Phase IV

How to Fight Global Warming?

Probability & Statistics

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Will Global Warming Continue to Increase in The Following Years?

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I. Abstract

There is no doubt that global warming is one of earth's most serious problems and has been for the longest time due to human activities and industrial evolution. The rapid increase of the earth's temperature has various harmful effects such as, disturbing weather, ice melting, rising sea levels, and many effects on human health and other ecosystems. Although taking measures to fight climate change is necessary, multiple challenges must be addressed first, including the continuous evolution of technology and human needs. In this article we used descriptive data and observations to analyze the problem and help solutions to reduce greenhouse gasses emissions and improve global warming. Using statistical analysis and calculations, predictions were made as to what will happen to global warming in the future, and will we be able to find alternatives that can help save the planet.

II. Introduction

Throughout history, Earth's temperature and climate has been changing drastically, with alternates between ice ages and greenhouse periods. But in the past century, another force rather than only nature, has started to influence Earth's climate: humans.

Over the past century, we started to encounter Global warming in which is the unusually rapid increase in Earth's average surface temperature. This is primarily due to greenhouse gasses, deforestation, Industrial and agricultural activities.

To understand the problem better and take beneficial approaches. We need to understand the following:

With the evolution of technology, how is the production of greenhouse gases affected?

Based on past temperature recordings, what does the expected mean of temperature rise in the upcoming years?

A. Definition

Global warming is the unusually rapid increase in Earth's average surface temperature over the past century primarily due to the greenhouse gasses released by people burning fossil fuels.

B. Impacts

The impact of global warming is far greater than just increasing temperatures. Warming modifies rainfall patterns, amplifies coastal erosion, lengthens the growing season in some regions, melts ice caps and glaciers, and alters the ranges of some infectious diseases. Some of these changes are already occurring.

➢ **Changing Weather ➔** For most places, global warming will result in more frequent hot days and fewer cool days, with the greatest warming occurring over land. Longer, more intense heat waves will become more common. Storms, floods, and droughts will generally be more severe as precipitation patterns change. Hurricanes may increase in intensity due to warmer ocean surface temperatures.

➢ **Rising Sea Levels ➔** The weather isn't the only thing global warming will impact rising sea levels will erode coasts and cause more frequent coastal flooding. Some island nations will disappear. The problem is serious because up to 10 percent of the world's population lives in vulnerable areas less than 10 meters (about 30 feet) above sea level.

➢ **Ecosystems ➔** More importantly, global warming is already putting pressure on ecosystems, the plants, and animals that coexist in a particular climate zone, both on land and in the ocean. Warmer temperatures have already shifted the growing season in many parts of the globe. The growing season in parts of the Northern Hemisphere became two weeks longer in the second half of the 20th century. Spring is coming earlier in both hemispheres.

➢ **People ➔** The changes to weather and ecosystems will also affect people more directly. Hardest hit will be those living in low-lying coastal areas, and residents of poorer countries who do not have the resources to adapt to changes in temperature extremes and water resources. As tropical temperature zones expand, the reach of some infectious diseases, such as malaria, will change. More intense rains and hurricanes and rising sea levels will lead to more severe flooding and potential loss of property and life.

C. The Importance of fighting global warming

We humans are the ones who burn fossil fuels and chop down forests, causing average temperatures to rise worldwide. That global warming trend is increasingly disrupting our climate — the average weather over many years.

Earth has already warmed by about 1 degree Celsius, or 1.8 degrees Fahrenheit since the 19th century.

A warmer world — even by a half-degree Celsius — has more evaporation, leading to more water in the atmosphere. Such changing conditions put our agriculture, health, water supply, and more at risk.

The increased evaporation and additional moisture to the atmosphere have led to 30% more intense rain during heavy downpours. The crops get more flooded and damaged than they did half a century ago. It's how you go from half-degree of warming to economic hardship.

D. Challenges to fighting Global Warming

✓ For now, climate change is still hypothetical: The damage caused by most climate change pollutants will happen in the future. Which means most of us won't truly be affected by climate change. It's a hypothetical scenario conveyed in charts and graphs. While we'd like politicians and voters to be moved by altruism, this isn't always the case. In general, policymakers have little incentive to act. People (who stand to be) most harmed by climate change aren't even born yet. Going back to the policymaker's perspective, she has much less of an incentive to reduce greenhouse gas emissions because those reductions are going to benefit voters in the future and not her current voters.

✓ There is no direct link to a smoking gun: Despite the global threat from climate-altering pollutants, it's hard for scientists to link them to a specific environmental disaster. Without a definitive culprit, it's easier for skeptics to ignore or explain away climate change effects.

✓ Developing countries contribute to a large share of pollution: We're asking very poor countries that are worried about where their next meal is coming from, or whether they can send their kids to school, to incur costs to reduce greenhouse gas emissions to benefit the world. And that's a tough ask for a policymaker inside of a developing country.

✓ Modern living is part of the problem: It's a tough pill to swallow, but modern conveniences like electricity, transportation, and air conditioning contribute to climate change, and remedies potentially involve significant sacrifice and lifestyle change. Although we've seen great strides in reductions in solar costs and batteries for electric vehicles, these are still expensive alternatives. There is no free lunch when it comes to overcoming climate change.

✓ CO2 is a global pollutant that can't be locally contained: The first key feature of climate change that puts it at odds with past environmental issues is that it's a global pollutant, rather than a local pollutant.

III. Data Collection and Description

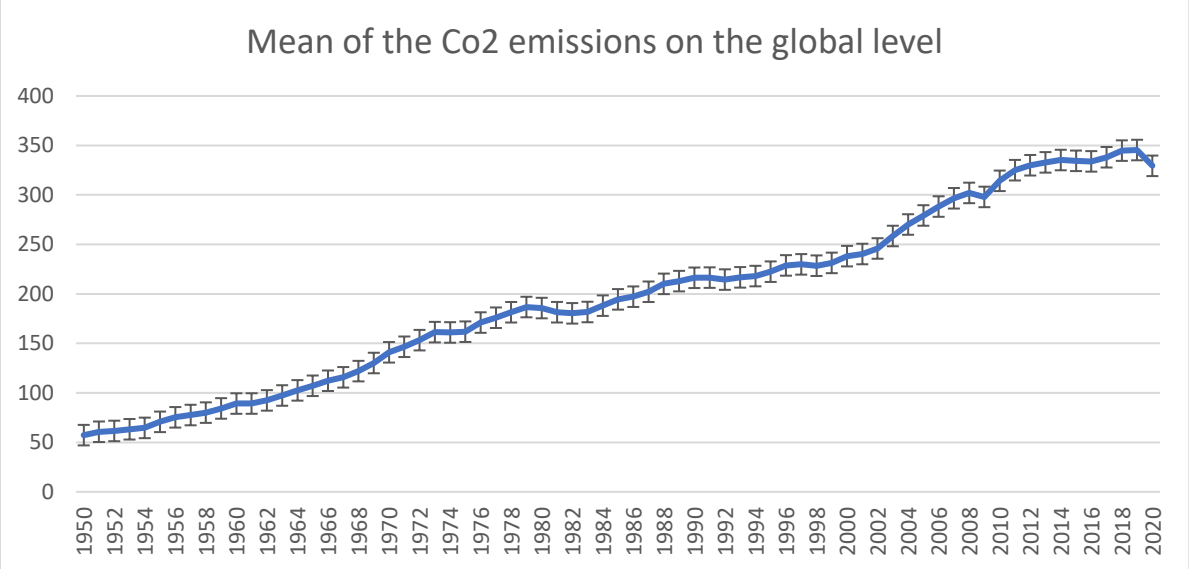
We collected data of:

