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CLARK UNIVERSITY
MASTER OF SCIENCE IN ENVIRONMENTAL SCIENCE AND POLICY PORTFOLIO

ANNALISE B. KUKOR

SPRING 2016

Submitted to the faculty of Clark University, Worcester,
Massachusetts, in partial fulfillment of the requirements for
the degree of Master of Science in the department of International Development, Community,
and Environment: Environmental Science and Policy Program

And accepted on the recommendation of

Frederick T. Greenaway, Chief Instructor

A handwritten signature in black ink, appearing to read "F. T. Greenaway". The signature is written in a cursive style with a horizontal line extending from the end.

SUMMARY

ENVIRONMENTAL SCIENCE AND POLICY MASTER'S PORTFOLIO

ANNALISE B. KUKOR

Through my work as a Master's student in Environmental Science and Policy at Clark University I have acquired a wide variety of knowledge and skills which will be showcased in this document. The breadth of courses and sub disciplines that I have taken has expanded my awareness and understanding of the current state of Environmental Science and Policy. My undergraduate degree from Clark University in Environmental Science focusing on Earth Systems Science focused primarily on comprehension of the Earth's physical processes with applications for Global Climate Change. This master's work has expanded upon those quantitative skills as well as deepened my understanding of American environmental legislation and has encouraged creative solutions in building a sustainable future. This portfolio is meant to represent the variety of knowledge that I have acquired through my work at Clark University's Environmental Science and Policy program including the state of climate denial in America, analyses of municipal environmental policies, social practices and their climate impacts, quantitative analyses of climate data, and critical examinations of energy systems. Some of the work showcased in the following pages was collaborative in nature as many courses in this program aim to simulate the collaborative nature of the field and the increasing collaborative nature of our world.

In order to promote a sustainable future within the capitalist framework that we live in, we must look at what it means to sustainably consume and produce. Through my work at Clark, particularly in a course called Sustainable Consumption and Production, I examined the structure of hyper consumerism, the concepts of well-being in America as it pertains to sustainability, growth within the capitalist framework, and the usefulness and downsides of technical

efficiencies to promote sustainability. The first paper included in this portfolio was a group endeavor that examined New York City's extensive OneNYC Plan for a Strong and Just City. This paper summarizes the extensive plan put out by the Mayor's Office and analyzes the plan based on how the concepts of human well-being, consumptive behavior and growth of the economy play into the sustainability of the city.

The second paper is a quantitative research project done using statistical analyses to compare historical O18 isotope ratios from coral cores at variety of locations around the globe. These ratios tend to be highly correlated with water temperatures. The analysis of historical coral cores is a technique used to give us a clearer idea of the paleoclimate. The raw data for this project was acquired from the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC). This project is one of the many exercises at Clark that tailored my ability to obtain, clean and organize data from external sources.

In a time where we are well on our way to reaching dangerously high levels of Green House Gasses in our atmosphere, I am committed to working towards a more sustainable future for ourselves and for future generations. Unfortunately, an alarming large percentage of the American population does not support the idea that climate change is a human induced phenomenon. The third paper here addresses climate denial in America and analyses and refutes arguments that are commonly used. My team and I examined the demographics of the communities that are most likely to deny human induced climate change, the actual arguments leaders of this movement tend to use, and, most importantly, examined techniques that can be harnessed to discuss climate change with those who do not believe in it. Communication with those who do not understand or agree with the grave implications involved with human induced climate change is vital to promoting a sustainable future.

The fourth paper is a discussion on the solar photovoltaic market which accompanies a solar panel planning spread sheet that I created to help companies or individual consumers can forecast their expenses and potential revenue from installing a single solar panel or a solar array. This paper discusses the historical increase in efficiencies of solar photovoltaics and the innovation that has occurred as well as the steep decrease in cost of photovoltaics since their release on the market in the 1970's.

Overall, this portfolio represents a wide variety of knowledge and skills that I have acquired through my Master's education at Clark University. Each piece of work, carefully chosen to be included here, represents a larger body of knowledge and experiences that I have acquired through my time at Clark University. Clark's Environmental Science and Policy program has helped cultivate me to be thoughtfully critical of environmental policies through collaborative and individual work. It has provided scientific training in environmental decision making and has fueled my commitment to finding creative solutions to promote a sustainable future and culture.

ACADEMIC HISTORY

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Date: March 2016

Baccalaureate Degree: Environmental Science

Source: Clark University

Date: May 2016

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A Critical Analysis of Well-being, Consumption and Growth within New York City's OneNYC Plan for a Strong and Just City



Source: www.nyc.gov

EN 277- Sustainable Consumption and Production

Professor Brown

15 December 2015

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Introduction

New York City is working towards environmental and economic sustainability to ensure continued growth and prosperity in the wake of climate change and OneNYC is the plan the city is using to achieve it. Mayor Bill de Blasio released this plan in April 2015, which sets stringent goals with specific targets for a strong, sustainable, equitable and resilient city. Mayor de Blasio's plan draws the link between poverty, consumption, and pollution, enabling the administration to present steps to make New York City one of the most environmentally sustainable cities in the United States. The plan is broken down into four visions which provide environmental protection policies with economic and social benefits. The visions include a vision for a growing, thriving city; a just and equitable city; a sustainable city; and a resilient city. This plan is an example of sustainable development for the prosperity of future generations (NYC press office, 2015).

The visions within OneNYC are interwoven and strongly connected through addressing the well-being, economic viability, and growth of New York. The plan includes a separate vision for sustainability, but sustainability is implicated throughout each of the other visions. Since a major goal of this plan is to ensure well-being and growth through resilience, equity and sustainability, a major disparity arises between sustainable development and sustainable consumption. Society's level of consumption is deeply embedded in the psychological and cultural search for meaning in life, which is subsequently linked to social practices and the structural features of the economic system. This plan does not explicitly address consumption through a social practices lens. New York City has a major financial sector which exponentially increases the city's economic income, but does not cycle through the local economy. In order to achieve sustainable development, New York City addresses the growth of the local economy.

Our economy is founded in the expectation that consumers will act under free markets, leading to growth and improved quality of life. This neoliberal ideology locks us into our levels of consumption in order to obtain a certain level of well-being while continuing to promote increasing consumption. Therefore, is it clear that sustainable development, which is present in OneNYC, addresses climate change issues through policies that encourage us to continue to consume at higher levels, only more efficiently and with fewer planned environmental impacts. The plan addresses persistent poverty issues within New York as urban environmental problems hit the poor and working classes the hardest. As New York plans to lift people out of poverty, it becomes more critical to address sustainable consumption, for with increased economic income, follows increased consumption. It is critical to break this link to attain sustainability. OneNYC successfully addresses the well-being and growth of New York City in a sustainable manner, but there is an implicit need to address sustainable consumption in the city and break the connection between economic growth and increased consumption within each vision to achieve a good life.

Background

OneNYC builds off of a previous effort the city first released in 2007, under the prior Mayor Michael R. Bloomberg administration, titled “PlaNYC: A Greener, Greater New York”. The overarching purpose of this document was to help the city responsibly meet the growing infrastructural needs of its ever-expanding population. PlaNYC included the city’s first approaches to sustainability and proposed a commitment to reduce greenhouse gas emissions. When the United States was struck by a severe economic recession in 2008, New York City was highly affected. As a result, the first version of the plan was expanded in 2011 to include additional and stronger commitments to improved environmental quality and to making neighborhoods more livable by increasing factors that impact quality of life. Disaster struck New York City again in the fall of 2012 when Hurricane Sandy touched down on the northeast United States. This initiated the release of the third and final version of PlaNYC in 2013 titled “A Stronger, More Resilient New York” which added in themes of resiliency and adaptation to the threats of climate change. Prior to the release of OneNYC, the city made significant progress on reaching goals set forth in PlaNYC through reducing greenhouse gas emissions, protecting their water supply, planting trees, installing bike lanes, phasing out heavily polluting oils used for heating, strengthening coastal infrastructure, improving the resiliency of neighborhoods, among other initiatives. That being said, the city recognized that PlaNYC was inadequate to address the needs facing the city in 2015 and beyond; OneNYC was born in the spring of 2015 under the Mayor Bill de Blasio administration (OneNYC, 2015).

The needs of New York City are continuously changing, and presenting new challenges. The population is at an all time high, currently numbering nearly 8.4 million and expected to increase to 9 million by 2040. The population is also getting older. By 2040 citizens over 65 are expected to exceed school-aged children, which will make for a new challenges relating to social services and the built environment. Population growth and demographic shift are paralleled by an economy that is expected to change over time. Infrastructure is failing and leaving New Yorkers with the highest average commuting time of all large cities, 47 minutes (OneNYC, 2015). Additionally, climate change poses real and imminent risks to the city. According to a 2015 report published by the New York City Panel on Climate Change, by 2050 the city could expect average temperatures to increase 4.1 to 5.7 °F, extremely hot days over 90 °F to double in frequency, and precipitation to increase by 4 to 11 percent compared to a baseline calculated between 1971 and 2000 (NPCC, 2015).

OneNYC differs from its predecessor in many ways. OneNYC offers a new focus on inequality, proposes a regional perspective, and recognizes that collaboration with a multitude of public and private actors will be needed in order to achieve the ambitious goals it sets forth. In OneNYC the city states that the poverty rate and level of income inequality remains concerning, and that reducing poverty would lead to a healthier, safer, and more economically successful city. The regional perspective that the document proclaims is a means by which the city can help to extend its national and global influence. The city also recognizes that it will have to work with a number of outside stakeholders in order to successfully address OneNYC goals because some

of them lie outside the scope of traditional city government control. Nonetheless, the city will lead the way with every aspect of the plan, even when goals are somewhat out of their control. The Mayor's Office of Sustainability oversees the development of the plan, and shares accountability for implementation with the Mayor's Office of Recovery and Resiliency; yet, all sectors of the city's government will be involved. OneNYC took into account the opinions of city residents in order to ensure a democratic process and that the plan would adequately address their concerns. Online and telephone surveys were conducted, community meetings in all boroughs were held, organizations from around the city had the opportunity to meet with elected officials, and leaders from outside communities were invited in to provide their feedback (OneNYC, 2015).

Well-being

Our Sustainable City

The "Our Sustainable City" vision is innately intertwined with city residents' ability to improve upon their own personal sense of well-being and happiness. The six goals presented in this section of OneNYC all have implications for personal well-being. Environmental justice is highlighted in this vision as, not a goal in and of itself, but as a result of a number of the initiatives that can be found in the vision (OneNYC, 2015). Addressing environmental justice is important as it aims to improve the quality of health for many New Yorkers who are subject to disproportionately poor environmental quality. Health is a key factor in happiness and the creation of feelings of well-being (Layard, 2005) so the focus on environmental justice should improve relative happiness.

The first goal of the "Our Sustainable City" vision aims to reduce New York City's greenhouse gas emissions 80 percent by the year 2050 compared to 2005 levels. The reduction of greenhouse gases will likely lead to reductions in other air pollutants, thereby reducing the risk of diseases brought on by air pollution. The second goal aims to stop sending waste to landfills by 2030. Focusing on reducing waste, is not guaranteed to, but should make neighborhoods cleaner and more aesthetically pleasing. The air quality goal in this vision aims for New York City to achieve the best air quality among all large U.S. cities by 2030. This goal should improve health outcomes in the city and reduce morbidity and mortality among residents. Healthier residents in turn are happier and able to achieve a greater sense of well-being (OneNYC, 2015).

The brownfields goal within this vision aims to "clean up contaminated land to address disproportionately high exposures in low-income communities and convert land to safe and beneficial use". The first initiative within this goal is to "Accelerate cleanup of brownfields to improve public safety and encourage private investment in new development on brownfield sites". This initiative should improve environmental quality, health, and public safety within the city, leading residents to feel safer, and happier in their own communities. The second initiative within this part supports community engagement in creating community brownfield planning areas (OneNYC, 2015). Getting the community involved in decision-making and brownfield

cleanup and redevelopment will bring new power and opportunities to residents looking to make a positive difference in their community.

Water Management is a goal within the vision that aims to “mitigate neighborhood flooding and offer high quality water services”. Water is a basic need, thus these management services are vital to the well-being and health of the city’s residents. One of the initiatives within this goal is to expand green infrastructure and design in order to manage storm water throughout the city (OneNYC, 2015). This initiative should reduce infrastructural damage resulting from flooding and help in avoiding any overbearing costs these disasters might cause financially or otherwise.

