DECADE OF CLIMATE CHANGE

DATA VIZUALIZATION CA1

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INTRODUCTION

Global warming has been a hot topic in the recent years as its effects are becoming more apparent. As most countries debate on ways to curb CO2 emissions and reducing their adverse consequences, one fact has not been given enough attention and that is the relation between a country's economy and its Greenhouse gas emissions. For a country to produce a healthy economic output it needs generation and usage of energy which in turn results in greenhouse gas emissions. This relationship is important to understand if countries want to make the right "green" policies and reduce the trade off between economy and ecology.

Contents:

IS ECONOMIC GROWTH BAD NEWS FOR THE ENVIRONMENT?

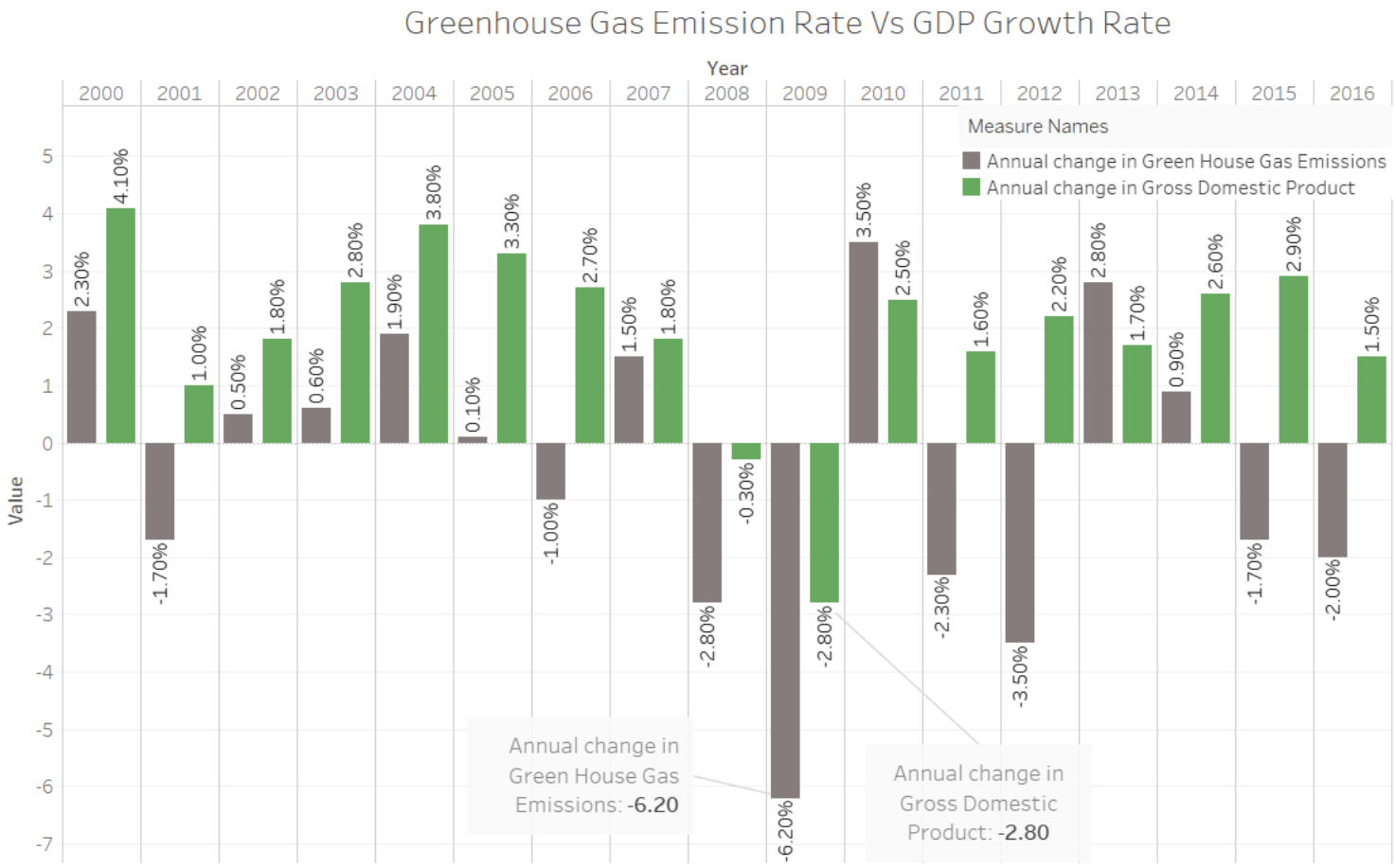


Figure 1: USA GDP Vs. GHG percentage change from 2000 to 2016

In the case of United States, before 2005 the energy use and greenhouse gas emissions were growing slower than the GDP. But post 2005 both energy consumption and the resultant carbon emissions were increasing as fast as GDP. Although in 2009, United States started the RGGI(Regional Greenhouse Gas Initiative) in which emissions from power generation were capped in ten states(New Jersey, Rhode Island, Delaware, Massachusetts, Maryland, New Hampshire, Vermont , New York, Maine and Connecticut).A drop of 6.2% was observed in the green house emissions that year, but it also came with a price of 2.8% dip in the GDP. However, in the recent years (2015), the greenhouse gas emissions have reduced and that is because the electric power sector substituted coal to non-fossil energy sources and natural gasses for power generation. In 2016, due to warmer winters the demand for heating fuel decreased in residential and commercial sectors[1].

There is an observable pattern between greenhouse gas emissions and different economies. Most south east Asian countries (except Japan), Russia and Canada have had a massive surge in industrialization, hence the energy consumption and generation have significantly risen and so have their GDP's. And the same is true for Australia and New Zealand and a result of this, the emissions of these countries are increasing faster than their GDP. Most large economies after signing the Kyoto protocol(treaty to reduce greenhouse gas emissions), started outsourcing more than before to south east Asian countries and Australia, which resulted in reduction of the emissions of the countries who outsourced. USA pulled out of the Kyoto protocol which is one of the explanations of why they still significantly contribute to the global greenhouse gas emissions.

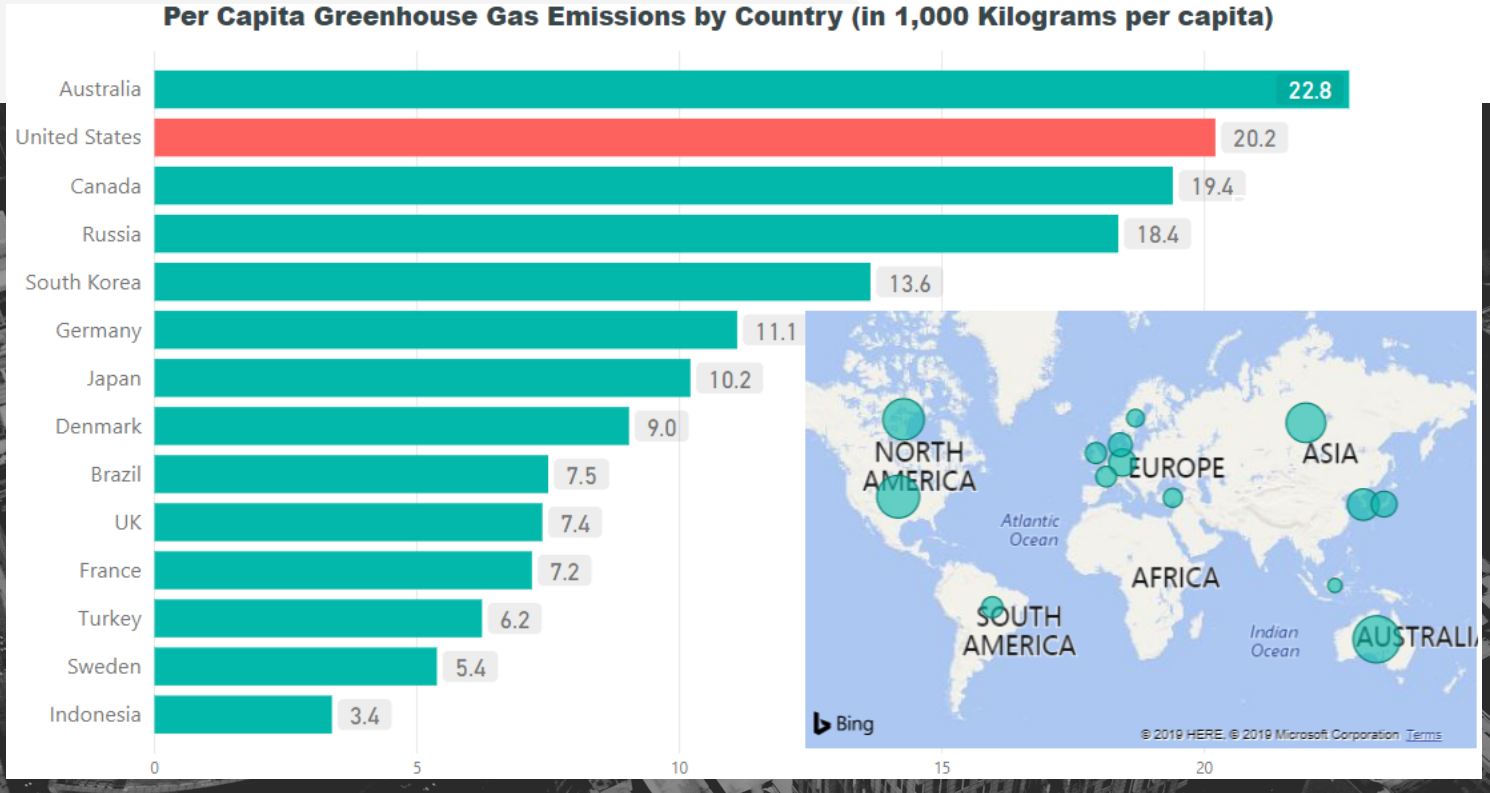


Figure 2: GHG Emissions By Country In 2016

UNCLE SAM IN THE LEAD

Economic growth of USA was 29% less carbon intensive[2] in 2017, but it still continued to be one of the top contributors of carbon dioxide emissions. The carbon dioxide emissions of USA in 2017 were nearly equivalent to the emissions of Russia, Japan and India combined who are also one of the top contributors of carbon emissions. USA also reported a 2.3% increase in GDP in 2017,which does not seem surprising given their carbon emission of 5,270 million metric tons. Reducing the effects of climate change will require a collective effort from all the major economies especially the G20 countries who account for 79% of the global greenhouse gas emissions[3]. The Paris climate change agreement required countries to set nationally determined contributions (NDC) of emissions, most large contributors of carbon emissions(Russia,Mexico,UK) have given really low commitments which would lead to a global warming of 2 to 3 degree celsius compared to the set target of 1.5 degrees. USA in addition to having a low commitment have also very conveniently opted out of the Paris climate agreement.

