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Climate Change Proposal: Coupling Equity and Scientific Rigor in Facing Global Warming

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Climate change proposal: coupling equity and scientific rigor in facing Global Warming

by

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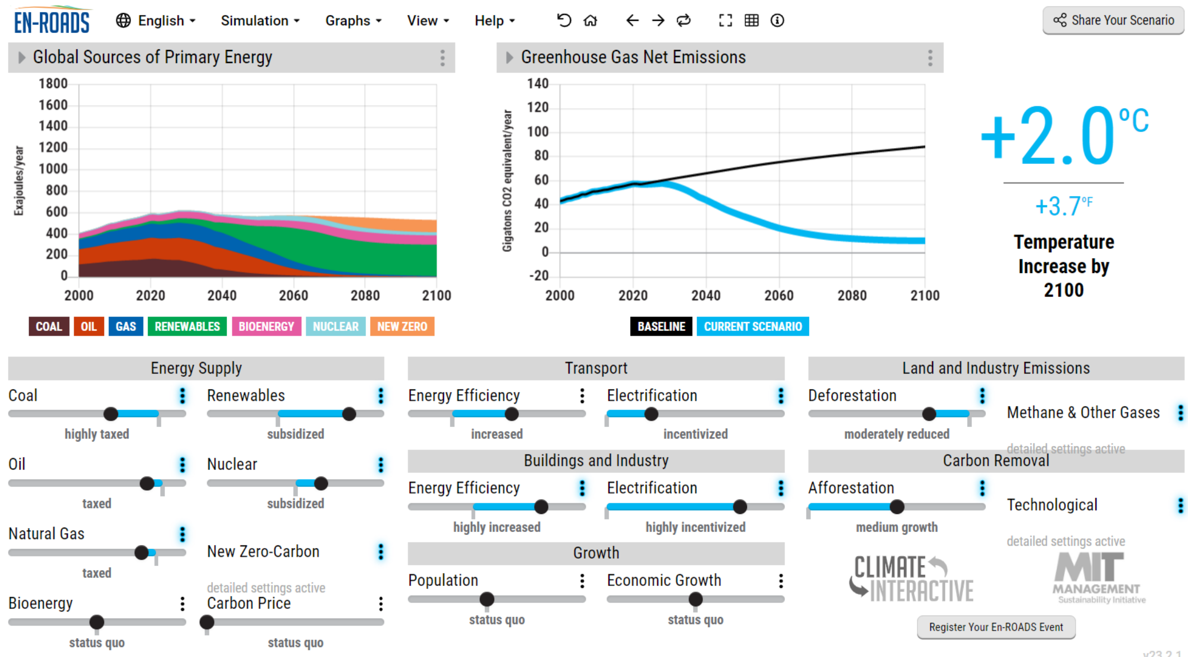

Actions

Coal
- Coal (tax/subsidy) = 35 $/tce
- Coal tax/subsidy start year = 2027
- % Reduction in coal utilization = 50 %
- % Reduction in coal utilization start year = 2028
- Stop building new coal infrastructure
- Year to stop building new coal infrastructure = 2035
- Coal plant accelerated retirement = 5 %/year
- Coal carbon capture & storage (CCS) (tax/subsidy) = 0.02 $/kWh
- Coal CCS R&D breakthrough cost reduction = 30 %

Oil
- Oil (tax/subsidy) = 12 $/boe
- Oil tax/subsidy start year = 2028
- % Reduction in oil utilization = 15 %
- % Reduction in oil utilization start year = 2040
- Stop building new oil infrastructure
- Year to stop building new oil infrastructure = 2040

Natural Gas
- Natural Gas (tax/subsidy) = 0.5 $/Mcf
- Natural Gas tax/subsidy start year = 2028
- % Reduction in gas utilization = 15 %
- % Reduction in gas utilization start year = 2040
- Stop building new gas infrastructure
- Year to stop building new gas infrastructure = 2045
- Gas carbon capture & storage (CCS) (tax/subsidy) = 0.01 $/kWh
- Gas CCS R&D breakthrough cost reduction = 20 %

Bioenergy
- Bioenergy (tax/subsidy) = 5 $/boe

Renewables
- Renewables (tax/subsidy) = -0.01 $/kWh
- Renewables tax/subsidy start year = 2028
- Renewables R&D breakthrough cost reduction = 30 %
- Renewables breakthrough year = 2040
- Storage R&D breakthrough cost reduction = 35 %
- Storage breakthrough year = 2035 year

Nuclear
- Nuclear (tax/subsidy) = -0.01 $/kWh
- Nuclear tax/subsidy start year = 2030
- Nuclear R&D breakthrough cost reduction = 25 %
- Nuclear breakthrough year = 2035

New Zero-Carbon
- New Zero-Carbon breakthrough year = 2050
- New Zero-Carbon time to commercialize = 8 years
- Initial cost relative to coal = 1.5

Transport Energy Efficiency
- Energy efficiency of new transport = 2.5 %/year

Transport Electrification
- Electrification of new transport—road and rail = 25 %
- Year electrification accelerates—road and rail = 2028
- Electrification of new transport—air and water = 10 %
- Year electrification accelerates—air and water = 2033

Buildings and Industry Energy Efficiency
- Energy efficiency of new buildings and industry = 3.5 %/year
- Start year = 2025
- Rate of buildings and industry retrofitting = 8.00 %/year

Buildings and Industry Electrification
- Electrification of new buildings and industry = 75 %

Deforestation
- Deforestation (reduce/increase) = -2.5 %/year
- Deforestation start year = 2028

Methane & Other Gases
- Agricultural and waste emissions (CH_4 & N_2O) = -20 %
- Energy and industry emissions (CH_4, N_2O, & F-gases) = -30 %
- Other greenhouse gases start year = 2030
- Years to achieve other greenhouse gas targets = 15 years
- HFC phase out start year = 2023 year

Afforestation
- Percent available land used for afforestation = 50 %
- Afforestation start year = 2030
- Afforestation planting time = 15 years

Technological Carbon Removal
- Bioenergy carbon capture & storage (BECCS) (% of max potential) = 5 %
- BECCS start year = 2030
- Direct air capture (% of max potential) = 40 %
- Enhanced mineralization (% of max potential) = 30 %
- Enhanced mineralization start year = 2035
- Agricultural soil carbon sequestration (% of max potential) = 50 %
- Agricultural soil carbon start year = 2028
- Biochar (% of max potential) = 25 %

Abstract

Global warming has detrimental effects on the health and population of our planet. For years, scientists have known that in order to preserve the earth for future generations, it is necessary to adopt more sustainable practices that reduce greenhouse gas (GHG) emissions and waste. Policy makers across the globe have attempted to address the issue but have received pushback from the general public, industry and politicians on the other side, alike. Controversy surrounding necessary changes encompasses issues from livelihood, to affordability, to health equity, to taxation. This multifaceted problem cannot be solved with a simple solution; rather, it requires consideration of all elements and all people, equally. This climate action proposal seeks to pair scientific backed solutions with maintaining equity across three main categories: the natural world, intergenerational marginalization, and social equity among existing groups to create an attainable plan to slow global warming.

