A Case Study of Greenhouse Gases in Ontario

CSDA1000_S19_S2 Group 8

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In Ontario, were certain sectors emitting higher amounts of Greenhouse Gases over the period of 2010 - 2017?

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Abstract

This research focuses on the emission of Greenhouse Gases (GHGs) by various facilities in Ontario for a period of 8 years. Ontario, having the largest population in Canada with more than 10 million people, has a large impact on GHG emissions in Canada. This report investigates how GHG emissions have changed over time for the facilities across various sectors reporting to the Ministry of Energy in Ontario. Following the steps of the CRISP-DM methodology, GHG emissions in Ontario will be reviewed based on industries for target based climate policies.

Section 1: Research Question

In Ontario, were certain sectors emitting higher amounts of Greenhouse Gases over the period of 2010 - 2017?

Introduction

Since the eighteenth century Industrial Revolution, also known as the Energy Revolution, human activities have caused a steady increase in concentrations of Greenhouse Gases (GHGs) such as Carbon Dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O), and as a result, the mean global temperatures have been rising[1].

In recent years, the focus of climate change has become a top policy issue with nations and organisations all around the world aggressively planning to tackle emissions that contribute to climate change. Scientists, analysts and policymakers have devised various metrics for calculating the potential climate impacts of different GHGs. These metrics use carbon dioxide as a baseline for comparison given that it is the dominant greenhouse gas in terms of annual emissions. The emissions of all the other gases are calculated in equivalency to the emissions of CO_2.

The ever-increasing climate change poses a very real threat to the world as we know it. We have already seen some examples of this such as extreme weather conditions and rising water levels, just to name a few. The question remains: can we do something about it? In this project proposal, we will be reviewing the GHG emissions data from the reporting facilities in Ontario and evaluating the trends in the data.

Literature Review

The Government of Ontario issued a Greenhouse Gas progress report in 2018, which outlined the need for Ontario to rebuild its climate change policies. This report shows why Ontario needs a climate change policy, which tools are available for reducing emissions and how it will impact Ontarians.

Overall, the report suggests that Ontario has decreased its GHG emissions since 1990[2]. One of the main contributors of this reduction was the phase-out of the coal-for-electricity generation. Most programs to reduce GHG emissions in the non-electricity industries were funded by the cap and trade program, which has now been cancelled. The challenge for Ontario now is how will they decrease non-electricity GHG emissions for sectors such as transportation, agriculture, waste without funding for GHG reducing initiatives.

Most greenhouse gases (GHGs) can be emitted by both natural processes and human activities.[2] In the Government of Canada's bulletin titled "Greenhouse gas emissions: drivers and impact", the sources of GHGs were published, the Canadian impact statistics of said GHGs as well as Canada's climate change target.

Globally, almost 80% of GHG emissions from human sources come from the burning of fossil fuels and industrial processes. Specific activities include driving vehicles, electricity production, heating and cooling of buildings, operation of appliances and equipment, production and transportation of goods, and provision of services and transportation for communities. In 2017, about 27% of Canada's total GHG emissions came from the oil and gas sector, 24% from transportation, 12% from buildings and 10% from electricity generation[3].

Canada's target for 2030 is to reduce its GHG emissions to 30% below its 2005 emission levels. It hopes that by doing so, it will help to limit global average temperature rise to well below 2 degrees Celsius[3].

Section 2: Proposed Plan and Methodology

Data

The data set was retrieved from the Government of Ontario data catalogue. This data shows the total annual emissions of 7 GHGs for each facility that reported to the ministry from 2010-2017. This data is said to be reliable given that it was sourced from a Government website.

Facilities in Canada generating more than 10,000 tonnes of GHGs are required to report it to the ministry. In addition, facilities that emit more than 25,000 tonnes of GHG must also have their emissions verified by a third party[4].

The 7 GHGs that were reported during 2010 - 2017 were:

1. Carbon dioxide (CO_2)
    a. Carbon dioxide (CO_2) from non-biomass in CO_2e
    b. Carbon dioxide (CO_2) from biomass in CO_2e
2. Methane (CH_4) in CO_2e
3. Nitrous oxide (N_2O) in CO_2e
4. Sulphur hexafluoride (SF_6) in CO_2e
5. Hydrofluorocarbons (HFCs) in CO_2e
6. Perfluorocarbons (PFCs) in CO_2e
7. Nitrogen Trifluoride (NF_3) in CO_2e

The data set also includes the Facility Primary NAICS code which will be used to aggregate the facilities to specific sectors. The North American Industry Classification System (NAICS)[5] has been developed by the statistical agencies of Canada, Mexico and the United States.