The last goal in the “Our Sustainable City” vision is to address parks and natural resources in the city to allow all New Yorkers to benefit from beautiful, useful, and accessible public spaces. The expansion of parks and open space within the city should help promote vibrant communities. The first initiative under this goal is to target the improvement of parks and other public land in “under-resourced and growing neighborhoods”. Another interesting initiative within this goal is to repurpose underutilized streets around to city to become “pedestrian plazas” or other types of areas where people can get together. This goal also has an initiative, which will improve aesthetics by planting trees and installing other amenities across the city (OneNYC, 2015). These initiatives are all important in creating a city that promotes healthy living and happiness among its residents.

The six goals contained in the “Our Sustainable City” vision have the potential to positively impact the community by increasing New Yorkers’ ability to thrive. Environmental justice is a focus of this vision, which positively impacts health and also reduces inequality. When considering the well-being of city residents, most of these goals and associated initiatives are technical remedies (e.g. brownfield planning, cleanup, and redevelopment), however some of the remedies have a social aspect as well as a technical one (e.g. turning streets into places for people to congregate).

Our Growing Thriving City

The goals within the “Growing Thriving City” vision of the OneNYC plan have the potential to help people attain parts of the American idea of a “good life”. Although the main point behind this section is to create infrastructural and economic growth of the city, these ideas are likely to improve quality of life for the residents. This vision addresses increasing job opportunities at all skill levels for New Yorkers. Unfortunately, the lower paying jobs are not living wage. The OneNYC plan addresses that by creating the Career Pathways Strategy. It is a program made to “support training programs that give people who historically struggle to enter the labor market the skills needed for entry-level work” (OneNYC, 2015) . This strategy address helping people gain the skills they need to progress their careers, but they do not address that even median wage jobs do not provide a particularly prosperous life.

This vision also makes reasonable commuting times a priority. A large goal of the OneNYC plan is to provide 90 percent of New Yorkers with at least 200,000 jobs within a 45-minute commute on public transit (OneNYC, 2015). It has been shown that higher commuting

times are strongly linked to a reduction in health related activities such as exercising, sleeping, preparing food, and eating with family (Christian, 2012). This goal of reducing commuting times for New York City residents is likely to allow for healthier behaviors and increase well-being for New Yorkers.

Mayor de Blasio and the creators of this plan also laid out a plan to create easy access to cultural resources and activities for all New Yorkers by ensuring cultural facilities in each neighborhood. They frame this as a way to provide jobs for New Yorkers, which would improve well-being and quality of life if they are living wage jobs, but leisure time and community engagement are tenants of a “good life”. They aim to increase local cultural partnerships and make the permitting process much easier for community centers. They ensure providing cultural experiences to people of all income ranges by expanding cultural programming in New York City’s public parks (OneNYC, 2015). In conjunction with reduced commuting time, this has the potential to positively affect the well-being of NYC residents. Unfortunately, many people, especially those who are paid low wages and must have many jobs, work hours too long to enjoy this cultural programming.

Our Just and Equitable City

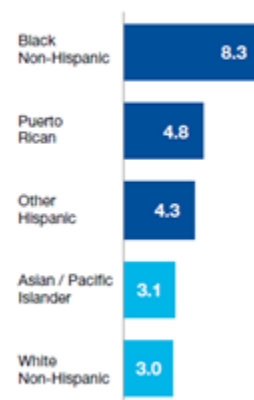
The goals within “Our Just and Equitable City” also aim to increase well-being and happiness of the residents of New York. Poverty and its negative impacts on residents’ well-being and happiness is the overarching issue within this vision.

Currently 45.1 percent of residents are at, near, or in extreme poverty. The six goals in this vision are aimed at those who are most affected by reduced income and those who have the largest gap in well-being. This vision aims to take 800,000 New Yorkers out of poverty or near poverty by 2025. This will be done through increasing government and public services, as well as increasing the minimum wage. By following through with both of these, the cost of living for many residents will go down while income goes up (OneNYC, 2015).

The first goal in “Our Just and Equitable City” aims to increase childhood well-being and happiness through increased education and childcare. The plan aims to reduce infant mortality rates, mainly in areas of high poverty. High poverty areas see nearly double the average infant mortality rate (IMR), 5.2 deaths versus 2.8 per 1,000 births. The figure to the right shows differences in race and ethnicity when it comes to IMRs. By targeting areas of high poverty, IMRs can see the largest reduction over time. About 80 percent of all infant mortalities come from injuries from either the baby's sleeping position or a dangerous environment. Through parent education and increased access to quality child health care, many of those could be prevented (OneNYC, 2015).

Another initiative is providing free all day quality kindergarten for four-year-olds. Increased education leads to increased cognitive and academic ability, increasing the high school graduation rate, reducing crime involvement and increasing college attendance. Many families

Infant mortality rate by race/ethnicity
Per 1,000 live births, 2013

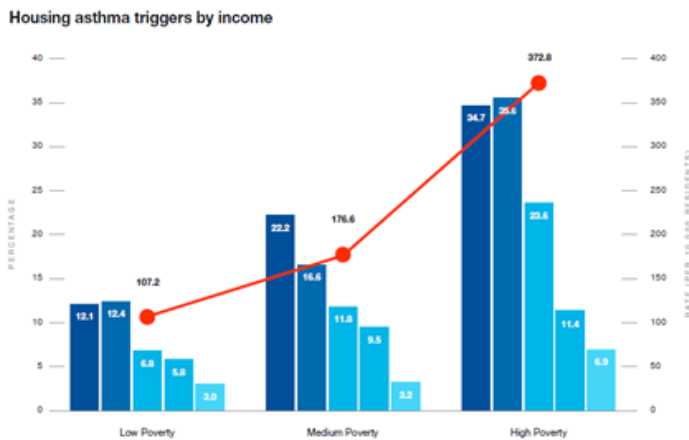


are unable to afford pre-k; those in poverty benefit the most decreasing inequalities while increasing happiness and well-being (OneNYC, 2015).

The other 6 goals include: Integrated Government and Social Services; Healthy Neighborhoods, Active Living; Health Care Access; Criminal Justice Reform; Vision Zero. The other goals intend to increase education for college and career success, increase transportation for workers, increase environmental quality and health care, increase affordable housing, increase government and community services and access to broadband (Wi-Fi) for all (OneNYC, 2015). Each goal intends to increase general health and education, or reduce poverty. This is done through a couple general means: increasing access to a resources and services, reducing the costs of living, increasing minimum wage and days in workforce, changing the physical environment, and changing social practices.

The second goal, listed above, creates more local and accessible government resources allowing more civic participation, which can be usually limited by: physical location, information, transportation, language, etc. The city plans to make each school a community school. Within a community school students have high quality education, families have access to social services and communities have a place to address local issues and share resources. This gives the ability for families to have a larger role in child education, which is not seen in large public schools. Students are given dental, mental, and overall free health screenings at community schools. Neighborhood Health Hubs (NHHs) will be implemented in areas of “high health disparities”. NHHs plan to reduce health inequalities within the city while also being a one-stop solution to many service needs (OneNYC, 2015).

The third goal’s initiatives are to improve health include increasing food quality and affordability, change social behaviors to increase residential housing environmental quality, as well as create safer cleaner neighborhoods. As New Yorkers spend around 90 percent of their time inside, building design that increases physical activity can increase the number of people who meet daily activity goals. Residents with lower income see more



negative health impacts from their physical environments. The figure above “Housing asthma triggers by income” shows a large difference between those in low to high poverty. Again, many of the initiatives are aimed at groups who will see the greatest changes (OneNYC, 2015).

The fourth goal is to increase healthcare for residents at the highest risk and those who have not had adequate access. This is done through smaller community and government based

preventative care . Instead of a few large centralized hospital campuses, the vision is planning on creating many smaller health care access points within communities.

The fifth goal is aimed at reducing crime and incarceration through new technology, environmental design, new methodologies to use data, and increased community involvement in Justice Reform. This goal also plans to increase help for domestic violence victims including shelters and social services. By reducing crime rates within the city, residents will feel safer and spend more time outside, therefore improving overall well-being (OneNYC, 2015).

The last goal plans to reduce traffic fatalities to zero. This will be done by targeting high fatality roads, increasing biking and walking lanes, shortening pedestrian crossing distances, increasing shoulder sizes, increasing medians and repainting road lines (OneNYC, 2015).

This vision's main theme is that the root of inequalities in health, education, well-being and happiness come from poverty and the gap in living cost and income. That is why initiatives aim at decreasing the living costs of the poorest while increasing the amount and quality of services. New York's plan will try to pull 800,000 residents out of poverty or near poverty by increasing minimum wage to \$13/hour and by lowering the cost of living. The costs to the city of increased government services (healthcare, education, civic) along with new construction will be immense (OneNYC, 2015).

Our Resilient City

The social dimension of sustainability and the social infrastructure affects social equity within the city. A community that is sustainable and resilient displays a higher level of social capital and social cohesion. Social cohesion is the pride in and attachment to a place, social interaction, safety, trust and stability. Social capital and cohesion are likely to offer residents a good quality of life, with high levels of satisfaction with home and neighborhood and an appreciation of the local environment (Bramley G. et al., 2010). Therefore, by focusing on the growth of the local economy, in "Our Resilient City", to withstand any future shock events, New York City will be improving the social capital. People living in communities with a higher level of social capital are more likely to benefit from personal well-being, reduced crime rates, more empowerment, and a higher quality of life than those living in communities where social capital is lacking (Healey and Côté, 2001).

Social sustainability represents both public and collective goods and some key drivers of individual private choice. Social sustainability can save public costs, promote happiness, and can contribute to the kind of urban vitality, which underpins modern economic competitiveness. Sustainability and quality of life are inevitably linked. The resiliency indicator used to measure this is to reduce the Social Vulnerability Index (SoVI) for neighborhoods across the city and reduce average annual economic losses resulting from climate-related events (OneNYC, 2015). The SoVI measures the social vulnerability of U.S. counties to environmental hazards. According to the National Oceanic and Atmospheric Administration (NOAA), the index is a comparative metric that facilitates the examination of differences in social vulnerability among counties. SoVI is a valuable tool for policy makers and practitioners because it provides a tool to evaluate progress on different initiatives towards resiliency. This tool graphically illustrates any

geographic variation in social vulnerability and shows where there is uneven capacity for preparedness and response (NOAA, 2011). This resiliency indicator is useful in measuring the well-being of New Yorkers because it takes into account the social and economic variables to vulnerability and can show which boroughs are most susceptible to climate change. SoVI can be used to measure improved quality of life. Below is a list of initiatives in OneNYC resiliency that contribute to the well-being of New Yorkers (OneNYC Indicators, 2015).

Initiatives	Supporting Initiatives	Lead Agencies	Funding Status	Funding Sources
Initiative 1				
Strengthen community-based organizations	Work to build capacity in communities by strengthening community- based organizations that serve their neighbors and by working to expand civic engagement and volunteerism. Take steps to mitigate the risks of heat in order to reduce heat-related illnesses and deaths, and reduce disparities in vulnerability to climate change.	Mayor's Office, DYCD, NYC Service, DoITT	Funded*	City capital and operating
Initiative 2				
Improve emergency preparedness and planning	Secure and bolster operations and physical assets for emergency response, and expand public education efforts on how to prepare for and respond to extreme weather events and other disasters.	Mayor's Office, NYC EM, FDNY	Funded	City capital and operating
Initiative 3				
Support small businesses and local commercial corridors	Provide financial investments, technical assistance and tailored resources regarding preparedness and resiliency to small businesses and commercial corridors.	Mayor's Office, SBS, DOT	Funded	Federal and State
Initiative 4				
Ensure that workforce development is a part of all resiliency investments	Ensure that all investments in resiliency will create job opportunities for residents and low-income applicants, and build on successful workforce development models to encourage the hiring of Sandy-impacted residents.	Mayor's Office	Budget neutral	City operating and federal

Initiative 5				
Mitigate the risks of heat	Take steps to mitigate the risks of heat in order to reduce heat-related illnesses and deaths, and reduce disparities in vulnerability to climate change.	DOHMH, Mayor's Office	In planning	N/A

Social infrastructure costs include education, health, personal social services, and environmental, protective and cultural services together with public goods such as police and the fire service. A major focus present in the table above is social infrastructure, which strengthens communities, such as hospitals, community centers, libraries, and schools. OneNYC intends to ensure that New York City adheres to the utmost standards of resiliency in the social infrastructure by providing each borough with access to top notch social services (OneNYC, 2015). This can enhance social resilience and assist in immediate response after a disruptive event. Parks, in particular, can play a role in protecting adjacent neighborhoods from severe weather, and serve as gathering places after an event. Parks and rain gardens also help reduce heavy flows into sewage systems.

