REDUCING NET CARBON EMISSIONS: ROLE OF THE UNITED STATES IN THE 2015 PARIS AGREEMENT

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science, School of Engineering

Hana Sexton
Spring 2022

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Advisor
Travis Elliot, Department of Engineering and Society

Introduction

If there is no change to the current trajectory of carbon emissions, the world will experience widespread devastation and extreme weather within the next two decades due to climate change (Harvey, 2021). In order to curb permanent damage to the environment and avoid devastation, 190 countries gathered to make the 2015 Paris Agreement which aimed to limit global warming to 1.5°C. Climate change is an issue at an international level. It is insurmountable by a single country; it necessitates the cooperation and active participation by all world powers.

As a citizen of the United States, it is imperative to hold policy makers accountable and actively try to limit personal carbon emissions. The United States government attempts to uphold their side of the agreement by looking for green alternative energy sources and passing legislation putting a carbon emissions cap on companies among other things, but what are smaller entities doing (Johnston 2017)? More specifically, what behavioral and operational changes have entities gone through to become more carbon neutral? Through the scope of technological fix, this research will analyze the efforts to which entities and individual citizens within the United States are taking to mitigate greenhouse gas emissions and uphold the provisions laid out by the 2015 Paris Agreement.

Background

The issue of climate change is not independent to a single country; it is an issue that necessitates the collaboration of all nations. There have been a myriad of attempts to bind countries by a contract to apply restrictions on emitting methane and a common strategy to combat the ever escalating effects of global warming. Some climate change initiatives on a global scale include: The First International Climate Program (1980), Creation of the Intergovernmental Panel on Climate Change (1988), Rio Earth Summit (1992), Kyoto Protocol

(1997), Launch of the European Union Emissions Trading System (2005), Copenhagen Climate Change Conference (2007), Cancun Climate Change Conference and Green Climate Fund (2010), Paris Agreement (2015), Three IPCC Reports (2018-2019), European Green Deal (2019). Broadly, the first three initiatives focused on determining humanity's role in the climate change debacle, inventing tools and methods of gathering scientific knowledge, and creating the Conference of the Parties whose purpose was to gather annually to assess the current global status (*International Efforts to Combat Climate Change* 2021). The Kyoto Protocol was the first initiative to provide a tangible goal of reducing emissions to 5.2%. The other conventions implemented more rules and goals, but the Paris Agreement legally binded the countries of the COP– Conference of the Parties– to the international treaty on climate change. The latter two agreements strengthened the resolve to combat climate change.

The Paris Agreement binded countries to their commitment to reduce emissions. The COP 21 summit set a goal for the international community to limit the temperature change caused by climate change to stay "well below" 2℃ compared to pre-industrial levels. It also brings to light the disadvantages faced by developing countries that may need financial support, technological tools, and scientific knowledge from richer countries (*International Efforts to Combat Climate Change* 2021). This landmark agreement places further responsibilities on lower levels. They recognize that the State may implement laws and regulations to limit greenhouse gas emissions but depend on the actions of "cities, regions, businesses and individuals" in order to facilitate efforts towards their goals (*International Efforts to Combat Climate Change* 2021). Progress and accountability is tracked through the enhanced transparency framework (ETF) which consists of each country submitting their individual adaptation measures, mitigation plans, and support provided or received.

Although the United States is at fault for emitting the most cumulative carbon dioxide

into the atmosphere, the Trump administration ceased participation in the 2015 Paris Agreement. In response, U.S. states, cities, businesses, and universities committed to the reducing carbon footprint with "America's Pledge." The main goals are to collect data on non-national climate action, communicate research and data findings, and catalyze further action. The most recent data analysis showed a positive increase in changes regarding electricity. The bottom-up leaders invested in renewable energy and storage and grid modernization. Transportation has greatly improved as funding for public transit and electric vehicles went up. Methane and HFCs improved as well with advanced clean-up for idle or abandoned infrastructure and consumer efficiency incentives. The only category that has not seen any change are buildings (*Delivering on America's Pledge*). Under President Biden, the United States rejoins the agreement via an executive order (Mai, H). Although this plan still needs to be approved by Congress, the Biden administration aims to be in accordance with the Paris agreement by decarbonizing the power sector by implementing a Clean Energy Standard and investing $65 billion to modernize the power grid. To improve the transport sector, the goal is to make half of all new vehicles sold to be zero-emissions vehicles. There will be stricter fuel efficiency and emissions standards (*U.S. Climate Change Policy*).

