Analyzing New Jersey's Emission Reduction Goals by Combining Heterogeneous Data

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Abstract

Greenhouse gas emissions are the largest source of anthropogenic climate change, which has contributed to temperatures rising over 1.5C globally since the start of the industrial age. Such rising temperatures have significant long-term health and economic consequences, among them increased risk of death from heatstroke and loss of arable land through shifting biomes. To combat this, frameworks such as the Paris Agreement have been engineered to halt the rising temperatures, with many countries taking part in action to reach net-zero carbon emission status. In 2006 in New Jersey, the 80x50 framework was established with the goal to reduce net carbon emissions by 80% by 2050, a goal believed to align with the Paris Agreement. In 2020, the 80x50 framework was revised with a new set of proposed policies and milestones that kept the same 80% reduction goals in mind. Each emissions sector (commercial/residential, power generation, transportation, etc) has a set of individuals and milestones by certain years, with the earliest being 2025 and latest being 2050. This paper seeks to investigate the transportation and the residential/commercial sectors and their progress over the last 20 years to determine whether the 80x50 milestones are on target.

Introduction

The industrial age is estimated to have begun in the mid 18th century and ended in the late 20th century. This period of human history was characterized by a shift from agriculture-based economies to a more machinated society with a versatile output of goods. The industrial revolution not only massively changed the production sector by enabling the mass production of various products, but it also allowed for development of superior technology almost universally (van Neuss, 2015, pp. 3-6). The rapid expansion of the job market due to factory vacancies drove the development of densely-populated urban zones, a movement which also furthered the need for improved transcontinental and international transport. This was seen in the advancements made in railroad infrastructure, maritime trade through the creation of modern cargo ships. and eventually in the aviation industry (Alvarez-Palau, 2020). In addition, the growth of factories also led to the increased amount of local transport, namely in the form of automobiles. Even in agriculture, an industry which was heavily reduced during this time, machination and pest management paved the way for large increases in the efficiency of food production (OER Commons, 2018). All of these changes in infrastructure coupled with revolutions in healthcare, education, and communication have led to an overall increase in the quality of life (Cutler & Miller, 2005).

That being said, there are significant drawbacks that are also associated with the industrial revolution (Obschonka, 2018). Despite the many successes this period had, they also somewhat contributed to massive problems which have developed into major global issues today. The prime example of this is the constantly rising average global temperatures since the start of the industrial age. As of 2024, the average global surface temperature is about 1.55 degrees Celsius higher than its counterpart in 1850 (Barrage & Nordhaus, 2023). While a certain amount of temperature variation as a result of changing long-term climates is somewhat expected, such a drastic increase in less than two centuries dismisses this idea. The rising of surface temperatures has been attributed both directly and indirectly to anthropogenic causes (US EPA, 2025). The earth's surface temperature maintains its warmth via the greenhouse effect. This effect stipulates that certain gaseous compounds in the atmosphere act as a blanket to trap heat near the surface of the earth. While this effect may often receive a negative connotation due to its association with anthropogenic climate change, it is essential to human life as without the presence of these gasses the earth would not retain enough heat to sustain life. However, human action during the industrial age has amplified the effects to the point that they are severely harmful to human life (US EPA, 2025).

Impacts to Humans

The impacts to human life that result from rising surface temperatures range from direct illnesses to indirect social costs through the damaging of infrastructure. Increasing temperatures globally have caused shifts in typically tropical diseases to spread further from the equator to more temperate climates, namely Malaria (Rocque et al., 2021). In already temperate/cooler climates such as that of NJ (the focus of this paper), heat-related illnesses such as heatstroke have become significantly more common and threaten populations to a larger extent, most notably the elderly. New Jersey has issued official warnings to the elderly and the demand for better urban cooling in these areas has increased drastically. In addition to these, there are also more indirect health concerns posited by the overall increase in surface temperatures, including more favorable conditions for harmful bacteria, vector species, asthma, toxic algal blooms, and respiratory diseases such as asthma (Rocque et al., 2021). There are also environmental costs to consider when evaluating the total impact of rising surface temperatures on humans.