Introduction

Greenhouse gas emissions have been damaging our climate for hundreds of years. Scientists suggest that human activity began affecting the climate in the 1830s with increased industrialization[1]. Preliminary data shows that in 2022, the world collectively emitted 38.2 gigatons of of carbon dioxide (CO_2), a 0.9% increase from 2021[2]. This correlates with 420 ppm of atmospheric CO_2. Compared to preindustrial levels of atmospheric CO_2, which resided at about 280 ppm, this is a 64.2% increase. In order to understand global warming, it is necessary to have a grasp on the carbon cycle, as a carbon atom is the building block of two of the most important heat capturing molecules. Carbon exists in many forms and is the foundational element of our natural world. Some molecules have only one carbon and

Figure 1: Structure of carbon dioxide (left) and methane (right)

[1] Pidcock, R. (2019, May 13). *Scientists clarify starting point for human-caused climate change*. Carbon Brief. Retrieved December 2, 2022, from https://www.carbonbrief.org/scientists-clarify-starting-point-for-human-caused-climate-change/#:~:text=Scientists%20generally%20regard%20the%20later,date%20forward%20to%20the%201830s.

[2] Iea. (n.d.). *CO2 emissions in 2022 – analysis*. IEA. Retrieved March 17, 2023, from https://www.iea.org/reports/co2-emissions-in-2022

are light enough to exist in free gas form in the atmosphere.[3] The structures of carbon dioxide and methane can be seen in Figure 1. Carbon dioxide is the molecule on the left; it has one carbon atom with double bonds to two oxygen atoms. Methane is the structure on the right; it has one carbon atom attached to four hydrogen atoms. Carbon dioxide and methane are two of the most abundant heat capturing molecules in our atmosphere, preceded only by water vapor.[3] The carbon cycle describes the process by which carbon moves from one storage reservoir to another and how it does so. Most of the carbon present on the earth is stored in rocks and sediment and the rest of it is in the atmosphere, oceans and living organisms.[4] One mechanism by which carbon changes reservoirs is photosynthesis. In the process of photosynthesis, atmospheric carbon is absorbed by plants and combined with sunlight and water to create glucose ($C_6H_{12}O_6$) and oxygen (O_2). Animals may come along and consume the plants and eventually excrete the digested glucose. As this excrement decomposes, the carbon that was consumed by the plant during photosynthesis is released back into the atmosphere.[4] This process kept the earth in balance until the introduction of human inflicted GHG emissions. The climate changes caused by increased GHG emissions are a result of a process called the greenhouse effect. Scientists suggest that 30% of incident light, that is, light entering earth's atmosphere from the sun, is reflected back into space[3]. The remaining 70% of incident light is absorbed by the earth and is then re-emitted, and these light waves interact with greenhouse gases, which absorb the light and emit weaker light. These interactions inhibit the light energy from leaving earth's atmosphere, increasing the overall energy and thus, the overall temperature of the earth. The increased quantity of atmospheric greenhouse gases due to human activity has led to the *anthropogenic* greenhouse effect. Anthropogenic describes pollution and environmental change that originates from human activity.[5] The large increase in the presence of GHGs has led to a corresponding increase in reflected light not leaving the earth's atmosphere, leading to additional warming. According to the Intergovernmental Panel on Climate Change (IPCC), 93% of the resulting increase in heat goes into our oceans. The average temperature of the earth's oceans has risen by approximately 0.13°C per decade over the last 100 years[6]. That is an average of a temperature increase of 1.3°C, or 2.34°F in the last 100 years. Increased temperature of

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[3] Perona, John. *From Knowledge to Power: The Comprehensive Handbook for Climate Science and Advocacy.* Portland, Ooligan Press, 2021.

[4] "Carbon Cycle." National Oceanic and Atmospheric Administration, www.noaa.gov/education/resource-collections/climate/carbon-cycle.

[5] Weiner, Edmund., Simpson, John., "*Anthropogenic",* Oxford English Dictionary, 1989.

[6] "Ocean Warming." *IUCN*, 20 July 2022, www.iucn.org/resources/issues-brief/ocean-warming#:~:text=Data%20from%20the%20US%20National,over%20the%20past%20100%20years.

our oceans is responsible for sea level rise, marine heatwaves, sea ice melting and ocean acidification[7]. However, this is only one of many fallouts of increasing temperature. In 1850, the average temperature of the surface of the earth was 14°C (57°F). This average has increased to 15.2°C (59°F) as of 2021.[3] This increase in temperature, both in the oceans as well as the earth itself, has widespread impacts on biodiversity, weather patterns, population health, global economy and food production.

Climate change is one of the most pressing economic, political, ethical and social issues of our time. According to the United Nations Climate Action team, the fallout from climate change includes impacts like increasing earth surface temperatures, more severe storms, increased drought, rising oceans, loss of biodiversity, food scarcity, and increased poverty and displacement. According to an article published by the Washington Post using data from the research non-profit Climate Central, 4.4 million acres of land in the United States alone are projected to fall below changing tidal boundaries by 2050, with this number rising to 9.1 million acres by 2100. The forementioned acreage encompasses almost 650,000 privately owned parcels.[8] Additionally, an increase in heatwaves has been seen in recent years. In the summer of 2022, Europe saw an unprecedented heat wave, with record temperatures in London, France and Spain. Heat related deaths were estimated to be in excess of 20,000 people.[9] One example of the impacts that heatwaves can have on a country is the persistent drought in Somalia. In 2011, Somalia experienced a drought induced famine that killed over 250,000 people. In 2022, Somalia again faced drought with 1 million fleeing their homes by September of 2022 to find food and water in neighboring countries.[10] Another fallout of heatwaves is increased forest fires. New data published by the World Resources Institute shows that incidence of forest fires has increased by 200% in the past 20 years. This rise in wildfire frequency translates to an increase in boreal tree cover loss at a rate of 271,816 acres per year. As boreal forests are found primarily in northern latitudinal regions, these data indicate that northern regions are heating at a faster rate. This is alarming because boreal forests are one of the largest carbon

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[7] United Nations. (n.d.). *How is climate change impacting the world's Ocean*. United Nations. Retrieved December 2, 2022, from https://www.un.org/en/climatechange/science/climate-issues/ocean-impacts#:~:text=As%20the%20excessive%20heat%20and,marine%20heatwaves%2C%20and%20ocean%20acidification.

[8] Dennis, Brady. "Rising Seas Could Swallow Millions of U.S. Acres within Decades." The Washington Post, WP Company, 8 Sept. 2022, www.washingtonpost.com/climate-environment/2022/09/08/sea-level-rise-climate-central/.

[9] Laville, Sandra. "Over 20,000 Died in Western Europe's Summer Heatwaves, Figures Show." The Guardian, Guardian News and Media, 24 Nov. 2022, www.theguardian.com/environment/2022/nov/24/over-20000-died-western-europe-heatwaves-figures-climate-crisis.