Carbon Dioxide Emissions By Select Country In 2017(in million metric tons)

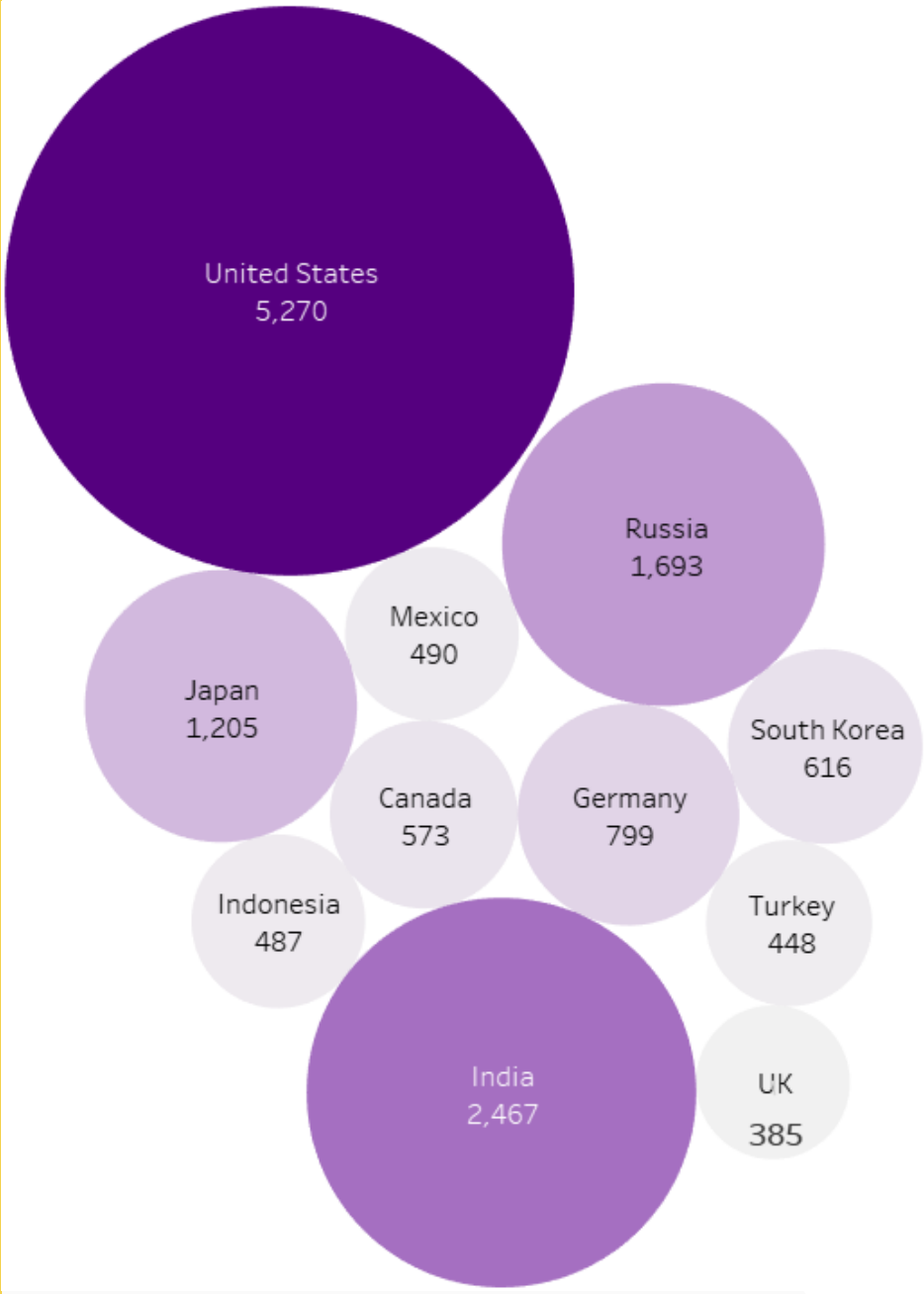


Figure 3: CO2 Emissions By Country In 2017

BRIGHTER FUTURE AT THE COST OF ENVIRONMENT?

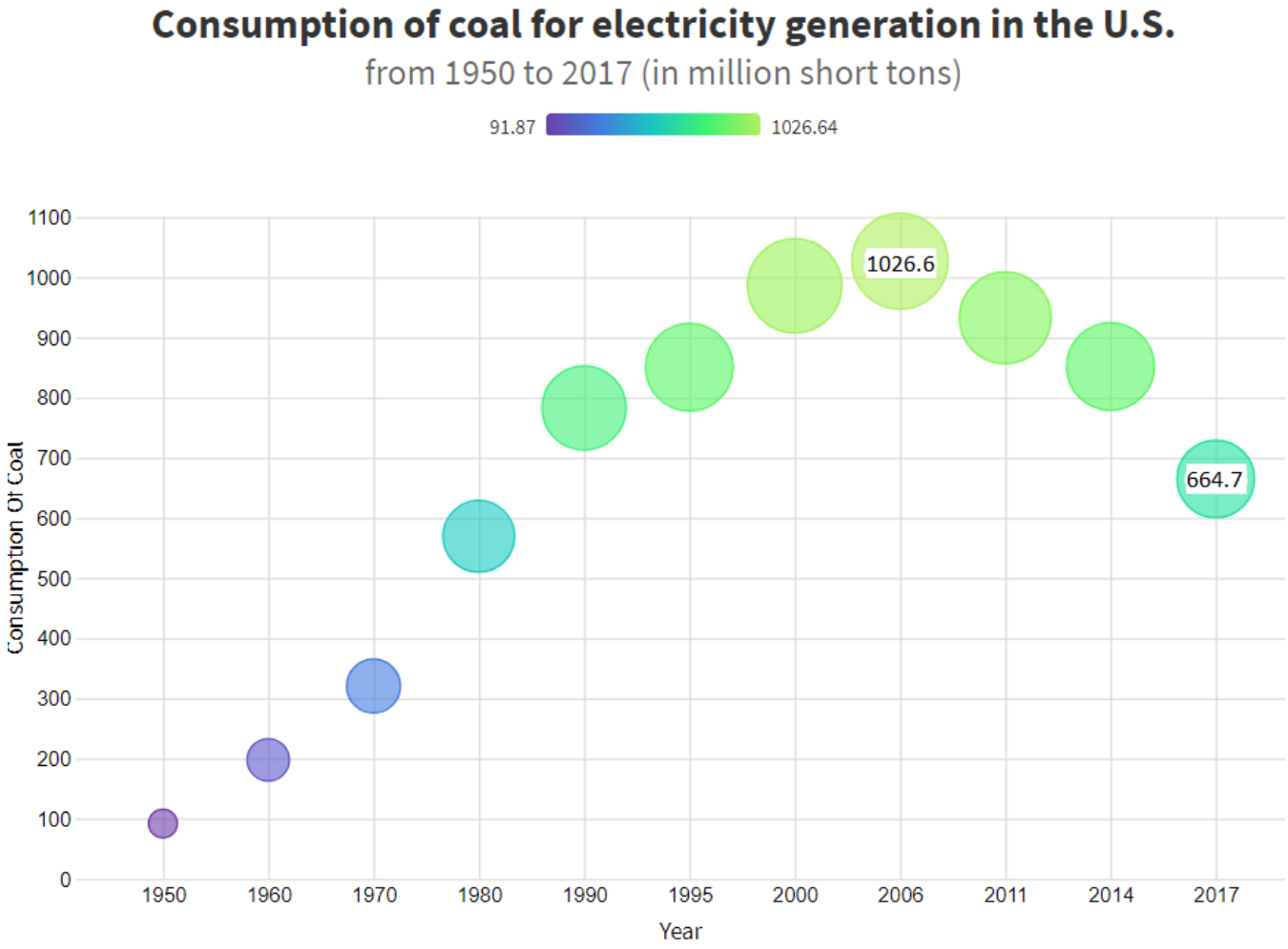


Figure 4: Consumption Of Coal For Electricity Generation

One of the biggest sources of carbon and greenhouse gas emissions are coal powered plants in USA.30% of the of the total electricity generated in 2017 by the States was powered by coal[6] as a result electricity generation continues to remain one of the highest contributors of greenhouse gas emissions. Use of coal for electricity generation peaked in 2006 when USA used 1026.64 million short tons of coal for electricity generation. 227.1 GW(1.99 trillion kilowatt hours per year) electricity was generated from coal in 2006 which was the highest compared to other countries. EPA(Environmental Protection Agency) announced cross state air pollution rule in 2010 after which most companies had to retire their old coal powered power plants. As a result, the consumption of coal for electricity dropped in 2011. The EPA in 2015 announced MATS(Mercury and Air Toxics Standard) that required industries to have significant reductions in toxic metals, mercury and acid gasses. Because of this standard a lot of old coal power plants were shut down and hence the use of coal for generating electricity in the following years.

The projections in figure 5 were made by Annual outlook energy[7] using the National Energy modelling system, who claim the values are not predictions but projections keeping certain assumptions. According to their projections from 2017 to 2050 the GDP of US is set to grow 2% annually and the energy consumption will grow 0.4% every year.
The carbon emissions from Natural Gas are set to increase significantly by 2050 compared to 2017, this is partly because the renewable energy tax credits are scheduled to expire in July of 2020 which would lead to increase in Natural gas consumption.
Electricity generation currently depends a lot on fossil fuels which is the reason why it is one of the highest contributors of carbon emissions. But the carbon emissions due to electricity generation are projected to reduce by 2050 and that is because the capital costs required to generate solar and wind energy are projected to decrease as well. Electricity generated by wind and solar energy are projected to increase by 64% by 2050 compared to 2017 [7].
The emissions related to petroleum do not show a lot of fluctuation. The difference between petroleum and natural gas prices has always been significant and the difference is set to increase every year, which creates a greater incentive for all industries to use natural gas for energy instead of petroleum. So the consumption of petroleum would not increase and hence the emissions would also not show a lot of fluctuation.

