Climate Change Initiative at the Institutional Level:

An Analysis of Legal, Financial, and Institutional Energy Consumption Followed by a Proposal for Roanoke College to Take Climate Action

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1.0 Introduction: Time is Ticking

7 years, 31 days, 15 hours. According to the Climate Clock posted in Manhattan, as of 3:00 p.m. on November 29, 2020, this is the deadline for the world to achieve zero greenhouse emissions if society hopes to avoid irreparable damage caused by climate change (Golan, 2020). The Climate Clock, created by a team of both climate specialists and artists, aims to inform the public how long it will take at current rates of emissions for the world to burn through its "carbon budget" (Golan, 2020). The term "carbon budget", refers to the amount of carbon dioxide that can be released into the atmosphere while limiting climate change to 1.5°C above pre-industrial levels (MCC, 2018). The Carbon Clock is based on research from the Mercator Research Institute on Global Commons and Climate Change (MCC) and includes data from the IPCC Special Report on Global Warming (Golan, 2020). The IPCC first introduced the idea of a CO_2 budget, calculated to be 420 Gt in 2018, and is believed to provide a 67% chance to stay under 1.5°C of global warming (Golan, 2020). A 67% chance of remaining under the 1.5°C temperature rise is only possible if the world reaches zero emissions prior to the deadline, which doesn't sound like very comforting odds. Perhaps an even more concerning realization about the Climate Clock is that its calculations assume that emissions in the coming years will be close to those generated in 2017, as emissions have continued to rise despite increasing concerns about irreversible climatic damage (MCC, 2018). This means that if the world doesn't respond appropriately and emissions continue to rise, the Climate Clock's deadline can be moved ahead.

The Climate Clock is not entirely negative, as there is a second portion to the clock that serves as a lifeline. This portion of the clock monitors the percentage of the world's energy production that comes from renewable sources, which stands at 27.92% as of November 29, 2020 (Golan, 2020). If contributions from renewable energy reach 100% prior to the deadline reaching zero, then the world will have theoretically averted a climate crisis. However, if the alternate scenario ensues, there is theoretically no ameliorating the climate crisis.

The Climate Clock is not a perfect measure. At present, it can't account for the near scientific impossibility of linear warming, the time lag between the concentration of emissions and their impact on temperature, and perpetuates the notion that when the Climate Clock hits zero, the world has reached what many may associate as "doomsday" (Golan, 2020). While the concept of a Climate Clock has its innate flaws, the idea that it attempts to convey is critical for humanity. Climate change is a serious problem that, if not addressed within the next few years, can have serious negative implications throughout both the natural world and human civilization. Thus, it is important that the world focuses on boosting its lifeline before its deadline is reached

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2.0 What is Climate Change? Science and Human Impacts

2.1 Background

Climate change, also referred to by many as “global warming”, is a simple concept to understand once the science behind the phenomena is explained. However, many people are uninformed about what climate change really is, which is why there is debate throughout society as to whether it is real or not. However, once the science and evidence of climate change is presented, it is impossible to deny its existence. The Earth’s climate has fluctuated throughout geologic time. Over the past 650,000 years, there have been seven cycles of glacial advance and retreat (NASA, 2020). The abrupt end of the last ice age occurred roughly 11,700 years ago, marking the beginning of the modern climate era as well as of human civilization (NASA, 2020). Most of the changes in climate can be attributed to small variations in Earth’s orbit around the sun that alter the amount of solar energy that the planet receives (NASA, 2020). Climate change does occur naturally, but it is also important to consider how humans have impacted the Earth’s natural heating and cooling cycles in the modern era.

Although climate change is a natural phenomenon that occurs over time, current rates of warming are unprecedented. Human activities impact the natural warming and cooling of the Earth, as recent studies have highlighted that current warming is abnormal. In fact, the current warming trend is particularly significant, as most of it is extremely likely (greater than 95% probability), to be the result of human activity since the mid-20th century and is advancing at a rate that is unprecedented over decades to even millennia (NASA, 2020). In multiple studies included in peer-reviewed scientific journals, 97% or more of actively publishing climate scientists agree that climate change over the past century is to the result of human activities (NASA, 2020).

2.2 The Science Behind Climate Change

How do humans contribute to climate change? The answer lies in the ways in which the composition of the Earth’s atmosphere is being altered through everyday activities. The Earth’s atmosphere contains a complex mixture of gases that re-radiate heat back to earth, which are referred to as greenhouse gases (GHG) (EPA, 2020). The four main types of greenhouse gases that are most relevant to climate change are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO_2), and fluorinated gases (EPA, 2020). Each greenhouse gas has a global warming potential (GWP), that allows for comparisons of the global warming impacts between each of the gases (EPA, 2020). Scientifically speaking, GWP is a measure of how much energy the emissions of one ton of a specified gas will absorb in the atmosphere over a given period (typically 100 years), relative to the emissions of one ton of CO_2 (EPA, 2020). GWP is significant because it provides a common unit of measurement that allows analysts and policy makers alike to compare emission reduction opportunities across gases (EPA, 2020). Thus, it is important to understand how each of the gases affects the atmosphere and climate change, as not all gases have the same affect.

Carbon Dioxide. CO_2 has a GWP of 1 and is used as the gas of reference (EPA, 2020). CO is released through natural processes such as plant and soil respiration as well as through human activities such as deforestation and burning fossil fuels (EPA, 2020). This GHG has an average residence time of 300 to 1,000 years, which is why even with the lowest GWP it has a great impact on the Earth's climate (NASA, 2020). In 2018, CO_2 made up 81% of total emissions generated (EPA, 2020). Since the beginning of the industrial revoluation, humans have increased atmospheric CO_2 concentrations by 47%, making this the most important long-lived contributor to climate change (EPA, 2020).

Methane. CH_4 on the other hand only lasts a decade on average in the atmosphere but has a GWP of 28-36 over 100 years due to the amount of energy it absorbs in comparison to CO_2 (EPA, 2020). This GHG is produced both through natural and human activities such as the decomposition of waste, agriculture, and even ruminant digestion and manure management associated with livestock (EPA, 2020). While $CH_4$is far more impactful on climate than CO_2 on a per unit basis, it is much less abundant in the atmosphere and contributes just 10% of total GHG emissions (EPA, 2020).

Nitrous Oxide. NO_2 is a GHG that is released through soil cultivation, fertilizer use, fossil fuel combustion, and biomass burning (EPA, 2020). The increased energy absorption of NO_2 is reflected in its GWP, as it boasts a GWP of 265-298 times that of CO_2 over 100 years, even though it only remains in the atmosphere for roughly 100 years (EPA, 2020). Although NO_2 contributed just 7% of GHG emissions in 2018, its extreme GWP requires that theseemissions be monitored carefully.

Fluorinated Gases. Fluorinated gases, also referred to as chlorofluorocarbons (CFC), have a GWP of anywhere between 1,000 and 10,000 depending on the specific CFC (EPA, 2020). These gases are also referred to as high-GWP gases because they trap substantially more heat than $CO_2$for a given amount of mass (EPA, 2020). CFCs are synthetically generated compounds from industrial origin that are used in a wide variety of applications but are now heavily regulated due to their ability to destroy ozone (EPA, 2020). CFCs contributed to roughly 3% of total emissions generated in 2018 (EPA, 2020).

To combat climate change, it is important for society to monitor emissions of GHG's and attempt to reduce them before too much damage has been done. One way to reduce the impact of GHG's is to change how society generates electricity, which will be discussed later in this paper (4.0).

2.3 Evidence of Climate Change: The Earth Tells a Story

Some of the most compelling pieces of evidence supporting the concept of human-induced climate change come from the Earth itself. Just as one can tell the age of a tree based on the number of rings, the Earth's climatic responses to past levels of greenhouse gases can be observed through similar observations. Paleoclimateic scientists use information such as this, known more formally as "proxy data", to reconstuct past climatic conditions (NOAA, 2021). Proxy data reveals climatic history distinctive to past geological ages, as it consists of preserved physical characteristics of the environment that can stand in for direct measures (NOAA, 2021). Paleoclimatic evidence and proxy indicators of climate change can be found in ice cores drawn from different glacial regions around the world, tree rings, ocean sediments, coral reefs, fossil pollen, and layers of sedimentary rock (EPA, 2020).

Ice Cores. Ice cores drawn from Greenland, Antarctica, and tropical mountain glaciers indicate that warming is currently occurring at a rate ten times faster than the average rate of ice-age-recovery warming (NASA, 2020). The Greenland and Antarctic ice sheets have significantly decreased in mass;data from NASA's Gravity Recovery and Climate Experiment indicate that Greenland lost an average of 270 billion tons of ice per year between 1993 and 2019, and Antarctica lost roughly 158 billion tons of ice per year in that same timeframe (NASA, 2020). This is undeniable evidence of visual change that can be seen from a bird's-eye view.

Surface Temperature. Another source of evidence that supports human-induced climate change can be observed through changes in Earth's average surface temperature. Since the late 19th century, Earth's average surface temperature has risen roughly 2.05°F (1.14°C), a change that can be attributed largely to the increased levels of $CO_2$and other GHG human-induced emissions into the atmosphere (NASA, 2020). $CO_2$is increasing more than 250 times faster than from natural resources after the last ice age (NASA, 2020). Most of the increase in temperature has occurred within the past 40 years, with six of the warmest years ever recorded occurring since 2014 (NASA, 2020). To further support these findings, let it be noted that 2016 was the warmest year on record, and eight months out of that year, from January to September except for June, were the warmest on record for those respective months (NASA, 2020). In addition, the number of record high temperature events in the United States since 1950 has been increasing while the number of record low temperatures have been decreasing (NASA, 2020). Numbers don't lie, and numbers concerning the Earth's temperature certainly have a story to tell.