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Statistical Modelling and Methodology

The focus our research analysis will be to determine if there is a relationship between time and the top 3 contributors of GHGs: CO_2, CH_4 and N_20. We will also be comparing GHGs for each sector as defined by the Facility Primary NAICS code to evaluate if there has been a significant increase or decrease over time.

A correlation is a statistical measure of the relationship between two variables. The measure is best used in variables that demonstrate a linear relationship between each other[7]. The fit of the data can be visually represented in a scatterplot. Using a scatterplot, we can generally assess the relationship between the variables and determine whether they are correlated or not.

The correlation coefficient is a value that indicates the strength of the relationship. The coefficient can take any values from -1 to 1.

Correlation coefficient formula:

$$r_{xy} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

Where:

r_{xy} – the correlation coefficient of the linear relationship between the variables x and y
xi – the values of the x-variable in a sample
$\bar{x}$ – the mean of the values of the x-variable
yi – the values of the y-variable in a sample
$\bar{y}$ – the mean of the values of the y-variable

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CRISP-DM

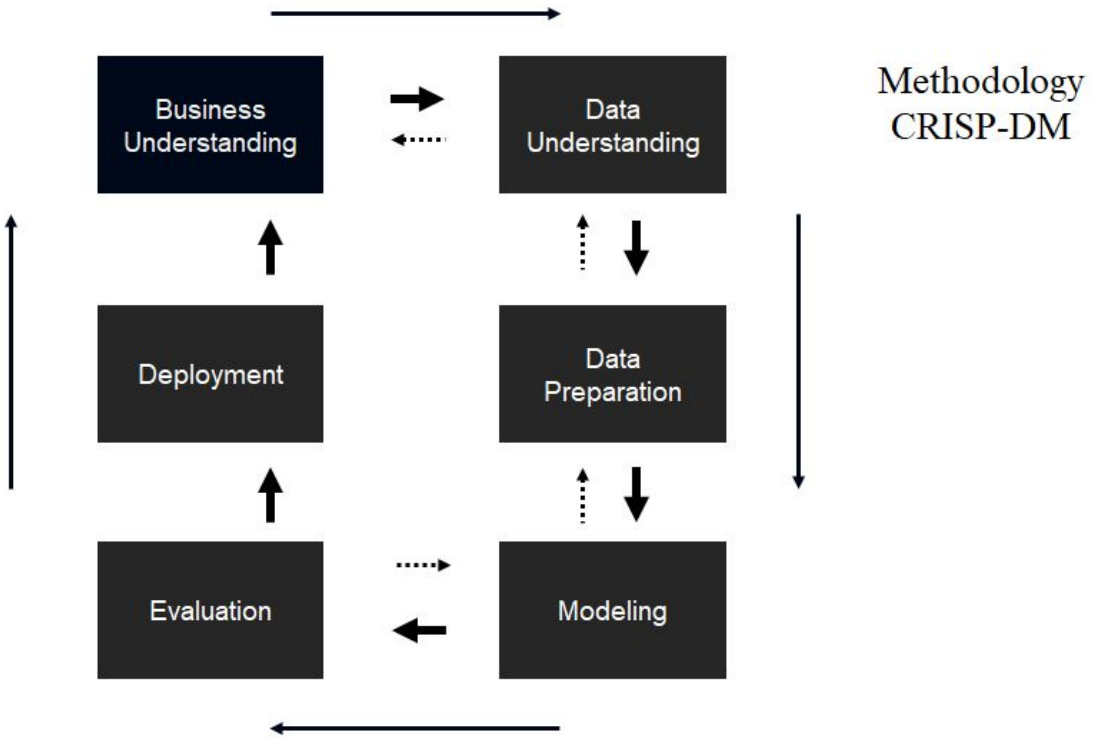

Image Source: Introduction to Big Data Analytics - Week 4 module

The figure above shows the cycle of CRISP-DM (Cross-Industry Standard Process for Data Mining).

This is a methodology which describes the typical phases of a project including the tasks related to each phase and relationship between the phases. It also provides an overview of the data mining cycle[8]. A brief summary of each of the phases is as follows:

1. Business understanding: To start the project requires an understanding of the business question to be answered or a business problem to be solved.
2. Data Understanding: This involves the gathering of available data and identifying the limitations and quality of the data.
3. Modelling: Models are needed to categorize and analyse the data in some form.
4. Evaluation: This phase involves testing the model for accuracy.
5. Deployment: Once the model has been evaluated and if the results are satisfying, then the model can be deployed.