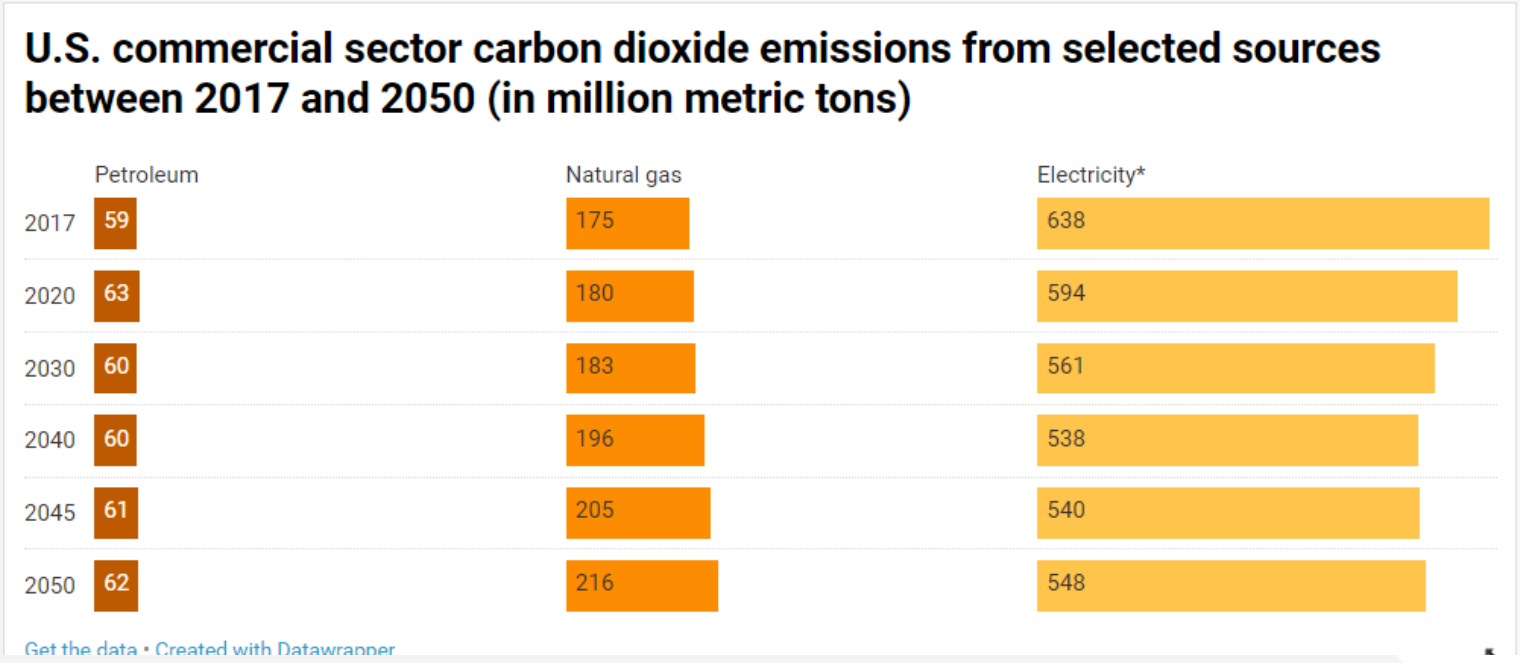


Figure 5: Consumption Of Coal For Electricity Generation

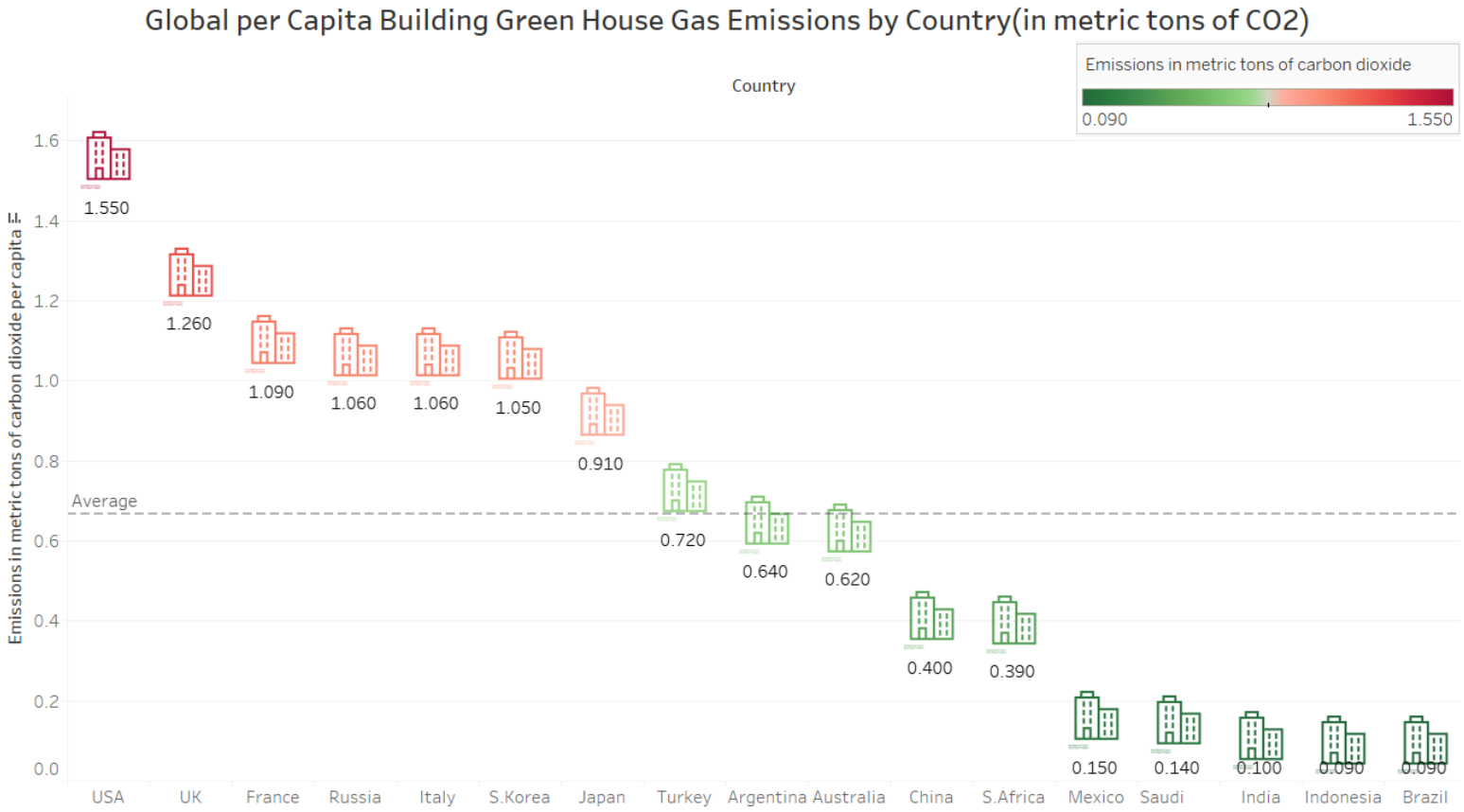


Figure 6: Per Capita Building Greenhouse Gas Emissions

CITIES ARE THE KEY FOR COUNTRIES TO GO FROM GREY TO GREEN

Cities in all countries have a huge challenge of developing climate change policies and they need a system to assess their emission levels with respect to the development. They need to make sure that as they're developing, they are making sure the emission levels are still under control. One such factor that can be useful is greenhouse gas per capita buildings, where emissions coming from commercial buildings, Industrial buildings, residential buildings, the infrastructure associated with them(roads,bridges) are calculated. USA, UK and France have the highest per capita building emissions of 1.55,1.26 and 1.09 metric tons of CO2 respectively, while India, Indonesia and Brazil are on the opposite end of the spectrum with emissions of 0.1,0.9 and 0.9 respectively.

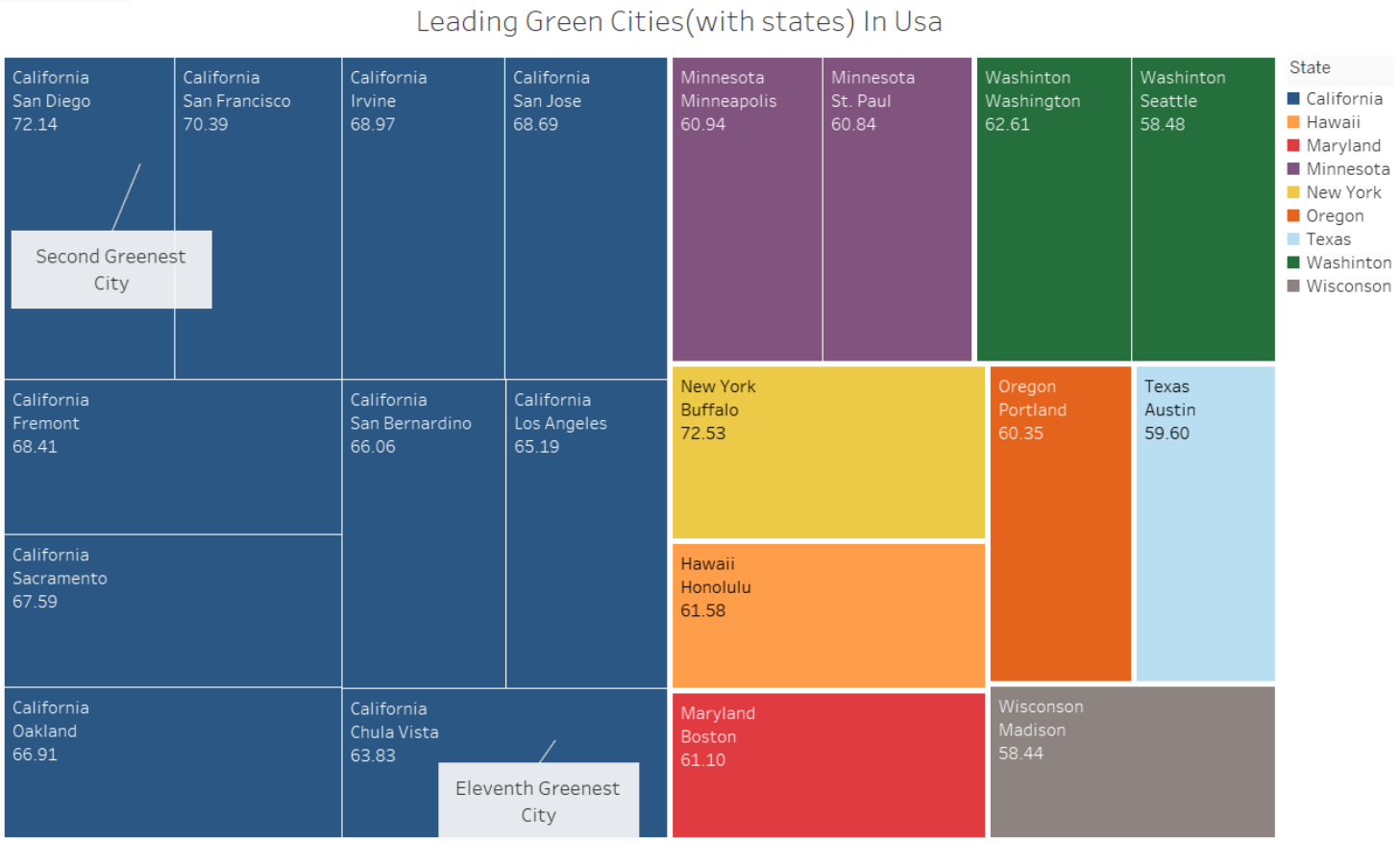


Figure 7: Leading Green Cities In USA.

With the Trump administration rolling back the Obama administrations coal emission standards and President Trump pushing to “revive” the coal powered industry, US is taking two steps back in terms of moving towards a greener economy. But things don’t seem all that bad for some cities as they realize that having “green practises” such as urban agriculture, recycling don’t just contribute to the environment but also to the economic bottom percentage of its citizens.

Green points were given to every city based on various factors such as air quality index, green space, transportation (presence of carpooling programs, distance in miles of cycle lanes, electric fuel stations), green job opportunities and promotion of alternative energy. Out of the top twenty green cities, ten cities belong to California, and two to Minnesota and Washington each. Buffalo in New York is the greenest city followed by San Diego in California. California itself also has some disparities, as it has both the second and eleventh greenest city, so not all the cities are in the top ten green cities.

So a natural question would be why do California, Minnesota and Washington lead in the green city race. The obvious reason is their political leaning. One thing that all these three states have in common is that they are all a democratic stronghold, and despite Trump administration going easy on the use of fossil fuels, these states continue to go green.