As temperatures increase across the earth, biomes (areas characterized by particular longlasting precipitation and temperature) shift. Generally, temperature and tropical zones have expanded farther from the equator to replace cooler biomes, such as the northern boreal forests and snowy tundras in Canada (Bonannella et al., 2023). These changing biomes lead to changing habitats for all species living in these areas. While these conditions may benefit or harm certain species, general trends point to most experiencing the latter (Bonannella et al., 2023). A primary example of this in North America is the rapidly diminishing population of the monarch butterfly due to habitat loss of both breeding and feeding habitat as a result of climate change. Shifts in biomes also impact agricultural output, as the efficiency of certain crops often decrease as areas may shift away from ranges of tolerance (Bonannella et al., 2023). These impacts have social and economic implications. According to projections, each metric ton of CO_2e emitted costs about $258. In the United States alone, emissions reach over 6 Billion MT annually. This equates to about 1.6 Trillion USD annually in social costs (Barrage & Nordhaus, 2023), although this is a global estimate and regional differences may decrease this number. More importantly, climate change related deaths are projected to reach 83,000,000 by the year 2100. This number could be as high as 275 Million or as low as 20 million depending on what is done to combat climate change in the coming years (Barrage & Nordhaus, 2023).

Causes of Global Warming

Global warming and the magnification of the greenhouse effect are caused by greenhouse gasses (GHGs) which are quantified on the basis of their potency and how long they remain in the atmosphere. The basic unit for quantifying GHG emission impact is via CO_2e or Carbon Dioxide equivalent. One metric ton of CO_2e equates to how much global warming potential one metric ton of CO_2 has over the span of 100 years. Other gasses use CO_2e as a scale to determine their potency and longevity in the atmosphere. For example, one metric ton of methane (CH_4), one of the most prominent GHGs, has the same polluting power of 25 metric tons of CO_2e. This means that even though methane takes up a smaller share of the atmosphere compared to Carbon Dioxide, it still plays a significant role in the greenhouse gas effect due to its potency.

The sources of greenhouse gasses are numerous but can vary in relative presence depending on each individual area. Generally, the main sources for anthropogenic greenhouse gas emission are transportation, energy production, commercial/residential, industrial, landfills, black carbon, and agriculture (Barr et al., 2020). Each individual source has its own subcategories which consist of different GHG sources, but they in total contribute to over 99% of total emissions. For example, agricultural emissions are most commonly related to land-use and the majority of CO_2e is produced via methane. Alternatively, the energy and transportation sectors (which are most commonly the largest shareholders of global CO_2e emissions), pollute primarily via CO_2 itself. Each of these sectors has, since the start of the industrial revolution, grown extensively in production, mechanization, and efficiency. However, overall sustainability was not as significant of a theme during this period, leading to drastic increases in emissions overall (Graven et al., 2020). To put this into context, CO_2 emissions alone in 1850 and 1900 were roughly 200 million and 2 billion metric tons per year. Today that number is close to 40 Billion. These numbers continue to follow positive trends although at less steep rates (Ritchie & Roser, 2020). Part of this is due to the general idea that populations and the global economy increasing are directly proportional to the increasing amounts of CO_2e being emitted.

Legal Frameworks and the 80x50 Report

As a result of carbon emissions and subsequent climate change, legal frameworks both nationally and internationally have been implemented. The most popular of such frameworks is the Paris agreement which stipulates that countries should continuously slash emissions in an effort to become net 0 in the near future. The objective of these frameworks is to structure the development of smaller goals and policies. A more local example, particularly in select parts of the USA, is the idea of the 80x50 initiative (Barr et al., 2020). This stands for 80% reduction in carbon emissions by the year 2050. One state to implement this is New Jersey, a state known for already being a leader in climate-friendly policies. Given its small size but large population density, New Jersey is unique in its approach to 80x50, having ambitious milestones that include having only EVs on the road by 2050, fully decarbonizing buildings, and slashing total emissions from 124 million metric tonnes (MMT) in 2006 to about 24 MMT in 2050 (Barr et al., 2020).