[10] Hujale, Moulid. "Somalis Abandon Their Homes in Search of Food, Water and Aid as Drought Deepens." UNHCR, UNHCR, The UN Refugee Agency, www.unhcr.org/en-us/news/stories/2022/9/633419134/somalis-abandon-homes-search-food-water-aid-drought-deepens.html.

storehouses on the planet, meaning the continued burning in these areas could result in a dramatic increase in atmospheric CO_2.[11] These are only a few of the immediate implications of the state of our earth.

Climate change does not affect people equally. According to the EPA, racial and ethnic minorities as well as impoverished and underserved communities are likely to experience the biggest impacts from climate change. Communities of this demographic are likely to be less able to prepare for and recover from climate related adversities such as heat waves, wildfires, natural disasters and food scarcity.[12] While disadvantaged communities are the most impacted by climate change, they are often the lowest GHG emitters. For example, data from CDP, an environmental disclosure agency, reports that China, the US, and the EU make up 23%, 19% and 13% of global emissions, respectively. Comparatively, the entire continent of Africa only accounts for 3.8% of global emissions, yet 98% of cities that report data to CDP, report that they are experiencing climate related hazards.[13] In addition to natural impacts on disadvantaged communities, policies implemented in efforts to mitigate climate change must take into consideration social equity. Poorer communities may not be able to meet demands of implemented policies, for example, tax on oil and gas, being required to transition to a more fuel-efficient vehicle or make their homes more energy efficient. In addition to disadvantaged peoples, those with health issues are also likely to experience greater impacts from Global Warming. Atmospheric warming has the potential to increase ground level ozone and particulate matter in some areas. Ground level ozone is associated with diminished lung function and is correlated with increased mortality and morbidity.[14] Effects of decreased air quality are likely to be exacerbated in individuals with preexisting health conditions.

An article published in the Columbia Climate School newspaper reported that if global temperatures increase to 2.8°C above preindustrial levels by 2100, it will cost the US economy $296 billion per year. If temperatures rose to 4.5°C above preindustrial levels, it would cost $520 billion per year.[15] Everything in our world is tied to money. With the potential for global warming to cause increased incidence of

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[11] MacCarthy, James, et al. "New Data Confirms: Forest Fires Are Getting Worse." World Resources Institute, 17 Aug. 2022, www.wri.org/insights/global-trends-forest-fires.

[12] "EPA Report Shows Disproportionate Impacts of Climate Change on Socially Vulnerable Populations in the United States." EPA, Environmental Protection Agency, www.epa.gov/newsreleases/epa-report-shows-disproportionate-impacts-climate-change-socially-vulnerable.

[13] *CDP Africa Report: Benchmarking Progress Towards Climate Safe Cities, States and Regions.* CDP. March, 2020.

[14] CDC, "*Climate Change Decreases the Quality of the Air we Breathe".* N.d.

[15] Cho, Renee. "How Climate Change Impacts the Economy." State of the Planet, Columbia Climate School News, 20 June 2019, news.climate.columbia.edu/2019/06/20/climate-change-economy-impacts/.

drought, wildfires and extreme weather events, localities that are dependent on agriculture would experience severe financial losses. In 2019, Nebraska lost $440 million worth of cattle from the floods. Additionally, projections indicate that the Midwest will lose up to 25% of current corn and soybean yield by 2050.[14] These economic impacts are far reaching, affecting the livelihood of farmers, grocers, food manufacturers and consumers. A Rhodium Group study published in 2014 predicted that the largest climate caused economic losses in the United States will be from decrease of labor productivity. These projections indicate a loss of two billion labor hours per year, a figure that translates to $160 billion in lost wages.[14] In addition to agriculture and labor productivity, infrastructure, the tourism industry and business are all estimated to experience significant financial loss. Economic impacts of climate change are already far reaching, but with the current trajectory, it will only get worse.

Fossil fuels, which include coal, oil and gas, are the biggest proponents to climate change. Fossil fuels account for over 75% of global greenhouse gas emissions, and roughly 90% of all carbon dioxide emissions.[16] Coal, oil and gas play many roles in our society including generating power, manufacturing goods, transportation, and food production. In order to cut the emissions from coal, oil and gas, sustainable sources of power must be put into practice to replace those that are damaging the environment. Transitioning from fossil fuels to renewable energy sources is one of the main keys to solving climate change. Renewable energy sources include solar energy, wind energy, geothermal energy, hydropower, ocean energy and bio energy. Three renewable energy sources stand out due to their widespread use. Hydroelectric power is the oldest and largest source of renewable energy. Hydropower works by using the natural flow of water. Water flows through a pipe, spins the blades of a turbine that is connected to a generator which produces electricity. Hydroelectric power

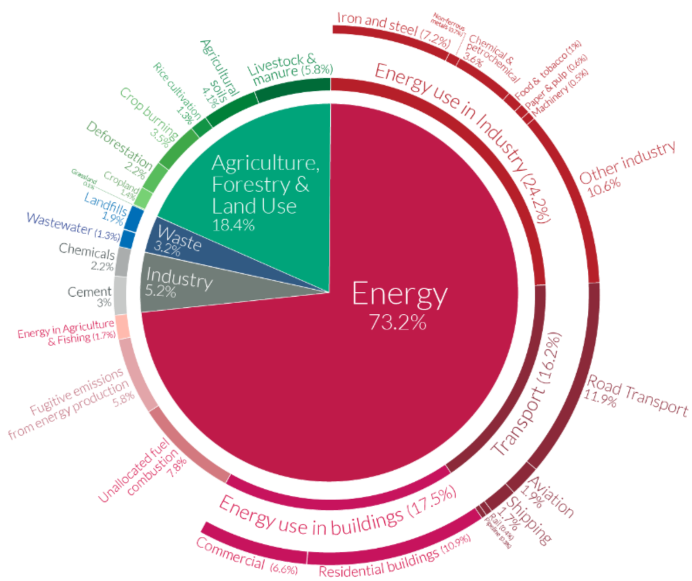

Figure 2: Global emissions proportions by sector

[16] "Causes and Effects of Climate Change." *United Nations*, United Nations, www.un.org/en/climatechange/science/causes-effects-climate-change.

accounts for 6.1% of total US electricity generation.[17] Wind energy works by using wind turbines to harness the kinetic energy of the wind[18]. This causes the blades of the turbines to turn. Currently, wind energy is responsible for about 9.2% of total US utility scale generation. Solar energy works by using solar photovoltaic panels (solar panels) which function to harness incident light waves and generate an electric current. The current then flows to an inverter, which converts the power from direct current (DC) to alternating current (AC). The newly converted AC electricity is connected to a breaker box, allowing for it to be used as normal.[19,20] Solar energy makes up 2.8% of US energy generation. Altogether, renewable energy sources make up only 19.8% of total energy generation in the United States, with 61% coming from fossil fuels and the other ~20% coming from nuclear power and other varied sources. [21]

Introduction to En-Roads and Experimental Methods

En-Roads is an extensively peer reviewed, interactive, climate simulation software that allows the user to engage with various policies to gain insight into how we can slow global warming and reach the 2015 Paris Climate Agreement of 1.5°c. En-Roads was developed in partnership by Climate Interactive, the System Dynamics Group at MIT Sloan, and the University of Massachusetts Lowell Climate Change Initiative. En-Roads is powered by roughly 14,000 equations that allows the user to explore roughly 30 policies including electrification, carbon pricing, fossil fuel tax, afforestation/deforestation and more.[22] The software primarily works off its own equations, using few external data sets in its calculations. When they are included, external data sets are used to set the default values and bounds on system

[17] "Hydropower Basics." Energy.gov, US Department of Energy, www.energy.gov/eere/water/hydropower-basics#:~:text=Hydropower%2C%20or%20hydroelectric%20power%2C%20is,of%20total%20U.S.%20electricity%20generation.