OneNYC sets the precedence to adopt policies to support infrastructural adaptation. The city will use the best available climate science, as well as robust research, legislative action, advocacy, and regional coordination to adapt the city’s infrastructure to be resilient against disruption. In order to do this, the city will design standardized guidelines by 2018 for resiliency that ensure the city adheres to the highest performance standards (OneNYC, 2015). These performance standards will include energy efficiency, as well as improved processes within the social and physical structure of the city. This initiative will ensure there are enough food, fuel, materials and consumer goods to sustain the city during a shock event. This will encourage the growth of local food and urban gardening, as well as alternative forms of energy. This will improve the well-being of New Yorkers because the political infrastructure will set standards for better food quality through local sources, as well as growth in the local economy. By growing the local economy, the money is not going to national or multinational corporations; it is staying within the parameters of New York. There will be a growth in urban and sustainable agriculture, as well as investment in the Hunts Point Food Distribution Center, which provides almost all New Yorkers with their food (OneNYC, 2015). While OneNYC may not explicitly say the word well-being in its initiatives for resiliency, it is clear that the quality of life is inevitably improved through a truly sustainable and resilient city.

Consumption

Our Sustainable City

Consumption and production are not addressed explicitly in the “Our Sustainable City” vision. The first goal of reducing New York City’s greenhouse gas emissions focuses on the

electricity, transportation, solid waste, and building construction sectors. Significantly altering the behavior of consumers is not addressed in these initiatives.

The goal of zero waste addresses consumption to an extent, though not as much as would be ideal in order to help the city achieve this ambitious goal. Zero waste should encourage reduced consumption, at all levels of society. One of the supporting initiatives is to reduce the 15 pounds of waste that New Yorkers create at home every week and the other 9 pounds created while at work and away from home. These figures are staggering when considered over the course of a year. Three million tons of residential waste, plus another three million tons of commercial waste are created every year in the city that diverts only 15.4 percent of this waste. The initiative most likely to alter consumptive behavior is the proposed “Pay-As-You-Throw” volume based program. This type of program incentivizes residents and property owners to dispose of less waste because they are charged by volume for disposal. This program will decrease waste generation, increase recycling, increase organics composting, and create consumers who reduce their consumption and are cognizant of the products and associated packaging that they purchase. The city expects that this initiative could reduce waste by up to 30 percent. Another initiative supporting the goal of zero waste that may prove to have a beneficial impact on consumptive patterns is the expansion of the New York City Organics program to all residents by 2018. The city plans to expand their organics program by creating more curbside organics collection and drop-off sites. The expansion of organics composting would have to be instituted along with significant behavior change and marketing campaigns around the city to ensure success. Composting will likely be new to many urban dwellers thus it will be vital to disseminate information about the benefits of composting, what can be composted, and how to properly prepare waste for organic collection (OneNYC, 2015). These behavior changes and marketing campaigns should prove to raise environmental consciousness among residents, leading to a society that is more thoughtful and critical of the purchases that they make and the goods and services consumed.

The other goals in the “Our Sustainable City” vision do not explicitly touch on reducing consumption and production however they could be expected to result in a more environmentally conscious and sustainability minded population which could lead to decreased consumption.

Our Growing Thriving City

The “Growing Thriving City” vision of the OneNYC plan proposes growth in a variety of both the public and private sectors. This plan promises great investment in public transportation for the city. This means that people can spend their money on public goods instead of having the need to increase consumption of products private vehicles and all of the products that come with them. These investments that the city is putting into public transportation infrastructure promote the use of public transportation rather than private vehicles and are a more sustainable option for the city. This vision of the OneNYC plan looks to expand the availability of broadband across the city. This availability of the internet is intended to allow New Yorkers to have an equal playing field for connectivity and access to information, but this will increase the consumption of the internet, and therefore, energy within the city.

We cannot forget that this plan is still functioning within the parameters of hyper-consumerist capitalist America. It does not challenge the culture of consumerism at all. In fact it promotes growth of jobs. The commitment that they have to reducing commuting time and create job training may provide residents with slightly more money and more free time if they are successful. This may be the increase in income that makes their well-being better which is undoubtedly important and needed, but in that, they may be consuming more. This consumption is not necessarily bad but increased consumption would decrease the true sustainability of this plan. This plan encourages growth within the city and consumption is key for that. Since gross domestic product (GDP) is largely made up of consumption and growth of GDP is important in capitalism for achieving perceived prosperity, consumption is likely to continue to increase in this plan. A large flaw of this plan is that it completely avoids discussing behaviors or cultural practices. Without personal changes in behavior or changes in cultural practices, sustainability becomes much more difficult if not impossible to attain.

Our Just and Equitable City

In the section of consumption, “Our Just and Equitable City” brings to question the increase in consumer buying power, a reduction in prices and sustainability. Are the goals of the sustainability vision possible, while increasing the wages and reducing costs of living for about 50 percent of the population? Demand theory says that individuals will change behaviors if price or income changes. “Our Just and Equitable City” plans to do two things, increase wages and decrease living cost for those with the least. By increasing accessibility to social services and reducing their costs residents will end up using more of those services. Not only will they use more services intended to increase health and education these families will have more income left over for other goods. Not only will there be a large increase in residential consumption most of the initiatives to increase health and education will mean new construction and increased energy consumption.

In the work of Daniel Aaronson, research has been done to show that minimum wage increases can lead to increased debt and spending beyond the amount of income. In a \$1 wage increase minimum wage families spent \$750 more a quarter while only increasing income by \$250. Data was taken from 1982-2008 looking at multiple federal and state minimum wage increases. A \$1 wage increase doubles quarterly spending on durable goods (furniture, floors and windows, household items, large appliances, electronics, leisure activities, miscellaneous household equipment, and net outlays on transportation). About 90 percent of the increase in durable goods comes from transportation, or the purchase of vehicles. The biggest issue is that previously workers on minimum wage spent 85 percent of income on non-durable goods (Aaronson et al., 2011).

If New York City plans to increase minimum wage while reducing the cost of living research needs to be done to show if they can reduce greenhouse gas emissions as well as solid waste. In Aaronson’s work the largest change in consumption comes from material consumption and transportation possibly jeopardizing sustainability within New York City. To reduce the amount of spending on luxury goods serious social practices would have to be altered. If this

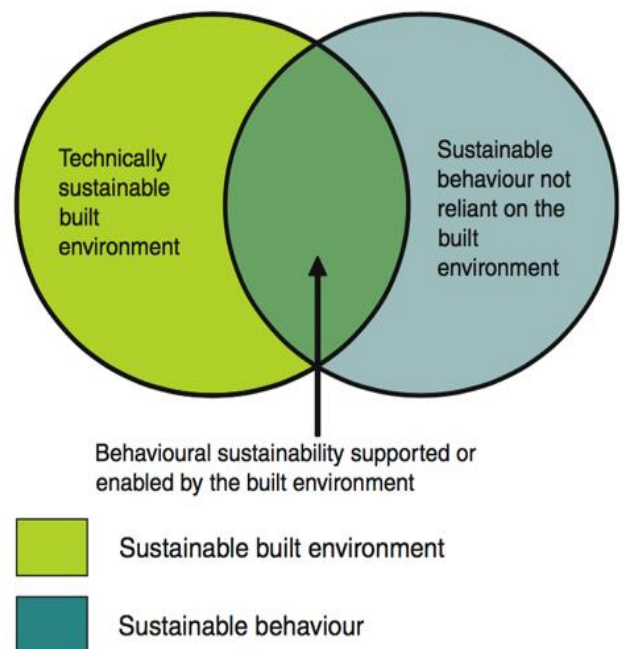
vision is carried out allowing a more face-to-face community social practices could change. Education of residents through social services and community groups could help curb some of the problems facing a growing class when it comes to sustainability and consumption.

Our Resilient City

Reduced consumption of energy may result indirectly from OneNYC as a product of having accessible key services within each neighborhood. This is very important for different groups of residents such as the unemployed, older people, and young families. It will help reduce the gap in equity across New York City, which will enable the city to become more resilient (Bramley G. et al., 2010). The OneNYC resiliency vision includes technical changes that do not call for sociotechnical changes to the system in New York City that will change the social behavior around consumption. This vision is calling for improved infrastructure (technology) to prepare for shock events and ensure the city is able to recover even stronger than before. Reduced consumption of energy will be seen through the buildings and infrastructure initiatives that seek to upgrade them against changing climate, make the more efficient, and adopt policies to support infrastructure adaptation.

The issue is that the determinants of energy use are not simply determined by the nature of the built form as it is recognized that lifestyle and the dynamic effects of occupant behavior (Baker K. et al., 2010). Therefore, reluctance to address sustainable consumption in resiliency leaves a gulf between sustainable development of the city and mitigating the effect of climate change. By addressing consumption, the plan would be able to combat climate change along the entire supply chain. Only addressing the infrastructure and building efficiency will create a rebound effect, particularly when the gap in income equality begins to decrease, bringing thousands of New Yorkers out of poverty, enabling them to consume at greater lengths. The relationship between energy consumption in buildings and urban form suggest that while the nature of the building is important, equally important are the ownership and use of appliances and the fitting of energy efficiency measures (Baker K. et al., 2010).

The figure to the right from Williams et al. (2010) shows some elements of the built environment can enable or support behavioral sustainability, which would reduce consumption. For example, New York City should invest in bicycle paths and pedestrian routes, as well as reduce the number of taxis on the road. There are also sustainable behaviors that are not reliant on the built environment, such as New Yorkers social practices. OneNYC address the technically sustainable built environment, but does not



thoroughly address sustainable behavior that is not reliant on the built environment. It would be beneficial to include initiatives under the resiliency vision that include consumption because it will help create social practices that will not be devastated during shock events. This can be done through home-based sustainable behavior such as reducing energy consumption, using water efficiently, waste recycling and composting, urban gardening, as well as travel behavior using public transportation or walking/biking. By adopting these sustainable practices, residents will be able to further conserve during shock events. These practices will also help New York City mitigate the effects of climate change, the ultimate goal of OneNYC.

The initiatives in OneNYC's vision for resiliency sets the foundation to include consumption by creating the link between social participation and the physical environment by providing access to community facilities and amenities within each neighborhood. Including consumption in the plan will also encourage social participation, which is at the cornerstone for building and maintaining social capital, which is one of the goals of OneNYC (Williams et al., 2010).

Growth

Our Sustainable City

The "Our Sustainable City" vision does not address growth or gentrification explicitly, though some of the goals' supporting initiatives relate to these notions. The goal of reducing greenhouse gas emissions stresses increasing renewable energy generation in and outside of the city. Developers of renewable energy could encroach on certain communities, and build installations around the city. This goal also stresses the reduction of greenhouse gas emissions from transportation. The consideration of alternative transportation methods such as walking and biking, using low or zero emission vehicles, increased and improved public transit, and the continued alteration of zoning and parking policies could help this transition (OneNYC, 2015). These sort of changes could significantly change many neighborhoods across the city, though if the changes are properly planned it should benefit neighborhoods by reducing congestion on streets and air pollution from fossil fuel burning vehicles.

The goal of reaching zero waste includes plans of increasing construction by building facilities to accept, sort, and process increased organic waste streams. Implementing community composting has also been proposed to ensure the success of the city-wide composting initiative. Community composting initiatives would be great opportunities to involve and engage residents in an important waste reducing activity while reducing the need for municipality or privately held organic waste processing facilities to be developed (OneNYC, 2015).

Other goals, such as cleaning contaminated land in order to convert it to safe and beneficial use imply growth in order to succeed. For example the first supporting initiative under the brownfields goal aims to clean up, and then redevelop approximately 750 properties, of which 375 exist in "low- and moderate-income communities". This initiative is expected to "enable \$14 billion in private investment and create 5,000 new units of affordable housing" (OneNYC, 2015). Remediating polluted and dangerous land is great for the neighborhoods and city but this initiative assumes that all of these sites will turn into construction projects after the

environmental issues have been resolved. The city might benefit from considering connecting this goal with the goal of providing and improving upon its parks and natural resources. As long as remediation efforts are successful, brownfields could be turned into parks and open space much easier than into housing or other kinds of development.

The “Our Sustainable City” vision does not guarantee gentrification, though growth appears an inevitable result of its goals and supporting initiatives. The city should consider the effects of growth critically and analyze how new infrastructure contributes to its enormous environmental footprint.

Our Growing Thriving City

The “Growing Thriving City” vision of the OneNYC plan proposes prosperity through the capitalist framework that New York City is already centered around. As the physical location of America’s stock market, it was unlikely that Mayor De Blasio would have proposed a system of prosperity to undermine these capitalist frameworks that are so firmly in place. This vision proposes 8 main goals that focus on growing New York City in its infrastructure, workforce, industries, and culture and thriving neighborhoods. All of these goals are clearly aimed towards expanding economic growth, as a growth in GDP is viewed as a cornerstone of economic prosperity. However, this proposal still attempts to reconcile environmentalism and growth through proposing triple bottom line investments in infrastructure and publicly owned goods. Triple bottom line investments mean that any investments done will produce the highest economic, social, and environmental returns.