- CO2 emissions per country from 1950 to 2020. [12],[13]
- Mean of GISTEMP (Global Surface Temperature) from 1880 to 2016. [14]

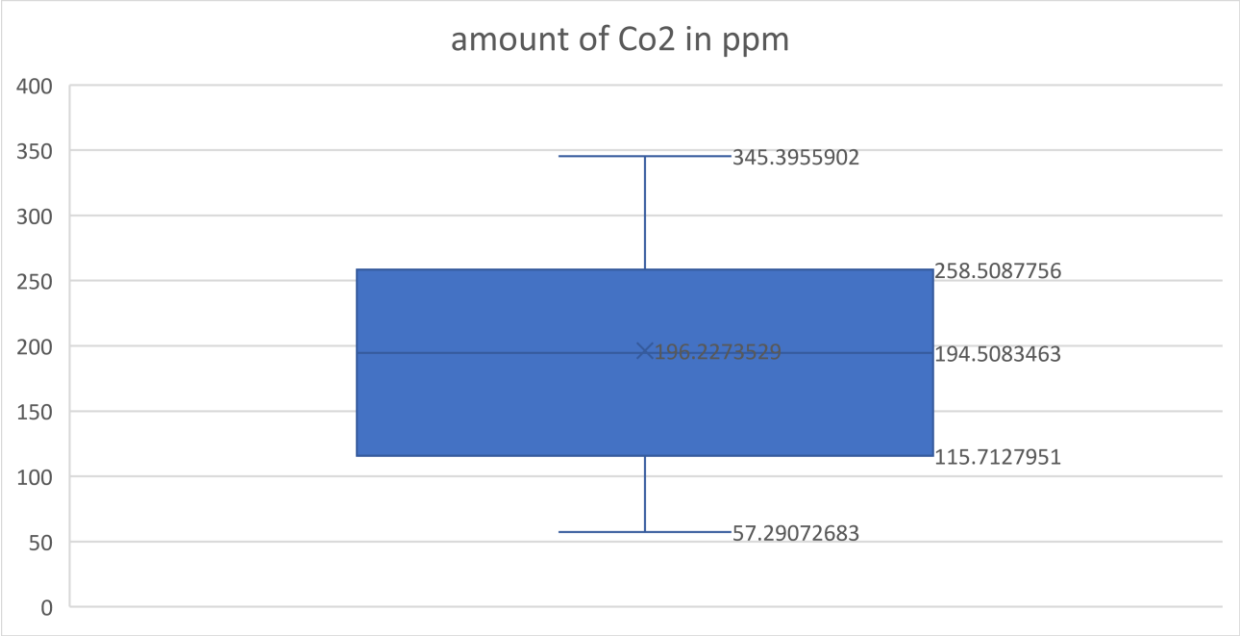
1. **CO2 emissions per country:** Our analysis was on the global level, so we calculated the mean of CO_2 emissions all over the world to analyze this data as the following
    a. Numerically

Mean	196.2273529
Standard Error	10.37468709
Median	194.5083463
Standard Deviation	87.41866727
Sample Variance	7642.023388
Range	288.1048634
Minimum	57.29072683
Maximum	345.3955902
Sum	13932.14205
Count	71

b. Graphically



We can see from this graph that the CO2 emissions increase about 82.6%. We can see the standard error of our calculations in the graph.