Greenhouse gasses is a blanket term for any type of gas that is emitted and traps heat in the atmosphere. Carbon dioxide makes up for 80% of these emissions: methane takes up 10%, nitrous oxide 7%, and fluorinated gasses 3% (*Overview of Greenhouse Gases*). Once emitted, these gasses remain in the atmosphere for a variable amount of time ranging from a few years to thousands of years. Although the atmosphere naturally contains some Carbon Dioxide, there is too much of this gas to be supported by the carbon cycle: the current volume present is overwhelming natural sinks (*Overview of Greenhouse Gases*). Human activities such as transportation, electricity, and industry are the main culprit to this ever increasing level of carbon

dioxide. Since 1990, carbon dioxide emissions in the United States have increased by about 3%. This was caused by the growing demand for fossil fuels. Increasing energy use, expanding economy and population, and increasing travel have all required the combustion of fossil fuel at a greater rate. These trends also increased methane and nitrous oxide emissions. The former is emitted from energy, industry, agriculture, land use, and waste management activities. The latter is also emitted from agriculture, land use, transportation, and industry (*Overview of Greenhouse Gases*).

STS Framework

The concept of technological fix has been around for centuries as humans have been inventing tools and using technology to solve their perceived problems. This idea, however, was not defined until 1966. The framework came into fruition when the Director of Tennessee's Oak Ridge National Laboratory, Dr. Alvin Weinberg posed the question: "will technology solve all our social problems?" (Johnston, 2018). This human strategy of scientific management reached the public and invited criticisms over the imperfections of modern society. One such group that voiced their opinions was the Technical alliance– which later evolved to Technocracy Inc– with Chief Engineer, Howard Scott, as their spokesman. Scott perceived that many societal issues arose from the inefficiency and incompetence of industrialists and government leaders. He emphasized rationale and accurate fact finding and believed that through the use of common sense and wise engineering, society can solve a lot of problems faster than if they were to wait for government intervention (Johnston, 2018).

A technological fix is an attempt to use engineering to shortcut or solve a problem. This theory depends on the rapidly developing technological innovation to solve social, political, or cultural issues (Johnston, 2018). This swift fix is the exact tool necessary to tackle such a dilemma such as climate change as it escalates at an alarming rate. There is a sense of urgency as

the current rate of climate change is deemed to cause irreparable damage to the Earth as well as every creature populating it.

As Richard Meier– a wartime research chemist who sought technological solutions in a postwar era– put it, technological fix was the "process of directing technical solutions… envisages as cooperation between engineers and communities, but ultimately guided by those with expert knowledge" (Johnston, 2018). The statutes laid out by the Paris Agreement are aligned with this philosophy. The world leaders of COP 21 agreed that countries must depend on smaller entities– down to the individual– to implement changes in production and use of fossil fuels to have any hope of meeting their emissions goals.

Research Questions and Methods

This research will study how America has evolved to meet the target emissions set by the 2015 Paris Agreement. Rather than focusing on policies, this research will look specifically at any technological tools that have been or are planning to be developed to reduce waste and increase efficiency. Through the use of case studies, this paper will examine changes that have been made and their effectiveness.

Results and Discussion

If there is no change to the current trajectory of carbon emissions, the world will experience widespread devastation and extreme weather within the next two decades due to climate change (Harvey, 2021). Emissions of gasses such as carbon dioxide, methane, nitrous oxide, and fluoride gasses are the causes of this great concern. The proportion of economic sectors that contribute to climate change are 25% electricity and heat production, 21% industry, 24% agriculture and other land use, 14% transportation, 6% buildings, and 10% miscellaneous causes (*Embodied Carbon Call to Action Report*). The research done for this paper sought out technologies that have been or in the process of being developed to mitigate some of these

emissions. The findings have proved that America has been actively seeking ways to reduce emissions and more eco-friendly alternatives to some traditional technologies.