[18] "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." *Electricity Generation from Wind - U.S. Energy Information Administration (EIA)*, www.eia.gov/energyexplained/wind/electricity-generation-from-wind.php#:~:text=Wind%20turbines%20use%20blades%20to,which%20produces%20(generates)%20electricity.

[19] "How Do Solar Panels Work? the Science of Solar Explained." *Solect Energy*, Solect Energy, 27 Mar. 2018, solect.com/the-science-of-solar-how-solar-panels-work/.

[20] "Difference between AC and DC - Definitions, Comparison, Video, and Faqs." *BYJUS*, BYJU'S, 27 Oct. 2022, byjus.com/physics/difference-between-ac-and-dc/#:~:text=Electric%20current%20flows%20in%20two,and%20then%20backwards%20in%20AC.

[21] "Frequently Asked Questions (Faqs) - U.S. Energy Information Administration (EIA)." Frequently Asked Questions (FAQs) - U.S. Energy Information Administration (EIA), US Energy Information Administration, www.eia.gov/tools/faqs/faq.php?id=427&t=3.

[22] En-Roads is a "high order, nonlinear differential equation system dynamics model that is built in the Vensim software. It was then translated into WebAssembly so that it can be run on a web browser." (En-Roads website)

dynamics and are backed via extensive review of literature and current and historical data. For example, the approximate world population was 5.3 billion people in 1990. Thus, in the En-Roads software, the population in 1990 is set to 5.3 billion people. The same thing is done with other initial conditions such as current atmospheric CO2 levels, current usage of coal, etcetera.

I chose to use En-Roads as the basis of my thesis for many reasons. My main reason is that En-Roads is not entirely dependent on external research and data, but instead, the creators of En-Roads placed an emphasis on building their own equations to accurately model all the varying systems of our climate. Although En-Roads had to rely on the same information as other climate model software developers, their framework and functionality is unique in that the equations were translated into a program that can be run on a basic web browser. This means that results are essentially obtained instantaneously, something that sets En-Roads apart from other, difficult to understand software. This feature of the program makes it so policy makers can see the effects their proposed policies might have on the environment, economy and equity issues. En-Roads includes additional advanced settings so that a user can, for example, decrease the level of natural gas being used and produced without placing a hefty tax on consumers. This gives flexibility to users to adjust the settings in En-Roads to not only mitigate temperature increase, but do so while maintaining personal ethics, equity, and scientific integrity What this translates to is that legislators, climate scientists, students, educators, hospitality workers and stay at home parents alike have access to sophisticated software that allows them to explore the complexities of climate change while learning what they can do on a large scale and individual level to slow climate change.

I have not found an easily accessible, free, user-friendly software that competes with En-Roads. Most of the alternative programs I found are difficult to understand, hard to access and don't allow for much interaction.[23,24,25] In fact, En-Roads is the only software that I have found that gives users the power to change tangible parameters and visualize the predicted outcomes that come with those changes. Another benefit of the En-Roads software is that for each policy change, it provides detailed descriptions of predicted outcomes, pitfalls, and equity issues while also addressing the overarching issues such as temperature increase, coral reef bleaching, and ocean level rise. For example, one of the policies that can be adjusted is renewable resources. Increasing the use of renewables alone does not decrease

[23] SimClimat Software (developed by Cabinet d'Études Informatiques, Alain Deseine. This work was supported by the IPSL Climate Graduate School which is funded by the ANR (ANR-11-IDEX-0004 - 17-EURE-0006).

[24] Clima-Sim (http://www.weathergraphics.com/climasim/)

[25] GISS GCM ModelE Software, NASA (https://www.giss.nasa.gov/tools/modelE/)

emissions significantly. Instead, it must be coupled with the displacement of fossil fuels – something that often doesn't happen. A user might wonder why they aren't seeing big changes when they are adjusting the renewables section, and the description provided by the software addresses this. This gives the power back to the user through providing them the knowledge to consider something they previously hadn't.

In creating a plan to mitigate climate change, I chose to research from a deductive methodology, that is, backing up the generalized statement that reducing greenhouse gas emissions will help quell climate change with specific policies that break down the problem and provide pointed solutions. I used this approach in contrast to an inductive point of view because it is already known that reducing greenhouse gas (GHG) emissions will slow the rate at which our climate declines. Choosing to study global warming from an inductive point of view would lead to too general of a conclusion. For example, one could observe that there has been an increase in ocean temperature, instance of natural disaster and an increase in GHG emissions. This would lead to the conclusion that GHG emissions are bad for the environment but would not provide much more than that which is already known. There are many standpoints from which this problem can be approached, and many alternative routes to reach a stable, healthy climate. The oversimplified conclusion is that reducing emissions will help bring about a positive change for our world, and this thesis is my deduction of the best and most realistic way for that to be accomplished.

Proposed Climate Action Plan

The proposed plan chooses to focus on policies that make the biggest impact on reducing GHG emissions while factoring in the effects on the earth, the economy, and current and future generations. The first policy to implement is a coal tax coupled with a large decrease in coal usage and no new coal infrastructure. Specifically, the policy includes a heavy tax on coal of $35/tce followed by a 50% decrease in coal usage. The tax and reduction in coal usage are set to begin in 2024 and 2027, respectively, with a 10-year period allotted for phase in. The burgundy line in figure 3a shows the current and projected CO_2 emissions by coal and figure 3b shows the projected emissions with the changes I have proposed. As can be seen, the change is dramatic, facilitating a decrease in CO_2 emissions from burning coal from the projected figure of 25.34 gigatons CO_2/year by 2100, to 0.05 gigatons CO_2/year by 2100. A 50% reduction in coal usage would naturally be followed by a phase out of coal plants, with a 5%/year increase in phase out rate beginning in 2030. I chose to aggressively eliminate coal because it emits significantly more CO_2 than both oil and natural gas and it does not contribute anything unique to the energy industry. Coal makes up 1/5th of the world's emissions; replacing it with oil and gas would lead to a huge decrease in emissions.[26] The electric grid in the United States is already paring down coal usage as a source of electricity within the grid – in 2021, 6,000 MW of electricity generating by coal was retired. Additionally, it is less widely used than oil and natural gas, making it a relatively easy thing to minimize while making a big impact on decreasing CO_2 emissions. In addition to the drop in CO_2 emissions, an immediate result of reduction of coal usage would be an increase in air quality, particularly in the vicinity of coal powered plants. Ironically, most coal plants are in low-income areas where the air pollution has a greater impact on those who are already at a disadvantage. A 2014 study showed that air pollution around coal plants can include mercury, sulfur dioxide, nitrogen oxides, and particulate matter on a large scale. Additional emissions included toxic heavy metals, carbon monoxide, arsenic and volatile organic compounds.[27] All the above-mentioned emitters can have significant adverse health effects including, asthma, heart and lung diseases, cancer and neurological problems. Although these proposed changes would have a relatively small effect economically, the changes could have significant impact on the approximately 50,000 people who are employed by the coal industry and their families[28]. However, a recent study showed that 52,000 lives could be saved per year by making the transition from coal to photovoltaic