RED, BLUE AND GREEN

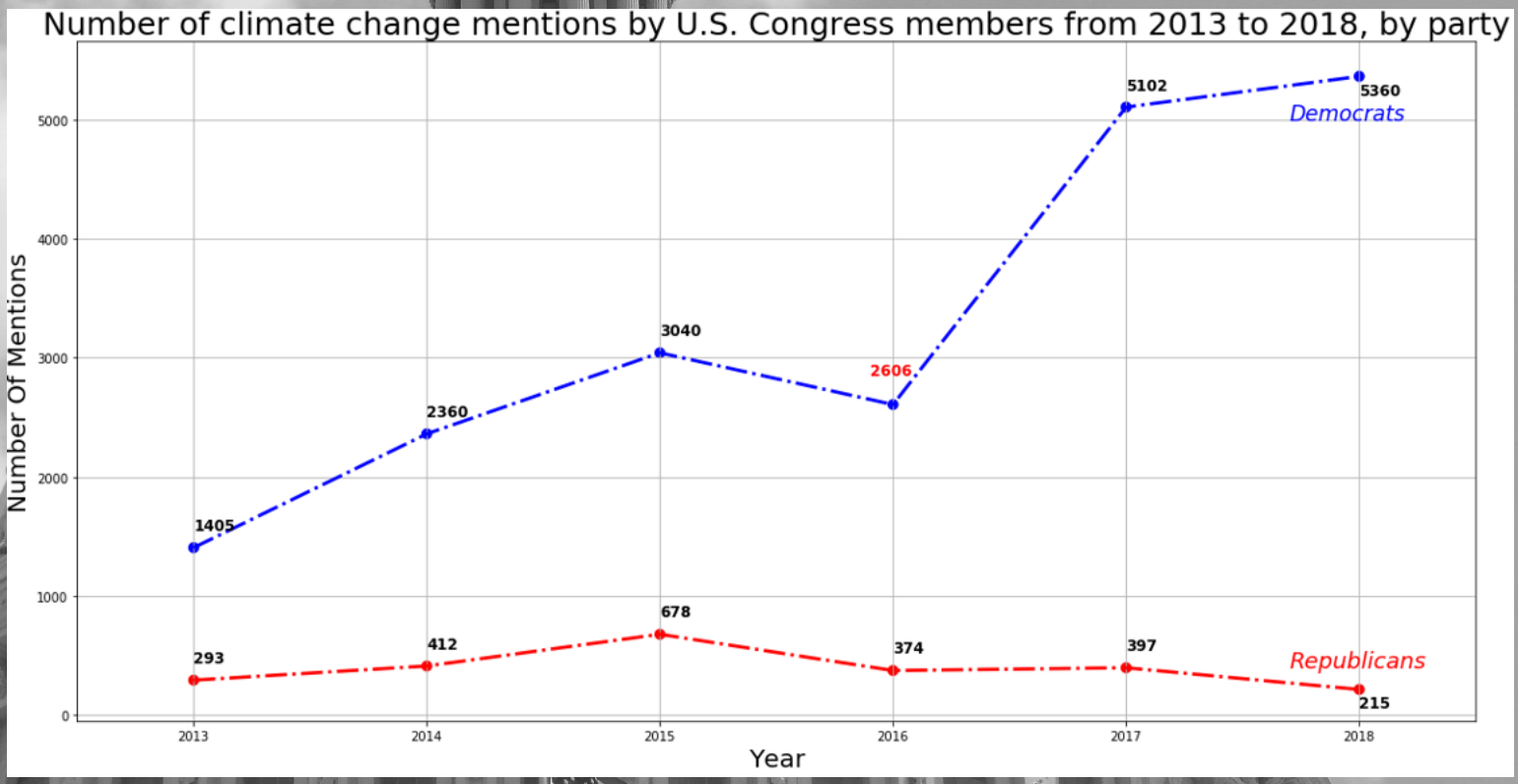


Figure 8: Leading Green Cities In USA.

Climate change continues to be a subject of debate in the US, even when they've had traumatic hurricanes in the east and devastating wildfires in the west. After June,2017 when Trump opted out of the Paris climate deal, climate change debates got fuel to their fire and the party lines[between republicans and democrats] had also been further divided.The climate change mentions of the democrats were always higher than Republicans, but the mentions conveniently got low in 2016 during the elections, which was probably to please and gain some right wing support.

Since then climate change mentions of the democrats have increased exponentially. This makes you question if the democrats really believe in climate change or its just another plot to keep the votes coming. We don't need a machine learning technique to forecast if the mentions of climate change by the democrats are going to reduce during the next presidential elections.

GREAT WALL OF "CHINESE HOAX"

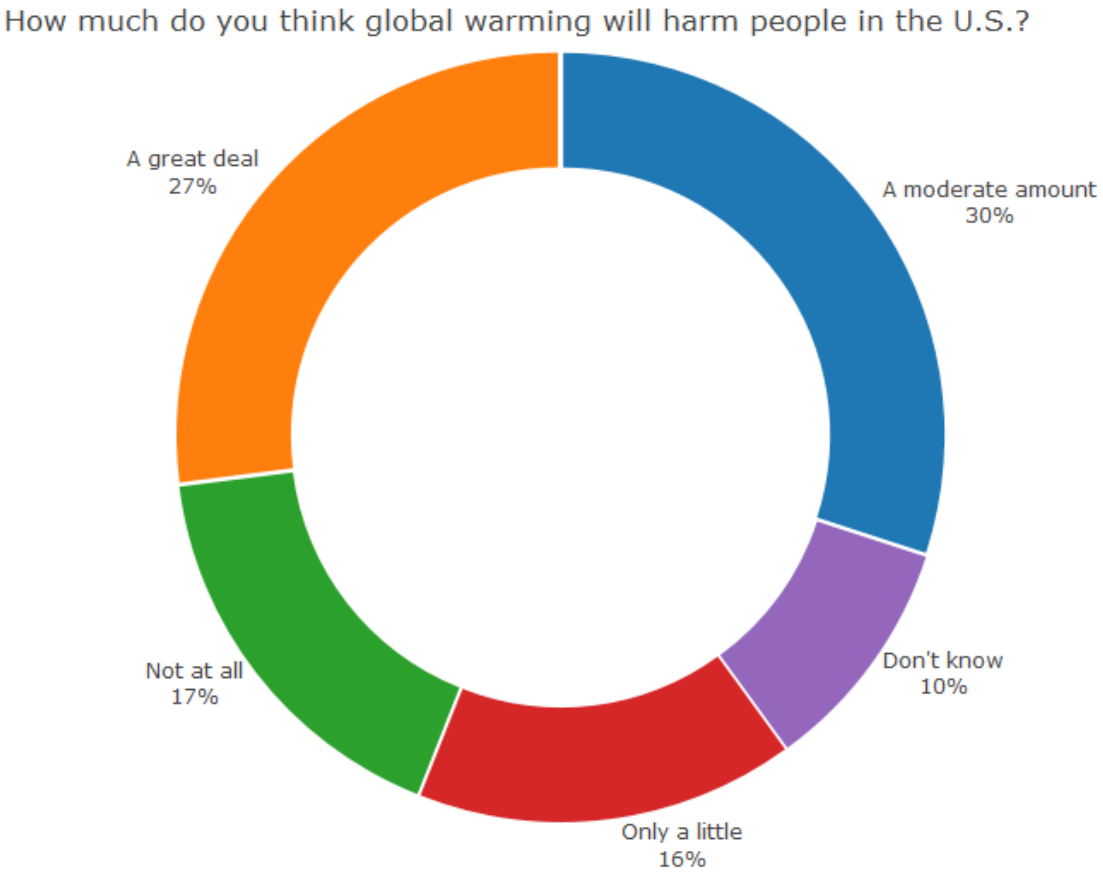


Figure 9: Global Warming Survey

Last Summer USA had the highest recorded heat wave, which resulted in catastrophic wildfires in west USA. Wildfires in 2017 burned nearly 5.6 million acres of land which was 27% above average. 15 states in the US reported large fires from Alaska to New Mexico[5].
Yale University has a program dedicated to climate change communication and promote climate change awareness. Despite the clear consequences of climate change according to their survey from December,2018(just a few months after the wildfires) 16% of the respondents still believe global warming wont harm them, whereas 30% believe it will only moderately affect them. According to their other survey, only 51% people in America are “extremely” sure that global warming is happening.

7%

Americans are extremely sure global warming is not happenng[4].

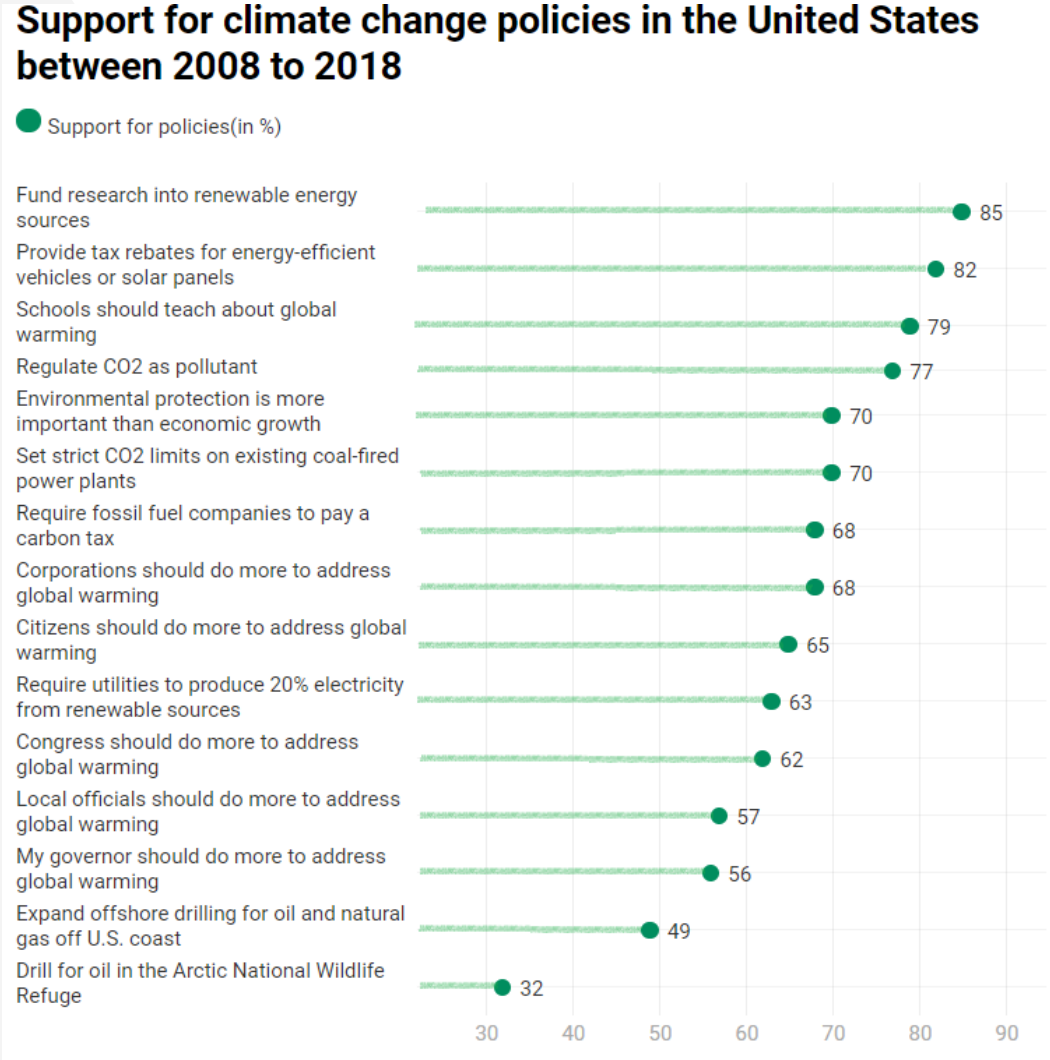
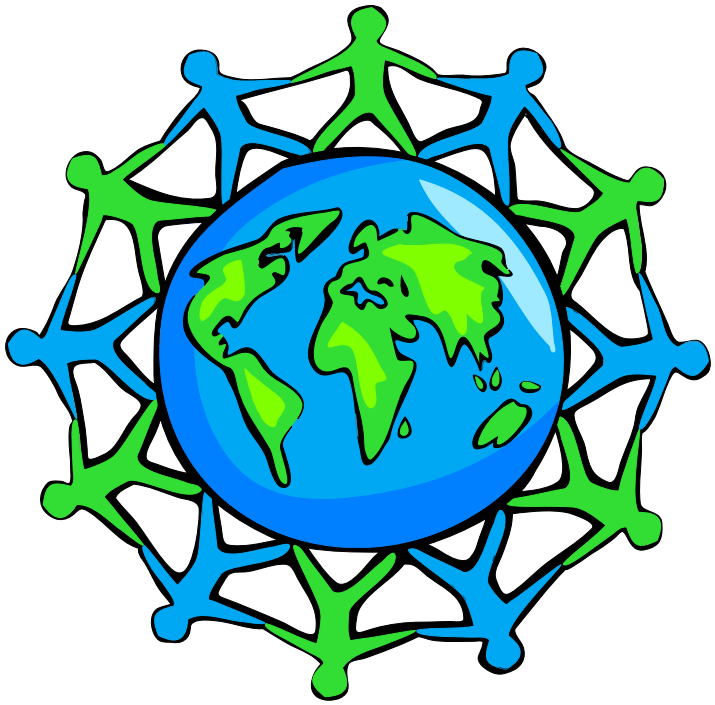


Figure 10: Support for Climate Change Policies

The seasonal threat of the wildfires has now transitioned into year-round threats in some states such as California. The officials for National Interagency Fire centre refer to fire seasons as fire years now. Now that the consequences are clear, reforms to tackle climate change are a must for United States and are not an option. The government will only take actions if people support the cause and that has become very apparent over the years. In another survey conducted by the Yale centre for climate change communication, 85% of the respondents agree that the government should fund researches for renewable energy sources and 56% believed that their governor should do more to address global warming. It's a good sign that more people are supporting these policies as global warming is not on its way, its already here and it's here to stay.