Ocean. The ocean covers roughly 70% of the Earth's surface and has absorbed much of the increased heat generated from climate change. The top 100 meters of the ocean has warmed 0.6°F (0.33°C) since 1969, and global sea level has risen roughly eight inches in the last century (NASA, 2020). The rate of sea level rise in the past two decades is nearly double that of the last century, and continues to increase slightly every year (NASA, 2020). This can be attributed to two major causes; the increased melting of ice and the thermal expansion of water (NASA, 2020). The ocean absorbs more than 90% of the increased atmospheric heat asscoaited with emissions from human activity which has caused water to expand greatly (NASA, 2020). Another way the ocean has responded to human-induced climate change is through its acidity level. Since the beginning of the Industrial Revolution in 1760, the ocean's surface level acidity has increased about 30% because of increased CO_2 emissions from human activities (NASA, 2020). Higher acidity levels can be detrimental to wildlife as well as to phytoplankton, which contribute to the majority of oxygen generation on Earth (NASA, 2020)

2.4 How do Humans Contribute to Climate Change?

Humans contribute to climate change daily. Whether through the clothes they wear, the food they consume, or the temperature they set their thermostat,, all have an impact on the Earth's climate. However, two of the primary ways that human energy consumption contribute to climate change are through transportation and electricity production (EPA, 2020).

Transportation. In 2018, the transportation sector generated the largest portion of greenhouse gas emissions, contributing 28.2% of total emissions (EPA, 2020). The emissions from transportation are generated primarily by burning fossil fuels to power cars, trucks, ships, trains, planes, and any other form of transportation imaginable (EPA, 2020). This statistic should come as no surprise, as humans are constantly transporting both themselves and goods, night and day. Energy use from transportation is expected to increase worldwide, due to factors such as population growth and increases in global production markets (Wang & Ge, 2019). The figure below provides the expected projectory of global emissions generated from transportation as CO_2 equivalents, through four scenarios (Wang & Ge, 2019). In all scenarios, emissions generated from transportation are expected to increase unless relioance on fossil fuels to do so is shifted (Wang & Ge, 2019).

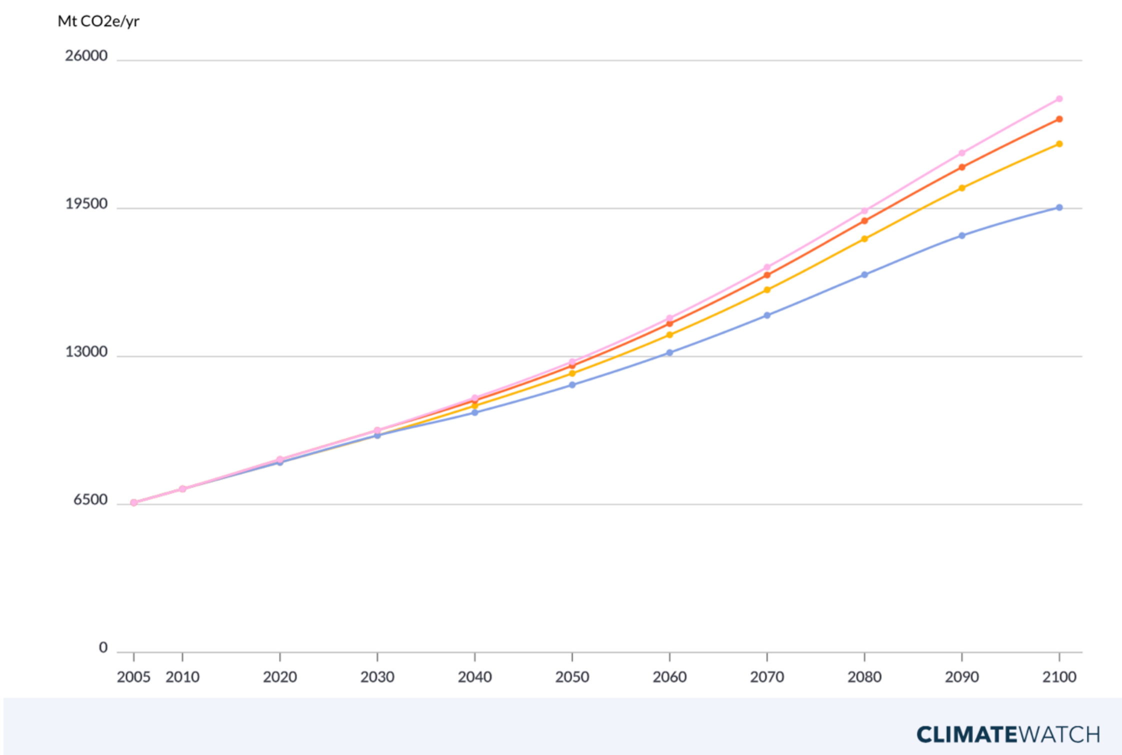


Image 1. Projection of global emissions from transportation expressed as CO_2 equivalent. Four scenarios depicted as different colors; No Policy (pink), Low Policy (orange), Continued ambition of Paris Agreement (yellow), and Increased ambition of Paris Agreement (blue).

Electricity production. Electricity production was the second largest contributor to GHG emissions, accounting for 26.9% of total emission in 2018 (EPA, 2020). In the United States alone in 2019, about 4,127 billion kilowatt-hours (kWh) of electricity were generated at utility scale electricity facilities (EIA, 2020). Of this, about 63% was generated from fossil fuels including natural gas (38%), coal (23%), and petroleum (1%) among other gases (EIA, 2020). On the other hand, only 18% of this electricity can be attributed to renewable sources such as wind (7.3%), hydroelectric (6.6%), solar (1.8%), and biomass (1.4%) (EIA, 2020). If society hopes to reach zero emissions before the Climate Clock's deadline, then the percentage of energy created from renewable sources must increase significantly.

Other human contributions. Since burning fossil fuels emits greenhouse gases, and both transportation and electricity generation primarily use fossil fuels as a resource, human activity has continued to contribute to climate change. Since 1990, gross U.S. GHG emissions have increased by 3.7% (EIA, 2020). Global carbon emissions from fossil fuels have also significantly increased since 1970, especially CO_2emissions, which have increased roughly 90%, with fossil fuel combustion and industrial processes contributing 78% of total GHG emissions from 1970 to 2011 (EIA, 2020).

2.5 Variation in Damages Across Fossil Fuels

Just as not all greenhouse gases have similar GWP, not all fossil fuels have similar impacts on climate. For example, although coal only represented 28.4% of electricity generated in the United States in 2018, it accounted for 65.8% of CO_2 emissions from the electricity-generating sector (EIA, 2020). Natural gas, considered a much cleaner fossil fuel than coal, accounted for 34.1% of electricity generation over the same period, and contributed much less CO_2than coal (EIA, 2020). Although all fossil fuels have an impact on climate change, some contribute to the issue much more than others.

Given the enormity of these challenges, how can the world reach zero emissions in 7 years, 31 days, and 10 hours? The answer may lie in environmental policy and regulations.

3.0 Energy Policy

Environmental policy serves as a driving force for generating real and lasting change in the current climate crisis. Energy policies concerning environmental issues are apparent at all different levels of governance (international, federal, and state), and address a wide-range of environmental issues. However, for the purpose of focusing on climate action, an analysis of environmental policy regarding energy production and consumption will be the focus of this section. Energy policies can be divided into two further categories, which include rules and regulations as well as financial incentives.

Rules & Regulations. Environmental policy in the category of rules and regulations typically mandate actions from an obligated entity (Delmas & Montes-Sancho, 2011). Rules and regulations such as Renewable Portfolio Standards (RPS), Mandatory Green Power Options (MGPO), and fuel disclosure rules can all be found in this category. Renewable Portfolio Standards are policies designed to increase the renewable energy electricity generation (EIA, 2020). As of June 2019, 29 states have enacted RPS or other renewable energy policies, and eight states have voluntary goals for renewable energy generation (EIA, 2020). Typically, RPS sets a minimum requirement of electricity supply that is generated from renewable energy by a certain date (EIA, 2020).

Other environmental policy rules or regulations include MGPO, which require electricity companies to provide an option for consumers to purchase electricity generated from renewable sources either directly from their company or from an alternate provider (Delmas & Montes-Sancho, 2011). Regardless of the rule or regulation enacted, environmental policy in the category of rules and regulations forces states to take initiative on tackling the climate crisis from a position of electricity generation.

Financial Incentives. Financial incentives are legal actions that has been generated to incentivize companies and states to become more climate conscious. These policies include tax incentives, grants, loans, rebates, and energy production incentives (Delmas & Montes-Sancho, 2011). The goal of these policies is to make transitioning to renewable energy more feasible and appealing, as it can be difficult to do so.

Regardless of the type of policy enacted, all environmental policies concerning renewable energy attempt to increase the amount of energy generated with zero emissions and decrease the amount of energy generated from non-renewable resources. Thus, it is through environmental policy that real change is going to be made throughout the United States, as well as the world at large.

3.1 International and National Environmental Policy

International and national environmental policies exemplify the cohesive nature necessary to combat climate change on a global scale. The fight against climate change will not be successful unless, at the very least, most of the governing bodies in the world are committed to ameliorating the issue. Thankfully, progress on renewable energy standards and emission reductions on the global scale has increased exponentially over the past decade. Below are a few examples of international and national environmental policies that aim to diminish environmental degradation related to energy production and usage.