Our research methodology will be following this process to answer the business question at hand.

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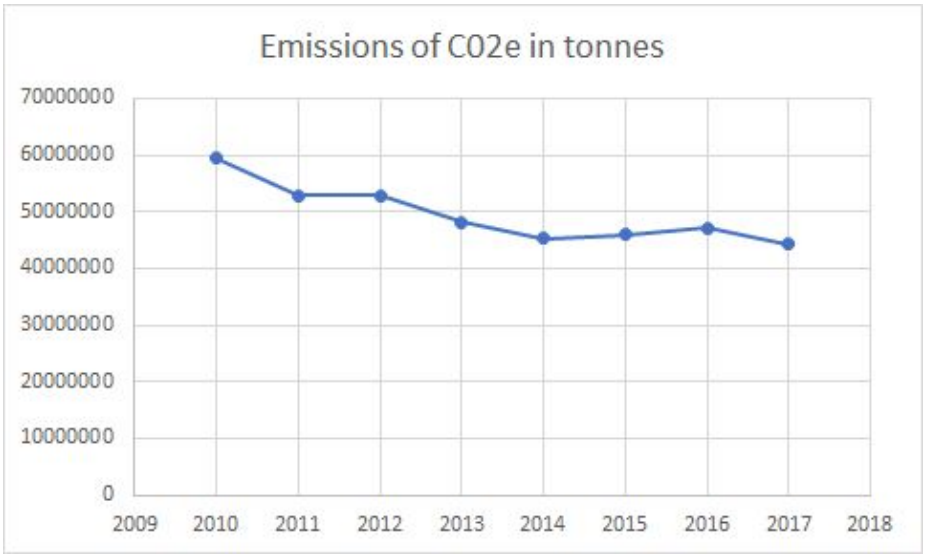
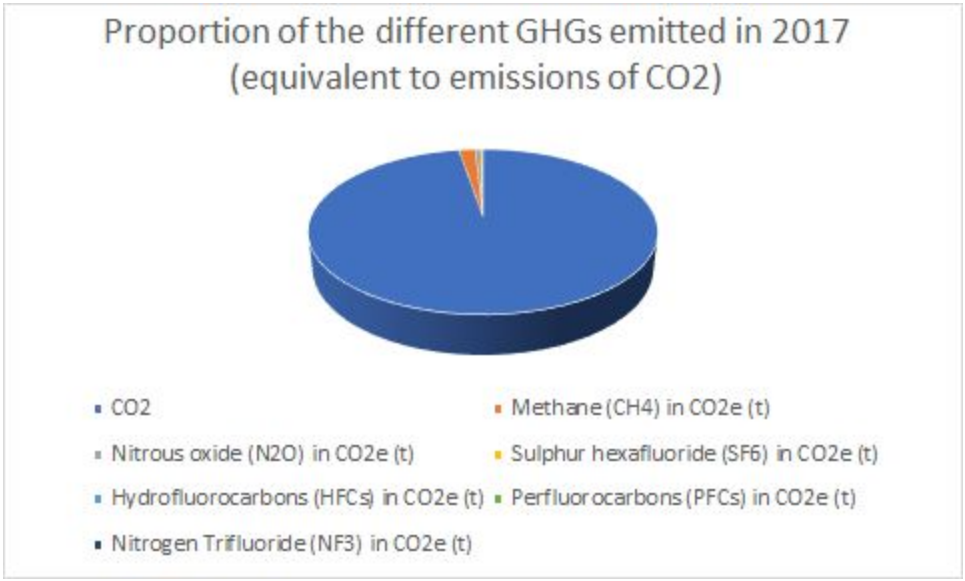
Section 3: Data Discovery and Expected Results

We are proposing to use a mix of scatter plots and histograms to present the GHGs of Ontario, GHGs by Industry as well as any correlation through time. For this, we would be using the various available plotting libraries for Python.

Tables and Charts





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Hypothesis

The purpose of this project is to determine whether GHG emissions have increased from 2010 to 2017 in Ontario across reporting facilities in various sectors.

Expected Results

It is expected that GHG emissions have changed over time, which reinforces the need to have climate change policies in Ontario. Our preliminary research shows that in some sectors, GHGs have increased with time, thereby negating the effects of a decrease in emissions in other sectors. Thus, signalling the need for sector-based reforms.

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