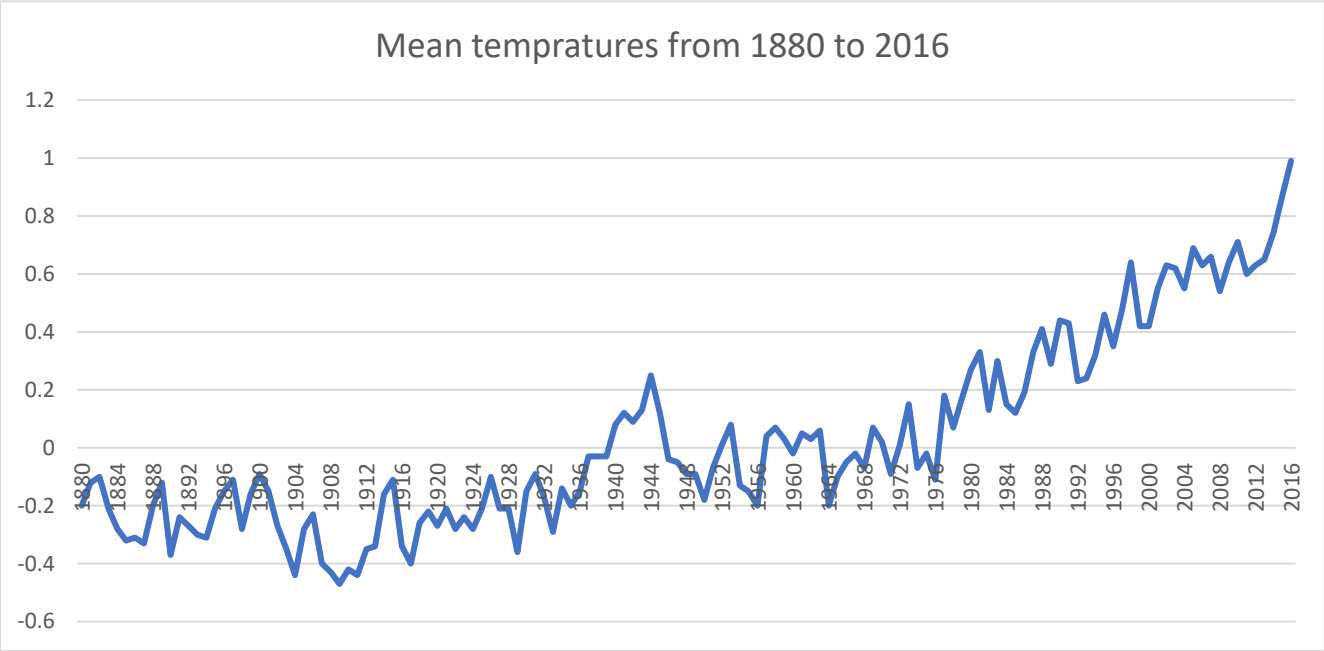


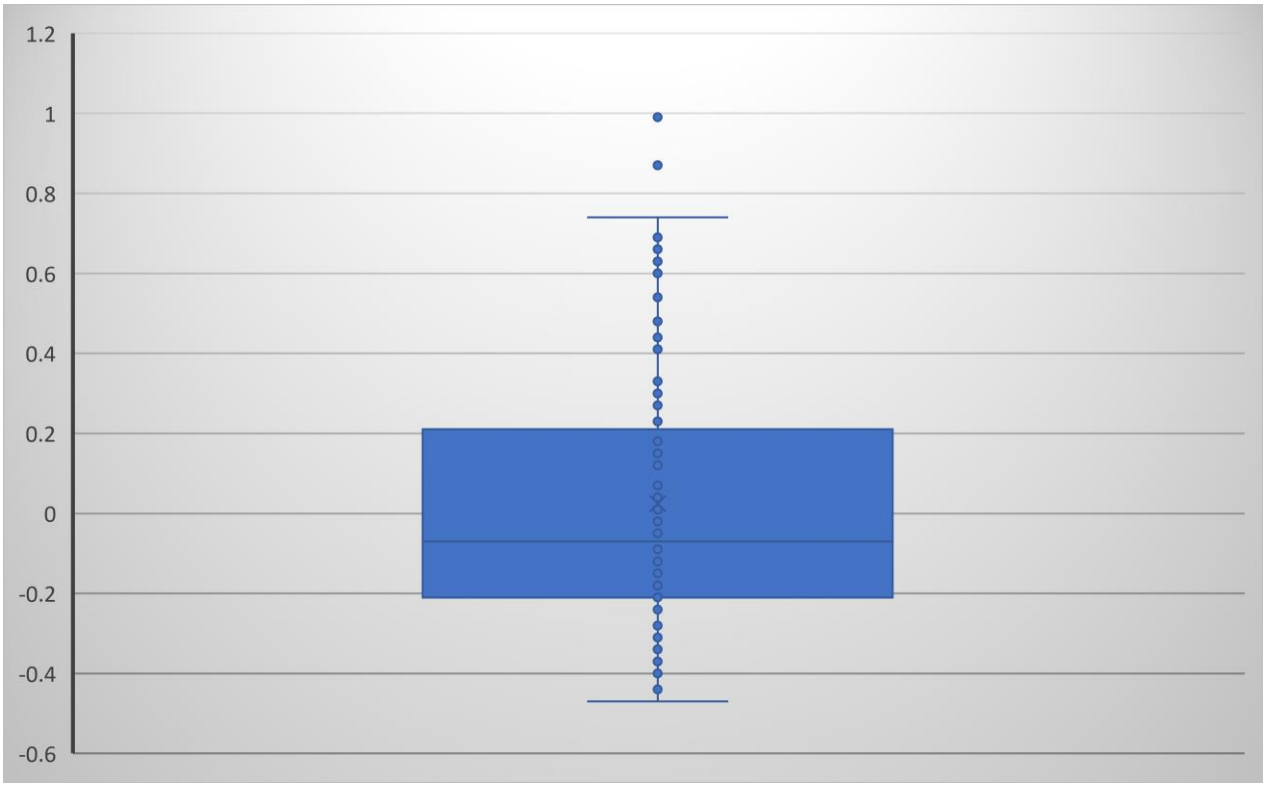
2. Mean of GISTEMP

a. Numerically

Mean	
Mean	0.024379562
Standard Error	0.027947703
Median	-0.07
Mode	-0.21
Standard Deviation	0.327119472
Sample Variance	0.107007149
Range	1.46
Minimum	-0.47
Maximum	0.99
Sum	3.34
Count	137
Confidence Level(95.0%)	0.05526828

b. Graphically





From our observation we noticed that CO2 emissions in increased and the average temperature on the global level, that happens due to increasing of global warming but why did the global warming increase in the first place?? And how will we analyze this problem??