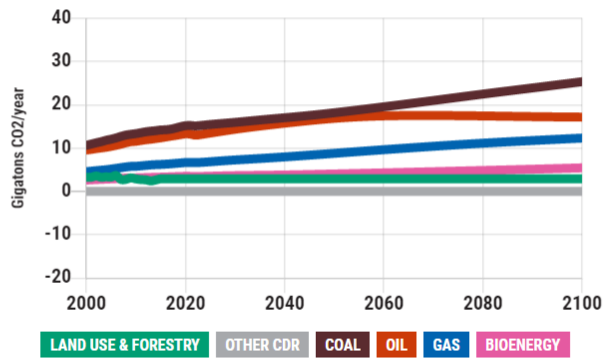

Figure 3a: Current projected emissions by sector; to note is the burgundy line representing coal.

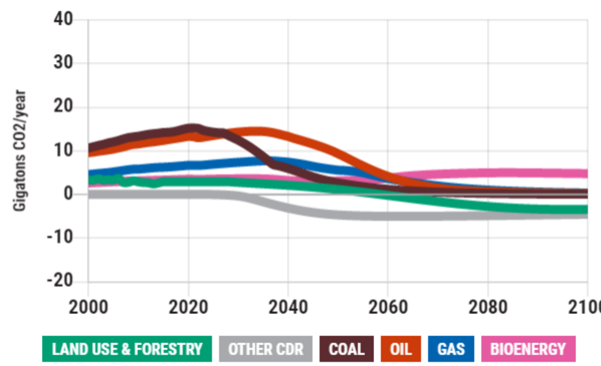

Figure 3b: Projected emissions by sector with proposed changes

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[26] Birol, Faith, and David Malpass. "It's Critical to Tackle Coal Emissions – Analysis." *IEA*, 8 Oct. 2021, www.iea.org/commentaries/it-s-critical-to-tackle-coal-emissions.

[27] "Coal and Air Pollution." Union of Concerned Scientists, Union of Concerned Scientists, 8 July 2008, www.ucsusa.org/resources/coal-and-air-pollution#:~:text=Air%20pollution%20from%20coal%2Dfired,environmental%20and%20public%20health%20impacts.

[28] John Perona, *From Knowledge to Power: The Comprehensive Handbook for Climate Science and Advocacy*, page 133, Portland, Ooligan Press, 2021.

technology (PV)[29], a number greater than those employed in the coal industry. For my proposed changes to be realized, it is essential that they be coupled with governmental policies that aide those who are financially affected. Policies that give the option of free higher education and transitional jobs for workers in the coal industry, ensuring stable housing, and provision for food throughout the change. Without these co-policies, it does not work. In addition to impacting people who are involved in production of coal, there would be more widespread economic, and equity impacts on small businesses and homeowners who use coal as their primary source of energy – those individuals would be subject to a noticeable increase in their household or business costs with the temporary transition to the use of oil and natural gas before renewables can take over. Therefore, it would be necessary to ensure that the increase in electricity cost for those individuals is met with governmental support, which could come in the form of temporary financial assistance while the transition is taking place, thereby incentivizing installation of solar panels, and funding of R&D to ensure the swift and affordable takeover of renewable energy sources.

Renewable energy sources are a key factor in reducing GHG emissions and limiting global warming. Renewables have the potential to overtake energy output of the fossil fuel industry and along with it, transportation, and the electricity grid. This plan focuses a large part on renewables and introduce a 0.01$/ kWh subsidy to producers of renewable energy to incentivize the transition to and use of renewable resources as our primary modality of energy. This subsidy would begin in 2028 and be phased in over 10 years to allow companies time to begin plans to make the required changes to meet this goal. Figure 4 shows the perpetually decreasing cost of electricity production by renewables over the next 77 years, as can be seen from the downward trend of the green line. An additional benefit of subsidizing renewables would come in the form of a decreased demand for coal, oil and gas, thus working in tandem with the coal policy mentioned above. In conjunction, this policy would increase financial assistance to R&D of new

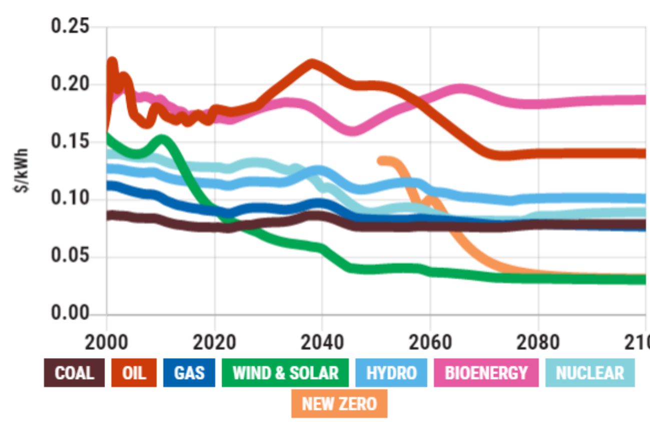

Figure 4: Marginal cost of electricity production by source; notice the downward trend of the green line representing renewable energy sources

[29] Emily W. Prehoda, Joshua M. Pearce, Potential lives saved by replacing coal with solar photovoltaic electricity production in the U.S., Renewable and Sustainable Energy Reviews, Volume 80, 2017, Pages 710-715, ISSN 1364-0321, https://doi.org/10.1016/j.rser.2017.05.119.

technologies and strategies to aid development of renewable energy storage, dispatchment, and utilization. This can support the development of a positive feedback loop by creating a low cost, climate friendly, realistic alternative to oil and gas resulting in an increase in demand for more renewable energy options. This quickly growing industry has the potential to create jobs, quickly surpassing the 50,000 workers who are now employed by the coal industry. For perspective, on a global scale a 65% increase of renewable energy in the global supply could create 6 million jobs and add $19 trillion in the world economy by 2050[30]. As a step in the right direction, in 2022, President Joe Biden passed The Inflation Reduction Act (IRA), described as "a foot coming off of the break and stepping lightly on the gas pedal."[31] Criticized for its failure to meet the halving of emissions promised by the United States at the Paris Climate Agreement, the IRA provides 'tax incentives for investments in clean energy, electric vehicles and nuclear power production', rather than focusing on regulation. The implemented policy puts the US on trajectory to reduce emissions by 40% by 2030. The IRA focuses on incentivizing the transition to clean and renewable energy sources, which is one of the key steps in mitigating climate change.