3.1.1 International Environmental Policy

The United Nations Environment Program (UNEP) is the leading environmental authority for the global environmental agenda, promotes coherent implementation of the environmental dimension of sustainable development, and serves as an authoritative advocate for the global environment (United Nations, 2020). UNEP works in collaboration with all nations and stakeholders to implement the 2030 Agenda for Sustainable Development (United Nations, 2020). The 2030 Agenda includes 17 Sustainable Development Goals (SDG's), 169 targets, and 241 indicators that serve to measure the progress toward achieving a more sustainable future (United Nations, 2020). Specifically, the UNEP is the custodian agency of 25 of the SDG indicators which include resource management and protection of water, marine and terrestrial ecosystems, circular economy, the sustainable management of natural resources, and environmentally sound management of chemicals and waste. For the purposes of this report, SDG's 7 and 13 which include goals for affordable and clean energy, sustainable consumption and production, and climate action respectively, will be outlined to provide a sense of global environmental policies that are directed by the United Nations involving energy production and consumption.

SDG-7 ("Ensure access to affordable,reliable, sustainable and modern energy for all") focuses on ensuring access to affordable, reliable, sustainable, and modern clean energy for all (United Nations, 2020). Included in SDG-7 are several target goals that are set forth to be attained by 2030. The goals outlined for 2030 are more subjective rather than objective, with many of them left up to interpretation rather than having specific targets with concrete numbers. For example, target 7.2 is to "increase substantially the share of renewable energy in the global mix" (United Nations, 2020). Others are more specific such as target 7.3, which calls for doubling the global rate of improvement in energy efficiency (United Nations, 2020).

Similar to SDG-7, SDG-13 ("Take urgent action to combat climate change and its impacts") focuses on vaguer goals towards combatting climate change as it is more difficult to attain more specific goals when including larger populations. SDG 13 focuses on taking urgent action to combat climate change and its impacts (United Nations, 2020). Included in this climate action plan are goals to integrate climate change measures into national policies, strategies, and planning, mobilize $100 billion annually by 2020 to address the needs of developing countries with regards to the Green Climate Fund, and promoting mechanisms for raising the capacity for effective climate-change related planning among several others (United Nations, 2020). While neither of the two policies mentioned provide specific goals with concrete levels of improvement, it must be taken into consideration that on a larger scale, goals must be vaguer to make them attainable for the larger population that is aiming at reaching them.

Perhaps the most significant international policy on Climate Change is the Paris Agreement. The Paris Agreement is a legally-binding international treaty that aims to limit global warming well below 2°C, and preferably to 1.5 °C compared to pre-industrial levels (UNFCC, 2021). This treaty was signed by 195 countries and had been ratified by 190 as of January 2021 (UNFCC, 2021). The Paris agreement works on a five-year cycle of increasing climate action carried out by countries, to which countries communicate actions they plan to take in order to reach the goals of the Paris Agreement (UNFCC, 2021). As of now, the Paris Agreement is the most progressive and effective international environmental policy in place.

3.1.2 National Environmental Policy

On the national level, there are 409 policies concerning climate action, including 60 policies that focus on electricity generation alone (IEA, 2021). Policies range from generating more renewable energy production sites to the reduction of emissions from current energy production, as well as tax incentives that help businesses transition into more environmentally friendly practices (IEA, 2021). To provide an example, Renew300 is a federal renewable energy policy that aims to reach

300 MW of renewable energy through onsite and community scale renewable installations targeted for low-and moderate-income housing by 2020 (IEA, 2021). Other policies address different types of renewable energy such as hydroelectric, solar, or wind power. Nonetheless, national environmental policies aim at improving energy standards as well as initiate climate action for the country.

3.2 Virginia Environmental Policy

Environmental policy regarding electricity is a relatively new concept, as most of the momentum behind regulation of electricity production has occurred in the past two decades. To fully understand how environmental policy has evolved, a history of the progression of policies in Virginia will be assessed. Virginia was chosen as the first state to assess, as the Roanoke College is in Virginia, and the goal of this section is to understand the framework of legislation that Roanoke College must work with to increase its sustainability with regards to energy use and production.

3.2.1 A Progression of RPS in Virginia

Virginia's recent history of environmental policy regarding energy production was first witnessed in 2007, when the state enacted a voluntary RPS to re-regulate their electricity industry (NC State University, 2020). The initial RPS created in Virginia was not mandatory, however, it did require the state's energy suppliers to do the following if they chose to participate. Each investor-owned electricity utility (IOU), was asked to report to the commission yearly by November 1st on its efforts, if any, to meet the RPS goals outlined, its overall generation of renewable energy, and any advances made in renewable energy technology (NC State University, 2020). Eligible energy resources defined in the RPS include solar, wind, geothermal, hydropower, wave, tidal, biomass energy, energy from waste, landfill gas, and municipal solid waste energy generation (NC State University, 2020).

The goals of the initial RPS created in Virginia in 2007 are as follows. RPS goal I aims for companies to reach 4% of base year energy sales in 2010 (NC State University, 2020). This means that companies involved would be able to generate renewable energy sales equal to 4% of total energy sales in the year of 2010. The second RPS goal was for companies to average 4% of base year sales in 2011 through 2015, and 7% of base year sales in 2016 (NC State University, 2020). The third goal of the initial RPS asked companies to average 7% of base year sales in 2017 through 2021, and 12% of base year sales in 2022 (NC State University, 2020). Finally, the fourth goal of RPS was to average 12% of base year sales in 2023 and 2024, and 15% of base year sales by 2025 (NC State University, 2020). Essentially, the initial RPS goals outlined a slow increase in the amount of energy sales attributed to renewable energy sources by 2025.

Certain incentives and multipliers were included in the initial RPS goals in Virginia and are as follows. Onshore wind, solar, and animal waste energy generation received double credit towards

RPS goals (NC State University, 2020). This means that if an electric company utilized any of these forms of energy production as part of their RPS goal, they received double the credit towards RPS standards compared to other forms of electricity generation. Companies were also incentivized heavily to invest in offshore wind energy production, as companies that included this form of energy generation as part of their RPS received triple credit towards their goals (NC State University, 2020). Energy companies were also granted the ability to use renewable energy credits (REC) to meet up to 20% of their annual requirement (NC State University, 2020). RECs are not generated by the company, however, are purchased to contribute to the support of electricity generation from renewable sources (NC State University, 2020).

Twelve years later in 2019, Governor Ralph Northam signed Executive Order 43, which aimed to expand access to clean energy and grow clean energy jobs in Virginia in the future (Yarmosky, 2020). Outlined in this executive order was a statewide goal for Virginia to achieve 5,500 MW of wind and solar energy generation by 2028, with at least 3,000 MW of this target to be under development by 2022 (Exec Order No. 43, 2019). This advanced the initial goals set out by RPS and designated specific goals for both wind and solar energy production. In addition, the order outlines that Virginia has a statewide goal of reducing retail electricity consumption by 10% by 2022, using 2006 as a baseline (Exec Order No. 43, 2019). This goal aims to actually decrease the amount of electricity consumed by Virginians, which would help decrease overall emissions in the long run.

Many of the large-scale energy suppliers in Virginia made accommodations that reflect what was outlined in Executive Order 43. Dominion Energy, a large supplier of electricity throughout Virginia committed to many renewable energy production goals in response to the Executive Order. Two of the pledges Dominion Energy made was to procure up to 500 MW of utility-scale solar and onshore wind projects, as well as procurements of smaller-scale solar energy, which include rooftop solar (Exec Order No. 43, 2019). Appalachian Energy, also known as American Electric Power, also pledged to generate a procurement process of 200 MW of utility-scale solar projects throughout Virginia, with hopes that the projects will be operational by the end of 2021 (Exec Order No. 43, 2019).

In April of 2020, Governor Northam signed the Virginia Clean Economy Act, which established a mandatory RPS goal that displaced the voluntary one proposed in 2007 (Yarmosky, 2020). This act stresses the importance of change for public interest and includes goals for both offshore wind and solar energy generation (Yarmosky, 2020). 5,200 MW of offshore wind generation is “in the public interest”, so the act requires Dominion Energy to prioritize hiring local workers from historically disadvantaged communities, as well as to advance job training and apprenticeship in the field (Yarmosky, 2020). As for solar, the act established that 16,100 MW of solar and onshore wind is also in “public interest” and expands “net metering” allowing rooftop solar to be more easily implemented across the state (Yarmosky, 2020). The new RPS goal also placed Virginia on a path to achieve 100% clean electricity generation by 2050 (Yarmosky, 2020). This act also requires nearly all coal-fired power plants to close by the end of 2024 (Yarmosky, 2020). The two primary companies that supply electricity to Virginians, Dominion Energy and American Electric Power, both are set to achieve 100% clean energy by 2050, with Dominion Energy achieving the goal by 2045 (Yarmosky, 2020).

Under the mandatory RPS program, both power companies are required to produce their electricity from 100% renewable sources by 2050, which is a promising goal that can, and hopefully will be achieved. If either utility company fails to meet its targets outlined in the mandatory RPS, they are required to pay a specific deficiency payment or purchase RECs (Sullivan, 2020). The proceeds from these payments are to be deposited into an account controlled by the Department of Mines, Minerals, and Energy, which will allocate the payments in percentages to job trainings and renewable energy programs in historically poor communities, as well as to energy efficiency measures and administrative costs (Sullivan, 2020).