By Sector, transportation is a great source of anthropogenic pollution producing 14% of all emissions (*Fast Facts on Transportation Greenhouse Gas Emissions)*. Of these transportation sources, cars and trucks that may be seen in urban areas make up 82% of the transportation greenhouse gas emissions; although the numbers vary based on geographic location, use, and gas prices, passenger vehicles emit an average of 4.6 metric tons of carbon dioxide annually (*Fast Facts on Transportation Greenhouse Gas Emissions)*. In an ideal world, society would make a transition to public transportation, but that is not a realistic solution. However, individual transportation is essential for services and economic opportunities, so the use of transportation will only increase with the population. The issue with a traditional car is that it runs on fossil fuels. Electric Vehicles are a great modern solution that has been increasing in popularity over the last couple of years. Electric vehicles have a smaller carbon footprint than the traditional car (*Electric Vehicle Myths, 2021).* Traditional petroleum based cars emit carbon dioxide through an internal combustion engine, the vehicle's fuel system, and during the fueling process (*Emissions from hybrid and plug-in electric vehicles)*. EVs do not emit tailpipe emissions. So although EVs themselves do not emit any greenhouse gasses, they run on electricity and the battery production emits GHGs, so they are not completely carbon neutral (Hall & Lutsey, 2018). However, even taking those aspects of EVs in consideration, a typical electric car still produces 29% less GHG emissions than the most efficient internal combustion engine vehicle (Hall & Lutsey, 2018). A downside to electric vehicles is that their batteries take a lot of energy to produce and they require rare metals which may be expensive and not accessible to some. Another key factor that affects how "green" the electric vehicle is is the energy source. Users must keep in mind that their vehicle is only as clean as the power source.

Energy efficiency is another area of concern. Due to their large size and heavy foot traffic, commercial buildings make up nearly 30% of greenhouse emissions from buildings in New York city (Wiggers, 2020). Older buildings especially, lack modern technology that uses energy more efficiently, so they are prone to use more. Sidewalk Labs, an urban planning and infrastructure subsidiary of Google, attempts to mitigate energy usage through technological solutions (*Energy regulations are on the rise - here's how Mesa can help: Insights, 2021)*. Mesa was a tool that was recently invented that can be installed in buildings to reduce energy waste. This kit comes with sensors that track environmental metrics– occupancy level, thermal dynamics, plug loads, HVAC efficiency– for owners and operators to identify energy sinks and take an appropriate course of action to mitigate it. Mesa is also an automation tool that can change the settings in a building without the user manually doing so. With the plug load sensors, Mesa can detect which outlets are not being used and turn off the energy supply (*Energy regulations are on the rise - here's how Mesa can help: Insights, 2021)*. It can also passively manage the temperature. By using the building's pre-existing wifi, Mesa can detect patterns in the weather and adjust the temperature accordingly. For example, if Mesa foresees an unusually warm fall day, it can adjust the internal system to lower the heating. Although these changes may seem minute, their effects compound into substantial financial and environmental savings. Based on a commercial buildings model published by the U.S. Department of Energy, if a 5,500 sq ft building turns down the air conditioning unit from 73 to 75 degrees in the warmer months, they can reduce cooling energy consumption by 24%. With the kit, users also gain access to Sidewalk Labs support lines and installation guides based on individual floor plans. Mesa is estimated to save an average of 22 MWh of energy per year per building (Wiggers, 2020). The only drawback for this technology is that users fear their privacy will be violated. In that case, there are other competitors such as Brainbox and Aquicore that offer similar products.

It is difficult to reduce emissions from the energy-intensive industry sector due to the emissions from the excessive energy use and emissions from the process itself (Dwortzan, 2021). The Greenhouse gas emissions come from the burning of fossil fuels for energy and chemical reactions that come from the production of goods from raw materials. However, there has been hope in technology behind carbon capture and storage (CCS). This option involves extracting point-source carbon emissions and trapping them underground beneath a caprock before they can reach the atmosphere (Dwortzan, 2021). From there, there are mineral formation reactions and the carbon dioxide dissolves into water. Researchers from the MIT Joint Program on the Science and Policy of Global Change believe this technology has the potential to remove up to 90-99% of carbon dioxide emissions related to the industry sector. This method will not stifle production and will allow it to continue its growth trajectory. There are also more advanced CCS options that cool the carbon dioxide to a solid form. This process called cryogenic carbon capture uses less power than conventional coal and gas technologies (Dwortzan, 2021). There are currently twenty six commercial-scale carbon capture projects that are in operation with more in the development stages. A major con of CCS is that it is expensive to install. Unless it extracts at least 90% of the carbon dioxide, it is not worth the investment.