The immediate fallout of reducing coal usage will be that the void is filled with the use of more gas. However, a temporary increase in natural gas utilization will still reduce emissions comparatively. The proposed plan implements a $12/boe (barrel of oil) tax on oil producers that would begin phase in in 2033, with a 15% reduction in oil usage due to start in 2040. Moreover, a natural gas tax of 0.5 $/ Mcf (dollars per thousand cubic feet) on producers beginning in 2036, coupled with a 15% natural gas use reduction starting in 2040, would also be put into place. The timings of these taxes and reductions are critical – with the loss of coal as an energy source, natural gas will be required to fill in, as previously stated. With oil and gas taxes being realized 9 years after coal tax implementation, it gives those taking advantage of the funding and incentives provided by the IRA time to employ additional renewable energy sources, making the transition to renewable energy more seamless. In order to ensure that these taxes do not unequally burden those at a disadvantage, the goal would be to have renewable energy sources lined up and implemented prior to the tax beginning. However, if this did not happen, additional governmental assistance would be necessary for low-income families who would experience the impacts of rising electricity and transportation costs as a result of the proposed taxes. One problem with

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[30]IEA/IRENA. (2017) Perspectives for the Energy Transition – Investment Needs for a Low-carbon Energy System. Paris/Abu Dhabi: IEA/IRENA. https://www.irena.org/DocumentDownloads/Publications/Perspectives_for_the_energy_transition_2017

[31] Risi, Lauren Herzer. "Wilson Center Expert Analysis of the Inflation Reduction Act." Wilson Center, 15 Aug. 2022, www.wilsoncenter.org/article/wilson-center-expert-analysis-inflation-reduction-act.

diminishing the oil and gas industry is that in the United States alone, it supports 9.8 million jobs which equates to 5.6% of total employment.[32] However, it should be noted that the oil and gas industry will never completely be gone, nonetheless, equity considerations should be made when policies cutting back on oil and gas usage begin to be implemented.

The proposed policy for electrification is a mandated 75% electrification of new buildings and industry beginning in 2026, coupled with a 3.5% increase per year in the energy efficiency of the new infrastructure beginning in 2025 as well as an 8% per year retrofitting requirement. Electrification coupled with increases in energy grid capacity from clean energy sources is necessary to ensure an emission free future. However, it should be noted that electrification will not immediately reduce GHG emissions. The US electricity grid is powered by many sources. The amount of each source responsible for power output varies depending on location. Some states – Oregon, California, Washington D.C., Idaho and several others, do not employ coal as a source of power at all. However, for others – Arkansas, Colorado, Indiana, Kentucky and more, coal is the primary electricity source. Likewise, the electricity grid in some states relies heavily on oil, while others on wind or hydroelectric. [33] This means that electrification in states that rely on electricity sources that have a high carbon intensity – such as coal – would cause an increase in GHG emissions. Although this is not the desired result, a long-term outlook is necessary to see that electrification will eventually lead to a reduction in GHG emissions. From the previously mentioned policies, those states that rely heavily on fossil fuels will eventually be required to eliminate coal and reduce oil and gas use. This means that electricity grids that were once powered by fuels with high carbon intensities will be replaced by cleaner and more sustainable sources. To be coupled with electrification, my plan also includes an increase in nuclear power infrastructure and funding R&D of renewable energy sources, both necessary in making the transition to electric. The current electric grid in the United States has 1.2 million megawatts of power generation capacity, with another 412,000 MW under development. Nuclear, wind, solar and hydroelectric together make up 32.4% of electric grid capacity in the US, while natural gas makes up 43.89%[34]. For electrification to be a sustainable option, it must work in conjunction with a revamp of nuclear power and renewable power

[32] "How Many Jobs Has the Oil and Natural Gas Industry Created?" Energy API, American Petroleum Institute, www.api.org/oil-and-natural-gas/energy-primers/hydraulic-fracturing/how-many-jobs-has-the-oil-and-natural-gas-industry-created#:~:text=Industry%20supports%209.8%20million%20jobs,U.S.%20employment%2C%20according%20to%20PwC.

[33] "State Electricity Generation Fuel Shares." Nuclear Energy Institute, www.nei.org/resources/statistics/state-electricity-generation-fuel-shares.

[34] *America's Electricity Generation Capacity*. American Public Power Association. 2022.

sources. As stated, energy is the main source of GHG emissions, therefore, a policy that mandates 75% electrification of new building and industry is critical in reducing emissions. Moreover, data shows that electrification of new homes and buildings reduces costs less over the lifetime of an appliance[35]. This is also true for retrofitted electrification. Figure 5 shows the market price of electricity with proposed changes. As can be seen, a steep climb is seen initially, followed by a sharp decrease in price, leading to an overall more affordable cost of energy. Data from the Clean Energy Finance Forum shoes that conventional retrofits provide annual savings of 15-25%, while more extensive retrofits can provide up to a 50% savings per year.[36] Not only is electricity cheaper to run than direct natural gas and oil overall, but it also has a lower carbon footprint. Buildings that get power from electricity rather than direct use of oil or natural gas decrease their carbon footprint as the energy sources are a combination of high carbon intensity and low carbon intensity. Equity impacts to be considered would be to ensure disadvantaged communities are given opportunities to be taught why electrification is critical in curbing global warming, as well as gaining perspective from community members on what would make electrification possible for them. This would invite people into the discussion, rather than enforcing a governmental rule that might not be attainable for some people. A positive equity result is that electrification leads to greater air quality in and around buildings that are powered by electricity. This limits exposure to particulate matter and other harmful gases that have adverse health effects. For example, using gas as a direct source of power for household appliances has been shown to increase levels of nitrogen dioxide, carbon monoxide and particulate matter, which can lead to lung problems, increased incidence of bronchial infection and cancer.[37] Policies introducing incentivization and action of

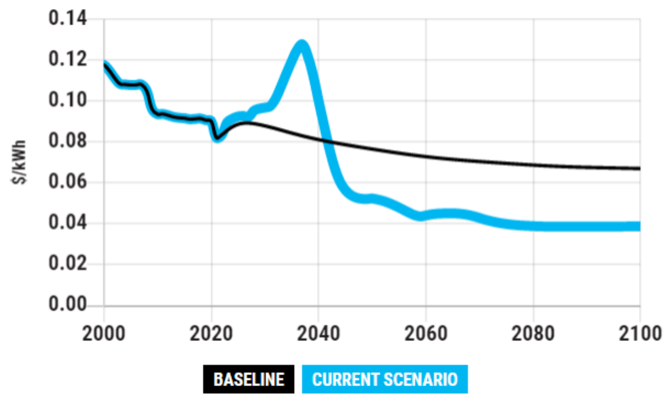

Figure 5: Market price of electricity with current projections (black line) versus with proposed changes (blue line)

[35] *The economics of electrifying buildings*. RMI. (2022, March 2). Retrieved March 10, 2022, from https://rmi.org/insight/the-economics-of-electrifying-buildings/.

[36] Stagg, Elizabeth. "Explainer: How Do Retrofit Economics Differ for Commercial Buildings and Homes?" Clean Energy Finance Forum, 4 May 2022, cleanenergyfinanceforum.com/2022/05/04/explainer-how-do-retrofit-economics-differ-for-commercial-buildings-and-homes.