3.2.2 Financial Incentives

Virginia has many environmental policies in the category of financial incentives that aid in generating more sustainable practices. To be exact, Virginia has 70 programs from both state and federal levels, which include 42 policies falling under the category of financial incentives (DSIRE, 2020). For example, the Virginia SAVES Green Community Program is a viable option for local governments, non-profit organizations, businesses, and industries (Virginia Department of Environmental Quality, 2020). This program is sponsored by Virginia's Department of Mines, Minerals, and Energy (DMME), and aims to provide subsidized financing options for energy efficiency, renewable energy, and alternative fuel loans (Virginia Department of Environmental Quality, 2020). The DMME initially capitalized the program to have $20 million of Qualified Energy Conservation Bonds (QECBs), with the ability to build upon that figure with additional funding from the Commonwealth (Virginia Department of Environmental Quality, 2020). The program offers a direct pay subsidy from the U.S. Treasury to offset interest rates on financing, as well as increased the life of financing of up to 20 years or longer (Virginia Department of Environmental Quality, 2020). This allows for companies who decide to engage in this program to have a better chance of handling the financial stressors of transitioning to green energy consumption.

Another example of environmental policy in Virginia that pertains to financial incentives is the Energy Efficient Buildings Tax Exemption (Code of VA §58.1-3221.2) (DSIRE, 2020). This statute allows any county, city, or town to exempt or partially exempt energy efficient buildings from local property taxes (DSIRE, 2020). Buildings that meet the requirement include those that exceed efficiency standards outlined in the Virginia Uniform Statewide Building Code by 30%, meet performance standards of the Green Globes Green Building Rating System of the Green Building initiative, meet performance standards of the Leadership in Energy and Environmental Design (LEED), or meets the guidelines of Energy Star qualified homes (DSIRE, 2020).

While all these policies can be found in Virginia, there are many others that can be found across the United States that are even more progressive. Virginia is certainly not last in the race for attaining a sustainable future, however, there are many other states that started their journey to zero emissions prior to Virginia, and thus, have made further progress. Regardless of where an individual state is with regards to achieving zero emissions, it is important that every state has a plan of action, as every step, no matter how small, can help shape a more sustainable future.

3.3 Environmental Policies in Representative States: Case Studies

While it may seem as though Virginia is doing a lot to combat climate change with regards to energy production and consumption through policy, they rank 33rd in the nation, which places them at the bottom half (Virginia Department of Environmental Quality, 2020). Other states, such as California and Vermont, which are ranked #1 and #2 respectively, have accomplished greater progress than any other states due to several factors in their social, economic, and geographic make ups (Union of Concerned Scientists, 2017). Below are a few of the many rules and regulations along with financial incentives offered by each state, which highlights their advanced progress in the realm of combatting climate change through policy that structures energy efficiency.

3.3.1 California

Rules & Regulations. California established its RPS program in 2002 by Senate Bill 1078, with an initial requirement of accomplishing 20% of electricity retail sales served by renewable sources by 2017 (California Public Utilities Commission, 2021). Since then, the program has been restructured twice; once in 2015 with Senate Bill 350 which mandates that California have a 50% RPS by 2030 and accelerated once more in 2018 with Senate Bill 100 to 60% RPS by 2030, and for all the state's electricity to come from carbon-free sources by 2045 (California Public Utilities Commission, 2021).

Financial Incentives. Among the state rules and regulations California has enforced are financial incentives that encourage renewable energy production and usage. An example of a financial incentive in place is the Residential Renewable Energy Tax Credit, which affords a 26% personal tax credit on any solar water heat, solar photovoltaics, geothermal heat pumps, wind, or fuel cells using renewable fuels (DSIRE, 2020). A stipulation of this incentive is that solar water heating property must be certified by SRCC or a comparable entity endorsed by the state, or at least half of the energy used to heat the dwelling's water must be from solar (DSIRE, 2020). While there are other stipulations of this financial incentive, it is still a very promising offer for residential landowners who want to receive a tax credit. Another example of a financial incentive offered in California is the City of San Francisco's Solar Energy Incentive Program, which provides incentives to residents, businesses, and non-profits who install photovoltaic systems on their properties that are at least one kW in capacity (DSIRE, 2020). Low-income residential participants can receive $2,000 per kW and non-profits can receive $1,000 per kW (DSIRE, 2020). This incentive, while focused on generating more solar energy production, makes an impact in the promotion of generating more renewable energy on the city level to those who would like to receive a rebate alongside their contributions to renewable energy progression.

3.3.2 Vermont

Rules & Regulations. Following closely behind California with regards to renewable energy policies and progress is Vermont. Vermont created its RPS under Act 56, which jointly created a Renewable Energy Standard (RES) in 2015, that was set to take effect in January of 2017 (State of Vermont, 2021). Under the RES, Vermont's distribution utilities were mandated to obtain a defined percentage of their total retail electric sales from renewable energy, which are broken down into three tiers (State of Vermont, 2021). Tier I requires that Vermont distribution utilities get 55% of their electric sales from any source of renewable energy by 2017, and to increase this by 4% every three years to eventually obtain 75% in 2032 (State of Vermont, 2021). Tier II requires that Vermont distribution utilities get 1% of annual retail electricity sales from new distributed renewable generation and have that number increase by 3/5's of a percent each year until reaching 10% in 2032 (State of Vermont, 2021). Under this tier, distributed renewable energy is defined as electrical generation facilities that have a capacity of 5 MW or less (State of Vermont, 2021). Tier III of Vermont's RES requires that distribution utilities either obtain more newly distributed renewable energy consistent with the requirements under Tier II or acquire fossil fuel savings through energy transformation projects equivalent to 2% of their annual retail sales in 2017, which shall increase by 2/3's a precent each year until reaching 12% in 2032 (State of Vermont, 2021).

Financial Incentives. Vermont also offers many financial incentives for both residents and businesses that are attempting to increase their commitment to renewable energy production and consumption. In fact, Vermont has a website called "Efficiency Vermont", which provides objective advice, technical services, and financial support to help residents and businesses take part in opportunities involving renewable energy. One example of a financial incentive that Vermont offers residents and businesses is $6,000 cash back on switching to a central wood pellet furnace and boiler instead of gas or coal (Efficiency Vermont, 2021). While this is an alternative renewable energy atypical to the more common solar, wind, and geothermal technologies, the wood pellet system still reduces detrimental impacts on the environment compared to that of coal and natural gas. Other financial incentives in Vermont focus on helping residents and businesses reduce their energy use by offering programs that clients can participate in that help save them money, as well as further their contribution to combatting climate change (Efficiency Vermont, 2021). While it is important to provide policies and incentives that prioritize a shift in energy production and consumption to that of renewable sources and more efficient technologies, it is equally as important to provide information and guidance to residents on how to reduce their overall energy consumption. A reduction of energy consumption can reduce the amount of energy generation required, which will ultimately help reduce emissions and combat climate change.

3.4. Environmental Policy at Roanoke College

Now that a multitude of examples of environmental policy have been illustrated in the preceding sections at the international, national, and state levels, it is important to explore an even deeper analysis of environmental policy at the level of institutions, specifically, colleges. The focus here will be on Roanoke College, with the goal of understanding how policy at the institutional level impacts enedgy consumption.

Strategic Plan

Roanoke College currently does not have any defined environmental policies in action, which is the primary reason behind conducting this study. However, Roanoke College has taken a few initiatives that commit to sustainability on campus and contribute to overall reduction of environmental degradation. On the college's website under sustainability at Roanoke, the college asserts that "Our purpose is to present an overview of the "green" plans and practices currently underway at Roanoke. Some items have far reaching effect and some very minor. All are an effort to continue our path toward environmental responsibility and "green awareness" (Roanoke College, 2021b).

Roanoke College has also developed a Strategic Plan for 2018-2023. Included in Objective 1.2 ("Make Roanoke College more nationally competitive and regionally distinctive"), subsection 1.2h calls to "Foster an environmentally sustainable campus and prepare students for living in a more envrionnmentally sustainable world" (Roanoke College, 2018). While not well defined, this objective opens the door for more focus on the environment and sustainability in the future. Another objective outlined in their Strategic Plan is Objective 4.3 ("Sustain and enhance the campus technology infrastructure to provide secure, reliable, and efficient technology"), which is also loosely defined, but still points towards making future progress (Roanoke College, 2018).

These objectives serve well to include sustainability on campus in the future, however, they lack specificity as to how they plan to achieve them. Many colleges have Sustainability Plans that chart a course for what sustainability looks like, including specific targets and goals, deadlines, and areas of responsibility. While the objectives pertaining to improved sustainability on campus are vague at the moment, the mere inclusion of them in the Strategic Plan is promising.

Recognition for Energy Efficiency. Roanoke College has been recognized by the Princeton Review's Guide to Green Colleges and a Pride in Salem Green Award for energy efficient renovations on campus (Roanoke College, 2021b). The student organizations that take on environmental issues at the college consist of RC Electric, Earthbound, Alternative Breaks at RC, Gardening Club, RC Sustain, and RC Divest (Roanoke College, 2021). Of these, RC Divest and RC Sustain are the only two organizations that deal with renewable energy. RC Divest tasks the college with looking at their investments with the endowment to divest from companies that exploit fossil fuels and reinvest in companies that are more sustainable for the college's future (Roanoke College, 2021). RC Sustain is an organization that consists of students, faculty, and staff that hold meetings to discuss sustainability on campus (K. O'Neill, personal communication, May 7, 2021). While they meet to discuss issues concerning sustainability on campus, they can only make recommendations to the college regarding issues and hold no authority to enforce their suggestions (K. O'Neill, personal communication, May 7, 2021).RC Sustain is not an organization that is publicly posted on Roanoke College's webpage; however, its existence was discovered through discussion with professors about sustainability groups on campus.