CONCLUSION

Climate change and global warming is unequivocally evident from the rising sea levels worldwide, significant increase in the global temperature, melting of ice and snow in the North and South Poles, acidification of the oceans and an increase in frequency of extreme events. If the rate at which greenhouse gases are emitted now continue, it won't be long before Earth becomes inhabitable. Even If the greenhouse emissions were stabilized, anthropogenic warming(global warming caused due to humans) and the rise in sea levels would continue for centuries[8]. The actions we are taking now are not enough to tackle global warming, and it has become clear as out of 157 countries who made commitments to cut down emissions in the Paris climate change agreement only 58 countries have taken actions[9] in the form of policies on renewable energy, green transport etc. and out of those 58 only 16 are taking actions that would meet their nationally determined contribution.



Countries around the world need to decouple their economic growth from carbon emissions and change turn their economies from brown to green. And that is not impossible as some countries like Sweden have a rising economy while their emissions are reducing. This is not an easy task but its way easier than moving to another planet.

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9."Only 16 countries have emissions reduction targets matching their promises to avoid catastrophic climate change", The Independent, 2019. [Online]. Available: https://www.independent.co.uk/environment/climate-change-greenhouse-gas-emissions-targets-paris-agreement-a8603456.html. [Accessed: 23- Feb- 2019].

All the images used in the report were freely available on Canva

DATASETS FOR IMAGES

1. Figure 1:
GDP ANNUAL CHANGE-
BEA. n.d. Real GDP growth of the United States from 1990 to 2017 . Statista. Accessed February 21, 2019. Available from https://www.statista.com/statistics/188165/annual-gdp-growth-of-the-united-states-since-1990/.
Release Date: January 2018
GREENHOUSE GAS ANNUAL CHANGE-
Environmental Protection Agency. n.d. Annual change in greenhouse gas emissions in the United States from 1991 to 2016. Statista. Accessed February 21, 2019. Available from https://www.statista.com/statistics/517392/us-annual-change-in-greenhouse-gas-emissions/. Release Date: February 2018

2. Figure 2:
Climate Transparency. n.d. Per capita building greenhouse gas emissions worldwide in 2017, by select country (in metric tons of carbon dioxide). Statista. Accessed February 21, 2019. Available from https://www.statista.com/statistics/943181/global-per-capita-building-greenhouse-gas-emissions-by-country/.
Release Date: November 2018

3. Figure 3:
IEA. n.d. Per capita CO2 emissions worldwide in 2016, by select country (in metric tons). Statista. Accessed February 21, 2019. Available from https://www.statista.com/statistics/270508/co2-emissions-per-capita-by-country/.
Release Date:September 2018

4. Figure 4:
EIA. n.d. Consumption of coal energy for electricity generation in the U.S. from 1950 to 2017 (in million short tons)*. Statista. Accessed February 21, 2019. Available from https://www.statista.com/statistics/184333/coal-energy-consumption-in-the-us/
Release Date: March 2018

5. Figure 5:
EIA. n.d. U.S. commercial sector carbon dioxide emissions from selected sources between 2017 and 2050 (in million metric tons). Statista. Accessed February 21, 2019. Available from https://www.statista.com/statistics/184188/us-commercial-sector-co2-emissions-2008-and-2035-by-fuel/.
Release Date: January 2019

6. Figure 6:
WalletHub. n.d. Leading U.S. cities based on environment, transportation, energy sources, and lifestyle and policy as of 2018. Statista. Accessed February 21, 2019. Available from https://www.statista.com/statistics/709150/ranking-of-eco-friendly-states-in-the-us/
Release Date: October 2018

7. Figure 7:
WalletHub. n.d. Leading U.S. cities based on environment, transportation, energy sources, and lifestyle and policy as of 2018. Statista. Accessed February 21, 2019. Available from https://www.statista.com/statistics/709150/ranking-of-eco-friendly-states-in-the-us/
Release Date: October 2018

8. Figure 8:
Quorum Analytics. n.d. Number of climate change mentions by U.S. Congress members from 2013 to 2018, by party* . Statista. Accessed February 21, 2019. Available from https://www.statista.com/statistics/951862/climate-change-mentions-us-congress-members-by-party/
Release Date: December 2018

9. Figure 9:
Yale University, Center For Climate Change Communication. n.d. How much do you think global warming will harm people in the U.S.?. Statista. Accessed February 21, 2019. Available from https://www.statista.com/statistics/242394/views-of-us-adults-on-impact-of-global-warming-on-people-in-the-us/.
Release Date: December 2018

10. Figure 10:
Yale Program on Climate Change Communication. n.d. Support for climate change policies in the United States between 2008 to 2018. Statista. Accessed February 21, 2019. Available from https://www.statista.com/statistics/942493/support-climate-change-policies-united-states/.
Release Date: August 2018

APPENDIX

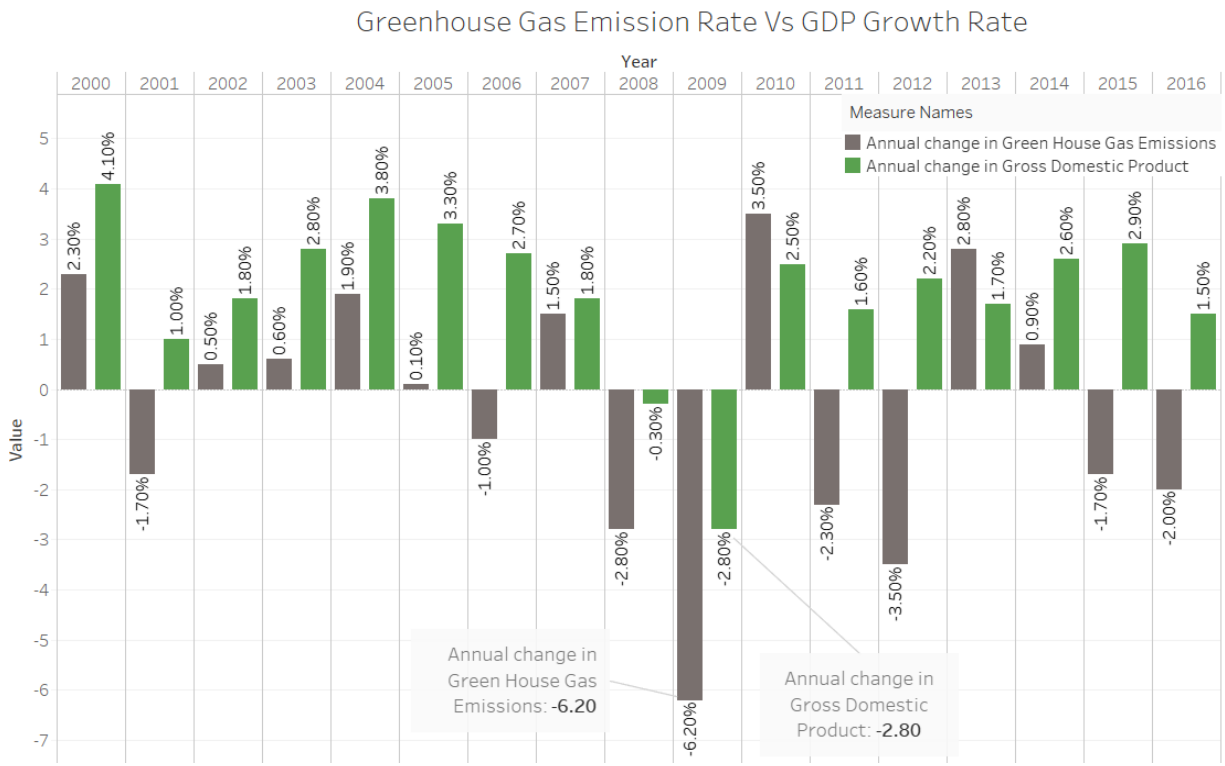

Figure 1: Visualization was created using Tableau

Data varied over time and had few periods that had only two categories, so a column chart seemed appropriate to use. Two different data sets from statista were clubbed together for this visualization. There was an option of using two different column charts for comparison, but clubbing them together made the GDP and GHG comparison easier to notice over years. The colors green which represents money was used for GDP growth and grey which represents smoke for greenhouse gas emissions.