Gap and Justification of Gap

Given the perceived ambitiousness of New Jersey's 80x50 report, there are concerns that the milestones set by the report on the road to 2050 will not be reached in time. Currently, no cross-examination of information on New Jersey's carbon emission reduction efforts exists. This may prove detrimental as pivoting to a different strategy in the recent future would be more plausible if the goals themselves were found to not be as effective as what was previously intended. The report itself states that no large scale analysis has been done to determine whether or not these milestones are set to be achieved (Barr et al., 2020). However, data for multiple variables strongly correlated with carbon emission reduction is available on the internet for public use (Ritchie & Roser, 2020). This research paper intends to expand upon this gap by analyzing whether or not individual sectors that emit CO2e gasses are on track to reach their eventual targets by 2050. As of 2024, NJ has dropped from roughly 124 MMT of CO2e in 2006 to about 96 MMT. However, almost all of this progress had been made in the energy production sector as coal-power plants shifted to fossil fuels (and nuclear to an extent (USEIA, n.d.)). The other sectors have seen marginal decreases or have remained stagnant during this time. Thus, it is also vital to understand why the goals may not be reached if they are not projected to do so. To be more specific, this research paper will focus specifically on the transportation sector and the residential/commercial sectors as these are the largest contributors to carbon emissions in NJ (Barr et al., 2020). Data for other sectors exists but is not plentiful enough to conduct meaningful analysis on at this time.

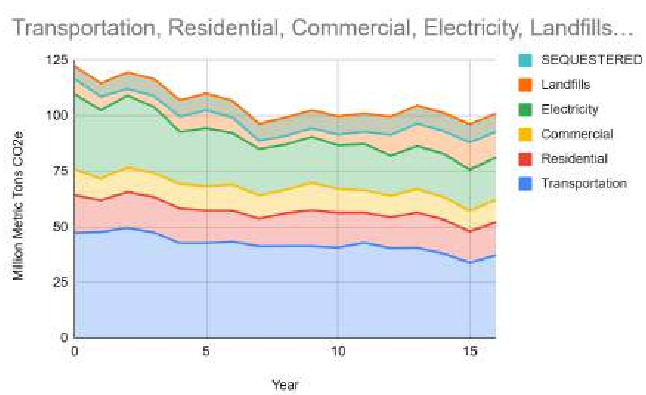

Fig 1: Layered map of CO2e emissions MMT by sector since 2006

Methodology

This study aims to analyze and quantify the progress that New Jersey has made in the past two decades in regards to the milestones outlined in the Global Warming Response Act 80x50. The objective will be to determine whether the milestones of the report are in line with the progress being made and the data produced and analyzed will be used to further explain the trends found. This study will specifically pertain to the transportation sector and the commercial/residential sectors (this was done due to the fact they have very similar patterns as will be highlighted). When performing a study such as this, comprehensive data is required in order to base judgements that can be used to derive meaningful conclusions (Wang et al., 2023). A sample size too small such as one that only incorporates a timeframe of 2-3 years or a limited amount of considered variables would lead to likely inaccuracies in analysis. Additionally, only drawing from one or two datasets would increase the likelihood of bias and would not derive any new meaning from the data (Wang et al., 2023). Due to the scale of the data analyzed being on a state level, it would only be feasible to draw data from sources already available publicly as opposed to physical experimentation. This meant that a meta-analysis of data was the most suitable methodology for conducting this paper. That being said, a traditional meta-analysis approach would have to be modified given the heterogeneity of the data being considered. Conventional meta-analyses of data involve searching multiple related studies for common trends or themes in conclusions found. However, the data used for this experiment had to be more widespread and thus it was more difficult to get them in similar formats to compare them. An approach that was considered was to calculate an I2 value which measures the exact amount of heterogeneity in the data (Ruppar, 2020). This would allow for direct comparison of the datasets without having to combine them. This was ultimately rejected because the data was too heterogenous and the common year variable made it significantly more justifiable to directly combine the datasets. While an I2 statistic is commonly used to quantify the heterogeneity of data in meta-analysis, it is ultimately inappropriate for this study as the datasets used vary significantly in format, scale, and measured variables. All datasets did however align along one temporal variable: year. This consistent annual categorisation across datasets allows for accurate chronological alignment which is a better solution than trying to statistically harmonise inherently incompatible formats. Ultimately, these factors led to the selection of a meta-analysis of heterogeneous data online by first collecting, cleaning, aggregating, combining, and then correlating and regressing the resulting datasets. In addition, alternative charts were also created to help explain the trends shown in the regression by relating it to other variables that were part of the data.