This plan does not intend to physically expand the sprawl of New York City, but instead plans to grow its businesses and the economy. Its proposed Small Business First Initiative is intended to make it easy for entrepreneurs to navigate legal parameters. This allows opportunity for people to create more jobs, hopefully living wage jobs, for residents. This section does a good job at promoting consumption of public goods like transportation, but it still works within the capitalist idea of prioritizing growth. This prioritization of growth at all costs has some clear flaws. The economic growth intended is not necessarily growth and prosperity for all. Without implementing citywide living wage and paid sick leave policies, many residents will not see improvements in their quality of life from the growth of the city. The words living wage are only mentioned once in this entire proposal, which can be interpreted to mean that it is not necessarily a priority.

Our Just and Equitable City

As community schools, Neighborhood Health Hubs, and clinics are created jobs will be made in areas of higher poverty (OneNYC, 2015). The plan does not mention them within Vision 2, but if local residents are given some of these jobs they can create further community involvement, along with the ability to reduce commuting. With the creation of more services, infrastructure and housing in low-income neighborhoods gentrification could occur due to increased taxes and rent. But, New York City plans increase and maintains current affordable houses to reduce tax and rent burdens for the lowest income group.

If consumption increases with income, New York City should see economic growth as residents spend more within local communities. Having increased numbers of local services and businesses money will more likely stay in New York as residents consume. Even though increased consumption may not be sustainable, if money recycles longer in low-income communities, economic growth should increase.

Our Resilient City

OneNYC includes the vision to become a resilient city where the neighborhoods, economy, and public services will be ready to withstand and emerge stronger from the impacts of climate change and other 21st century threats. In this plan resiliency is referring to the ability of people, the places where they live, and the infrastructure systems—such as transportation and energy—to withstand a stress or shock event, to recover, and emerge even stronger than before. Through this the city will ensure the growth and well-being of New Yorkers. In order to achieve this New York City will have to achieve social sustainability that is defined by Polese and Stren (2000) as

Development (and/or growth) that is compatible with harmonious evolution of civil society, fostering an environment conducive to the compatible cohabitation of culturally and socially diverse groups while at the same time encouraging social integration, with improvements in the quality of life for all segments of the population.

This emphasizes the need to empower all sectors of the community to participate in decision-making and to consider the social and community impacts with an emphasis on economic and environmental objectives.

In order for New York City to continue to grow in a sustainable manner, it is vital to employ mitigation within the resiliency efforts. This reduces the impact of a stress or shock event or prevents the impact altogether, such as bolstering the defenses of coastal communities to withstand flooding. The resiliency indicator employed to measure this is to eliminate disaster-related long-term displacement (more than one year) of New Yorkers from homes by 2050. In response to future threats, adaptation takes place to change the physical form or function of a structure, a place, or a community, such as hardening power supplies to withstand the effects of extreme weather and a changing climate. This plays an important role in the growth of New York, not only in the sense of being able to recover from a shock event, but enabling the city to sustain its growing population and demand on the physical infrastructure within the city (OneNYC, 2015).

Michael Berkowitz, President of 100 Resilient Cities, pioneered by the Rockefeller Foundation, said, “To truly build resilience a city must not only consider sustainability and disaster response, but also take into account social and economic issues, and it needs to consider them together“ (NYC Press Office, 2015). Growing economic inequality poses challenges to the city’s social fabric. Inequality threatens to disrupt the connections between neighborhoods, institutions, and communities that are relied on in times of crisis and prolonged stress. OneNYC addresses these issues of inequality to ensure these connections remain so that recovery is possible (OneNYC, 2015). By considering social, physical and economic issues together, the city

will be able to address not only the challenges it knows are coming, but also those it does not anticipate. Making the city stronger overall, in the wake of climate change, makes the city better able to withstand all types of shocks.

By focusing on strengthening the local economy to achieve resiliency, New York can focus on the urbanization of economies that result from the common location of firms belonging to different and unrelated industries. There are numerous benefits to this including the availability of a range of municipal services, public utilities, transportation and communication facilities, the existence of a wide variety of business and commercial services, and a complementary of labor supply (Henderson, 1974).

Urban transportation is a theme of urban economics because it affects land-use patterns because transportation affects the relative accessibility of goods and services. Issues that tie urban transportation to urban economics include the deficit that most transit authorities have, and efficiency questions about proposed transportation developments (Jones C. et al., 2010). OneNYC has initiatives centered on the transportation sector to improve its efficiency and ability to withstand climate change. One of these initiatives intends to pursue programs that coordinate resiliency investments across city agencies and infrastructure providers and operators (transportation, utilities, cell phone providers, etc.) (OneNYC Indicators, 2015). Improved transportation within the city will enable New Yorkers to access jobs, as well as goods and services that will contribute to the local economy. This is extremely important because cities and urban systems have been subject to decentralization pressures. This is a result of a combination of the transport infrastructure in large cities unable to resolve congestion and increasingly improved inter-urban transport links, which fosters growth in medium sized towns (Jones C. et al., 2010). This enables suburbanization outside of cities with commuters coming into New York, while low-income residents who cannot afford to take advantage of the inter-urban transportation methods remain stuck. By addressing transportation and other infrastructural problems, New York City will be able to decrease the threat of decentralization, which will allow the city to continue to grow.

The fact that NYC is a coastal city is an important factor to its resiliency initiatives. This calls for the need for a diversified economy because it can become extremely difficult to access New York City after a shock event. Local economic growth helps the city recover from emergencies, particularly when outside resources are cut off. To be resilient, New York City cannot solely rely on outside sources for emergency aid. The resiliency indicator to measure this is to reduce the average annual economic losses resulting from climate-related events. This indicator ensures that all resiliencies related initiatives are met because the core threat to resiliency is economic and social issues. By addressing these issues, the city will see reduced economic losses from climate change.

Recommendations

Based on the analyses of each vision under the perspectives of growth, well-being, and consumption, we have developed recommendations for the OneNYC plan to better address social and economic aspects. The following recommendations fit within each vision and their standing

initiatives, including open spaces and public parks, local energy and food sources, a measurement of growth, and the economic feasibility of the plan. With these recommendations New York City will be able to bridge any gaps that are present with the plan, as it exists today.

Brownfields to public parks and open spaces

Within the “Our Sustainable City” vision the goals of addressing brownfields, and increasing and improving upon parks and natural spaces are presented separately. Thinking about and restructuring these two goals, as one would be useful for the city in its quest to become more sustainable. Instead of focusing solely on improving parks and natural spaces that already exist, the city should refocus its efforts on increasing the total area of city parks and natural spaces by assigning some of its brownfield land to be turned into parks and open space.

Currently, over 40 percent of New York City’s land area is made up of “parks, public spaces, streets, and natural habitats” which are utilized every day by residents and visitors. However, most streets differ significantly from other public spaces such as parks and natural habitat in that they primarily serve vehicles and aid in transportation. The OneNYC parks and natural resources goal that aims to allow all residents to equally benefit from “useful, accessible, and beautiful open spaces” would be more achievable if the goal of transforming contaminated land to constructive and safer uses was reconsidered so some brownfields are turned into natural spaces. New York City has over 10,000 commercial and residential sites that have been flagged for environmental review, up to 40 percent are brownfields. As it currently stands, the city plans to redevelop and turn a proportion of these sites into affordable housing units (OneNYC, 2015) which makes sense considering the expected continued growth in coming years. Nonetheless, additional resources could be utilized to convert remaining brownfields into parks and natural spaces by planting native species of plants and increasing greenery in the urban setting.

Research has demonstrated that natural areas contribute positively to quality of life of urban residents in numerous ways. The most commonly considered impacts are environmental and ecological (e.g. flood suppression, air quality improvements, etc.), however natural spaces in urban settings can also provide residents with psychological and social benefits. Parks have been shown to produce a calming effect in visitors by reducing stress (Ulrich, 1981), which allows for contemplation, rejuvenation, and senses of tranquility and peacefulness (Kaplan, 1985)—experiences and feelings not common to life in urban areas. Chiesura (2004) conducted a study involving a survey and secondary research in the Netherlands to determine why people visit nature in urban settings and what emotional responses are invoked by these visits. The most common reason for visitation was to relax, while feelings of freedom, unity with nature, and happiness were three of the most commonly experienced emotions by survey respondents. In her discussion she claimed these feelings and emotions produced by the park were perceived by those participating as very important to personal well feelings of well-being. When discussing her survey results she wrote:

Direct benefits are perceived in terms of regeneration of psychophysical equilibrium, relaxation, break from the daily routine, and the stimulation of a spiritual connection with

the natural world. All these emotional and psychological benefits contribute critically to the quality of human life, which in turn is a key component of sustainable development. (Chiesura, 2004)

Nature itself is valuable to people for the benefits it provides, even beyond those in the environmental and ecological realm.

By combining these two important goals within the “Our Sustainable City” vision New York City could improve sustainability by offering its residents additional opportunities to visit open, natural spaces and experience beneficial psychological and social impacts firsthand. Parks and natural spaces could help satiate people’s need for novelty, one of the major drivers of consumerism.

Invest in local energy and food sources in preparedness for shock events

New York City has invested in anaerobic digestion in Brooklyn, which will convert local food waste into clean, renewable energy instead of paying millions of dollars each year to send it to landfills. This is an example of how to combat organic waste, as well as investment into renewable energy. Yet, this is not enough, particularly if the goal is to prepare for any future shock events. Therefore, New York City should look into other forms of renewable energy. Renewable energy provides energy "insurance". This is because renewable energy sources lend themselves to distributed generation and microgrids, which will help keep the lights on and the house warm during natural disasters and other grid interruptions (New York State, 2015). This will provide energy resiliency for New York City.

Renewables also provide economic vitality. Locally generated renewables means that the money spent for energy is invested into supporting stable, well-paid jobs, right in New York. Renewable energy products, systems and services are already playing into New York's traditional strength in technology, industry, commerce and finance (New York State, 2015). In continuing to do so, the local economy will become much stronger and help take an abundant amount of New Yorkers out of poverty and into viable jobs.

Investing in local food sources will also strengthen the economy by putting cash flow into urban agriculture. Local food sources in New York City can include community gardens and sustainable forms of agriculture, such as vertical farming and aquaponics. This investment will foster sustainable behavior by encouraging New Yorkers to buy their foods locally and efficiently, without over purchasing and therefore wasting. There should be access to farmers markets in each neighborhood, and it would be beneficial to do so indoors so that they can subsist year round. By having local agriculture and a local, sustainable form of disposal through composting and anaerobic digestion, New York can reduce travel miles for both food and waste, therefore reducing the city’s ecological footprint.

Implement a measure of growth and well-being beyond GDP

New York City should implement a measure of growth and well-being that extends

beyond GDP. The SoVI is used as an indicator for resiliency, but there should be an index that measures areas within each vision to get an overall sense of growth and well-being in New York City. An alternate measure a well-being beyond GDP, such as the Canadian Index of well-being (CIW), should be considered for New York City. This plan intends to improve NYC in a variety of ways, yet still works within the capitalist framework of celebrating constant growth. This plan discusses providing jobs for a variety of NYC residents as well as lifting many of them out of poverty. While increased income may be beneficial it does not provide a well-rounded picture of the lives of New Yorkers. This new index of well-being would allow the NYC government to better analyze the effectiveness of each of their visions and goals as well as pin-point what is still needed. Creating this indicator may even provide less motivation for incessant growth for growth's sake. It would allow government to assess the health of NYC instead of just the size of its economy.

Economic & Environmental Feasibility of OneNYC

The plan needs to include a section on where the funding is coming from for each initiative, and if long term funding is necessary for the subsistence of the plan. Currently the plan includes a section on the different initiatives for each goal under each vision. It states whether the funding is from the state, federal, city level, or N/A, but this does not include whether further funding will be needed to support the initiative in the long-term. Since this plan focuses so heavily on sustainable development for future generations to ensure the continued growth of the city, it is vital to ensure funding is available to make any repairs to the physical changes within New York, as well as social changes that might occur. New York City should also include research on rebounds in consumption when income increases and the gap in inequality shrinks. For those living on minimum wage, increases in consumption can lead to spending greater than increased income (Aaronson et al., 2011). This connects back to the structure of our economic system where increased consumption represents the good life and well-being. Unless this social practice can be broken, increased consumption in New York City due to increased income levels is inevitable; therefore it would be wise to citywide access to broadband to communicate to residents about sustainable practices, as well as financial assistance in saving and investing income. Education about consumption patterns must be included within the visions about increased minimum wage if New York City plans to bring 3.7 million more spending dollars into the city. While this increased revenue for this city will increase GDP, the city should focus on encouraging New Yorkers to spend their money within the local community to ensure New York's growth, not the growth of multinational corporations or Wall Street.