Fuel sources for electricity include: coal, natural gas, petroleum, nuclear, and renewable energy. Coal is the most carbon intensive and accounts for 61% of the emissions for the electricity sector (*Sources of Greenhouse Gas Emissions).* Nonrenewable energy sources take a very long time to replenish and have negative effects on the environment when trying to retract it. Renewable energy is an innovation that has been flourishing over the past couple decades for its promise of clean energy. The Earth has an abundant supply of solar energy; according to the National Renewable Energy Laboratory, “more energy from the sun falls on the earth in one hour than is used by everyone in the world in one year.” This offers energy security unmatched by any

nonrenewable source. Solar energy is harvested from solar panels that contain photovoltaic cells that convert the sun's rays directly into electricity (Shinn, 2022). Apart from the manufacturing of solar panels, creating solar energy does not leave an effect on the environment. As with solar, wind is also not limited. Tall turbines are spun through the force produced by wind that powers an electric generator that produces electricity. It is the cheapest source of energy available. Wind and solar energy currently generate one eighth of the U.S.'s electricity (Shinn, 2022). Although renewable energy produces less emissions than its fossil fuel counterparts, not all are without consequences (Shinn, 2022). Biomass and large electric dams come with steep trade-offs due to its effects on the surrounding environment and ecosystems. Very large electric dams are a hindrance on rivers. They have the potential to completely stop the flow of water, affecting any organism or people that rely on rivers. Biomass is sourced from organic materials which are then burned to create heat for a steam turbine. Recent studies have started to categorize biomass as nonrenewable sources because they emit more carbon dioxide emissions than fossil fuel alternatives (Shinn, 2022).

The agriculture sector is the one that is most affected by climate change as farmers rely on predictable weather and season changes for crops. It serves in the farmers' best interest to seek solutions to mitigate the effects of GHG emissions. Deforestation and the burning and cultivation of organic materials are big contributors to greenhouse gas emissions from the agricultural sector. One innovative alternative is digital agriculture. Digital Agriculture is the use of technology to help farmers have a more accurate prediction of crop management and animal production and behavior (Ambrose, 2020). According to Karen Plaut, the Glenn W. Sample Dean of the College of Agriculture, "[Digital Agriculture] enables the development of apps with specific functions, real-time decision making, and expanding the field of predictive agriculture" as it is able to pool large amounts of data for streamline collection and analysis. Some forms of technology that

make up digital agriculture are sensors, communication networks, robotic machinery, and artificial intelligence. Based on the estimations of the World Economic Forum, farmers can increase their yield by 10-15% by 2030, while reducing gas emissions by 10% by incorporating precision agriculture supported by the data and technology from digital agriculture.

The aforementioned technologies all exemplify a technological fix. They were invented purely to solve the issue of climate change. By searching for the alternatives that are available, individuals up to the big business owner can implement these changes to be proactive in reducing emission in the spirit of Howard Scott who believed in using logic and engineering to their advantage to solve their perceived problems rather than waiting for government policies and regulations to give orders.

Although this research was useful to inform oneself on the technologies available for all economic sectors used to decrease emissions, it was very broad and should only be used as an introduction to the climate change efforts. Further research on this topic can delve deeper into each category to explore all possible technologies that exist and compare them to each other to find the most efficient one. Another possible related area of research would be how this affects individual Americans and what initiatives they can take to contribute in this fight against climate change.

Conclusion

Technological fixes are the world's best strategy at reducing emissions and mitigating the effects of climate change. As climate change becomes a greater issue, scientists around the world have sought new alternatives to everyday things ranging from renewable energy to digitable agriculture. Through the use of sound thinking and accurate facts, engineers can solve a myriad of problems through their own innovation and inventions rather than hoping and waiting for the government to initiate change.