IV. Methods of solution:

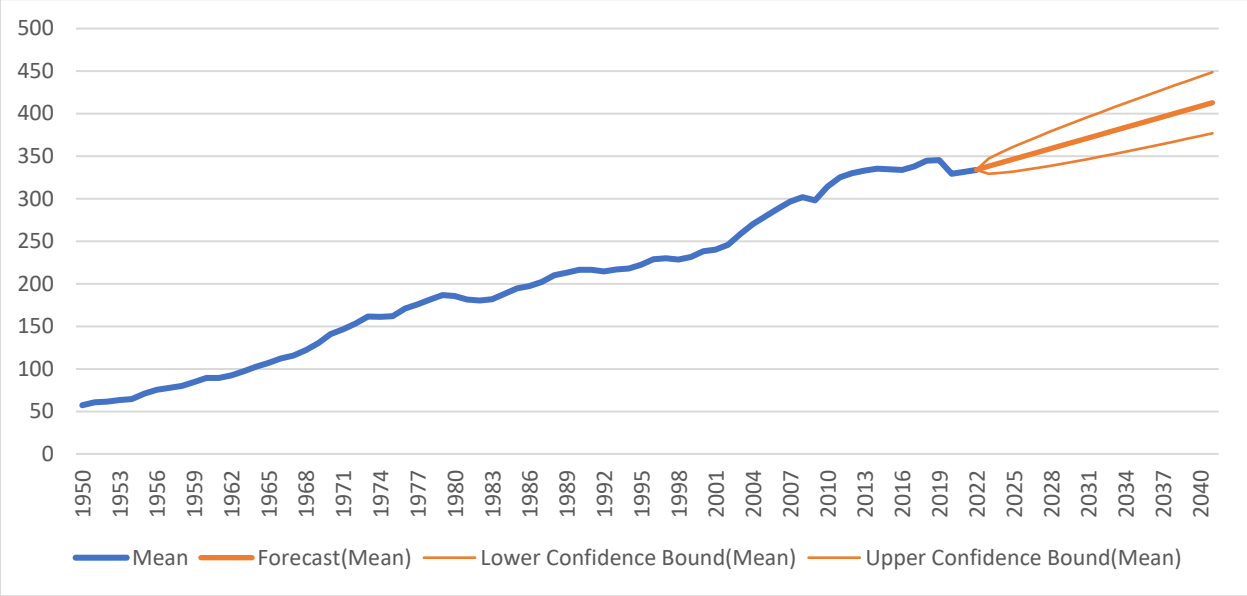
A. CO2 emissions algorithm

We found that from our data description that CO2 emissions increased 82.6%. from 1950 to 2020 with true mean equals 196.23. how sure we are that this percentage or this value will or won't increase? Is there any chance that CO2 emissions will decrease? To know the answers to those questions we will use the **hypothesis testing**, Hypothesis testing is a systematic procedure for deciding whether the results of a research study support a particular theory which applies to a population. Hypothesis testing uses sample data to evaluate a hypothesis about a population, and there are some steps of hypothesis testing: The first is Specify the Null Hypothesis, the null hypothesis (H0) is a statement that the true mean is 150 (we want to know if the true mean will decrease up to 2022) The second step is Specify the Alternative Hypothesis, The alternative hypothesis (H1) is the statement that the true mean doesn't equal 150 . The third step is to Set the Significance Level a. The significance level (denoted by the Greek letter alpha— a) is generally set at 0.05. This means that there is a 5% chance that will accept the alternative hypothesis when the null hypothesis is true. The fourth step is Calculate the Test Statistic and Corresponding P-Value. The p-value describes the probability of obtaining a sample statistic as or more extreme by chance alone if the null hypothesis is true. This p-value is determined based on the result of the test statistic. And the step five is drawing a Conclusion and it is saying that P-value less than or equal significance level (a) greater than or equal Reject the null hypothesis in favor of the alternative hypothesis. Applying this algorithm on CO2 emissions data set using excel will give us those results

	Mean	
Mean	196.2273529	150
Known Variance	7534.389	7534.389
Observations	71	71
Hypothesized Mean Difference	0	
z	3.173139622	
P(Z<=z) one-tail	0.000754	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0.001508	
z Critical two-tail	1.959963985	

Using z-interval with alpha = 0.05 we can find that $Z_{critical} < Z$ so we tend to reject H0 and accept H1 that the true mean doesn't equal 150
But how can we make sure this analysis is right??????

By doing Interpolation on our CO2 emission data set we can find the values of CO2 emissions till 2041 with confidence level 95% we can see the following



From the previous graph it's obvious that our hypothesis was right that CO2 emissions won't decrease but it will increase. (All this analysis with more explanation in the Excel Sheet)

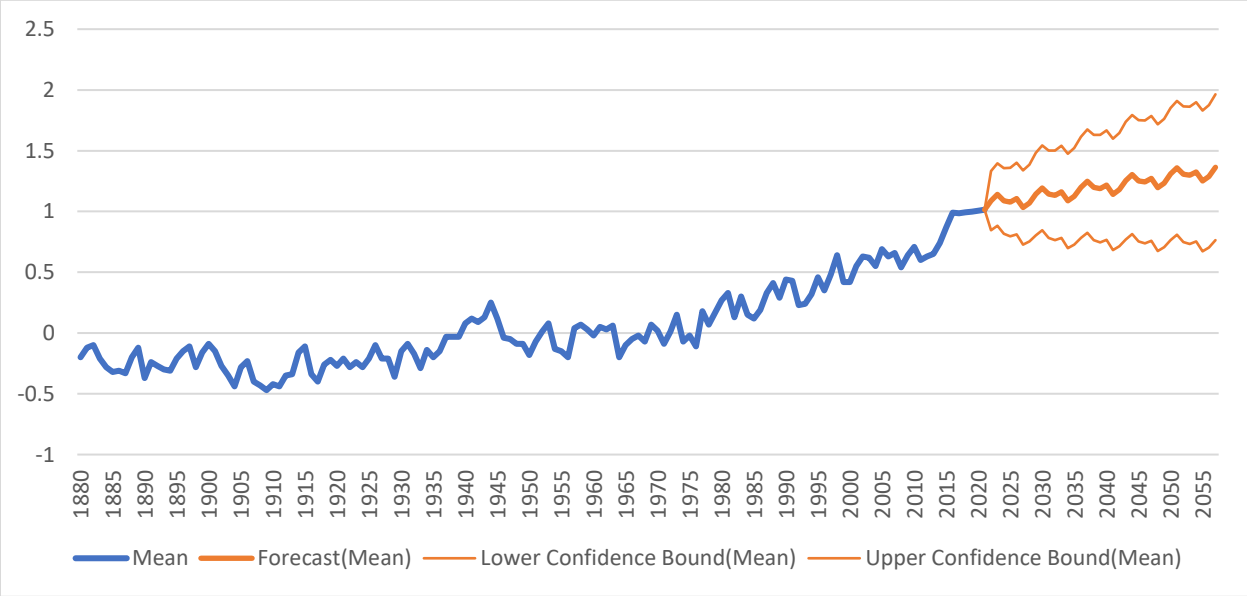
B. GISTEMP algorithm

We noticed from data description of GISTEMP dataset that the mean temperature in increasing over the years if we apply hypothesis testing as described in the previous algorithm on this dataset with significance level 5% and H0 is that true mean equals 0.8 (To assume the true population mean is degreasing) and H1 is the true population mean doesn't equal 0.8 we will get the following results

	Mean	*H0*
Mean	0.024379562	0.8
Known Variance	0.106226	0.106226
Observations	137	137
Hypothesized Mean Difference	0	
z	-19.696049	
P(Z<=z) one-tail	0	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0	
z Critical two-tail	1.959963985	

Using z-interval with alpha = 0.05 we can find that $Z_{critical} < Z$ so we tend to reject H0 and accept H1 that the true mean doesn't equal 0.8
But how can we make sure this analysis is right??????

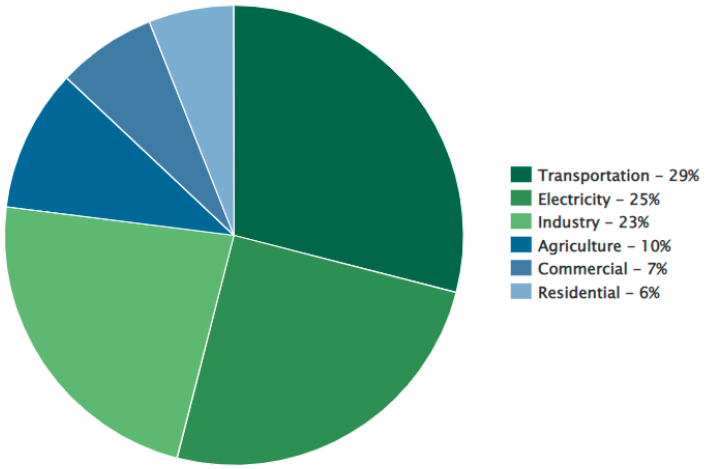
By doing Interpolation on GISTEMP dataset we can find the values of mean temperatures till 2057 with confidence level 95% we can see the following:



From the previous graph it's obvious that our hypothesis was right that mean temperatures won't decrease but it will increase. (All this analysis with more explanation in the Excel Sheet)

V. Analysis of Results

We will find the main sources of global warming and divide our big problem into subprograms to make the analysis easier and clearer. After doing research we could divide the reasons of global warming six main points are visualized in the following graph [1]:



This graph represents the percentage of global warming due to human activities. We can see that transportation has the highest percentage then electricity generation, industry, and agriculture so we will discuss the first four reasons for global warming in this report.