Conclusion

OneNYC is a wide-ranging and comprehensive plan that aims to address growth, inequality, sustainability, and resiliency within New York City. It addresses mostly technical remedies and leaves social practices unaddressed. However, after analyzing the initiatives within

the document, it has become clear that some social practices would change as a result of the initiatives the plan proposes to address within its four visions. Reduced consumption of energy will result in the early stages of implementation with infrastructural upgrades and building efficiency, but this will be met with the rebound effect with increased income of the lower class. Therefore, it is vital to ensure New Yorkers understand the implications of their consumption and sustainable best practices. Incorporating the local communities into each vision and strengthening the social fabric of New York will do this. The plan works towards a “strong and just city”, therefore it tackles issues of social justice and sustainable growth to ensure the city adheres to its highest performance standards, both environmentally and economically. While this plan is not a complete solution to the challenges ahead, it is a step in the right direction. Successfully implementing this plan will place New York City at the forefront of sustainable development and a model for other urban areas.

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An Analysis of Regional Distinctions in delta-18O in Coral Cores

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Introduction- Throughout human history, our Earth's climate has affected the way in which we can live and interact with our environment. Without the greenhouse effect and the intricate functions of climatic systems, the earth would not be suitable for supporting human life. Humans have always had an effect on inputs to the climate system, primarily CO₂ input and land use changes. The current large scale human effect on the climate, however, is unprecedented. Since western industrialization, human release of CO₂ into the atmosphere along with land use changes have greatly increased atmospheric CO₂ concentrations and augment the effects of naturally occurring CO₂. In order to contextualize these human effects on the global climate, it is imperative to understand the functions of Earth's climate systems.

The Earth's climate system is complex and incorporates a multitude of interacting processes. Feedback loops, timing, and tipping elements of the climate system complicate the regular patterns of this system. These systems are more readily understood through revealed patterns in paleoclimatology on many time scales. Direct measurements of paleoclimate and paleoclimate proxies are often used to reconstruct these records. Uniformitarianism is used to aid in determining future climate as uniformitarianism states that natural laws and processes that operate in the universe have always operated the way they do now and will always continue to operate that way.

Direct measurements of paleoclimate include samples of ancient atmosphere trapped as bubbles inside of layers of ice sheets sampled by drilling ice cores. The direct measurement

of gas concentrations in ancient atmosphere allows reconstruction of temperature records. Many indirect methods of paleoclimate reconstruction are also common and include speleothems, fossil records and coral cores to name a few.

Within corals the order *Scleractinia* within the subclass *Hexacorallia* contains what are known as the stony corals that secrete calcium carbonate structures. This subgroup is considered to be reef building organisms because calcium carbonate remains once these organisms die allowing new organisms to grow and build the reef on top of them (Goreau 1963). In old reefs, cores can be drilled. Many corals create yearly and sometimes seasonal layers that can be easily observed in cores which aid in assigning age to the corals in analysis (NASA Earth Observatory). Humans add many negative pressures on coral reef ecosystems caused by coastal development, ocean acidification, sedimentation, and many other pressures and this has been going on century scale (Carilli et al 2009). A common analysis performed on coral cores is a measurement of the ratio of the ^{18}O isotope to the lighter ^{16}O isotope. This ratio is commonly referred to as the delta ^{18}O ratio or simply the delta ^{18}O value. Through a process called fractionation evaporation and precipitation cycles preferentially moves the lighter ^{16}O isotope to the poles. This indicates that large amounts of polar precipitation common in ice house climates would leave more ^{18}O at lower latitudes where corals grow (Ruddiman 2014). Delta ^{18}O is known to be indicative of water salinity (Fairbanks et al 1997). The ratio of Strontium to Calcium (Sr/Ca) in corals is also commonly analyzed and is known to be a function of sea surface temperature (SST) (Fairbanks et al 1997).

Paleoclimate reconstructions are often done in order to understand the climate system in terms of global temperatures, but climate clearly differs by region. So, it logically follows that

climate indicators will also vary regionally. This paper examines regional differences in delta 18O isotope ratios of coral cores from 1895 to 1981 and possible climatic explanations for them. It will also explore these implications on paleoclimate reconstruction.

Data - Data for this analysis was collected by many research groups and compiled by the National Oceanic and Atmospheric Administration's National Climatic Data Center (NCDC) as an open access resource. Coral core data for the purposes of this analysis were chosen to from distinct regions including the Indian Ocean, Pacific Ocean, and Atlantic Oceans instead of taken at random to ensure that the largest oceans were represented. Coral core locations were chosen for analysis primarily based on availability of delta 18O data. Mayotte, Comoros and Mahe, Seychelles in the Indian Ocean were used (Zinke et al 2008, Charles et al 1997). Bermuda and Guadeloupe were used for the Atlantic Ocean Region (Goodkin et al 2008, Hetzinger et al 2010). Double Reef, Guam in the central Pacific Ocean and Urvina Bay, Galapagos Islands in the Eastern Pacific were used for the Pacific Ocean (Asami et al, Dunbar et al. 1994).

Methods- These data were imported into excel and cleaned. Timespan of the datasets was not uniform. In order to accurately compare them, only the common time period between all datasets was kept which was 1895- 1981. The resolution of delta 18O measurements also differed between sets. Monthly specific data were averaged to find a delta 18O value for each year to homogenize the scale of resolution. Missing data points were excluded from analysis as interpolation based on region, time, or any other factor is not necessarily justified without further knowledge. Delta 18O data were then plotted against the year that they were from in order to perform a visual inspection of the data. Data were then standardized using z-scores. A one- way ANOVA was then performed to examine differences in variances between the

datasets. This technique assumes that the datasets being used are normally distributed. Using z scores to perform the ANOVA would simply compare the differences in range of variation between the groups instead of comparing means. Performing the ANOVA with the non-standardized values compares the mean delta 18O values of the coral cores using the variance around the mean.

Results- Figure 1 shows the delta 18O values for each of the ice cores mentioned above. The delta 18O values for Seychelles, Comoros, and Guam all appear to oscillate around -5 while the delta 18O values for Bermuda, Guadeloupe, and the Galapagos appear to oscillate around -4. The z-scores of the delta 18O values at these 6 sites show that there are very few outliers as almost all of the values are within 3 standard deviations of the mean (Figure 2). The average delta 18O value appears to be decreasing very slightly over the time period being examined in this paper (Figure 2). In a one way ANOVA comparing mean Delta 18O values with one another, the groups were significantly different ($p=2.9 \times 10^{298}$, Figure 3).

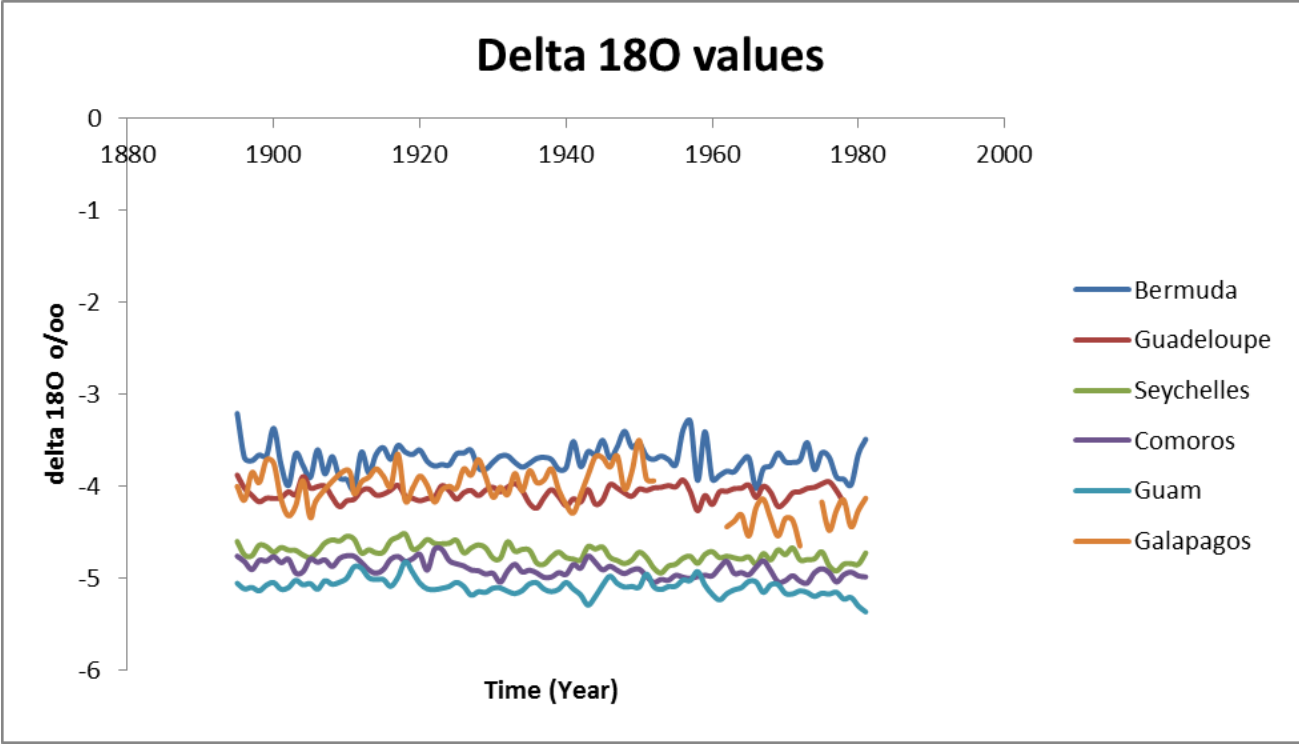


Figure 1: Delta 18O values over time from various ocean basins.

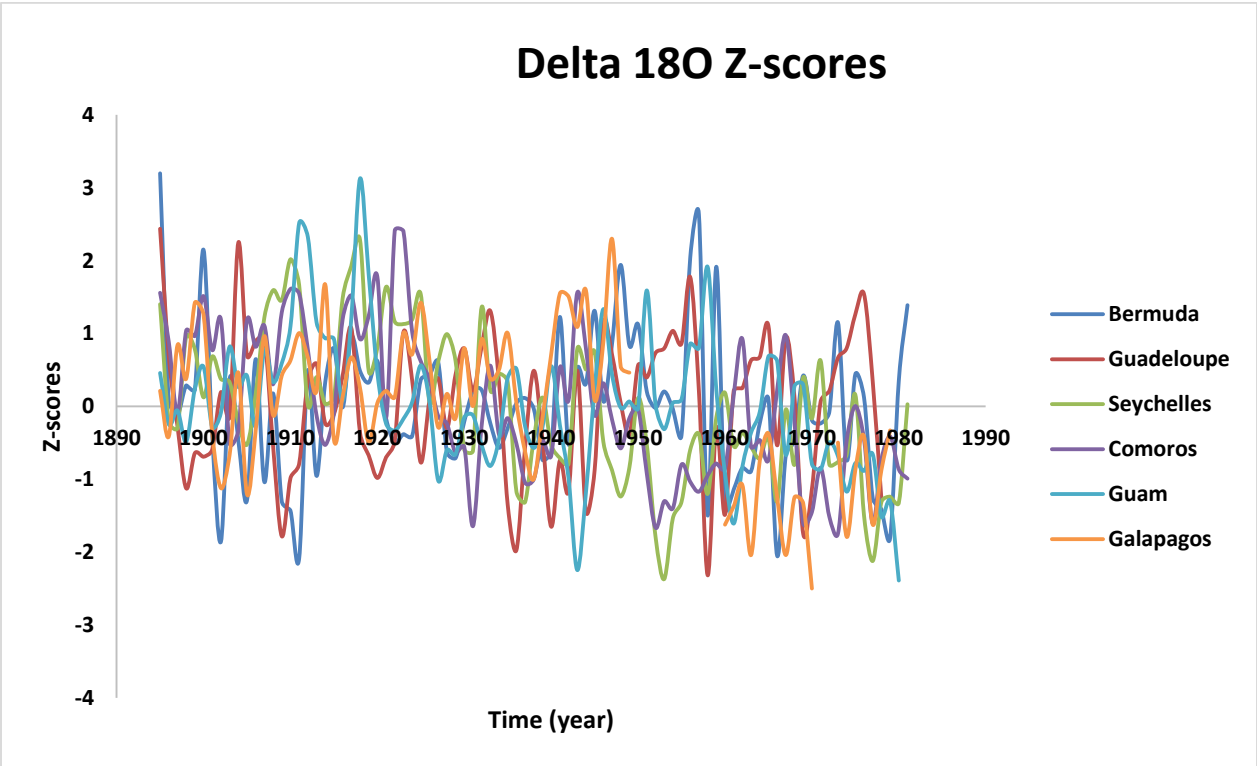


Figure 2: Z-scores of the delta 18O values from coral cores from various ocean basins.