Works Cited

Ambrose, E. (2020, August 7). Digital Agriculture: Why the future is now. College of Agriculture. Retrieved March 20, 2022, from https://ag.purdue.edu/stories/digital-agriculture-why-the-future-is-now/

America's pledge on climate change. America's Pledge On Climate. (n.d.). Retrieved March 12, 2022, from https://www.americaspledgeonclimate.com/

Dwortzan, M. (2021, July 21). *Reducing industrial carbon emissions*. MIT News | Massachusetts Institute of Technology. Retrieved March 20, 2022, from https://news.mit.edu/2021/reducing-emissions-decarbonizing-industry-0721

Emissions from hybrid and plug-in electric vehicles. Alternative Fuels Data Center: Emissions from Hybrid and Plug-In Electric Vehicles. (n.d.). Retrieved March 20, 2022, from https://afdc.energy.gov/vehicles/electric_emissions.html

Energy regulations are on the rise - here's how Mesa can help: Insights. Sidewalk Labs. (2021, April 12). Retrieved March 20, 2022, from https://www.sidewalklabs.com/insights/energy-regulations-are-on-the-rise-heres-how-mesa-can-help

Environmental Protection Agency. (2021, December 2). *Electric Vehicle Myths*. EPA. Retrieved March 20, 2022, from https://www.epa.gov/greenvehicles/electric-vehicle-myths

Environmental Protection Agency. (n.d.). *Fast Facts on Transportation Greenhouse Gas Emissions*. EPA. Retrieved March 20, 2022, from

https://www.epa.gov/greenvehicles/fast-facts-transportation-greenhouse-gas-emissions

Environmental Protection Agency. (n.d.). *Overview of Greenhouse Gases*. EPA. Retrieved March 13, 2022, from https://www.epa.gov/ghgemissions/overview-greenhouse-gases

Environmental Protection Agency. (n.d.). *Sources of Greenhouse Gas Emissions*. EPA. Retrieved March 20, 2022, from https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions#electricity

Harvey, F. (2021, August 9). *Major climate changes inevitable and irreversible – IPCC's starkest warning yet*. The Guardian. Retrieved December 8, 2021, from https://www.theguardian.com/science/2021/aug/09/humans-have-caused-unprecedented-and-irreversible-change-to-climate-scientists-warn.

Hall, D., & Lutsey, N. (2018, February). *Effects of battery manufacturing on electric vehicle life cycle greenhouse gas emissions.* The International Council on Clean Transportation. Retrieved March 20, 2022, from https://theicct.org/sites/default/files/publications/EV-life-cycle-GHG_ICCT-Briefing_09022018_vF.pdf

International efforts to Combat Climate Change. Planète Énergies. (n.d.). Retrieved March 7, 2022, from https://www.planete-energies.com/en/medias/close/international-efforts-combat-climate-change

Johnston, E. (2017, April 27). *Analysis: U.S. Role in the Paris Agreement*. Climate Interactive. Retrieved October 24, 2021, from https://www.climateinteractive.org/analysis/us-role-in-paris/.

Johnston, S. F. (2018, March). *The technological fix as social cure-all - philarchive.org*. IEEE TEchnology and SocIETy MagazInE. Retrieved March 20, 2022, from https://philarchive.org/archive/JOHTTF-2v1

Mazai, S. (2020, July 23). *Why Precision Agriculture is essential in Combating climate change*. AFN. Retrieved March 20, 2022, from https://agfundernews.com/why-precision-agriculture-is-essential-in-combating-climate-change

Shinn, L. (2022, February 14). *Renewable energy: The clean facts*. NRDC. Retrieved March 20, 2022, from https://www.nrdc.org/stories/renewable-energy-clean-facts

U.S. Climate Change Policy - crsreports.congress.gov. (n.d.). Retrieved March 13, 2022, from https://crsreports.congress.gov/product/pdf/R/R46947

Wiggers, K. (2020, September 22). *Sidewalk labs launches Mesa, an AI platform designed to help commercial buildings Save Energy*. VentureBeat. Retrieved March 20, 2022, from https://venturebeat.com/2020/09/22/sidewalk-labs-launches-mesa-an-ai-platform-designed-to-help-commercial-buildings-save-energy/