[37] Brady Seals and Andee Krasner, *Health Effects from Gas Stove Pollution,* RMI, Physicians for Social Responsibility, Mothers Out Front and Sierra Club, 2020. https://rmi.org/insight/gas-stoves-pollution-health

electrifying new buildings, coupled with subsidies for renewable energy and phase out of fossil fuels, are a good start to bringing about significant reduction in GHG emissions in an equitable manner.

Agriculture and land use practices have long been a topic of discussion in the realm of climate science. For many people when livestock comes to mind, so do methane emissions. In Ireland, agricultural emissions make up 37.1%[38] - the largest category of emissions on the island. Of that 37%, a huge 57.5% come from enteric fermentation, or in other words, ruminant animal digestion. This is not unique to Ireland; in New Zealand, nearly half of the GHG emissions come from agriculture, and roughly 75% of that is from livestock[39]. It is estimated that approximately 18% of all global GHG emissions come from livestock, with enteric fermentation making up 4.4% of total emissions[40]. These figures are staggering! Implementation of an action mandate which will require farms to take 20% of the possible action they can, to reduce waste sources of methane and nitrous oxide is the first step in reducing agricultural emissions. Figure 6 shows the expected methane emissions before action is taken (551.33 megatons CH_4 per year by 2100) and with action taken (278 megatons CH_4 per year by 2100). However, societally and culturally, some of these changes could prove difficult. The University of Nebraska Institute of Agriculture and Natural Resources published an article about reducing GHG emissions from ruminant animals. Some of the suggested practices involve including additives to feed and manure to decrease emissions as well as storing manure in a closed system and introducing anaerobic digestors to decrease GHG emissions.[41] With respect to feed additives, some supplements can be added to livestock feed to reduce methanogens in the rumen which functions to decrease methane emissions from waste. Some suggested additives include synthetic chemicals, natural supplements such as tannins and seaweed and fats and oils. Fat and oil additives show the most potential for practical application, as they are readily available and reduce methane emissions by 15-

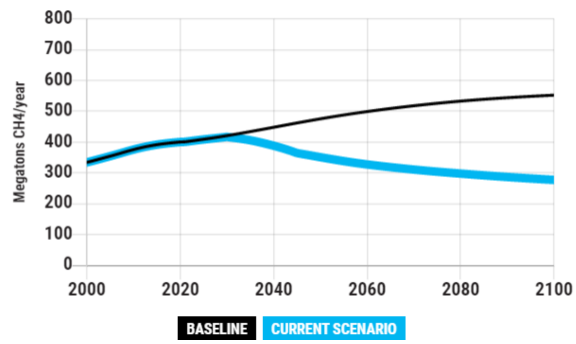

Figure 6: Methane emissions after proposed agricultural changes; blue line represents new expected CH_4 emissions until 2100

[38] https://www.epa.ie/our-services/monitoring--assessment/climate-change/ghg/agriculture/

[39] https://environment.govt.nz/guides/agriculture-emissions-climate-change/#about-our-agricultural-emissions

[40] Dominic Moran, Eileen Wall, Livestock production and greenhouse gas emissions: Defining the problem and specifying solutions, *Animal Frontiers*, Volume 1, Issue 1, July 2011, Pages 19–25, https://doi.org/10.2527/af.2011-0012

[41] Lindgren, Julia. “Reducing Greenhouse Gas Emissions from Cattle Production.” UNL Water, University of Nebraska, 14 Nov. 2019, water.unl.edu/article/animal-manure-management/reducing-greenhouse-gas-emissions-cattle-production.

20%.[42] All these above-mentioned practices are examples of actions that could fall into the 20% action mandate, making this an attainable goal. In addition to the decrease in agricultural emissions, a 30% action mandate on energy and industry emissions is also proposed. This would include changes like mitigation of emissions from landfills, mining, production and transportation of goods. GHG emissions from landfills are composed of up of 90-98% methane and carbon dioxide and make up an estimated 16.8% of all US methane emissions[43]. Much industry emissions also fall into the category of emissions from energy, as the foundation of much industry is the usage of electricity. Therefore, it is important to implement electrification of the industrial sector so that less energy consumption can be traced back to direct use of fossil fuels. This continues to show how imperative the transition to renewable energy sources is. Practical steps to meet the 30% action mandate would be to implement at *clean products standard.* This would require industries to establish maximum allowed emissions per unit of the produced products.[44] This method of regulation leaves the path of accomplishment up to the company so that they can utilize technologies that suit their specific needs.

The next step in the proposed plan is the development and implementation of technological carbon capture and storage (CCS). Although several techniques have been developed and have a few facilities in operation, there is no widespread use of CCS in the world. An investment into actionizing the various types of CCS could be a key turning point in the history of the climate of the earth. Bioenergy carbon capture and storage (BECCS) captures CO_2 from combustion of bioenergy. BECCS is limited due to the large amount of land it requires, as well as that there is limited sustainable biomass available. However, the Global CCS Institute 2022 Status Report showed that for the world to reach net zero emissions, maximum possible use of BECCS will be required.[45] Although large scale implementation of BECCS will require a lot of land, the proposed policy implement 30% of possible carbon removal from BECCS. Direct air carbon capture and storage (DACCS) removes CO_2 directly from the atmosphere. DACCS is typically more expensive than BECCS but does not require as much land. However, the economics of it is a big

[42] Curnow, Mandy. “Carbon Farming: Reducing Methane Emissions from Cattle Using Feed Additives.” Agriculture and Food, Department of Primary Industries and Regional Development, 1 Feb. 2022, www.agric.wa.gov.au/climate-change/carbon-farming-reducing-methane-emissions-cattle-using-feed-additives.

[43] https://www.epa.gov/lmop/frequent-questions-about-landfill-gas#:~:text=Per%20the%20most%20recent%20Inventory,methane%20emissions%20across%20all%20sectors.

[44] John Perona, *From Knowledge to Power: The Comprehensive Handbook for Climate Science and Advocacy*, page 207, Portland, Ooligan Press, 2021.

[45] “Global CCS 2022 Report.” Global CCS Institute, Global CCS Institute, 2022, status22.globalccsinstitute.com/2022-status-report/analysis/.

inhibitor as the cost of DACCS in the future is not yet known, but predictions indicate that large scale usage it is not economically feasible until 2042.[45] There are several DACCS facilities around the world, most of which are small scale and use the captured carbon dioxide for other things. The first large scale DACCS facility is underway in the United States, however, with projected operations beginning in the mid-2020s.[46]This is why the proposed plan implements a 30% employment of DACCS beginning in 2030, with hopes to increase this once more research has been done. The Infrastructure Investment and Jobs Act, which was passed by the Biden Administration in 2022, allocates resources for the improvement and deployment of CCS, particularly DACCS. Specifically, this bill offers 3.5 billion in funding with the goal of development of four regional DACCS hubs around the United States as well as incentives ranging from $15-$100 million for development of DACCS technology[47]. DACCS has the potential to remove as much CO_2 as we want. This means that after net zero is reached, DACCS could continue to be employed in order to reverse warming over decadal time frames. This would have the potential to restore earth's heat balance and systems, and thus be a huge step in the right direction regarding environmental equity. Enhanced mineralization is the process of accelerating the natural processes by which minerals absorb CO_2 by breaking apart newly mined rock and spreading it over the surface of soil. Approximately one billion tons of CO_2 are sequestered per year from mineralization. With industrial scale enhanced mineralization, that figure is projected to increase to 2-4 gigatons tons CO_2 by 2050 and more than 20 gigatons CO_2 by 2100.[48] However, while enhance mineralization seems promising, it is still in the early stages of R&D. The proposed step is 30% potential CCS from enhanced mineralization beginning in 2043 so that a plan can be more fully developed. Agricultural soil carbon sequestration describes the process by which carbon is naturally stored in soil. Unsustainable farming practices