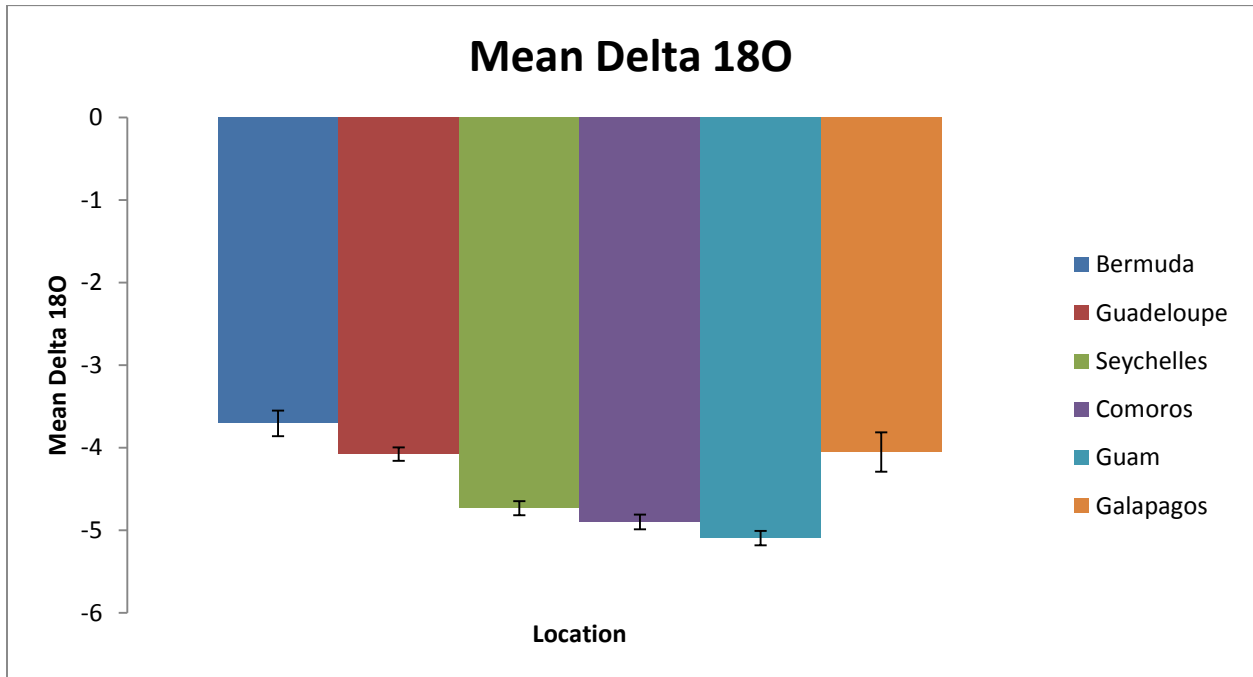


Figure 3: Mean Delta 18O values from 1895-1981 for each of these coral core locations. ANOVA showed a significant difference between means, $p=2.9 \times 10^{-298}$.

Discussion- As mentioned previously, some of the datasets had a higher resolution than others. Some of the datasets had monthly resolution due to the quality of the cores and the amount that the coral had grown. Since those with monthly values were averaged where those with yearly resolution were used as is, this may have affected the analysis of the data. It appears that the coral cores naturally break into two different groups (Figure 1). One group has delta 18O values near -4 while the other group has delta 18O values close to -5. The two groups separate naturally into those places in the western hemisphere and those in the Eastern

Hemisphere. Those near -4 delta 18O values are all in the Western Hemisphere where those with -5 delta 18O values are in the Eastern Hemisphere.

The z-scores of the delta 18O values mostly fall within 3 z-scores indicating that there are not any outliers (Figure 2). There seems to be a slight decrease in z-score of delta 18O in all six of the coral sites. The slight decrease in z-scores of delta 18O records over the last century may be due to a warming of global ocean temperatures (Druffel 1997).

The significant result provided by the ANOVA indicates that there are differences between the groups which was an expected result (Figure 3). Regional delta 18O values are likely to be different because of local precipitation and evaporation circulations. Regional delta 18O values may also differ due to regional ocean circulation differences. Visually comparing the means, it is clear that Bermuda and the Galapagos have much lower average delta 18O values than the other groups (Figure 3).

Coral reef health is a good indicator of ocean health and provides the rest of the ocean and humans with many good and services. Coral Reefs are the home of many species, many of which are caught for food and other man-made products. As climate change and ocean acidification continue, the less healthy coral reefs become. Coral bleaching has already been observed on a large scale on the Earth. If coral reefs do not continue growing, we will lose coral climate records and the calcium carbonate reef structures that exist now will likely disappear (Hoegh-Guldberg et al 2007).

Conclusions- Coral delta 18O values are used in paleoclimatology to reconstruct paleoclimate information such as sea surface temperature and salinity of the ocean. Delta 18O values in coral cores from around the globe over approximately the last 100 years are different from one

another. With global climate change and ocean acidification intensifying, we have the potential to lose not only our coral reefs, but we also have the potential to lose the calcium carbonate deposited by corals previously there. We could then lose these vastly important reef ecosystems along with specific local information on paleoclimate.

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An Analysis of Climate Denial and Skeptics
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1.0 Introduction

Over ninety-seven percent of climate scientists believe that climate change is very likely to be anthropogenically induced (Cook et al., 2013). Western science has been aware of the insulating and warming properties of greenhouse gases such as carbon dioxide and water vapor since the 1890's. The Intergovernmental Panel on Climate Change (IPCC) stated in their fourth assessment report that the increase in global temperatures is very likely to be due to anthropogenic increases in greenhouse gases (IPCC, 2007). As a part of their policy, the IPCC never says that they are completely sure about anything including anthropogenically induced climate change, yet the language that they use translates into quantifiable certainties. When the IPCC says that something is very likely, that means that they are 90-99% sure that it is true.

Changes to our planet's climate are observable, yet there is a growing movement in America and around that world where people are skeptical of the phenomenon of anthropogenic climate change. Among the American people, there is a wide range of beliefs in climate change that are not at all reflective of the scientific consensus that exists. According to a 2014 Gallup poll, only 39% of Americans believe in and are concerned by global warming, 25% of Americans are skeptical of climate change, and the remaining 36% are somewhere in the middle (Gallup, 2014). This denial works on political, economic, and social levels making it hard for necessary actions to be taken to mitigate the threat of climate change.

2.0 Objectives

Denial of climate change has been growing over the past years while the effects of climate change continued to increase. In order to combat climate change successfully, it is vital for climate change supporters to understand the arguments behind the denialists' claims so that this gap of knowledge can be bridged and global change can be made. Climate deniers use scientific inaccuracies to support their claims, yet peer-reviewed research displays deep flaws in their line of thought. Psycho-social tactics along with scientific theory can help to effectively communicate with climate deniers, debunk, and disprove them. The skeptic claims that will be addressed include: historical and predicted temperature changes, physical effects of climate change, and the barriers of social communications.

3.0 Methods

To begin this project, literature was reviewed to create a demographic and cultural analysis of who was more likely to reject climate change. Debates between prominent climate skeptic Marc Morano and climate supporter Bill Nye were viewed to create a general overview of denier claims. Comments made by Marc Morano were recorded and a list of arguments was created. Effort was put into locating peer-reviewed sources that strengthened the denier/skeptic perspective. Recent scientific papers were then located to debunk the science behind the denier arguments. Psychology papers were then read to give insight into how to talk to climate deniers and skeptics in such a way that that progress can be made in the direction of climate mitigation.

4.0 Background

The divide between climate skeptics and climate supporters coordinates with partisan divides. Republicans are much more likely than democrats to be anthropogenic climate skeptics (Dunlap and McCright, 2010). Belief in anthropogenically induced climate change is also a function of education, though democrats are more likely than republicans to support climate change theories as their level of education increases. Those who consider themselves independents tend to believe moderately in climate change and are moderately affected by education (Hamilton and Stampone 2013). Prioritizing concern for anthropogenic climate change also has been shown to decrease during times of economic strife when people's urgency for

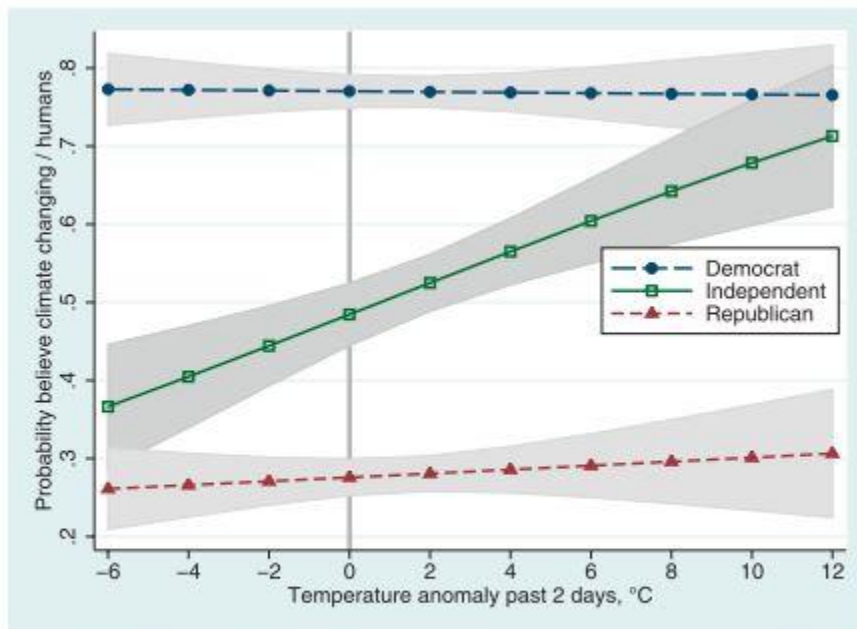


FIG. 2. Predicted probability of "climate change is happening now, caused mainly by human activity" response as a function of temperature anomaly and political party, adjusted for other variables in model 2.

Figure 1.

economic security takes precedence (Scruggs and Benegal 2012). During the 2008 recession, concern for climate change decreased significantly as people began to prioritize economic growth. The current local weather can also be a factor in believing in climate change. As shown below in Figure 1, the opinion of independents is positively correlated to the temperature anomaly in local weather (Hamilton and Stampone, 2013).

The Pew research center found that the number of Americans who believe in the solid evidence of climate change dropped from 71 percent in 2008 to 57 percent in 2009. The reasoning behind the fluctuation may be attributed to the cultural influences of climate skeptics (Hoffman, 2011). These skeptics retain their seats in the policy debate around climate change despite the majority of business leaders, policymakers, scientists, and academics who reject their viewpoints. It is imperative to understand the underlying motivations and cultural foundations of their arguments to find the most effective ways to counter their views.

For those that believe addressing climate change as an anthropogenic issue is of great importance, there is a great need to “better understand the cultural and ideological issues at play by systematically analyzing the frames used to mobilize the counter-movement” (Hoffman, 2011). There are three major cultural themes among climate skeptics that need to be understood.

The first theme is based on the viewpoint that climate skeptics view climate science and policy as a covert way for liberal environmentalists and the government to interfere in the market and diminish citizens’ personal freedom. The argument is that “the issue isn’t the issue” because “the environmental agenda seeks to use the state to create scarcity as a means to exert their will, and the state's authority, over your lives” (Hoffman, 2011). It is viewed as “just another attempt

to diminish our freedom” and decrease personal liberty. One skeptic brought this idea so far as to suggest that a binding international agreement on climate change would end with individuals being required to carry “carbon ration cards” on their person (Hoffman, 2011).

The second theme is a strong faith in the free market, which is partnered with the fear that climate legislation would hinder economic progress, and that the switch to renewable energy would not be feasible without large government subsidies. Denialists live under the viewpoint that “doing nothing about climate change is doing something [because] it enables people to keep their money and invest in the future” (Hoffman, 2011).

The third theme is a strong distrust in the scientific peer-review process. In the skeptic's viewpoint “peer review” turned into “pal review,” where scientific research was supported, funded, and published based on findings that agreed with a particular interest or motive (Hoffman, 2011). For example, thousands of emails were hacked into and read from the University of East Anglia’s Climate Research Unit, where scientists were discussing how to ensure their work could not be used by climate skeptics to refute climate change, and adjustments to data (Revoking, 2009). Multiple investigations have since cleared these scientists.