Roanoke College has also received LEED Certification for both New Hall and Lucas Hall. New Hall is the most recent residence hall constructed, and Lucas Hall underwent serious renovation to meet the requirements to become certified. LEED (Leadership in Energy and Environmental Design) is an internationally recognized green building certification system that provides verification that a building or community was designed and built using strategies aimed at improving performance in metrics concerning energy savings, water efficiency, CO_2 emissions reduction, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts (Boston University Sustainability, 2020). Essentially, the certification validates that the planning and construction of the building was environmentally conscious.

Roanoke College's Progress in Energy Efficiency

Roanoke College currently operates under net-metering rather than submetering, which makes it difficult to calculate the progress made by implementing energy efficient appliances around campus. Net-metering refers to a single meter tracking a congregation of buildings on campus, so there is no way to attribute energy consumption to individual buildings. One of the largest investments made by the College has been their goal to transition to LED lightbulbs in all their buildings, which is currently in progress. Unfortunately, due to net-metering, the true value of energy savings and progress towards greater efficiency is not as transparent as it would be under submetering, as the energy totals from a congregation of buildings are totalled under two net meters on campus. This issue creates difficulties with separating the College's advancements in one building as opposed to lack thereof in another. Nonetheless, this was uplifting information to hear as it shows that, while not done in necessarily the most structured, informative way, efficiency upgrades are being made around campus behind the scenes.

Furthermore, the college has installed other regulatory energy efficient technology such as high efficiency chillers and heating systems, energy efficient water pumps, energy efficient management systems, and automated schedules and limits for light and heating. While it is unknown how effective these transitions have been as opposed to the technology they replaced, it is still comforting to know that they are being implemented to improve the College's commitment to sustainable practices.

On the other hand, while the College has clearly received awards for sustainability, it still does not have a solid plan of action for attaining further progress in combatting climate change by means of introducing commitments to renewable energies and further expansion to their statements on energy efficiency. As the College moves forward with its new Strategic Plan, a greater emphasis on sustainability and energy conservation may open the door to further recognition based on strong environmental action. After all, the reason behind this study is to create a plan of action that will ultimately improve the college's position in environmental policy and planning.

3.4.1. Environmental Policy at Washington & Lee: A comparative analysis

Roanoke College is a small, private institution in a smaller city which makes its access to financial resources more restrained than other larger colleges and universities in larger, more prominent locations. Nonetheless, other colleges and universities comparable in size to Roanoke College have defied the odds and made environmentalism a priority on campus, generating greater environmental policies and energy standards. An example of such a college is Washington and Lee University, located in Lexington, VA.

Washington & Lee's Climate Action Plan

As part of their climate action plan, Washington and Lee has pledged a climate neutrality target by 2050 (Stewart, 2019). In addition to this goal, Washington and Lee has set other goals involving energy consumption, including but not limited to reducing greenhouse gas emissions by 20% of 2007 levels, improving equipment on campus such as on-site solar arrays, and other behavior and operations change initiatives (Stewart, 2019). The university generated these policies and initiatives by gathering data on current energy usage and separating their total usage into categories that they could then propose individual initiatives to make improvements. Washington and Lee attributes their success to meeting their initial goals to focusing on Equipment upgrades, operations and behavior changes, and sustainability initiatives. (Stewart, 2021).

Progress Still to be Made

While the success of Washington and Lee is very commendable, their efforts to climate commitment and energy efficiency are nowhere near complete. The Association for the Advancement of Sustainability in Higher Education, or AASHE, is the leading association for the advancement of sustainability in higher education (AASHE, 2020). Part of AASHE's contribution to institutions like Washington and Lee is to help them track progress and generate annual reports to guide institutions in the right direction of their goals (AASHE, 2020). To do so, AASHE has created the Sustainability Tracking, Assessment and Rating System (STARS). This program is presented as a transparent, self-reporting framework for colleges and universities that aids them in frame working for a better understanding of sustainability in all sectors, enable meaningful comparisons overtime, create incentives or continual improvement, facilitate information sharing between institutions on sustainability practices and performances, and build a stronger sustainability community (AASHE, 2020).

AASHE Report for Washington & Lee

Washington and Lee have received Silver status, lower than Gold and Platinum but higher than Bronze and Reporter for its efforts across all aspects of sustainability (AASHE, 2020). However, the STARS report is very thorough and breaks down information and grading scales by sector. Included in Washington and Lee's grade was information regarding energy usage specifically. In the section titled *Clean and Renewable Energy,* Washington and Lee received a score of .04/4.00 (Association for the Advancement of Sustainability in Higher Education, 2020). Part of the reason for this is because they only get 0.89% of their energy consumption from clean and renewable resources (Association for the Advancement of Sustainability in Higher Education, 2020). Despite their lack of commitment to energy consumption from renewable and clean sources, Washington and Lee has committed to other sections of sustainability that have drastically reduced their overall impacts on the environment. These changes are more difficult to attain due to the initial costs incurred, however, the college has many plans to increase their grade from STARS and commit to energy conscious practices in the near future, such as investing in on and off-site renewable energy generation, further advance on-campus energy policies, and implementing a purchasing policy that mandates that all appliances purchased by the University must be Energy Star Rated (Stewart, 2021).

Other Colleges

Other colleges worth mentioning are George Mason University, Hollins University, Randolph College, University of Richmond, Virginia Wesleyan University, Dickinson College, and Elon University. Below is a table that generates comparison between these colleges, which was created by Roanoke College graduate, Alaina Birkel. Due to Washington and Lee's comparative nature to Roanoke College as well as their apparent success through committing to sustainable practices, their policies and frameworks will play a vital role in the creation and advancement of Roanoke College's advancement in the realm of sustainability and renewable energy.

	George Mason University	Washington and Lee University	Hollins University	Randolph College	University of Richmond	Virginia Wesleyan University	Dickinson College	Elon University	Roanoke College
Signed a Presidents' Commitment	X	X		X	X	X	X (Achieved neutrality in 2020)		
AASHE STARS	Gold	Silver	No rating, but enrolled	Silver	Gold		Gold	Silver	
Princeton Review Green Colleges[1]	X	X		X	X	X	X (#6)	X	
'We Are Still In' Declaration[2]	X		X	X	X	X	X		
Sustainability Coordinator	X	X		X	X		X	X	
Composting food waste from dining halls	X	½[3]	X	½	X		X	X	[4]
Sustainability-focused curriculum	X				X	X	X		
Sustainability Committee[5]	X	X	X	X	X	X	X	X	[6]
Recycling campus-wide	X	X	X	X	X	X	X	X	
Drought-tolerant plants	X	X			X	X	X	X	
Reduce stormwater runoff	X			X	X		X	X	
New infrastructure must have LEED standards	X	X			X	X	X	X	[7]

Table 3. An analysis of peer and peer-plus institutions' sustainability initiatives.

[1] The Princeton Review's *Green Colleges* list is comprised of schools with environmentally responsible initiatives. Only the Top 50 schools are ranked.
[2] This is a declaration to the international community that American institutions are still committed action and the Paris Agreement.
[3] "½" represents a regular composting service that only composts from the college or university's Dining Services' kitchens.
[4] Roanoke College composts some waste from Dining Services' kitchen twice a week. This has been disrupted during COVID-19.
[5] Refers to an institutionally chartered committee, task force, or council that is comprised of at least students, faculty, and staff.
[6] RC Sustain is Sustainability Committee on campus comprised of faculty, staff, and students. However, committee is not chartered by the administrative body.
[7] This is a commitment thought to be said by the college, but it is not available in public writing or well-known.

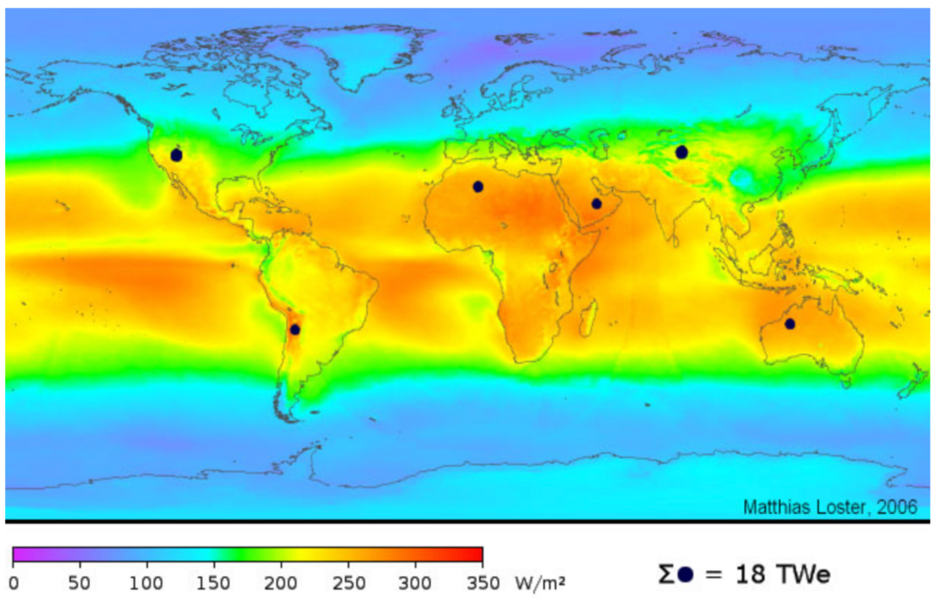
Table 1. An analysis of peer and peer-plus institutions' sustainability initiatives (Birkel, 2019)

4.0. Renewable Energy Potential

The landscape of the United States offers great promise when considering the development of renewable energy. Two of the most alluring aspects of renewable sources of energy are that they are free and they are practically limitless (PSU, 2020). However, it is important to recognize that not all areas on earth have equal energy generation potential. For example, areas that do not receive high wind speeds at the appropriate height will not have as great a potential for wind energy as somewhere that receives ample amount of wind year-round at the correct elevations. For these reasons, it is important to assess which energy sources are most efficient in the United States, and more specifically, around the institution in question. For the purposes of maintaining focus on categories of renewable energy that would be of utmost potential to Roanoke College, the renewable energy source that will be analyzed is solar, as other sources of renewable energy typically operate on larger scales than the institutional level. While wind is potentially viable in the form of smaller wind turbines, the lack of data on wind speeds specific to the city of Salem makes estimations of its potential less accurate and viable.