Methodology Justification

The proposed methodology of a meta-analysis consisting of a combination of largely heterogeneous data draws inspiration from similar studies conducted in the field of carbon emission analysis. The idea to combine data into a structured dataset before analyzing has proven to be significantly more accurate than analyzing individual datasets and creating predictive models from them (Nguyen et al., 2023). They conclude that models such as linear regression which are used in this methodology gain significantly more accuracy when fed more comprehensive data from a larger amount of sources. Another key aspect of this paper is properly addressing the heterogeneity, or the fundamental differences in data structure, of the various files used for this project. Unlike typical meta-analyses which use meta-regression plots to evaluate the differences in data based on select columns, such shared columns are not present in this set of data due in part to the lack of long term publicly available data. Thus, multivariable regression will be used to create models for the net carbon emissions per sector and then will be used to highlight future trends. This was used in a similar paper by (Zhou et al., 2021), which successfully used regression analysis as a tool for finding the driving forces for rising CO2 emissions in China. The data itself will be compiled partially in excel and in Python using the pandas library. The pandas library of code allows for the importation of csv files which are transformed into DataFrame objects. These DataFrame objects can be used to perform concatenation of multiple datasets and then can be used in conjunction with other libraries to perform regression on specific columns (Singh et al., 2024).

Methodology Enactment

The first major step in enacting the methodology was to select parameters for the types of data that would be gathered. The source, structure, and content of the data was considered in order to select useful data which would not obscure results. This paper only focuses on transportation and residential/commercial sectors which outlined multiple key areas of interest. Only structured data was widely available online and was almost exclusively found in CSV file format. The small amount of data provided in the 80x50 report through tables gives the amount of CO2e per source for each sector in every year since 2006. This table was converted to a CSV file and served as the primary dataset from which the rest of the data was built. Another parameter is that each subsequent file found had to have some sort of annual categorization of data. For example, one dataset found from the afv (alternative fuel vehicle) report categorized the amount of electric vehicles purchased per year over the course of the period 2019-2024. Although not a broad enough of a time span to be considered ideal, electric vehicle growth before this period was comparatively negligible and thus such a time span was appropriate. Although 2015 saw slight increases in EV investment on both the east and west coast, the number of registered vehicles is only about 1% of the total on the road today according to the report.

In addition, data that provided itemized lists of certain information (such as the complete vehicle registration registry of New Jersey and the solar panel installation registry of New Jersey) had to be aggregated by the year. For example, each row that represented an individual car registration had to be combined. This structured the data so that each row contained a year and all of the aggregated statistics, including the total number of cars sold, the total amount of new cars registered, the amount of each type of vehicle being sold (EV or gasoline powered), and so forth. Datasets that were considered to not be from a trustworthy source or had too small of a sample size were rejected to avoid considerable bias. The primary search terms used were

“New Jersey Vehicle Data”, “New Jersey emissions data”, and “New Jersey space-heating and natural gas data”. Data that was not specifically restricted to New Jersey was also rejected because the proportion of emissions per sector is different compared to neighboring states. In total, 8 sources of data were used which varied in size from 20 rows (emissions by sector by year) to roughly 830000 (total vehicle registrations). The main sources of data were the NJDEP, SustainableJC, the afv report, and the 80x50 report itself.