The cultural frames and ideological values within the climate skeptic culture have a strong impact on critical populations that have a lot of power in the functioning of social society and its political and economic structures. Yet we are still not fully able to evaluate which claims used by climate skeptics resonate with the general public to the highest degree. Gaining this understanding would allow for an opportunity to counter the negative effects climate skepticism has in our political economy, our environment, and our overall well-being.

5.0 Main Findings

5.1 Climate models and historical and predicted temperature changes

One area of research that climate skeptics tend to attack includes studies done on global temperature, both historical and predictive. Climate models created by the IPCC and other such climate supporters are highly complex and have a huge range of variability. Predictions are just that, predictions. However, whenever a model fails to incorporate a noticeable change, skeptics and deniers will attack it and use it to discredit climate change. Skeptics who cherry pick the data to skew numbers abuse historical data from temperature models. Two common arguments associated with climate models and temperature predictions will be analyzed. The first is known as the “Climate Hiatus” argument and the second is the Medieval Warming Period.

The Climate Hiatus refers to the 15 year period between 1988 and 2012. During this period temperature models demonstrated a slowdown in the increasing global surface

temperatures. The Fifth IPCC Assessment Report published in 2013 brought attention to this event and estimated the trend to be increasing at a rate of one third to one half as fast as the previous 60 years (Flato et al, 2013). The IPCC report asserts that it is very likely that the ocean is absorbing much of the energy instead of increasing surface temperatures. This is supported by increasing sea levels due to thermal expansion (Flato et al., 2013). Scientists scrambled to explain why such a trend would appear while denialists used the UN data to say that climate change has not been occurring in the face of increasing greenhouse gas concentrations.

Since the climate slowdown data began to appear researchers have been trying to explain where all the “missing” global heat has gone. On June 4, 2015 NOAA released a new study that said the hiatus never occurred. NOAA cites a number of issues that caused the previous data to show the climate slowdown. Among those cited are: an El Niño event, differences in temperature recording methods, incomplete data coverage over the Arctic and a short measuring period. None of which were included in the original IPCC report. The climate hiatus began in 1988 with a strong El Niño event that resulted in warmer than usual temperatures. This spike in temperature acted to mask increasing global temperatures (Karl et al., 2015). Global surface temperatures are recorded at land-based stations, thousands of commercial ships, and floating buoys. Discrepancies were found in temperatures recorded between ships and buoys. Temperature recordings from buoys have increased coverage of the ocean by 15% and tend to be .12°C cooler than readings taken from ships (Karl et al., 2015). A bias added to the buoy measurements can mimic the temperature that a ship would have read. New compiled data trends from the International Surface Temperature Initiative increased the spatial coverage of temperatures over the Arctic, which have been increasing rapidly. When all of these factors are taken into account and 2 more years of data, 2013 and 2014, are added, the evidence of a hiatus diminishes. The

results from NOAA's new study show that the rate of warming between 1950 and 1999 was 0.113°C per decade and between 2000 and 2014 was 0.116°C. Even looking at a timescale from 1988-2014 beginning with the El Niño event shows warming to be .106° per decade (Karl et al., 2015). These rates discredit the notion of a climate Hiatus.

Many climate deniers, including Marc Morano, use inaccuracies about historical climate variations to conclude that the current change in climate is due to natural heating and cooling periods. It is argued by climate denialists that the warming period that we are seeing now is just another one of the natural global fluctuations

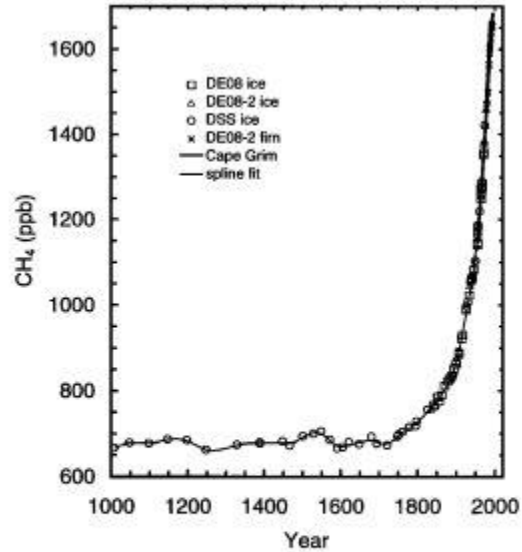


Figure 2. Methane over the last 1000 years found from the three Antarctic (Law Dome) ice cores corrected for system blank and gravitational fractionation. Precision is ± 5 ppb. The spline fit attenuates variations of 75 years periodicity by 50%. Also shown are the CH_4 records since 1978 from the DE08-2 firn and from Cape Grim, Tasmania (see text).

Figure 2

and has nothing to do with human intervention. One commonly referenced historical warming period is the Medieval Warming Period from 1000-1300 AD. Historical variations in climate change are often recreated through many methods including ice core sampling, climate sensitive tree rings, coral rings as well as a variety of other sources. From an analysis of mountain glaciers and tree rings from across the globe, it was determined that there was indeed some warming during this time period. This warming, however, was regional and not at all indicative of a global warming phenomenon. In some places like Scandinavia, China, and the Sierra Nevada temperatures were higher than average, but they were not synchronous (Hughes and Diaz 1994). So, this cannot be considered a period of true global warming, but instead a period of regional fluctuation due to slightly above average methane levels that played into a positive localized feedback loop. Although they were

slightly higher, the methane levels during that time period are significantly lower than they are now (Francey and Langenfelds 1998). So, there is some natural fluctuation in the climate and natural cycles, but we are not in one of those natural warming cycles today. In fact, if we were following natural trends, we would currently be in a period of cooling, the climate system is a complex series of feedback mechanism that are affected by changes in greenhouse gases. Methane is a greenhouse gas that is much more powerful at trapping solar radiation but it has a much shorter atmospheric residence time (EPA 2015).

5.2 Physical Effects of Climate Change

Climate skeptics, like Marc Morano, argue that there are no trends that indicating increased frequency of natural disasters. In looking at the Annual Disaster Statistical Review for the year 2013, there is evidence of both a rise and a fall in differing disasters of that year. Yet, when you look at overall recent trends in charts, there is evidence of an increase in overall natural disasters in recent years. In 2013, the number of people killed by floods was the highest of the decade, and the number killed by storms was the second highest. Extreme temperatures, drought, and wildfires were low on the disaster scale for 2013, while floods, mass movement of water, and storms were higher (Guha-Sapir, 2014). It is the fact that tectonic events remain steady and climatic events are increasing that raises concerns about the impacts of climate change (Banholzer, 2015).

Marc Morano made the claim that the US had been in its longest period without a category 3 or larger hurricane in a recent debate. However, hurricane Sandy, which hit the U.S. in the North East, had maximum sustained winds of about 100 kt at landfall in Cuba making it a

category 3 hurricane on the Saffir-Simpson Hurricane Wind Scale, however when it made landfall in New Jersey, its intensity was similar to a level 1 (Blake, 2013). Yet hurricane Sandy's pure kinetic energy for storm surge and wave "destruction potential" reached a 5.8 on the National Oceanic and Atmospheric Administration's 0 to 6 scale, which was the highest yet measured (Superstorm, 2012). Hurricane Katrina made landfall as both a category three to category 5 hurricane on the Saffir-Simpson Scale. The Saffir-Simpson Scale ranks the hurricanes potential damage based upon its wind-speeds. A wind-speed of a category three is between 111 and 129 MPH, while a category 5 is above 157 MPH, Katrina hit speeds up to 170 MPH when it was at a category 5 (Categorizing Hurricanes). In figure 3 Hurricanes and their category levels are shown in the U.S. between the years 1950 to 2011. From this graphic, and as evidenced by the scale of hurricane Katrina, it is evidenced that there have in fact been several hurricanes that have occurred at a category 3 or above, making Morano's claim false.

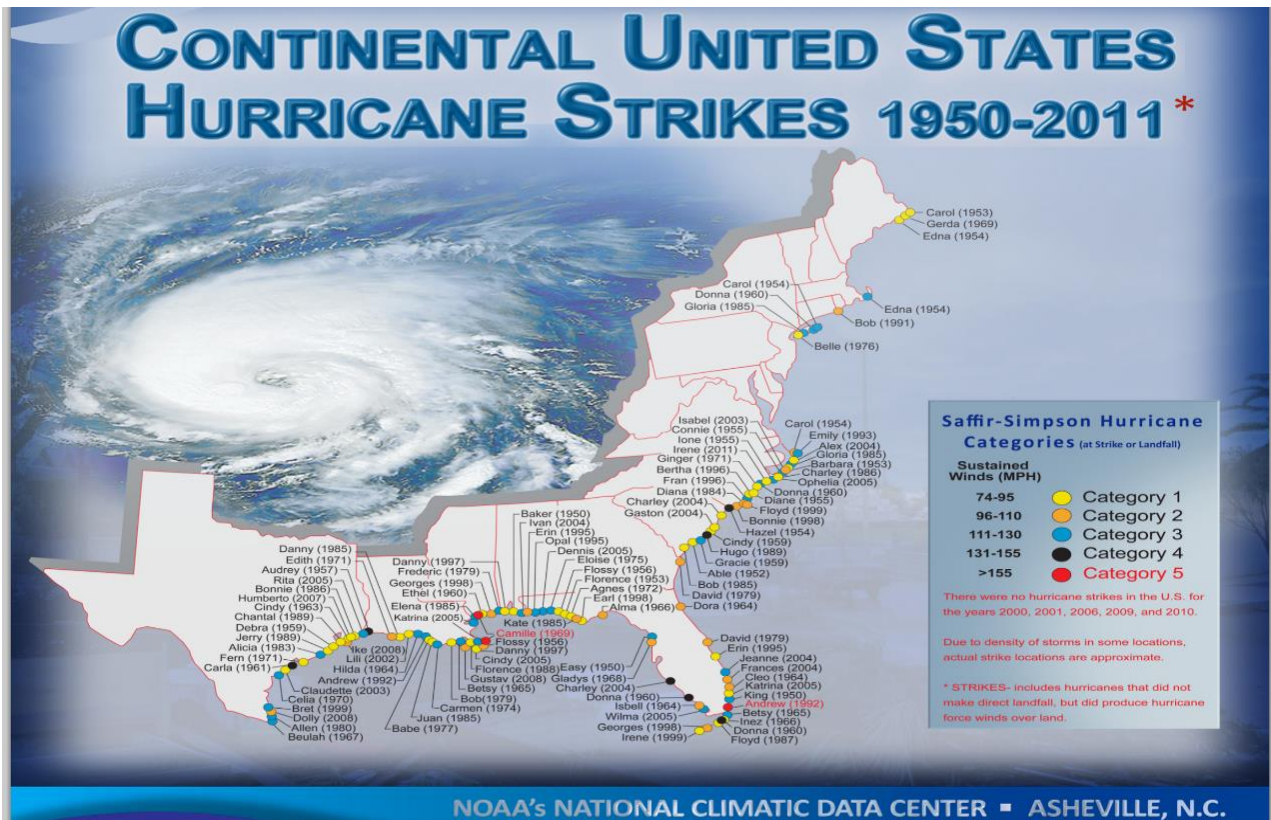


Figure 3. Continental United States Hurricane Strikes. (n.d.). Retrieved from <http://www1.ncdc.noaa.gov/pub/data/images/2011-Landfalling-Hurricanes-11x17.pdf>

Morano also stated that big tornadoes, sized F3 or larger, have decreased since the 1950's. Figure 4. represents killer tornadoes per year in the U.S. between the years 1800 and 2000. It is clear that there was a drastic increase in tornadoes after the year 1870, but that there is a slight decline after the 1950's, but the levels are still high for tornadoes occurring (Brooks, 2001). The number of reported F0, or weak tornadoes has increased dramatically, roughly doubling over the last 60 years (Tippett, 2014). This increase can be seen in Figure 5. (Tippet, 2014)