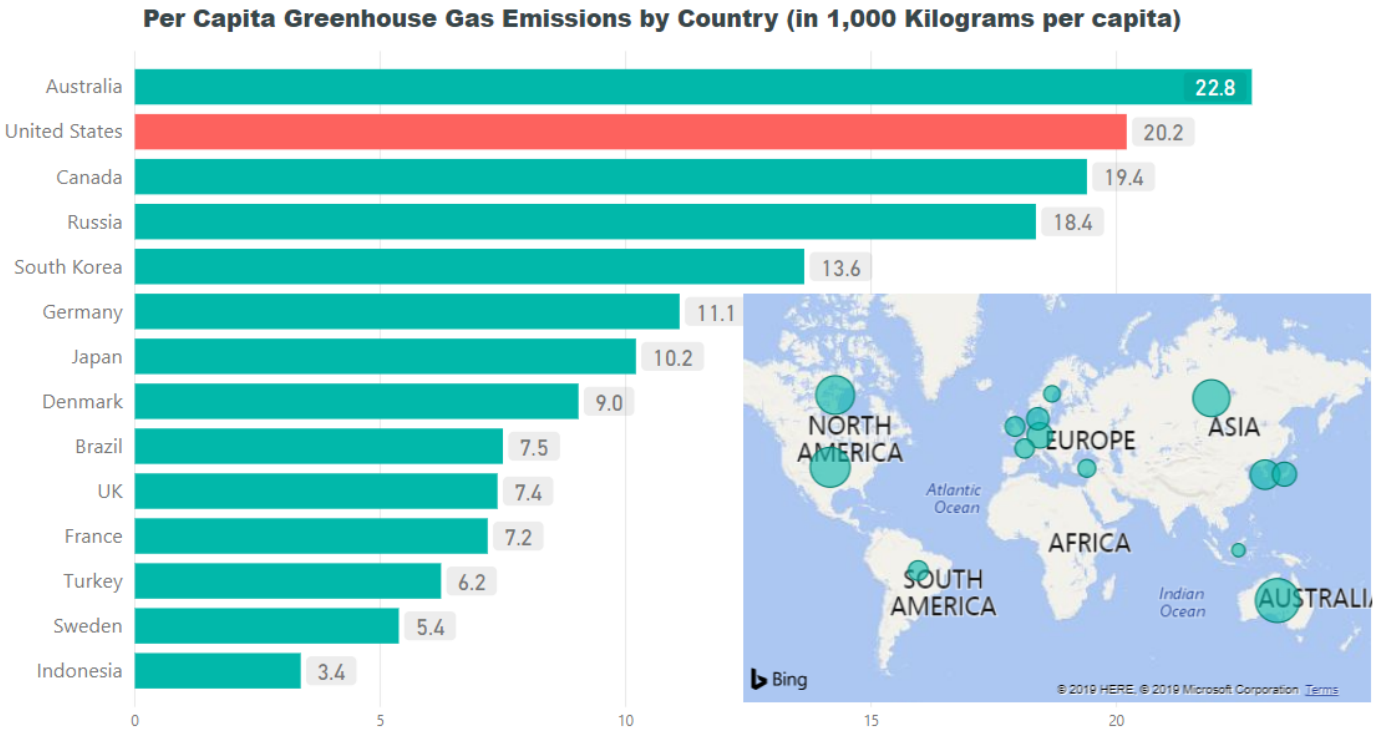

Figure 2: Both the Visualizations were created using Power BI

As there was a comparison between countries and there were many items(countries), horizontal bar chart was chosen. The horizontal bar for USA was purposely assigned red color as the magazine mostly revolved around US. This pre-attentive attribute was used to get the user's attention to the greenhouse gas emissions of USA, as it did not have the highest emission level, but I wanted the user to quickly notice that USA was at the top.

An additional visualization of the world map was added as chart junk as I felt it would aid in improving memorability while also not interfering with the understanding, it again shows that USA is one of the top contributors.

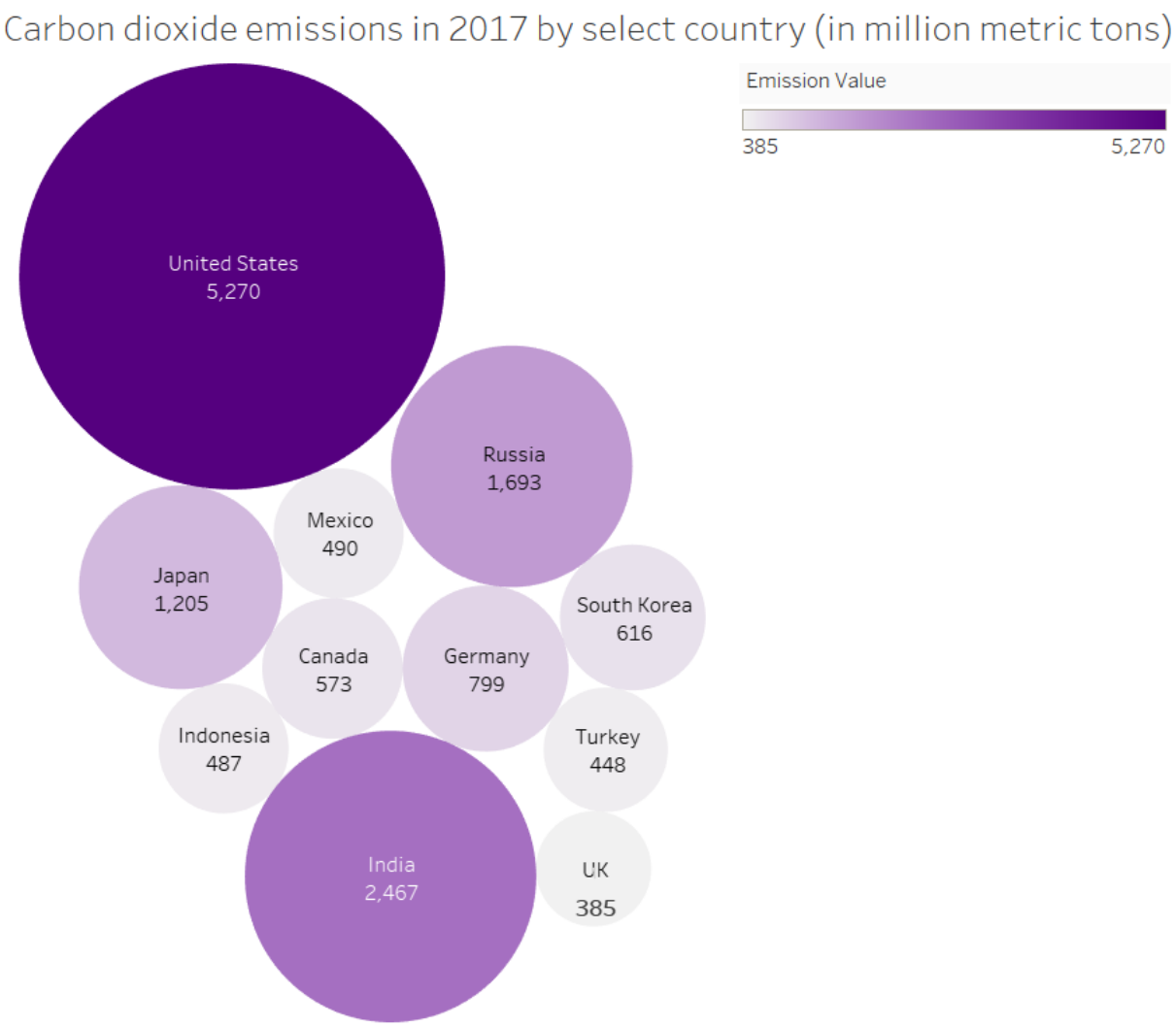

Figure 3: Visualisation was created using Tableau

Packed bubble charts usually work best for three dimensions of data, x and y for position of the bubbles and third value for the size of bubbles, although in my case I just had two dimensions but still decided to use the bubble chart. Technically the best option would have been column charts, but the volume of the circles based on values immediately lets the users know that there is a significant difference between USA and other countries. The colour also changes shade from lower values to higher values and a dark colour was purposely chosen so that the bubble size and the colour together act like a pre-attentive feature. The main intention was to make users quickly notice the emission difference between USA and other countries. The legend was also omitted in the magazine as it was not necessary as larger bubbles had darker colour which indicated nations having higher emissions were darker than others.

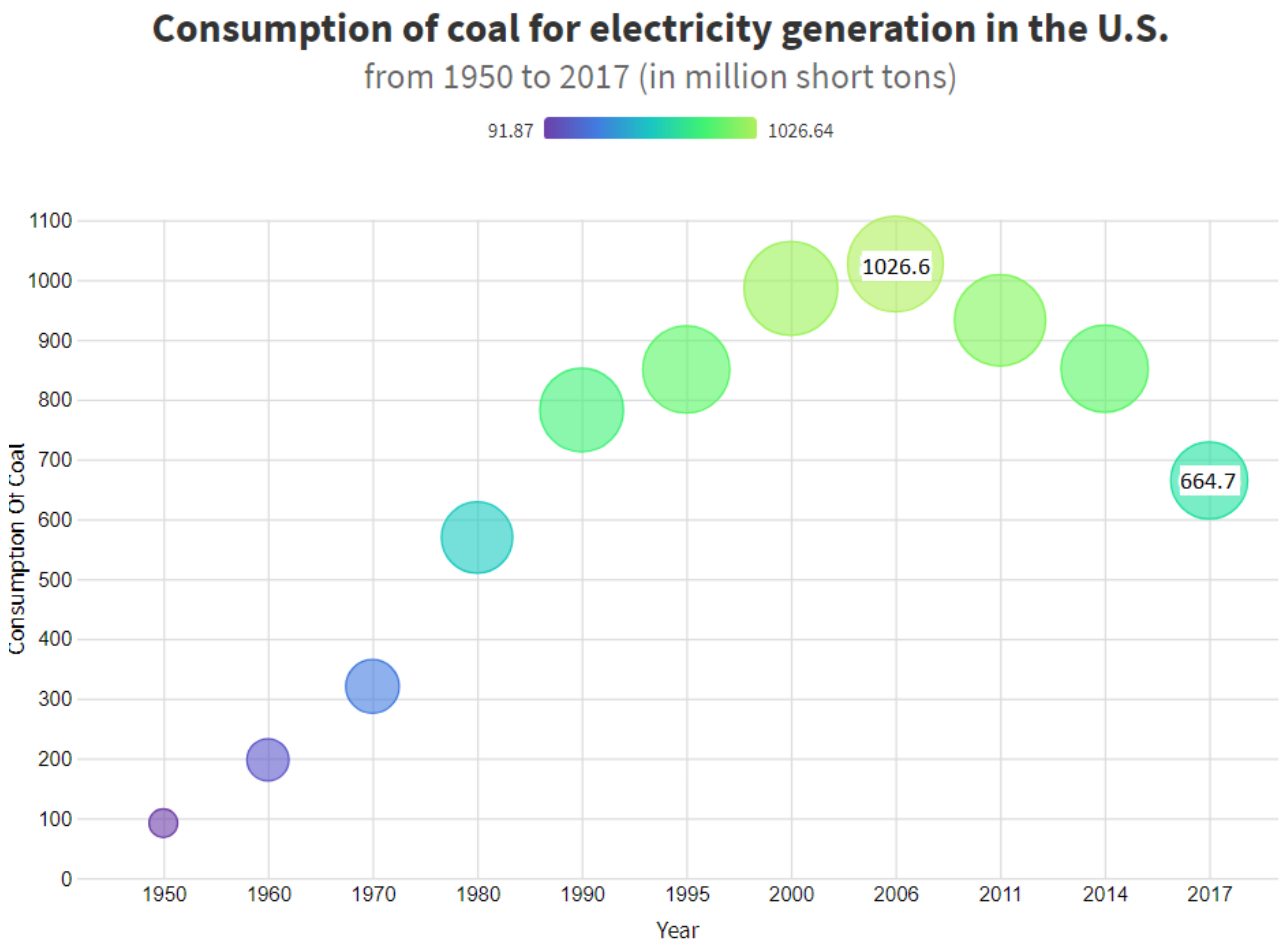

Figure 4: Visualization was created using Flourish

For showing the relationship between years and consumption of coal a scatterplot was used but using bubbles instead of dots looked more visually appealing and the focus in this plot was to show the change of pattern, that the use of coal was now decreasing. Using bubbles makes it harder for the users to read the values but the two most important values of 2006 and 2017 have been annotated.