The next step was to begin combining data into comprehensive datasets that could then be analyzed using regression. Two culminating datasets were produced to represent the transportation sector and the residential/commercial sectors respectively. Virtually all of both residential and commercial sector emissions are traced to natural gas being used for space heating and cooling so they were combined. The data had to be aggregated by year for both but more columns were added to avoid losing important information, such as counters to sum up the amount of vehicles that were unregistered and abandoned per year based on the discrepancy between registrations and total cars on the road. The transportation dataset was also used to calculate an experimental percentage of the amount of vehicles on the road and purchased per year that were EVs. The commercial/residential sectors were related to the expansion of solar panels as a clean energy investment. Solar panels are the primary source of clean energy on a domestic level (excluding nuclear power plants) and thus they stand the most significant chance of replacing natural gas as the source of energy for these sectors (The Conference Board, 2024).

A conversion factor of 0.375 kg of CO2e emissions per kilowatt hour of natural gas related energy production was found (Climeco). This coefficient was used in tandem with the wattage capability of existing solar panel installations to determine what level of investment in solar energy would be required to offset both sectors emissions by the year 2050. After this step, all 800000+ rows of data were condensed, combined, somewhat modified with conversion factors, and aggregated into more easily accessible data that could then be analyzed.

As stated before, the chosen method for analysis was regression. Before conducting the regression, several other charts were created to visualize the newly formed datasets and provide context for any conclusions that could be drawn from the regressions themselves. Such charts included an area graph that represented the proportions of electric vehicles and gas-powered vehicles as positively adding to the total number of vehicles whilst the amount of obsolete vehicles is also plotted on the negative y-axis.

Lastly, regression models were generated using the combined datasets. Regression was first used to calculate the predicted amount of CO2e emissions per year for each sector until 2050, and the final values were printed. This was accomplished by importing the complete csv files into a Google Colab code notebook and converting it to a DataFrame with the pandas library. Then with the addition of other libraries for model creation and visualization (numpy, matplotlib.pyplot, sklearn), these models were created.

Results

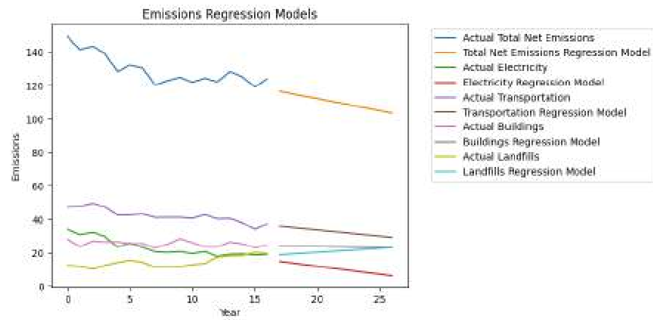

Figure 2: The overall regression model that plotted each individual sector of carbon emissions as a linear function is shown below:

This model shows overall decreasing linear trends in each sector as well as the net emissions, with the exception being landfills. The years are since 2006 which is the start of the available data for this model. This can be attributed to the growing problem of waste management and the subsequent methane emissions that follow as a result. The other sectors were hypothesized to have linearly decreasing trends, although the rate of decrease over time was less clear. The 80x50 report approximates the trend of carbon emissions to be decreasing and linear, although behavioral shifts and policies will create lag. That being said, time-series models carry the logical limitation that any future policy revisions or global irregularities such as the coronavirus pandemic cannot be predicted and thus are better taken as trends than predictive of exact values (Zillz, n.d.). Commercial and residential emissions in this scenario are aggregated under “Buildings” and it is apparent that the slope of this model is very minimal implying that there could be little to no change in this sector whereas the 80x50 report expects it to be a 0 emission sector by 2050 (Barr et al., 2020).

