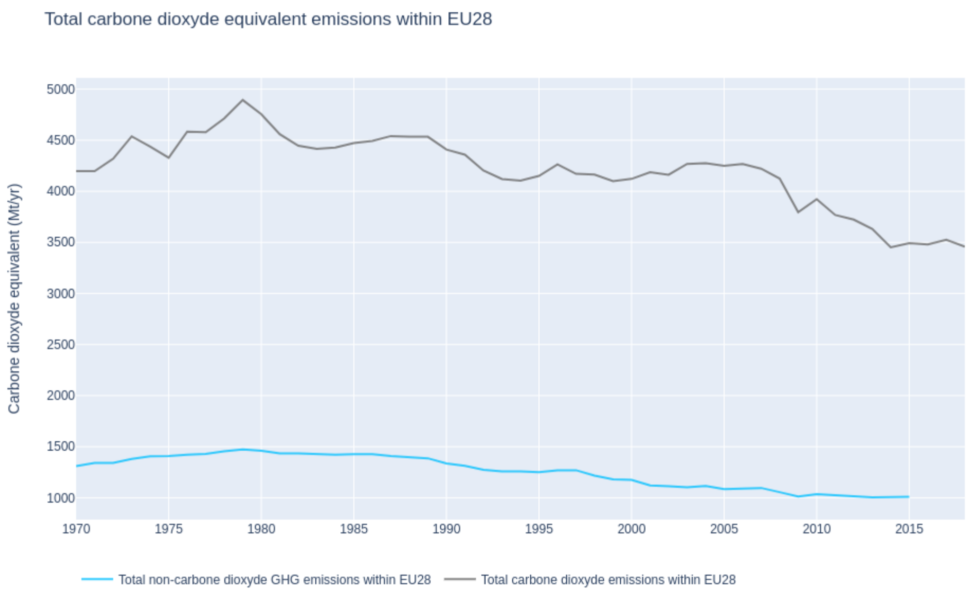

Figure 2: Evolution of GHG

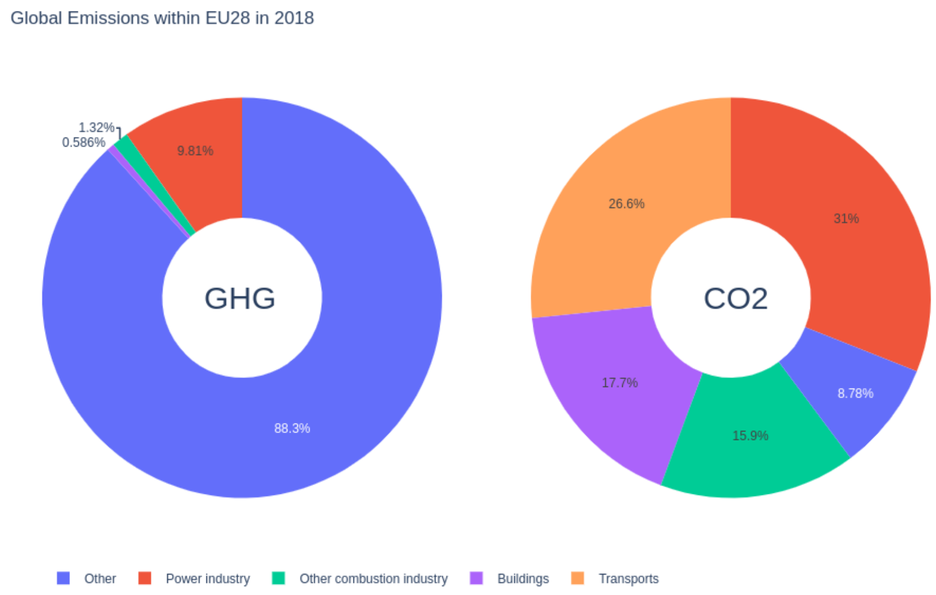

Figure 3: Repartition of GHG emissions within EU by sectors

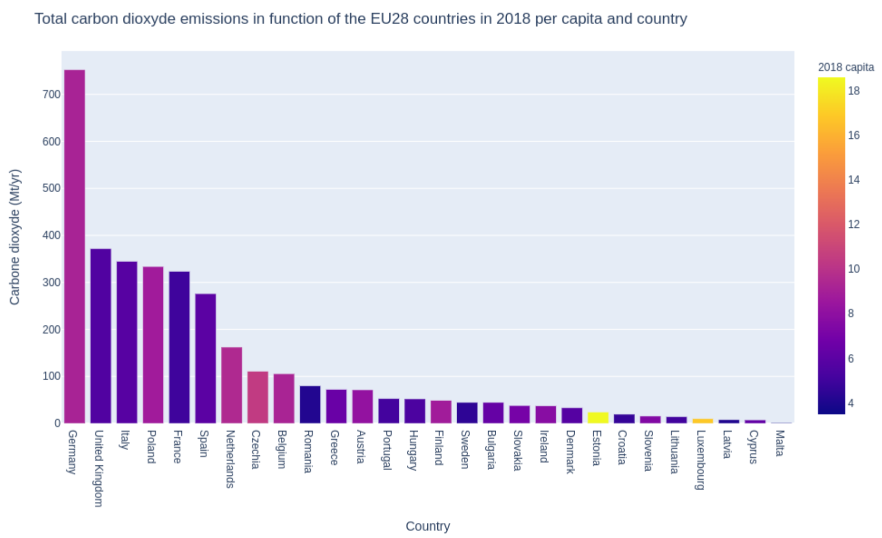

Figure 4: CO_2 emissions of European countries

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