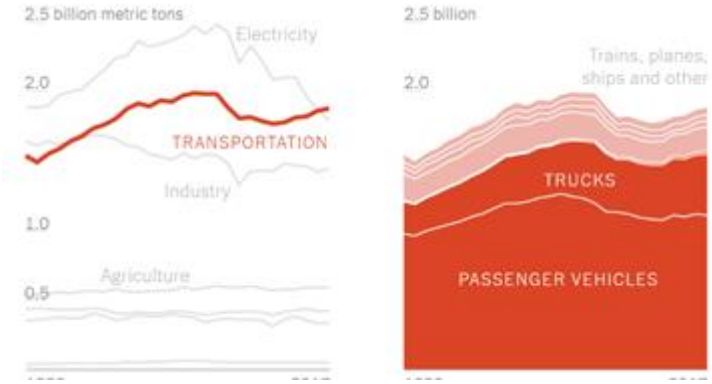
A. Transportation

Due to the increase of human population, is the GHG emissions due to transportation.

The transportation sector is a crucial industry sector in the economy that deals with the movement of people and products. Which is necessary in our everyday life for commuting, exporting, and importing goods.

With the evolution of technology, we have a wide variety of multiple airlines, trucking, railroads, shipping, and logistics firms.

One of the proposed solutions that is now available especially in Norway with 17.2% of them in use, are electric cars.[2]

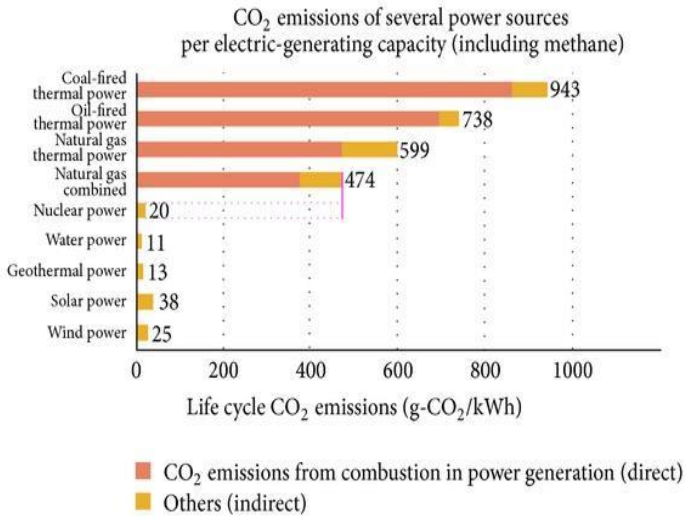


B. Electricity

Global emissions are emitted from the electricity generation sector through the combustion of fossil fuels like coal, oil, and natural gas to generate the heat needed to power steam-driven turbines.

The combustion of these fossil fuels results in the emission of GHG, namely carbon dioxide, in addition to sulfur and nitrogen oxides, causing temperature rise and contributing to the black cloud phenomena: an extreme air pollution phenomenon.

The Smart Grid (SG) can be regarded as a vision, a concept, a framework, or an umbrella for a modernized, evolutionary, next-generation step of our electrical power system. It is a combination of enabling technologies—hardware, software, or practices—that collectively make the electric power infrastructure environment friendly, more safe, secure, reliable, self-healing, efficient, and sustainable.



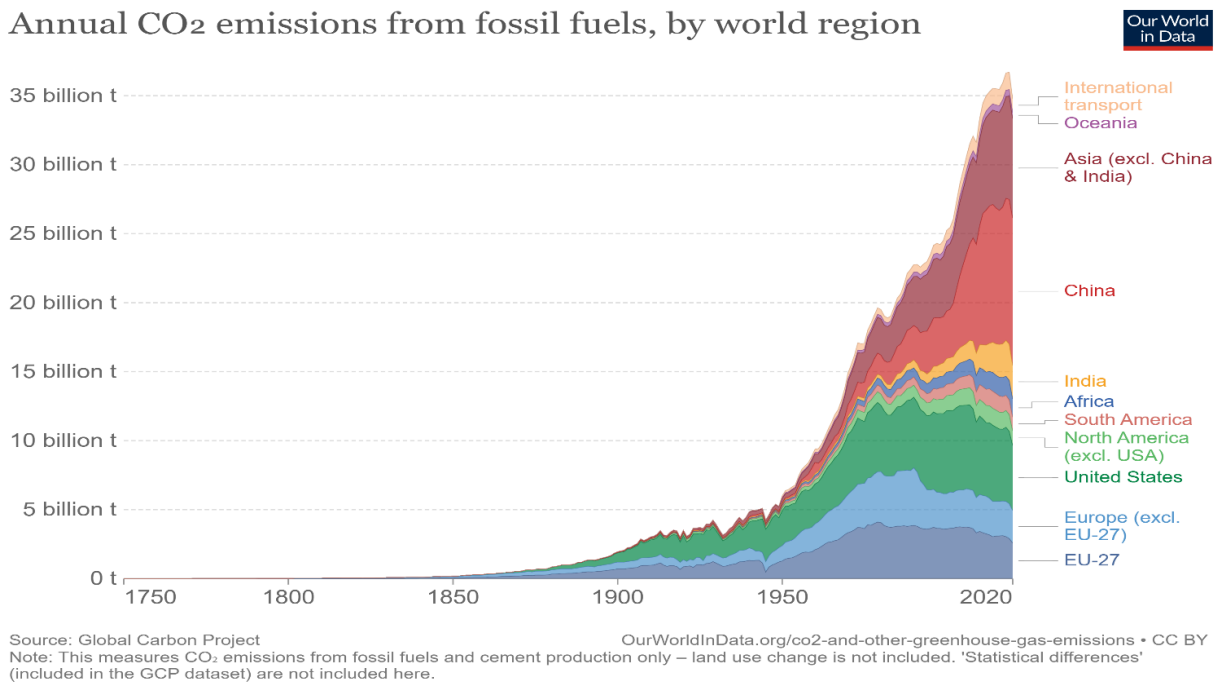
The use of renewable energy sources to generate electricity instead of traditional thermal power plants will lead to fossil fuel conservation and environmental improvements because of reducing greenhouse gasses (especially) emitted because of thermal generation.[16]

We note that the bar chart has a Right skewed distribution: we can see that The maximum value of Co2 emissions is generated from Coal-fired thermal power (943 g-Co2/kWh), and the minimum value of Co2 emissions is generated from Water power (11 g-Co2/kWh).