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Predicted Total Net Emissions for 2045: [76.72107843]
Predicted Electricity Emissions for 2045: [-11.19215686]
Predicted Transportation Emissions for 2045: [15.56372549]
Predicted Buildings Emissions for 2045: [20.64681373]
Predicted Landfills Emissions for 2045: [32.23480392]
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Figure 3: Predicted values for 2045 by the model in Figure 2

These are the predicted values of the regression model in Figure 2. The most notable observations include a very marginal drop in building emissions and a moderate (and still below expectation) decrease in both transportation and total net emissions.

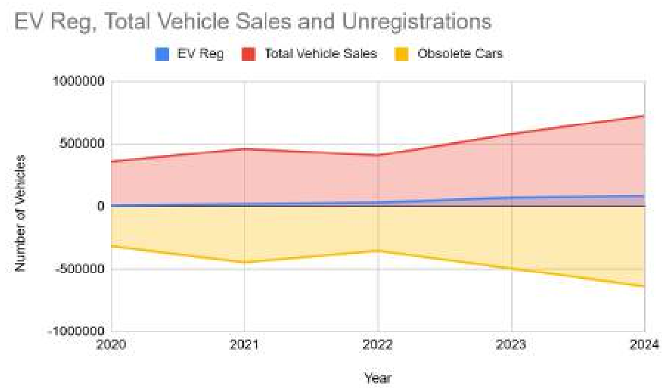

Figure 4: Area graph of EV and Vehicle sales over time.

Figure 4 illustrates how over time, even though the market share of electric vehicles in comparison to gas powered vehicle sales has increased from about 2% to 11% of all sold vehicles since 2020 (Barr et al., 2020), the total number of vehicle sales has also decreased and thus minimized the positive impacts that would have been associated with lesser gas powered vehicles on the road.

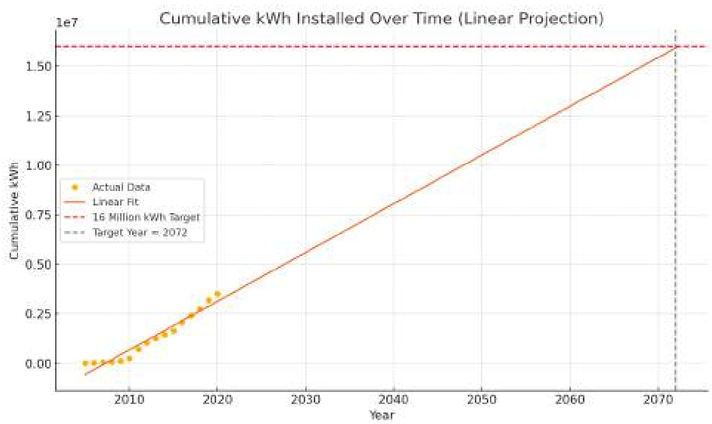

Figure 5: Linear regression of solar panel installations

This linear regression model shows the total solar panel wattage installed since 2005 and demonstrates a linear line of best fit. A linear line was chosen as opposed to an exponential one due to the amount of new solar panels every year stabilizing after having shot up massively since 2022 as evidenced by the chart. Using conversion factors, it is estimated that each kW of wattage saves 0.816 tons of metric CO_2 per year. Given the 24.6 MMT of residential and commercial sector emissions to date, the amount of solar installations required to offset this stands at around 16 million kW. The purple vertical line represents the year at which there would be enough solar panel installations to completely shift from natural gas production in buildings to pure electrification and solar panels (When the total available kWh in NJ reaches 16 million). This is a theoretical estimate that assumes ideal conditions where solar wattage is directly used to offset natural gas emissions in the residential and commercial sectors. In reality, grid transmission losses, electrification of appliances, and peak usage misalignment could increase or decrease this number. This aligns with the 80x50 goal to adopt clean energy in this sector, but is significantly slower than anticipated with the predicted year of reaching net 0 emissions being the year 2072.