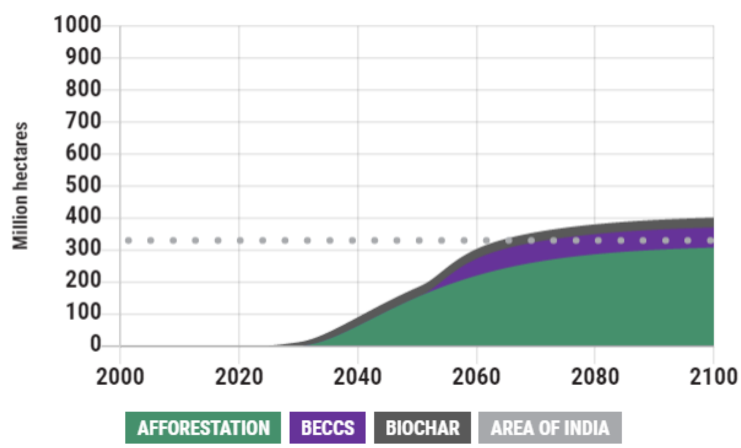

Figure 7: Land required for growing CO_2 removal biomass; grey dotted line represents the area of India

[46] IEA. "Direct Air Capture – Analysis." IEA, www.iea.org/reports/direct-air-capture.

[47] *The Infrastructure Investment and Jobs Act: Opportunities to Accelerate Deployment in Fossil Energy and Carbon Management Activities.* Department of Energy. 2022.

[48] "Fact Sheet: Enhanced Mineralization." American University, 24 July 2020, www.american.edu/sis/centers/carbon-removal/fact-sheet-enhanced-mineralization.cfm.

such as extensive tilling, overuse and pesticides have led to the release of over 110 billion metric tons of carbon from the top later of soil in the last 12,000 years. Rather than continuing the unsustainable path, practices that employ a cover crop to store more carbon as well as underground plowing which also contributes to higher carbon levels in soil should be implemented.[49] Therefore, 50% of maximum CCS from agricultural soil carbon sequestration by incentivizing sustainable farming practices. Biochar CCS removes atmospheric carbon dioxide by burning biomass for the purpose of transforming it into a more stable form. Biochar, though, has limitations and is not fully understood. Studies show that spreading burned biomass on soil has the potential to add nutrients and increase carbon content. On the other hand, it also has been shown to disrupt microbial populations and inhibit plant growth.[50] Thus, more R&D is needed to establish what types of biochar are effective. A 25% biochar CCS policy beginning in 2040 is implemented in this plan. Figure 7 shows that biochar and BECCS would potentially take up to 93 million hectares of land. Some of the equity concerns that arise with technology like BECCS, and enhanced mineralization is that there is little known about the potential environmental or community impacts it could have on its surroundings. In addition, because BECCS requires so much land, there is the possibility that it could be taking away from land that would otherwise be used for food production.

In conjunction with maintaining more natural practices, the final policy in this proposal implements afforestation of 45% of available land. The planning for this would ideally begin immediately, and the planting would take place over the span of 15 years beginning in 2030. This would allow 10 years to secure the necessary land, determine what the impacts of the land use change would be and who it would affect most. From 1850 to now, there has been a 630 million hectare decrease in forested area [51]. Typical tree densities range from 1500-2500 trees per hectare[52]. With the assumption that each tree on average holds approximately 400kg of CO_2 in its lifetime[53], this amounts to over 5.04×10^{14} kg CO_2 that has been released into the atmosphere from the deforestation of 630 million hectares. A recent study showed that the earths ecosystems would be able to support another 900 million hectares of forests,

[49] Melillo, Jerry, and Elizabeth Gribkoff. "Soil-Based Carbon Sequestration." MIT Climate Portal, Massachusetts Institute of Technology Climate Portal, 15 Apr. 2021, climate.mit.edu/explainers/soil-based-carbon-sequestration.

[50] "Biochar." Biochar : USDA Agricultural Research Service, 20 Mar. 2020, www.ars.usda.gov/midwest-area/stpaul/swmr/people/kurt-spokas/biochar/.

[51] *Afforestation,* EnRoads. 2022

[52] Planning for Tree Planting - Credit Valley Conservation. cvc.ca/wp-content/uploads/2011/03/plng_tr_plnt.pdf.

[53] One Tree Planted. "How Much CO2 Does a Tree Absorb?" One Tree Planted, onetreeplanted.org/blogs/stories/how-much-co2-does-tree-absorb.

which would increase the existing forested area by about 25%[54]. It is estimated that by afforestation at this scale, there would be approximately 205 gigatons of carbon removed from the atmosphere which amounts to about 25% of atmospheric carbon[14]. Afforestation could be a key proponent in the mitigation of the effects of climate change. Some of the impacts of large-scale afforestation could include land use change and effecting historic land access, both which would have the largest impact on indigenous peoples and low-income families. For afforestation to be realized, it would be important to include state and federal forestry leaders, researchers, tribal leaders, and agricultural representatives in discourse around the implementation of this policy because of the potential equity impacts.

Climate change is a complex problem that requires a thoughtful, but scientific solution. The climate proposal discussed in this document aims to account for all the complexities brought about by global warming. Putting the equity of existing people, intergeneration and environment as a top priority, this plan attacks the climate problem to bring the temperature change to not exceed 2°C. This plan accounts for equity of current peoples by ensuring that the transition to clean energy does not further disadvantage marginalized peoples. In addition, rigorous reduction of GHG emissions improves the chances that impoverished communities will have an opportunity to develop a plan to traverse natural disasters and drought. All policies in this plan improve intergenerational and environmental equity as they focus on preserving the earth and undoing some of the harm that has been done to it. This will help to ensure that the earth and its systems are maintained for centuries to come. When looking at this plan from a whole perspective, it notably emphasizes nurturing the earth by not overusing or over producing while looking to harness the naturally occurring energy sources available to us. It focuses in on 're-wilding' and reinstating the organically occurring carbon cycle where rocks and minerals, trees and fields, and the ocean work in harmony to maintain a healthy level of greenhouse gases. This plan aims to cut back on the resources that have long been overused so that we can leave behind a functional earth for future generations.

[54] "Examining the Viability of Planting Trees to Help Mitigate Climate Change – Climate Change: Vital Signs of the Planet." NASA, NASA, 11 Nov. 2019, climate.nasa.gov/news/2927/examining-the-viability-of-planting-trees-to-help-mitigate-climate-change/.