Overview of Solar Potential

Solar energy has vast potential not only in the United States, but across the globe. A study conducted by students at Penn State University projected that solar energy potential worldwide is 10,000 times that of energy the globe uses (PSU, 2020). To strengthen this argument, the students mapped out six specific points (radii of 100km) at which solar energy could produce enough energy to completely power the planet for an entire year, which can be observed in the figure below (PSU, 2020).



Global average solar irradiance. Areas in red have a higher-strength solar energy resource on average. The black dots indicate areas with sufficient solar energy potential to supply the entire world's energy demands.

Source: Total Primary Energy Supply

Image 2. Global Average Solar Irradiance. *Adapted from Penn State University*

While this does not hold direct relevance to solar potential available for Roanoke College, it emphasizes the point that solar energy is both an abundant and effective source. For a more relevant measure of the solar potential available to Roanoke College, an analysis of solar potential estimates generated by a Google software known as "Project Sunroof" alongside other similar software will be analyzed with emphasis on rooftop solar potential in the city of Salem, as well as the most energy intensive buildings to run on Roanoke College's campus.

Project Sunroof

Google's Project Sunroof is a tool that serves as a personalized solar savings estimator, powered by Google Earth Imagery (Project Sunroof Data Explorer, 2018). The software uses Google Earth imagery to analyze the shape of roof tops alongside local weather patterns to produce a personalized solar plan (Project Sunroof Data Explorer, 2018). This source will be referenced later as part of the cost-benefit analysis of rooftop solar implementation on Roanoke College's campus, but for the purposes of this section, it will be used to convey rooftop solar potential in both Salem, VA and on Roanoke College's campus.

Rooftop Potential in Salem, VA

While there is potential to generate solar energy in Salem that is not attributed to rooftop solar, this analysis will focus on rooftop solar technology due to its applicability to Roanoke College's campus. The estimate produced by Project Sunroof is based on 97% data coverage over buildings in the area of Salem, VA; estimates include all buildings viable for solar panels, meaning they receive at least 75% of the maximum annual sun in the county (Project Sunroof Data Explorer, 2018). The threshold for Salem is 1,048 kWh/kW (Project Sunroof Data Explorer, 2018). 87% of the buildings in the county are considered solar viable using the threshold above, and only 21 solar installations exist so far of the 9,000 roofs considered viable (Project Sunroof Data Explorer, 2018).

The amount of roof space available in Salem is equal to 16.6 million square feet, has capacity of 236 MW DC, and can produce a whopping 293,000 MWh AC per year (Project Sunroof Data Explorer, 2018). The software also provides a median estimated system size and solar electricity production per viable roof for the county, which uses a median roof space of 705 sq ft, has capacity for 10 kW DC, and can produce 12.4K kWh AC per year (Project Sunroof Data Explorer, 2018).

Potential Impact from Implementation

Another interesting calculation that Project Sunroof gauges is the potential impact if all viable solar installations were implemented, soliciting the amount of CO_2 emissions that could be avoided from the electricity sector in the county. In Salem, the amount of CO_2 that would be avoided is 172,000 metric tons, which is the equivalent of 36,400 electric cars taken off the road in just one year, or 4.4 million tree seedlings grown for 10 years (Project Sunroof Data Explorer, 2018). These figures, while not directly pertinent to Roanoke College, still help emphasize the potential and feasibility of implementing solar in the surrounding area.

5.0 Roanoke College Energy Use: Financial Analysis and Carbon Footprint

5.1 Overview: EnergyCAP

Roanoke College uses an energy monitoring service known as EnergyCAP, an energy management and utility bill accounting software that simplifies procedural tracking of energy bills and utility costs. EnergyCAP presents the information in a manner that aids institutions to make better decisions regarding consumption (EnergyCAP, 2021). When the College receives an energy bill, the bill code is typed into the EnergyCAP software, and the software breaks down all the electricity, water and sewage, and natural gas usage from that bill's timeframe. Once configured by the software, the information becomes easily accessible and comprehendible to users who wish to analyze the results, and new data is added to previous data that allows for comparisons to be made between buildings and timeframes. The software itself can prove extremely beneficial to an institution that understands how to reap the most benefits and is determined to make progress in energy efficiency.

5.2 Methodology

To estimate electricity usage and cost for individual buildings on the same meter, a direct correlation between square footage and electricity use was assumed. Square footage and annual electricity use might differ due to certain confounding variables such as hours of operation, number of light fixtures, and number of energy intensive appliances, however, this is the most accurate conclusion that can be drawn with the current implementation of net-metering. To produce estimates of usage and associated costs, square footage of individual buildings was divided by the total amount of square footage the meter covers to generate a percentage of individual buildings' contribution to the total square footage covered by the meter. This percentage was then used to calculate estimations for both usage and costs for individual buildings by multiplying the associated percentages by both actual cost and actual usage totals on the meter from 2019. Due to the impact Covid had on normal operation, the most recent totals from a typical year of operation were used (2019). The same logic was applied to estimate the contribution of individual buildings to the total carbon footprint recorded on the EnergyCAP software, with totals also drawn from 2019 data. As mentioned previously, this methodology is expected to produce rough estimates, as the College's operation on net-metering does not allow for accurate measurement of both energy consumption and associated costs for individual buildings.

Meter/Building Name	Roanoke College	High Street Meter	Cregger Center	New Hall	Fintel Library	Olin Hall
Square Footage (ft^2)	1,410,457	742,685	153,750	79,918	75,690	75,043
% of Roanoke College Total Square Footage	100%	52.66%	10.9%	5.66%	5.37%	5.32%
% of High Street Meter Total Square Footage	N/A	100%	20.7%	10.76%	10.19%	10.1%
Annual Electricity Consumption (kWh/year)	17,661,910	10,362,147	2,144,964.43	1,114,967	1,055,902.78	1,046,576.85
Annual Cost of Electricity ($/year)	$1,616,584	$906,328	$187,609.90	$97,520.89	$92,354.82	$91,539.13
Monthly Electricity Consumption (kWh/month)	1,471,826	863,512.25	178,747.04	92,354.82	87,991.90	87,214.74
Monthly Cost of Electricity ($/month)	$134,715	$75,527.33	$15,634.16	$8,126.74	$7,696.24	$7,628. 26
Daily Electricity Consumption (kWh/day)	48,184	28,017.53	5,799.63	3,014.69	2,854.99	2,829.77
Daily Cost of Electricity ($/day)	$4,420	$2,466.32	$510.53	$265.38	$251.32	$249.10
CO_2 Emissions from Electricity Use (MT/year)	7,964	4,673	967.31	502.81	476.18	471.97
CH_4 Emission from Electricity Use (MT/year)*	6	4	0.83	.43	.41	.40
NO_2 Emissions from Electricity Use (MT/year)*	42	25	5.18	2.69	2.55	2.53

Table 2. Breakdown of estimated electricity consumption, associated costs, and emissions generated for the year 2019. Estimations produced with methodology described above. Estimates rounded to nearest hundredth. (*) signals emissions represented as CO_2 equivalent.

5.3 Results: Financial Analysis

Roanoke College Electricity Use and Cost Totals. Due to the COVID-19 pandemic, data from the most recent unaffected year (2019) was used to construct the financial analysis. The total square footage of buildings on Roanoke College's Campus is 1,410,457 ft² (EnergyCAP, 2021). In 2019, Roanoke College's electricity usage amounted to 17,661,910 kWh with an associated charge of $1,616,584 (EnergyCAP, 2021). This equates to the college's electricity use averaging 1,471,826 kWh per month with an average cost of $134,715 per month (EnergyCAP, 2021). If the figure is broken down even further, electricity use averaged 48,184 kWh per day and resulted in an average cost of $4,420 per day (EnergyCAP, 2021).