Conclusion

To answer the initial research question regarding whether or not 80x50 goals are on target to be met in the transportation and building sectors, it is ultimately not likely given the current trends seen. New Jersey was predicted to reach 24.1 MMT of CO2e emitted by the year 2050 (Barr et al., 2020) but these regression models suggest that number to be over triple at about 76 MMT. The transportation sector is expected to see significant progress in the future due to the further incentivization of EVs as proposed by the 80x50 report which suggests that 85% of vehicles sold by the year 2030 will be electric vehicles (Barr et al., 2020). That being said, it is extremely unlikely for this to occur given the data collected as 2024 estimates place that number at around 11% instead. Meanwhile, the building sector remains largely untouched and this is likely to remain a significant obstacle in achieving 80% reduction in carbon emissions by 2050. New Jersey as a state has an infrastructure heavily dependent on natural gas from the past, and electrifying buildings to be net neutral entails a heavy cost. It is also important to note that even if buildings are electrified, unless their new energy source is renewable and a non-pollutant, their emissions would simply be transferred to the energy production sector.

The main questions that arise from these conclusions pertain to how the situation could be remedied without calling for a complete overhaul of policies. It is also crucial to understand why there have been significant difficulties when tackling this problem. This research implies through the chart and data collected that the battle with transportation emissions is less intertwined with electric vehicles than had previously been thought. While electric vehicles do not produce as much CO2e as their gas-powered counterparts, factors such as car prices, charging times, and location of EV chargers serve as heavy disincentives. The area chart also implies that the total share of vehicles is increasing, presumably due to a steadily increasing population. What this means is that the total number of vehicles must come down in order to reduce the net carbon emissions in this sector. There have been multiple proposed solutions for this endeavor, most notably the ideas of a 10 minute walkable city, increased work-from-home opportunities, and increased investment into public transport (J. Shope, personal communication, March 15, 2025). All of these would decrease the total amount of vehicles on the road, decrease the length of still existing vehicle trips, and encourage shifts to more environmentally-friendly transport, thus allowing total emissions to drop. On the building's front, both regression models imply that even if electrification of the grid is occurring, the rate at which it does occur is slow enough to not reach the 80x50 goals. The implications of this are that more investment is required in older buildings to convert from natural gas dependent temperature control to cleaner energy.

This research also supports the idea that the reason why NJ appears so off target may not have to do with the goals themselves but rather the awareness of their existence in the public (J. Shope, personal communication, March 15, 2025). As part of constructing this paper, Professor James Shope, who worked on the 80x50 report and a subsequent evaluation of NJ's emission reduction goals, was interviewed. He expressed the idea that one of the key reasons why NJ appears stuck is the fact that the general public aren't really aware of how they could help (J. Shope, personal communication, March 15, 2025). This means that one area of interest could be a better system of outreach or public awareness that connects the goals directly to the people meant to enact them. It has also been scientifically proven that improved education about climate change leads to increased support for climate-friendly policies (Dabla-Norris & Khalid, 2023).

Beyond the limitations expressed in the methodology, some also exist in the implications derived from this research. The most important factor to note is the forced simplification of regression models due to a few reasons. The biggest reason why much of the detail was abstracted was due to the lack of a sample size. Since many of the policies that drive impacts such as EV and solar panel incentives have only come into effect around 2019, it becomes difficult to understand whether trends will continue linearly as has been generally assumed. The methodology itself is also hindered in achieving complete efficiency because much of the data was missing key values and had to be cleaned out of the dataset entirely. Since the dataset also draws from multiple sources to reduce bias, some reference calculations such as those regarding EV percentage of cars on the road yield different values based on which source of data is used. In the future, more data will be available and trends may be more accurate compared to what is available as of April 2025. Future studies should also include direct collection of data rather than relying on what is publicly available as well as multivariable regression if more types of data can be maintained which would likely be more accurate of an indicator for a time-series prediction. In addition to having more data, a better statistical representation of demographic data in the regression models could serve to further highlight potential solutions.