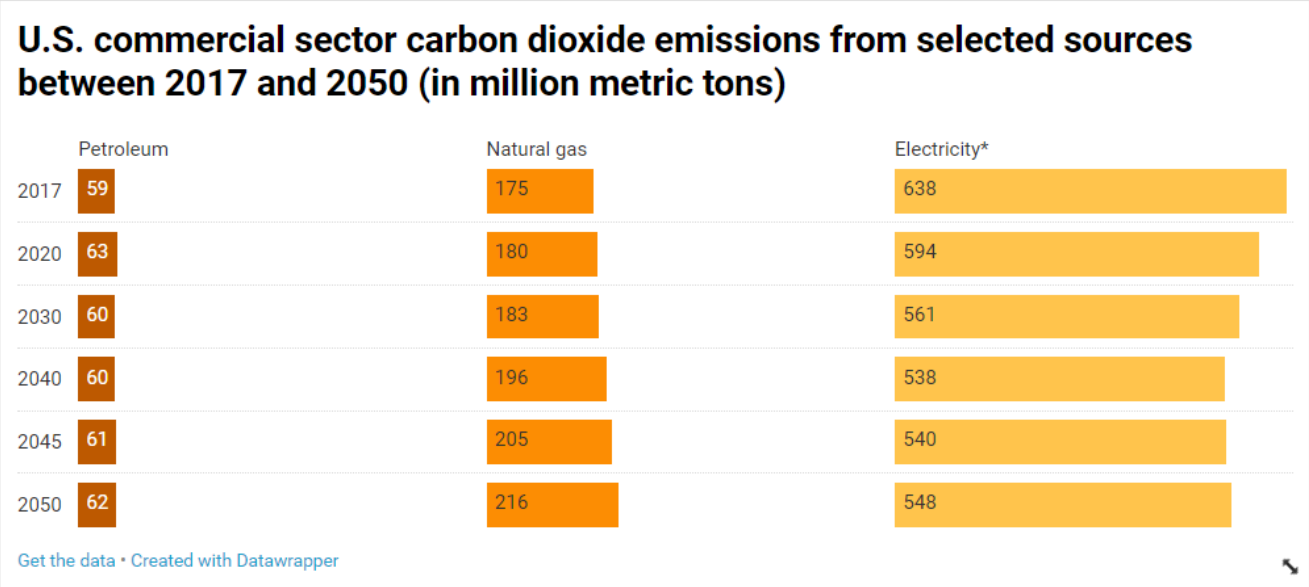

Figure 5: Visualization was created using data wrapper

Split Bar charts were used for this visualization as they made the difference in each source of carbon emissions clearly visible. For over time comparison between few categories column chart was technically the best option but the intention of using split bar instead was so that the users quickly notice that each category does not show significant difference in emissions from 2017 to 2050.

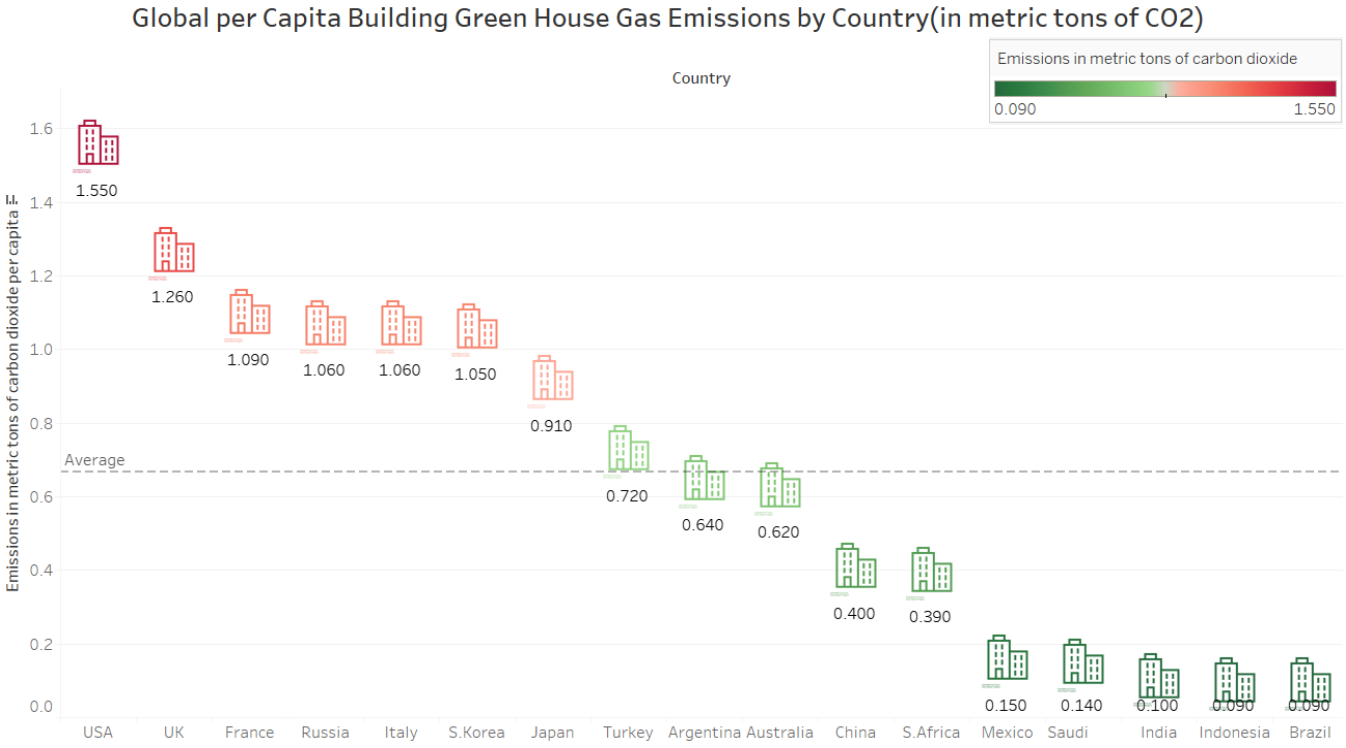

Figure 6: Visualisation was created using Tableau

To show the relationship between two variables scatter-plot was used but the mark used was of a building, as the visualisation is based on per capita building greenhouse gas emissions. The title is confusing but if the user were to look at the visualisation again, without reading the title he can figure out what the plot was about. The visualisation is also colour coded, darker green colour represents a more "greener" economy whereas a darker red zone indicates the per capita building emission was high indicating those countries are in more "danger" of global warming.

The shape used in the plot was downloaded from the noun project (https://thenounproject.com/)

The image was then added to a directory named shapes in, my tableau repository.

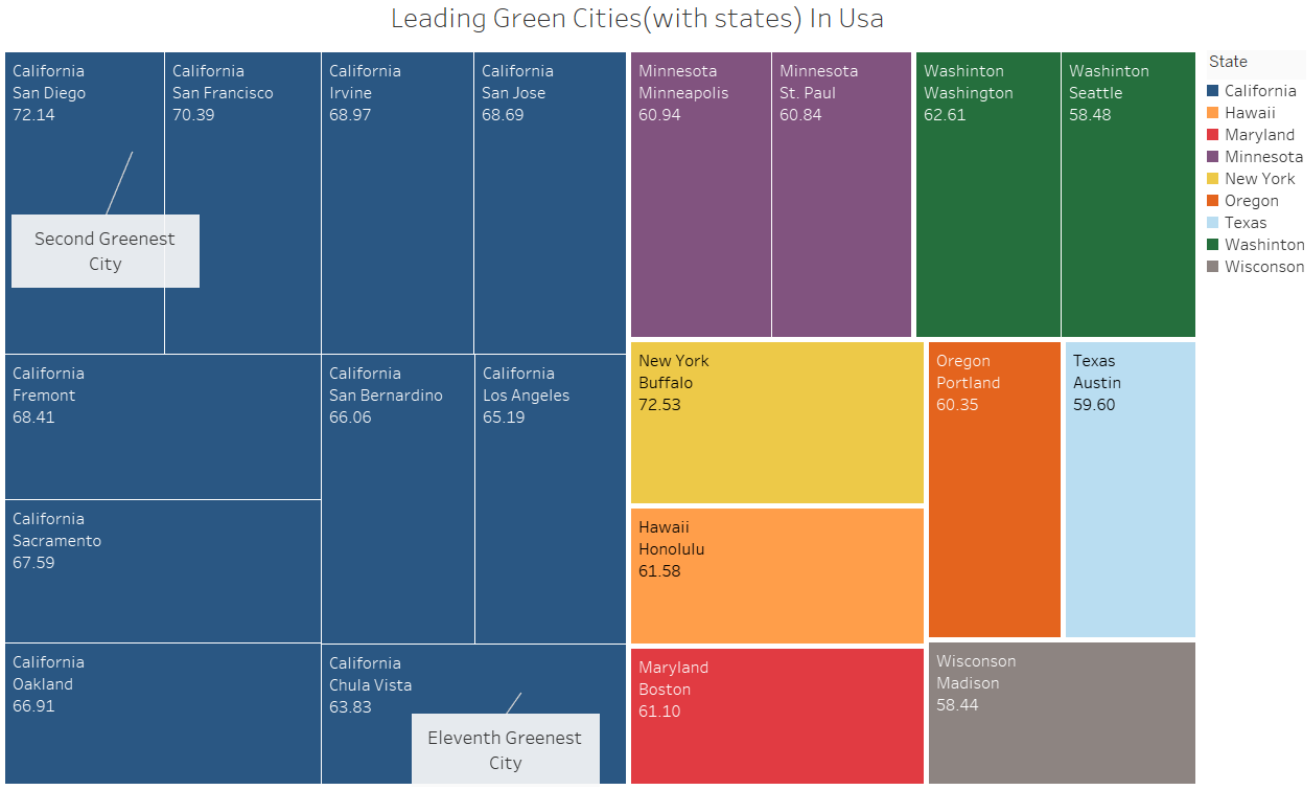

Figure 7: Visualisation was created using Tableau

A tree map was used for this visualisation as there was a hierarchical relationship in states and cities. The colours used in the plot are the official state colours of every state[10]. The visualization makes it clear that California has the greenest cities. The annotations have been added to convey to the user that even in states some cities are significantly greener than other cities.

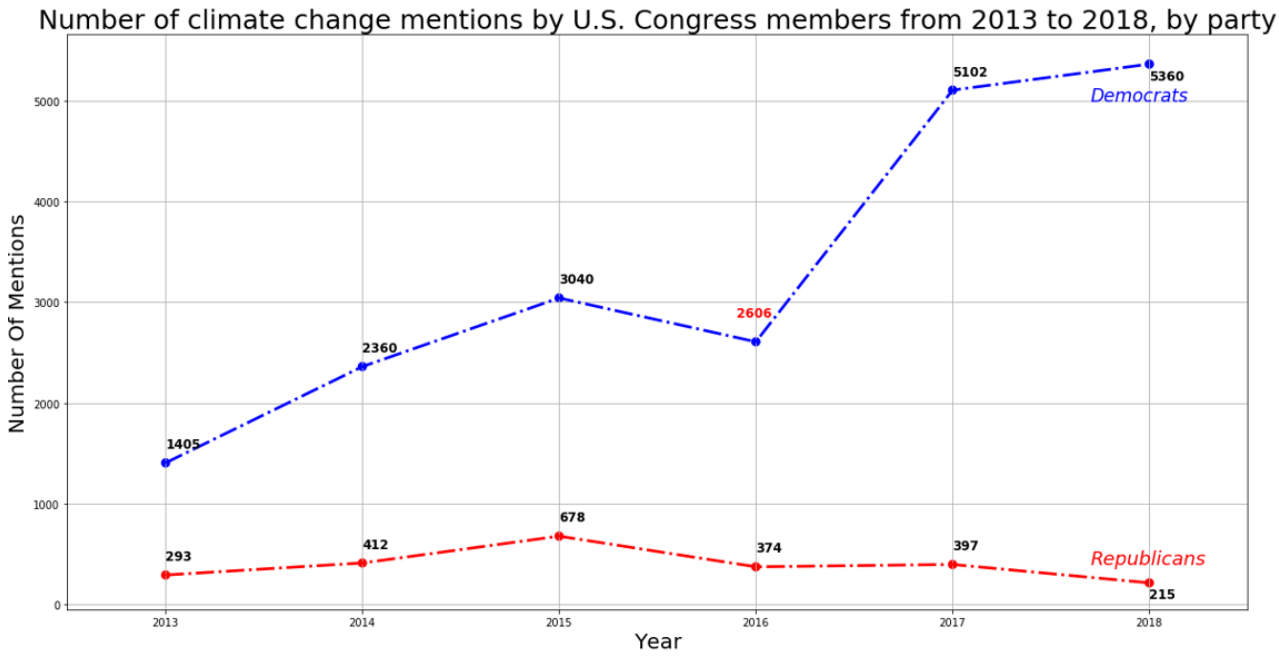

Figure 8: Visualization was created using Python(seaborn and matplotlib)
Line chart was used there was an over-time comparison in number of climate change mentions over many years. Blue line was purposely used to denote the democrats and red for republicans as they denote the colours of the parties. The value for number of mentions of climate change in 2016(year of elections) was annotated in red as the number to point out that the number of mentions of climate change went down to please the right wing who generally are in favour of the republicans.