High Street Meter Electricity Use and Cost Totals. The meter that contributed the most to totals concerning energy usage and associated costs was the High Street Meter, which is a combination of 20 buildings on campus (EnergyCAP, 2021). The total square footage covered on the High Street Meter equated to 742,685 ft², which constitutes roughly 52.66% of the college's total (EnergyCAP, 2021). In 2019, the High Street Meter's electricity usage amounted to 10,362,147 kWh with an associated cost of $906,328 (EnergyCAP, 2021). This equates to the High Street Meter's electricity use averaging 863,512.25 kWh per month with an associated average cost of $75,527.33 per month (EnergyCAP, 2021). Daily, the High Street Meter's average electricity use amounted to 28,017.53 kWh with an associated cost of $2,466.32 per day (EnergyCAP, 2021). From data associated with this meter, estimations of electricity usage and associated costs were calculated with the methodology mentioned above for the buildings with the largest square footage, under the assumption that square footage directly correlates with electricity use. Table 2 below provides the estimates calculated through the employed methodology for electricity use and associated costs.

Cregger Center. The Cregger Center is the primary athletic center on Roanoke College's campus and consists of a performance gymnasium, indoor track, Office of Athletics, fitness center, classrooms, faculty offices, athletic training room, and labs for the Health and Human Performance department (Roanoke College, 2021a). It is believed to be the largest contributor to electricity use and cost on the meter through estimations, as it is 153,750 ft², which constitutes 20.7% of total square footage measured under the High Street Meter, and 10.9% of the college's total square footage (EnergyCAP, 2021). Confounding variables with the building's estimations are due to the recency of its construction, as this enabled the building to include more recent technology that improves overall energy efficiency, such as LED lighting, as well as more efficient heating and cooling systems (M. Vaught, personal communication, April, 2021). In addition, as opposed to a residence hall, its hours of operation are fixed (6:00 AM -11:00 PM), which is also an important factor for consideration of the estimate. While calculations based on square footage alone may lead to slightly higher estimations for the building due to confounding variables such as the ones listed above, this building more than likely still places in the top three most energy and cost intensive buildings on campus due to its sheer size.

New Hall. New Hall is the second largest building on campus based on square footage. New Hall is the newest residence hall which includes four floors that can house up to 243 students in either apartments (3), suites, or single and double rooms(Roanoke College, 2021a). It also includes one standard classroom, one large seminar room, one small conference room, three offices, and large common area kitchens and pods (Roanoke College, 2021a). Each floor also includes study areas, and each room has individual heating/air controls (Roanoke College, 2021a). It is estimated to be the second largest contributor to electricity use and cost on the meter through estimations, as it is 79,918 ft², which constitutes 10.76% of total square footage measured under the High Street Meter, and 5.66% of the college's total square footage (EnergyCAP, 2021). Confounding variables with the building's estimates also include the recency of its construction, which has enabled it to qualify for LEED certification. A few factors that enabled the building to qualify for LEED certification are the water saving plumbing fixtures, recycling of construction waste, using materials with recycled content for construction, the utilization of low volatile organic compounds in construction, utilizing an energy efficient mechanical system, installing energy efficient windows, implementing rooms with ample natural light and individual comfort controls, and incorporating energy efficient lighting systems (Roanoke College, 2021a). Taking into account the energy efficient measures used in construction, estimations for energy use and associated costs may be higher than in reality.

Fintel Library. Fintel Library is the third largest building on campus based on square footage. Considered the intellectual center of Roanoke College, it consists of four floors and two computer labs (Roanoke College, 2021a). It is believed to be the third largest contributor to electricity use and cost on the meter through estimations, as it is 75,690 ft², which constitutes 10.19% of total square footage measured under the High Street Meter, and 5.37% of the college's total square footage (EnergyCAP, 2021). As opposed to the confounding variables mentioned for the previous two buildings, the variables at play in library may actually make the building more energy and cost intensive than estimated. The two computer labs situated in the building in addition to the construction of the building occurring much earlier than both Cregger and New Hall offers reason to believe that the estimates generated off square footage alone do not account for the excess demand for electricity as well as the lack of energy efficiency to recent standards. For these reasons, estimations for energy and associated costs may be lower than in reality.

Olin Hall. Olin Hall is the Fine Arts facility on campus, and houses a 400-seat theater with high-tech staging, lighting, and sound systems, an art gallery, a black box theater, several practice rooms for students to rehearse, photography labs, drawing studios, recital and rehearsal halls, and several classrooms (Roanoke College, 2021a). Estimates indicate this this is the fourth largest contributor to electricity use and cost on the High Street meter since it constitutes 10.1% of total square footage on the meter and 5.32% of the college's total square footage (75,043 ft²; EnergyCAP, 2021). Due to its size, estimations generated on electricity usage and cost are probably reliable, however, year to year this buildings energy use and costs may fluctuate depending on the ways in which the building is utilized. For example, if the theater is used frequently throughout the year, the technology used for the show probably is very energy intensive and cost prohibitive, so estimates might increase. On the other hand, if the building is not used frequently throughout the year, energy use and costs could decrease. Other variables that play a role are the pieces of equipment used in the art and photography labs, as equipment of this nature is typically energy intensive. Finally, depending on the instruments being kept in the building, it is typical to maintain specific temperatures to protect the instruments from detuning, so this is another factor to consider while viewing the estimations below.

Other Buildings to Consider. While this financial analysis focused on the four largest buildings on campus, other campus buildings may contribute more to energy and costs due to their usage and facilities. One building worth mentioning is the Colket Center and Sutton Commons, which is the College's primary dining hall and conference center. Due to the energy intensive appliances used for food preparation as well as for washing and cleaning, this building could potentially rank in the top three for most energy and cost intensive on campus. Other buildings that might have high levels of energy consumption based on usage are Trexler and Life Sciences, the academic buildings for mathematics and natural science students. These buildings both hold multiple computer labs as well as energy intensive equipment used for academic purposes, such as the ventilation hoods used to conduct labs, so their energy use and associated costs might be much higher than anticipated.

5.4 Results: Carbon Footprint

Using similar logic regarding the Covid-19 pandemic, data from the most recent unaffected year was used to construct the carbon footprint associated with electricity use. The year 2019 held the most recent data that accurately represents energy usage and emissions associated with operation. As mentioned previously in the section discussing the science behind climate change, it is typical to measure emissions of gases other than carbon dioxide in their CO_2 equivalent. All measurements and estimations for gases other than CO_2 mentioned int this paper (Methane (CH_4), and Nitrous Oxide (NO_2) will be presented using their CO_2 equivalent. The total carbon footprint generated from electricity use by all buildings on Roanoke College's Campus was 7,964 MT of CO_2, 6 MT of CH_4, and 42 MT of NO_2, totalling a CO_2 equivalent of 8,012 MT (EnergyCAP, 2021). Using a greenhouse gas equivalency calculator, the CO_2 of total emissions produced by the college can be represented in the following ways.

Greenhouse Gas Emissions. One of the conversions calculated by the greenhouse gas equivalency calculator is directly to greenhouse gas emissions. The CO_2 equivalent of Roanoke College's total emissions can be represented under this category in the form of GHG emissions generated from 1,742 passenger vehicles driven for one year (United States EPA, 2018). Passenger vehicles used for reference for the estimate are defined as 2-axle 4-tire vehicles that get 22.5 mpg, travel 11,556 miles per year, and emitt 8.89×10^{-3} metric tons of CO_2 per gallon of gasoline burned (United

States EPA, 2018). Roanoke's carbon footprint can also be equated to 20,135,741 miles driven by a car with the same standards listed above (United States EPA, 2018).

CO_2 Emissions. Another way to represent the CO_2 equivalent generated by the College from electricity use is through CO_2 emissions from various sources. The first source that represents Roanoke College's energy use that is very profound is the figure represented as CO_2 emissions generated by burning 8,855,531 pounds of coal (United States EPA, 2018). Other representations of the college's CO_2 equivalent emissions in the same category include emissions equal to 901,542 gallons of gasoline consumed, 18,549 barrels of oil consumed, and 974,600,883 smartphones charged (United States EPA, 2018).

Emissions Avoided and Carbon Sequestered. While the previous two sections provided representations that can be considered negative, this section will take the carbon footprint generated by Roanoke College and place it in reference to positive environmental actions, such as avoiding emissions and sequestering carbon. The CO_2 equivalent of emissions generated by the college can be represented as the greenhouse gas emissions avoided by 2,725 tons of waste or 340,906 trash bags recycled instead of landfilled, or as 303,663 incandescent lamps switched to LEDs (United States EPA, 2018). The College's carbon footprint can also be represented through the amount of carbon sequestered through 132,480 tree seedlings grown for 10 years, 9,816 acres of U.S. forests in one year, or 54.8 acres of U.S. forests preserved from conversion to cropland in one year (United States EPA, 2018).

The point of generating these comparisons was for two reasons. First, to emphasize the damage the college is dealing to the environment through electricity use in one year. Second, to emphasize the equivalent of positive contribution to the environment through reduction of the overall footprint. Through implementing more efficient technology as well as switching to renewable energy sources, the College can greatly reduce its impact on the environment.

5.5 Sources of estimation error

Lack of Accuracy: Net-metering

A key data limitation stands in the way of Roanoke College being able to utilize EnergyCAP to its full potential. This issue, the issue of not operating on submetering, restricts users from being able to accurately measure specific buildings consumption patterns on campus. Roanoke College currently operates under net-metering, which places several buildings in a zoned area under one of the two separate meters employed, causing all electricity, water and sewage, and natural gas data to be combined when looking at energy totals. While this does pose an issue in generating the most accurate financial and carbon footprint analysis possible, there is still a way that estimations can be generated to have a loose idea of the financial obligations of each building.