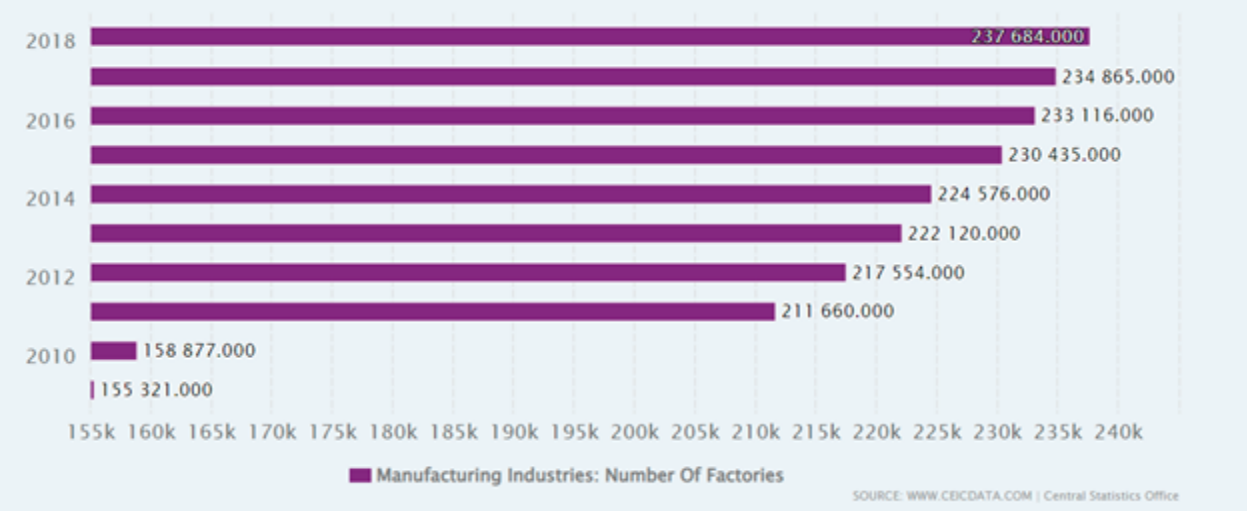
C. Industry

The industrial sector is responsible for more than 20% of our planet's greenhouse gas emissions. Primarily coming from burning fossil fuels for energy, as well as from certain chemical reactions necessary to produce some goods from raw materials. Throughout the years, the human population is increasing, therefore we must always increase our industrial power to keep up with their needs. That means more factories, more emissions and more GHG emissions.[13]

We note that the following graph has a Right skewed distribution: we can see that The maximum value of CO2 emissions is generated from fossil fuels (35 billion t), and the minimum value of CO2 emissions is generated from fossil fuels (5 billion t).

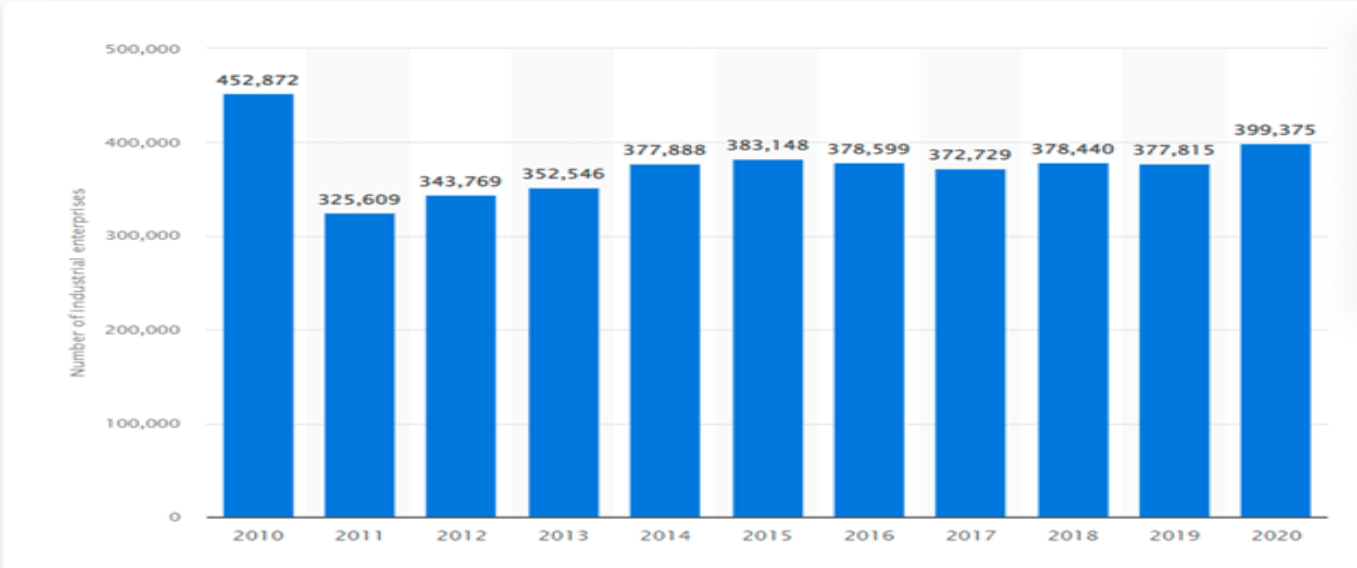


As a case study to confirm the predictions, we took two of the highest Industrial countries China and India. We see from the shown graphs that the number of factories is constantly increasing to cope with the increase of population and therefore the increase in demand for goods production.



Number of factories in India from 2008 to 2018 [3]

We note that the bar chart has a Right skewed distribution: we can see that the maximum number of Factories is 237,684 in 2018 in India, and the minimum number of Factories is 155,321 in 2009 in India.



Number of factories in China [4]