Works Cited

Alvarez-Palau, E. J. "Transport and Urban Growth in the First Industrial Revolution." Yale Economics, 30 Sept. 2020, https://economics.yale.edu/sites/default/files/marketaccessgrowth_presteam_sept272020.pdf.

Barr, H., et al. RESPONSE ACT. New Jersey Department of Environmental Protection, 15 Oct. 2020, https://dep.nj.gov/wp-content/uploads/climatechange/nj-gwra-80x50-report-2020.pdf.

Barrage, L., and W. D. Nordhaus. "Policies, Projections, and the Social Cost of Carbon: Results from the DICE-2023 Model." NBER, 10 Apr. 2023, https://www.nber.org/papers/w31112.

Bonannella, C., et al. "Biomes of the World under Climate Change Scenarios: Increasing Aridity and Higher Temperatures Lead to Significant Shifts in Natural Vegetation." PeerJ, 2023, https://doi.org/10.7717/peerj.15593.

Cutler, D., and G. Miller. "The Role of Public Health Improvements in Health Advances: The Twentieth-Century United States." Demography, vol. 42, no. 2, 2005.

Dabla-Norris, E., and S. Khalid. "Public Support for Climate Change Mitigation Policies: A Cross-Country Survey." International Monetary Fund, vol. 2023, no. 223, 2023, https://www.elibrary.imf.org/view/journals/001/2023/223/article-A001-en.xml.

Graven, H., R. Keeling, and J. Rogelj. "Changes to Carbon Isotopes in Atmospheric CO_2 over the Industrial Era and into the Future." Global Biogeochemical Cycles, vol. 34, 2020, https://doi.org/10.1029/2019GB006170.

Nguyen, T., et al. "Combining Datasets to Improve Model Fitting." arXiv, May 2023, https://arxiv.org/pdf/2210.05165.

Obschonka, M. "Research: The Industrial Revolution Left Psychological Scars That Can Still Be Seen Today." Harvard Business Review, Mar. 2018, https://hbr.org/2018/03/research-the-industrial-revolution-left-psychological-scars-that-can-still-be-seen-today.

OER Commons. "Statewide Dual Credit World History, The Period of Revolution 1650–1871 CE, Chapter 8: Industrial Revolution." 2018, https://oercommons.org/courseware/lesson/87910/student/?section=1.

Ritchie, H., and M. Roser. "CO_2 Emissions." Our World in Data, 2020, https://ourworldindata.org/co2-emissions.

Rocque, R. J., et al. "Health Effects of Climate Change: An Overview of Systematic Reviews." BMJ Open, 2021, https://doi.org/10.1136/bmjopen-2020-046333.

Ruppar, T. "Meta-Analysis: How to Quantify and Explain Heterogeneity?" European Journal of Cardiovascular Nursing, vol. 19, no. 7, Oct. 2020, pp. 646–652, https://doi.org/10.1177/1474515120944014.

Singh, B. P., et al. "Efficient Dataframe Systems: Lazy Fat Pandas on a Diet." arXiv, 2024, https://arxiv.org/html/2501.08207v1.

The Conference Board. “Report: Solar Power Is Cheaper than Ever—But Overreliance Risks Destabilizing US Electricity Markets and Undermining Energy Investments.” PR Newswire, 21 Feb. 2024, https://www.prnewswire.com/news-releases/report-solar-power-is-cheaper-than-everbut-overreliance-risks-destabilizing-us-electricity-markets-and-undermining-energy-investments-302067341.html.

U.S. Energy Information Administration (USEIA). U.S. Energy Information Administration - EIA - Independent Statistics and Analysis. https://www.eia.gov/state/?sid=NJ.

United States Environmental Protection Agency. “Causes of Climate Change.” EPA, 25 Mar. 2025, https://www.epa.gov/climatechange-science/causes-climate-change.

van Neuss, L. “Why Did the Industrial Revolution Start in Britain?” University of Liège, 2015, https://orbi.uliege.be/bitstream/2268/188592/1/Why