Python Code:

```
Using seaborn in Python for plotting a line chart
import seaborn as sb
import pandas as pd
import matplotlib.pyplot as pt
#importing the files
politic=pd.read_excel("C:/Users/rohan/OneDrive/Desktop/data-viz-project/2018/ready-to-use/congress-members-mentions.xlsx")
politics=pd.DataFrame(politic)
print(politics.dtypes)
a=politic.Republicans[1]
b=politic.Year[1]
f,ax1 = pt.subplots(figsize =(20,10))
pt.ylabel("Political Association")
x=sb.pointplot(x="Year", y="Republicans", data=politic, color='red',alpha=0.8,linestyles=['-.'], markers=['o']);
y=sb.pointplot(x='Year',y='Democrats',data=politic,color='blue',alpha=0.8,capsize=0.2,linestyles=['-.'], markers=['o'])
pt.xlabel('Year',fontsize = 20,color='black')
pt.ylabel('Number Of Mentions',fontsize = 20,color='black')
#annotating Republicans
line=0
for line in range(0,5):
    x.text(line,politic.Republicans[line]+150, politic.Republicans[line], horizontalalignment='left', size='large', color='black', weight='semibold')
x.text(5,politic.Republicans[5]-150, politic.Republicans[5], horizontalalignment='left', size='large', color='black', weight='semibold')
#annotating Democrats
l=[0,1,2,4]
for val in l:
    y.text(val,politic.Democrats[val]+150, politic.Democrats[val], horizontalalignment='left', size='large', color='black', weight='semibold')
y.text(5,politic.Democrats[5]-150, politic.Democrats[5], horizontalalignment='left', size='large', color='black', weight='semibold')
#annotating 2016 separately to prove a point
y.text(2.90,politic.Democrats[3]+250, politic.Democrats[3], horizontalalignment='left', size='large', color='red', weight='semibold')
#sns.pt.show()
#labelling
pt.text(4.7,5000,'Democrats',color='blue',fontsize = 17,style = 'italic')
pt.text(4.7,400,'Republicans',color='red',fontsize = 18,style = 'italic')
pt.title('Number of climate change mentions by U.S. Congress members from 2013 to 2018, by party',fontsize = 25,color='black')
pt.grid()
```

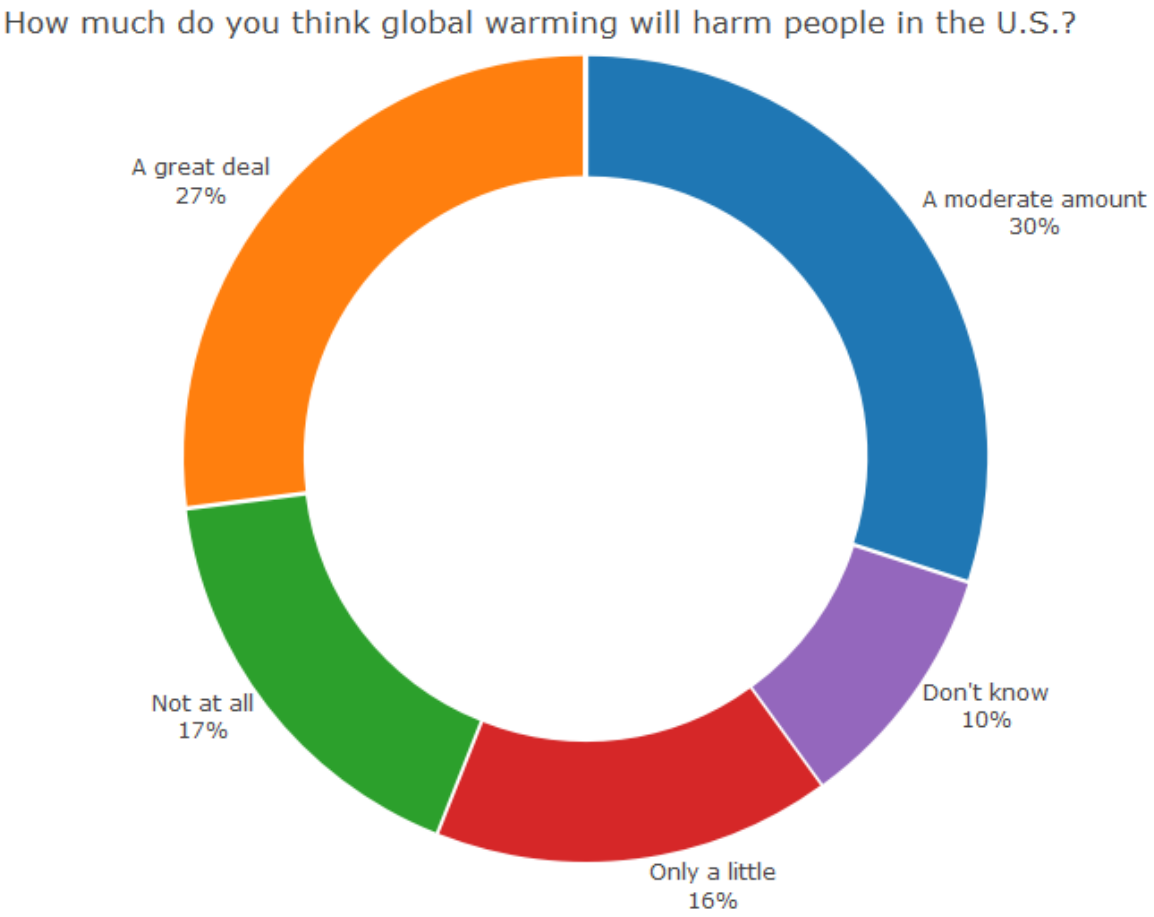

Figure 9: Visualization was created using R(plotly)

A donut chart was used for the visualization as there was a static composition of different opinions and all the opinions added to 100%.

R code:

```
library(plotly)
survey<-read.csv("C:/Users/rohan/OneDrive/Desktop/data-viz-project/2018/ready-to-use/how-much-global-warming-will-impact/survey-global-warming.csv")
View(survey)
col<-c('rgb(211,94,96)', 'rgb(128,133,133)', 'rgb(144,103,167)', 'rgb(171,104,87)', 'rgb(114,147,203)') p <-
survey
    plot_ly(labels = survey$Label, values = survey$Value,textposition = 'outside',
        textinfo = 'label+percent',pull=0.009
        ) %>%
  add_pie(hole = 0.7) %>%
  layout(title = "How much do you think global warming will harm people in the U.S.?",  showlegend = F,
        xaxis = list(showgrid = TRUE, zeroline = FALSE, showticklabels = TRUE),
        yaxis = list(showgrid = TRUE, zeroline = FALSE, showticklabels = TRUE))
```

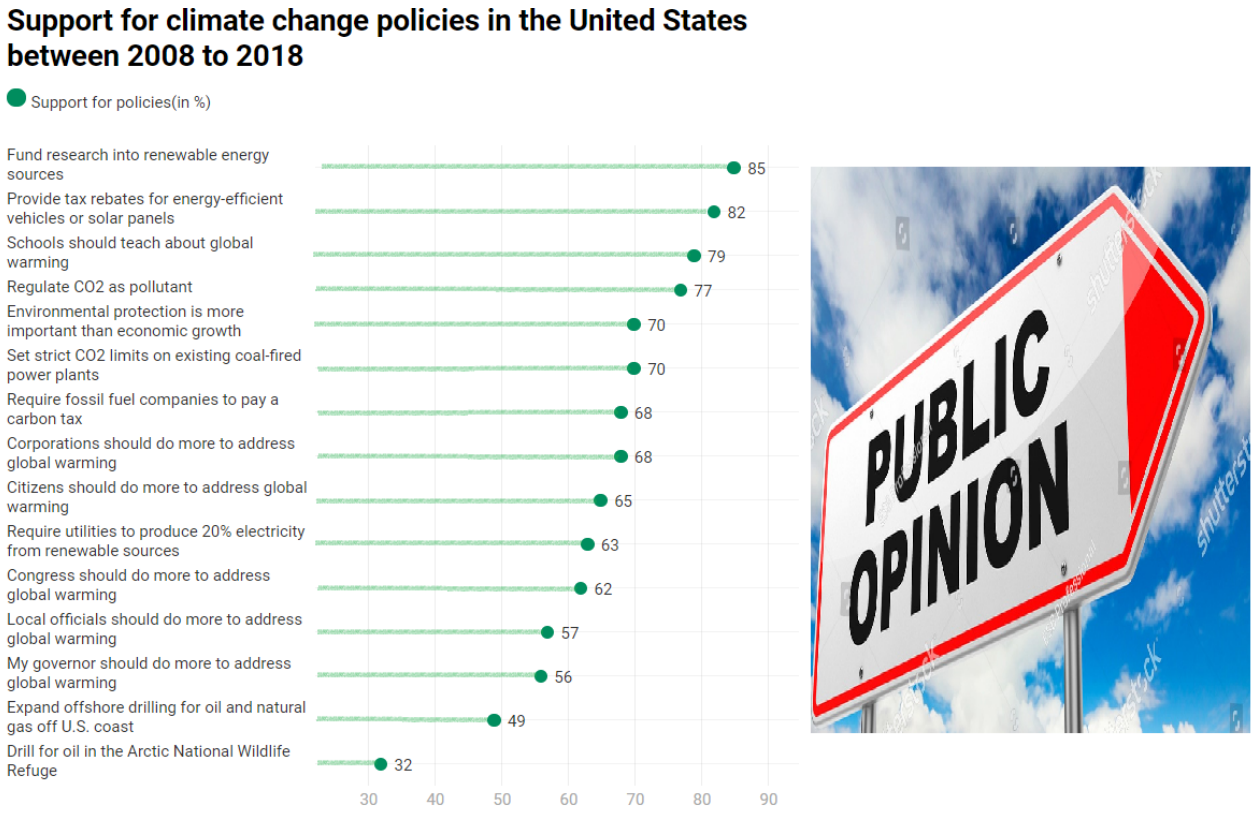

Figure 10: Visualization was created using Data Wrapper

As there is a comparison between support for different policies over the years, and there were a lot of policies, a horizontal lollipop plot was used which is very similar to a bar chart.

Data wrapper did not have in built lollipop chart, but had dot plots which I originally intended to use but that affected the readability. It was difficult to map policy and the percent support , so I connected the dots with solid lines.

The "public opinion" image was added as chart junk to let the user know the data was a part of a public survey.

[The image was downloaded from shutterstock.]