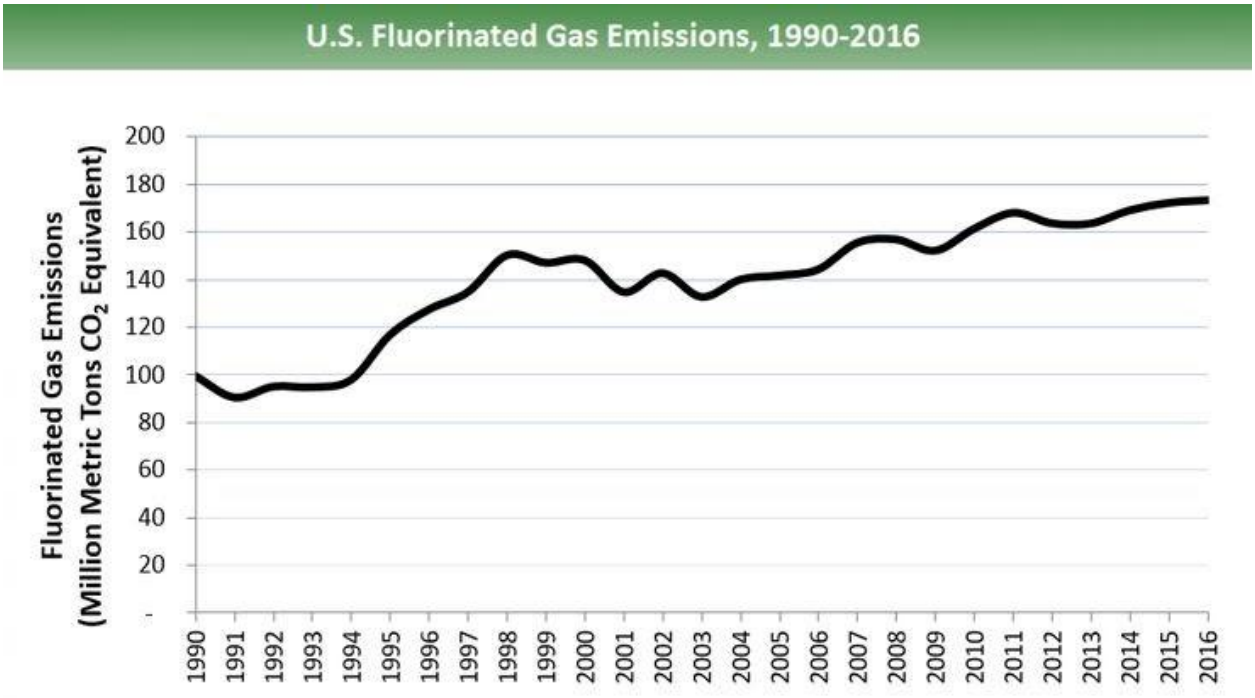
From graphs shown, we found that this was one of the reasons leading to the increase of emissions and temperature as a result, almost exponentially.

One of the recent solution trends is that we can start introducing clean sources of energy instead of fossil fuel to power up these factories.

Also, there are some products in our industries damage our environment like **Fluorinated gasses** which are highly potent greenhouse gasses that can significantly influence the global climate, specifically hydrofluorocarbons, which are high global warming and the fastest growing greenhouse gasses globally.[7]

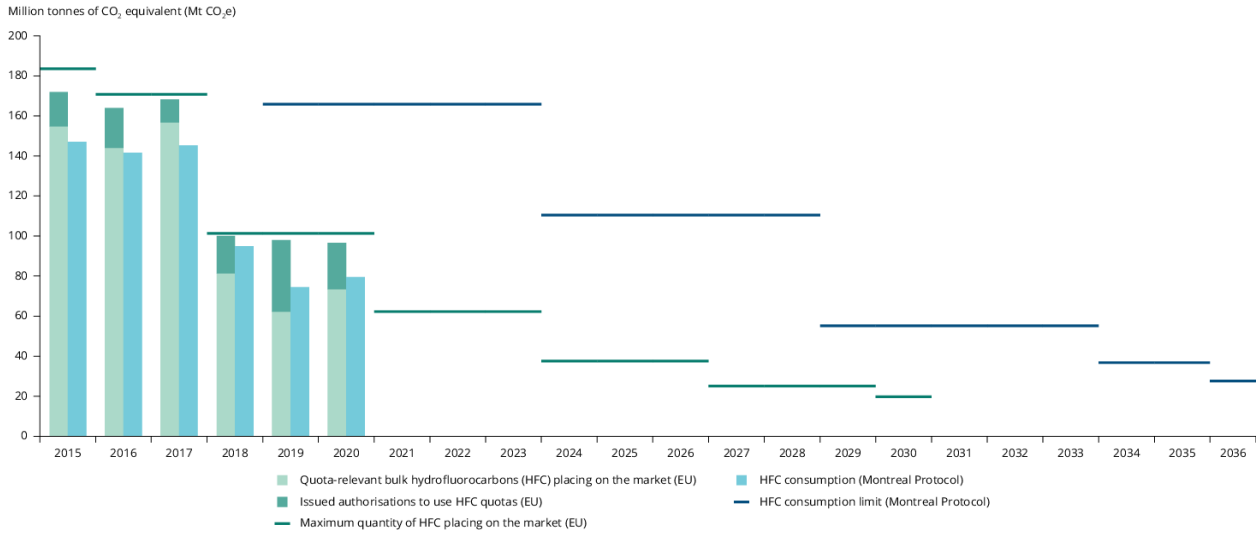
Some of the largest sources of F-gas emissions are refrigeration and air conditioning equipment, which use substitution of ozone depleting substances, and these are responsible for 89% of fluorinated gasses emissions.

The following graph shows the increase of fluorinated gasses emission over the years, which leads to the increase of global warming.



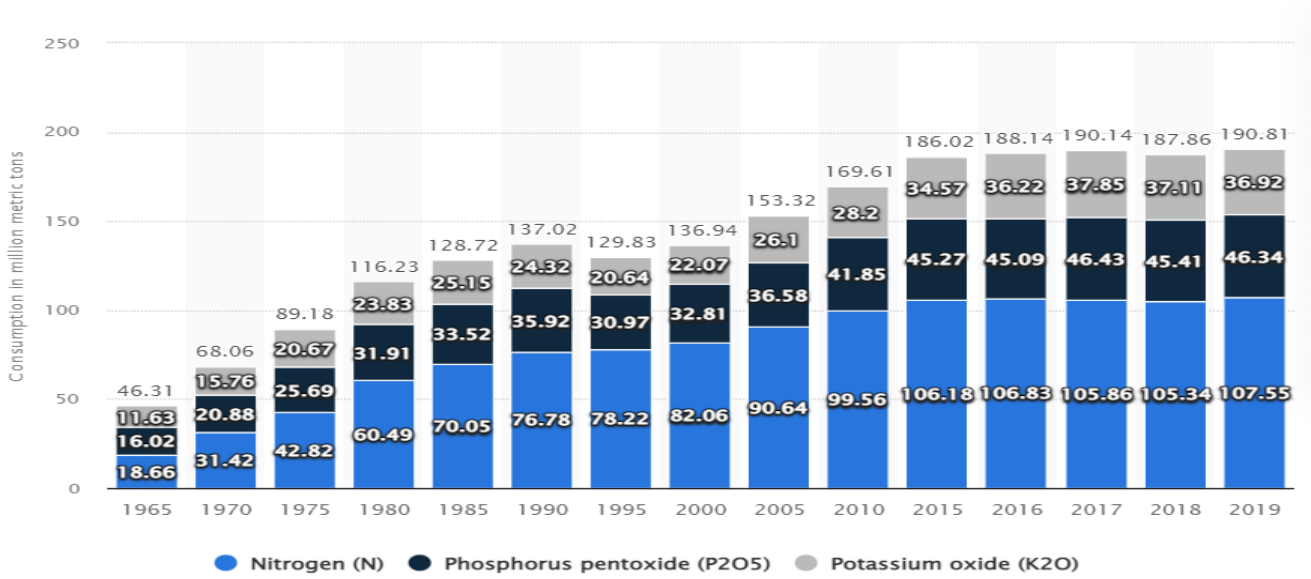
Global emission of agricultural fluorinated gasses from 1990 to 2016 (*in million metric tons) [8]*