Salem Electric Company

Roanoke College purchases its electricity from Salem Electric Company, which is the primary provider for electric utilities in the county. The City of Salem owns and operates its own electricity distribution system that purchases energy wholesale from American Electric Power (AEP), as well as receives a small portion of its energy from an allocation of federal hydropower from the U.S. Army Corps of Engineers Philpott Hydro Project through the Southeastern Power Administration (City of Salem, 2021). AEP's generating capacity is sourced primarily from coal fired power plants and natural gas, which contribute to 45% and 28% of total generation, respectively (American Electric Power Company, 2021). The remainder of electricity generation comes from wind, hydro, and pumped storage of other sources (17%), as well as energy efficiency (3%) (American Electric Power Company, 2021). The average charge per unit ($/kWh) is .092/kWh (EnergyCAP, 2021).

6.0 Plan of Action

Initially the rationale behind conducting this research was to develop a plan of action for Roanoke College to implement solar energy on campus through utilizing the cost-benefit analysis constructed, as well as providing examples of environmental policies that could prove beneficial to implementation. The logic of the argument relied upon the notion that if investing in solar energy would save Roanoke College money, and this could be proven, that there would be no rational argument to reject the plan, as the college would both reduce expenditures and its impact on the environment. However, after completing all the necessary research, it became apparent that the College has a lot of smaller projects to take action on first before reaching a position where implanting solar energy would be logical. This does not consist of policies that the college can make use of regarding the implementation of solar energy, but rather, smaller actions that are fundamental to attaining this goal in the future. While these actions may not be considered as revolutionary as implementing solar energy, enacting them will place Roanoke College in a better position than it is today with regards to initiating climate action.

Proposal 1: Installing Sub-Metering on Campus

Electrical sub-metering refers to the installation of energy monitors that are able to measure energy usage after it reaches the primary utility meter, which would allow the College to monitor individual buildings, departments, pieces of equipment, and other factors that contribute to electricity consumption to account for actual energy use (Rogers, 2017). Installing sub-meters provides benefits such as accurate and real-time monitoring or energy consumption, in-depth review of facility energy data at the building level, the ability to record and attribute actual energy usage without estimatation, and the ability to identify and eliminate wasted energy (Rogers, 2017). This would allow Roanoke College to make more informed decisions regarding energy use, create comparisons on energy use between facilities on campus, and understand changes that could be made in specific buildings that would ultimately lower costs (Rogers, 2017).

As previously discussed, Roanoke College currently operates on a net-metering system to track energy, water and sewage, and gas usage. While constructing the financial, carbon footprint, and cost-benefit analyses for this paper, it became apparent that sub-metering would have proved extremely beneficial. Sub-metering would have allowed for the extrapolation of concrete data on the exact figures associated with energy use, costs, and carbon footprints with regards to individual buildings. This would have not only made analyses on these topics much easier to produce, but also more accurate, as the estimations provided were constructed based off the percentages of square footage that buildings contributed to their respective meters. By calculating the figures from this basis, estimations could vary immensely from actual electricity usage, associated costs, and carbon footprints attributed to each of the buildings due to the plethora of confounding variables present. Despite making these analyses more difficult to produce, the benefits the college would experience are immense. As the adage goes “knowledge is power”, sub-metering would provide the college with more precise knowledge on energy, cost, and carbon footprint data that would ultimately lead to more informed decision making. The information provided by sub-metering is crucial if the college plans to become more energy efficient, as well as if it holds aspirations to become carbon neutral someday.

Proposal 2: Sign Second Nature’s President’s Climate Agreement (Climate Commitment)

One program that will provide Roanoke College with the necessary steps to generate a proper foundation for renewable energy commitment and sustainable development is Second Nature’s President’s Climate Agreement. More than 100 institutions have already signed this agreement to begin the process of generating a foundational commitment to sustainability (Second Nature, 2020). The non-profit out of Massachusetts provides three separate commitments that institutions of higher education can sign: The Carbon Commitment, the Resilience Commitment, and the Climate Commitment (Second Nature, 2020). The Carbon Commitment emphasizes institutions reducing GHG emissions and attaining carbon neutrality as soon as possible (Second Nature, 2020). The Resilience Commitment focuses on climate adaption and community capacity building to face climate change (Second Nature, 2020). The Climate Commitment is essentially a mix of both the previous commitments, prioritizing the lessening of detrimental aspects of the intuition with regards to climate change and promoting adaptation to climate initiatives (Second Nature, 2020). Of the three, the Climate Commitment would prove most beneficial for Roanoke to engage in, as it aligns with many of the aspirations, values, and visions of the Roanoke College Community. In addition, this commitment incorporates a mix of the previous two, which will help generate a better foundation for multiple levels of sustainable progress.

As part of signing this agreement, Second Nature provides structured advice such as deadlines for progress to help ensure that institutions are following through with their commitment. One of the most advantageous requirements outlined in the Climate Commitment, especially for Roanoke College, is the obligation for the institution to create an internal structure in the form of a committee, task force, or council that's sole purpose is to carry out the commitment (Second Nature, 2020). This requirement under the Climate Commitment would be extremely beneficial to Roanoke College, as they do not currently have any staff whose job is to work on improving sustainability around campus. After this initial obligation, the Climate Commitment then creates deadlines for the first three years to help the college progress in the ways in which it agreed.

Within the first year of signing, colleges must back a joint campus-community task force to ensure its commitment to the plan, as well as complete a GHG emissions inventory which specifies short-term prospects for reducing GHG emissions (Second Nature, 2020). Roanoke College last generated a GHG emissions inventory report in 2018, which will allow this portion of the commitment to flow more smoothly. After the first year and within years of signing, the college is tasked with completing a campus-community resilience assessment (Second Nature, 2020). This process was already started by the former Environmental Studies Department Chair, Dr. Valerie Banschbach, as well as Roanoke College alumnus, Abby Supplee. This requirement of the commitment has already begun, placing the college ahead of the game when attempting to make progress through the first three years of their commitment. Finally, within three years, the college must propose a practical date for achieving carbon neutrality (Second Nature, 2020). Along with this date will be interim achievement dates to track progress. Each college creates its own objectives and timeframe for attaining this goal, as every institution has different financial, communal, and social make-ups.

A foundational aspect of making progress with regards to climate action is an infrastructure that is devoted to the task. As the first requirement of signing this commitment is to do just that, it will prove extremely beneficial for future progress to ensue on the path to taking climate action. Think of developing the infrastructure as appointing a coach to direct a team of any kind. A coach provides the game plan in order to attain the teams ultimate goal, which is to win. Developing the infrastructure surrounding climate action will help the College (the team) attain its goal of taking climate action -- all it needs is someone with a game plan.

Proposal 3: Don't Wait, Act Now

The fact that Roanoke College has not made much measurable progress with regards to renewable energy commitment, and more broadly, climate action, is beneficial in many ways. The first, and potentially most important being that any type of initiative taken today will propel Roanoke College into a better position for future progress. Roanoke College must begin essentially from the ground up, as they have been unable to monitor the ways in which their previous improvements have furthered their commitment to a sustainable future. After reviewing a related project created by a fellow colleague, Alaina Birkel, which discussed the necessity for institutional climate action at Roanoke College, it became apparent that nothing will be accomplished unless there is advancement in the infrastructure governing decisions about renewable energy, as well as establishing a foundation to build upon. In economics, there is extreme emphasis based on the concept that a dollar today is worth more than a dollar in the future. This applies the same to many aspects of life, as well as taking initiative on climate action, as any action taken today will place the college in a better position to make progress in the future.

7.0 Summary

Through the process of constructing this analysis, there were many times that I found myself in a cloud of uncertainty. Whether about larger aspects such as the direction or goal for constructing this analysis, or smaller ones such as word choice, uncertainty tended to halt overall progress towards completion. Occasionally, uncertainty led to days of inaction, which often times made the next day worse than that of the previous one. On certain days, excuses were generated as to why progress couldn't be made, whether the excuses had legitimacy behind them or not, the excuses led to further inaction, which led to further displacement from completing the analysis. As days of uncertainty and excuses clouded my thoughts, days of inaction occurred ever more recently, and progress towards completing the analysis disappeared. If there is one lesson I learned from constructing this analysis, it is that progress today, no matter how insignificant it might seem, is better than no action taken at all. For actions today contribute to overall progress of achieving one's goal. Inaction, however, leads to a lack of progress, which can be an easy hole to fall into.

While it is understandable that the COVID-19 pandemic has created many obstacles for pursuing climate action and taking initiative, we must ask ourselves whether there is any better moment than the present. The truth is that nothing is promised. Time that is lost through inaction can never be brought back. A day without taking action is a day wasted in completion of a goal. Further inaction of the behalf of Roanoke College regarding climate initiative will only place the college in a worse position tomorrow than if they were to have taken action today.

7 years, 31 days, 15 hours was the time projected on the Climate Clock in Manhattan as of 3:00 p.m. on November 29, 2020 (Golan, 2020). This was the proposed deadline for the world to achieve zero emissions if society hoped to avoid irreparable damage caused by climate change when I began constructing this analysis. Today, as of 7:05 p.m. on May 6, 2021, the time projected on the Climate Clock projects 6 years, 239 days, 12 hours, and 53 minutes (Golan, 2020). The lifeline portion of the Climate Clock, which monitors the percentage of the world's energy production that comes from renewable sources, now projects 12.27%, a 15.65% decrease from when I began this analysis on November 29, 2020 (Golan, 2020).

It is easy to blame this on the COVID-19 pandemic. It is easy to hope that life will resume to normal, and claim that climate initiatives will take place and improvements will be made when hardships aren't presented. It is easy to be stagnant and make excuses for inaction. However, nothing worth having comes easy, and time is ticking.

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