Fluorinated gasses can be replaced by existing natural coolants such as ammonia gas, hydrocarbons or even CO2. Climate-friendly cooling technologies that utilize natural coolants are especially environmentally friendly.[11]



D. Agriculture

Mainly the effect of agriculture on global warming appears in our usage of **Nitrogen Fertilizers.** Nitrification releases a small amount of nitrous oxide which mixes into the stratosphere, where it destroys ozone. Not only does nitrous oxide destroy the ozone layer, but it also contributes to the greenhouse effect.[5]
The following graph shows the increase in Nitrogen fertilizers consumption over the years, which leads to the increase of global warming.

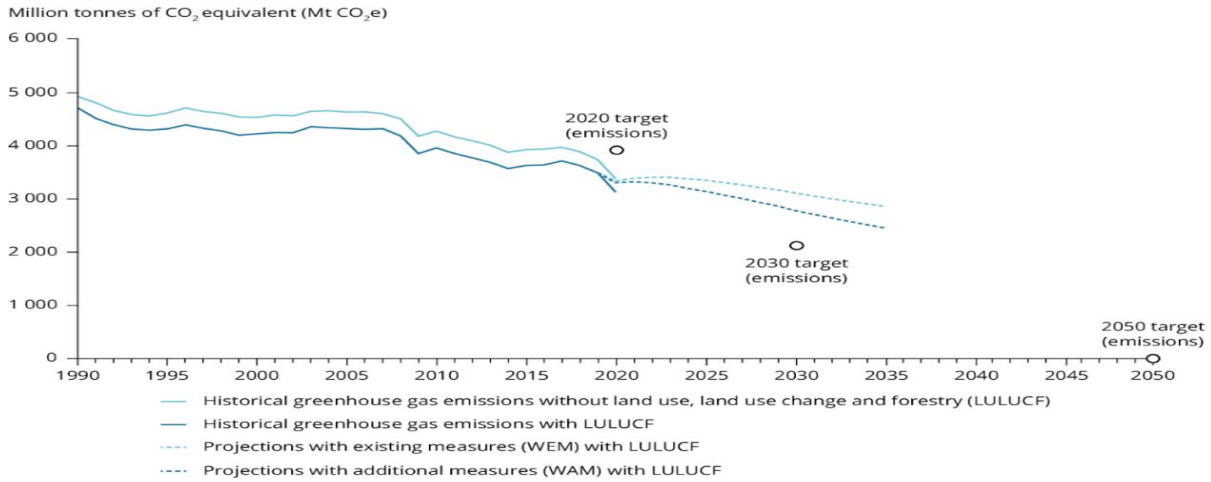


Global consumption of agricultural fertilizer by nutrient from 1965 to 2019 ***(in million metric tons)*** **[6]**

We note that the bar chart has a Left skewed distribution: we can see that the maximum consumption is 190.81 million metric tons, and the minimum consumption is 46.31 million metric tons.

Reducing the usage of Nitrogen fertilizers helps directly in reducing global warming. Taking Europe as a real-life example, N2O emissions from Europe's agricultural soils decreased by 21% between 1990 and 2010, and those from nitric acid plants dropped to 3% from 11% of the European Union's total emissions between 2007 and 2012. [9]

The improvement in global warming is illustrated in the following graph.

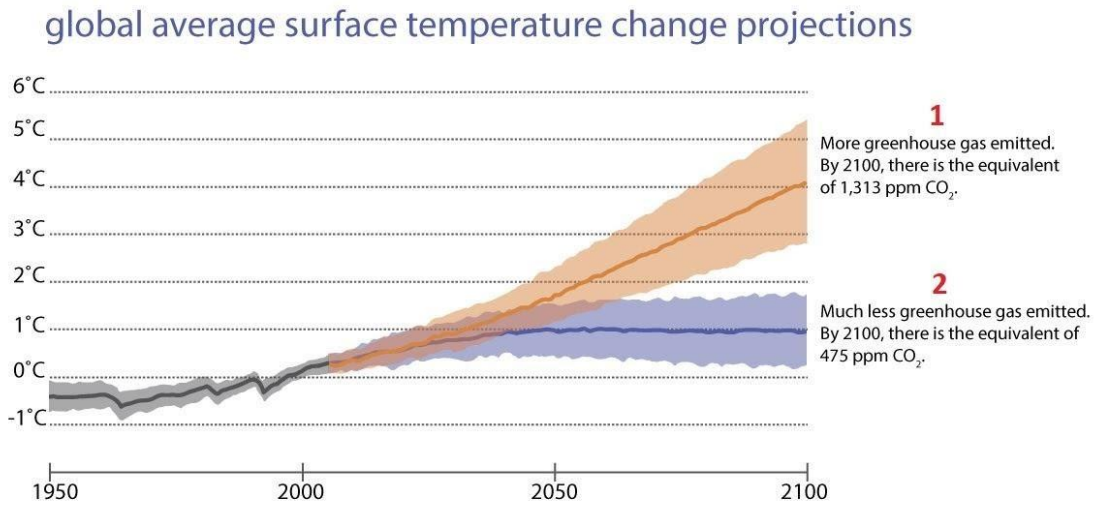


Historical trends and future projections of greenhouse gas emissions In Europe [10]

Therefore, only <u>two main scenarios</u> are either going to happen:

1. If we kept on emitting more greenhouse gasses throughout the next years.
2. If we started applying the methods of solution, we can contain the levels of emission and therefore contain all previous harmful impacts.

As shown in the following graph:



At the end, the prediction of all sectors leans towards the first scenario stated at the beginning of the conclusion.

VI. Conclusion and Expectations

Based on the previous analysis, we see that throughout time pollution is only increasing. Global warming is becoming a potential threat not only to humankind but to the whole globe.

Based on statistical analysis and calculations we made a prediction about:

- Future temperature (GISTEMP) changes
- Future CO2 emission

Predictions were made using hypothesis testing and interpolation to prove that the mean of CO2 emissions will be greater than the suggested average value which was the alternative hypothesis H1.

Then, we talked in detail about each sector behind the increase of global warming:

- Transportation
- Electricity
- Industry
- Agriculture

showing their effects visually on graphs, dividing the problem of global warming to several small problems that we need to fix individually to find the solution for the big problem.

VII. References

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