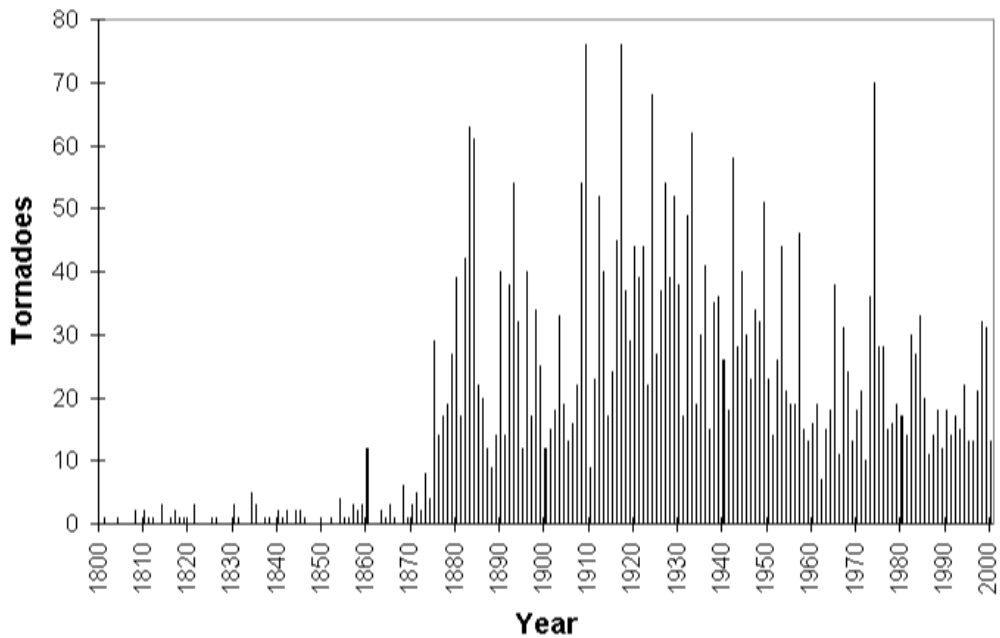


Figure 4 (Brooks, 2001)

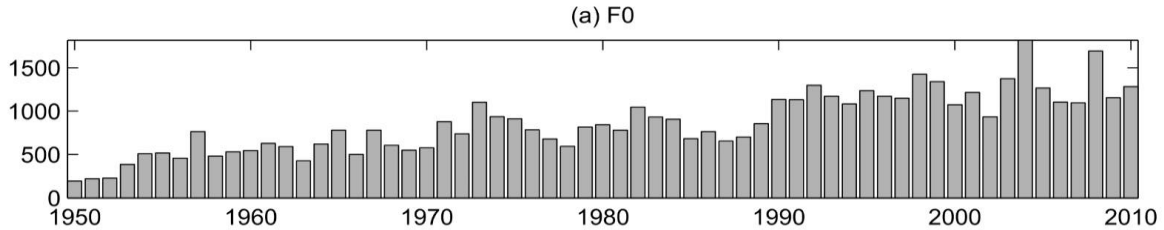


Figure 5 (Tippet, 2014)

Some skeptics argue that climate change is not occurring since sea ice is increasing in Antarctica, which, in 2014, reached its greatest extent in since late 1970's. This is referred to as a microcosm of global climate change (Zell, 2015) because, as the ice in the Antarctic is increasing, the ice in the Arctic is decreasing at a rapid and dangerous rate. The sea ice in the Antarctic is growing only at a rate of one-third the rate of the Arctic's decline. (Zell, 2015). This

is similar to when people suggest climate change is not occurring when temperatures in some regions of the planet are colder than average despite our planet's overall warming.

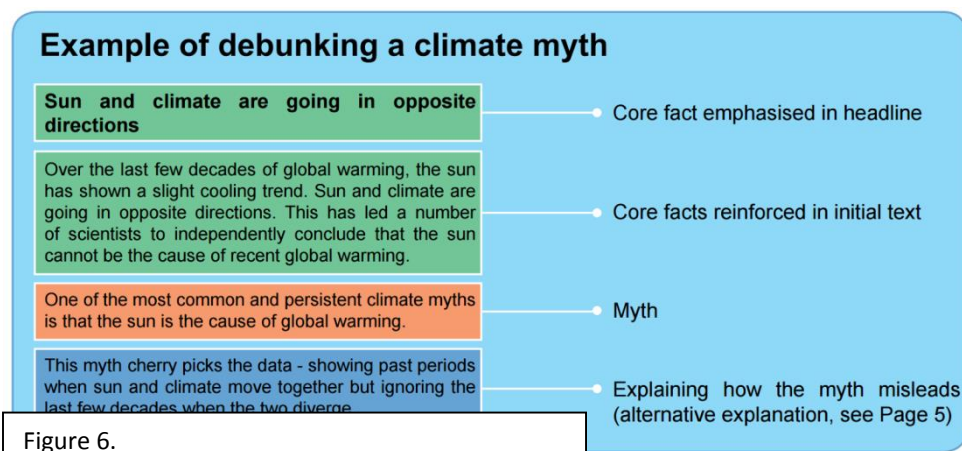
5.3 Barriers of Social Communications

A denialist's motive to deny climate change can be attributed to money (Powell, 2011). Likewise, tactics they use to deny climate science often involve money at some regard. Denialists are most likely to be supported by industries that will suffer from government intervention to free the economy of its fossil-fuel addictions and move towards renewable energies. To divert attention from these ulterior motives of funding, denialists fight climate enthusiasts by detailing the level of support climate researchers are receiving from government funds (Powell, 2011). Climate skeptics refute climate change as politics not science, and unfortunately for climate scientist's politics is not their repertoire and they lack the ability to accurately defend their researched work. The political twist used by the climate skeptic community is more catchy and considered as "the good entertainment" in comparison to a climate scientist's research theory, which is why skeptics are so good at catching the public's interests and beliefs, and difficult to combat for the scientists (Powell, 2011).

There is an inherent mistrust for climatologists' scholarly work among climate skeptics. It is important to understand this mistrust when talking to a denier and defending your scientific claims against their disbelief. There is also a fear for deniers that, if they agree that climate change is an issue, their freedom will be taken and diminished by the government as well as environmentalists (Hoffman, 2011). Personal liberty, the free market, and the growing economic structure seem to be all at threat in the mind of a climate skeptic, which is why many are afraid

to embrace climate change as an anthropogenic and important issue of our time. Taking these fears into account when speaking to a climate skeptic may help bridge some of the barriers present in the conversation, if empathy for their fears is expressed. The partisan divides are strong, and make it vital to frame these conversations well, in an effort to avoid immediate denial when attempting to refute the beliefs of a skeptic.

There is only so much scientists can do to convince the world that we are in a crisis. From there, psychologists take over by studying the thought process of climate deniers and skeptics. When talking to a climate denier, it is important not to fall into a few common traps outlined below. It is important not to begin the conversation with the myth you are trying to debunk and not to provide an excessive amount of supporting facts. This mistake leads to what is known as the familiarity backfire and the overkill backfire. The goal is to get your point across without making it too complicated and without reinforcing their current beliefs. Opening with the myth they believe leads to the familiarity effect where the listener becomes “familiar” with the misinformation and forgets the correct information. It turns out that too much information is not always better. It is psychologically easier to accept something as true when it is easy to understand. Providing too many facts, figures, and complex concepts to back up your argument can be counterproductive “overkill” that results in the listener believing more accessible myth.



Finally, the most powerful backfire is called the worldview backfire. This occurs when talking to someone whose values line up with the myth they believe. Discussing issues where the worldview backfire is possible is a waste of time as people like this fall victim to what are known as the confirmation and disconfirmation biases (Cook and Lewandowsky, 2011). These biases result in the listener seeking out information that bolsters their own view. In these cases, any information you give will result in their greater belief in the myth.

Experts in the art of persuasion present the most effective format to use when talking to a climate denier. Begin with the core fact you are trying to get across. Next, offer 2 or 3 more facts to support the argument. Now is the time to present the myth the listener believes, making explicit that it is a myth. Finally, it is important to explain where the myth went wrong in its methods or how it is misleading (Cook and Lewandowsky, 2011). For an example see figure 6.

6.0 Conclusion

The social sciences along with the hard sciences can help us to understand this debate between climate skeptics and those who follow the scientific consensus. It is important to attempt productive climate change conversations with independents and those people who are not sure about climate change. Communication efforts are likely to be most effective with those people instead of those who are firmly set on a climate denial ideology.

The climate debate is hard to resolve because it is nearly impossible to put a human face on a problem that will impact future generations more so than the present generations. “Few contemporary problems warrant social and cultural analysis by academics more than climate change. Unfortunately the climate change issue has become so contentious that any attempts at

bridging between the climate convinced and the climate skeptical communities has, at times, been met with extreme criticism” (Hoffman, 2011). The social research opportunities to bridge this gap are vast, and if the mistrust can be managed, we may be able to come together to address this vast and very important problem.

Now that we have demonstrated arguments made by climate skeptics within the topics of historical and predicted temperature changes, the physical effects of climate change, and the barriers of social communication to be mostly falsifications we can begin to conclude that increased research in the social sciences of climate skepticism are imperative to effectively use scientific theory and psycho-social tactics to have effective communications with climate skeptics.

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The Market of Solar Photovoltaics

As climate change continues to pose a threat to our coasts and to our future generations, we must continue to strive towards potential solutions to this problem. The ever increasing heavy usage of carbon based fuels paired with continuing population growth has led to atmospheric CO₂ levels today of approximately 400ppm (NOAA 2015). A continued reliance on fossil fuels is likely to create further harm to future generations. Since it appears unlikely that we will be reducing our global population size and even less likely still that our western way of life will suddenly opt out of valuing bigger lifestyles and continued growing prosperity, it is clear that a switch to renewable, non-carbon based fuel sources to energize our lives is important. In 2014, only 16.6% of New England's utility grid electricity was generated from renewables (ISO New England 2014). Only 0.3% of the total utility grid electricity produced was generated from solar. This, however, does not give a true representation of the true distribution of photovoltaics on the market because most of the solar photovoltaics used in New England are on private homes and that energy is typically consumed for private use. It is thought that, if used to its maximum potential, solar photovoltaics could make account for up to 50% of a utilities energy system (Denholm and Margolis 2007). There are many barriers to the use of renewables, intermittency being a large one. At higher latitudes, solar panels also face the barrier of becoming covered in snow or ice for many months of the year, making them useless for that period of time. Luckily, they very useful and productive during the time of year that energy demand is high: the summer. The popularity of private installations of solar photovoltaics has increased in the past few years, yet the technology has been available since the 1970's. The increase in solar panel efficiencies

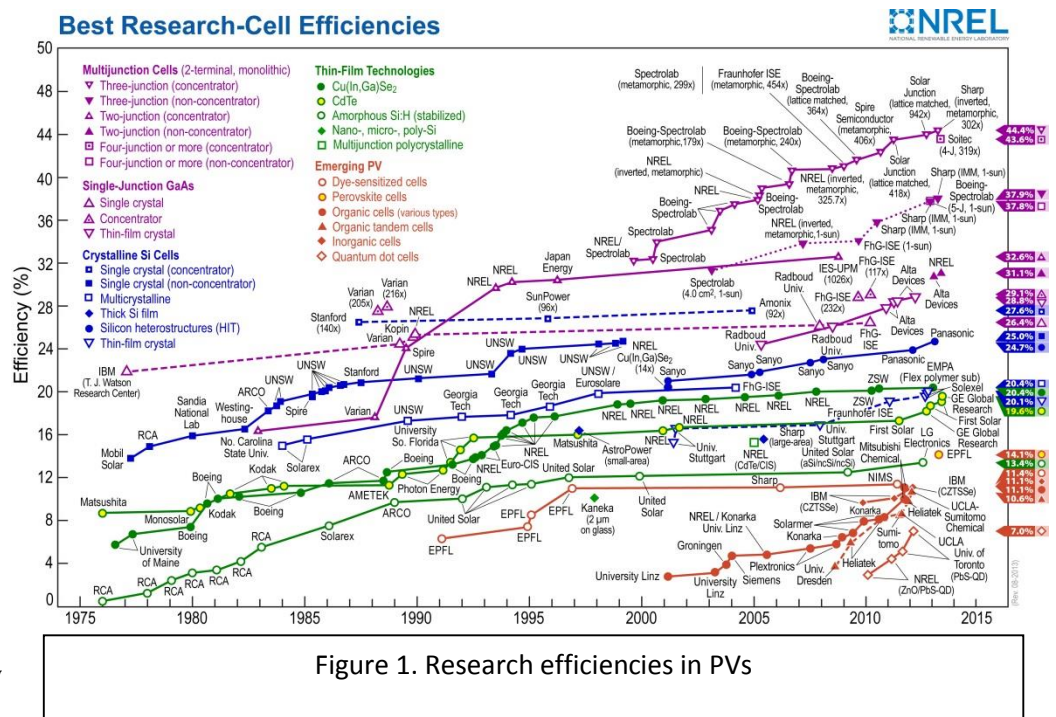
and the decrease in market prices have contributed greatly to making solar energy generation more readily available.

The popularity and efficiency of solar photovoltaics has increased dramatically since their creation in 1976 as you can see in figure 1 (NREL 2015). This figure describes the fleet of photovoltaic

technology that has been created and tested in labs. This diagram shows that panels have reached as high as 44.7% efficiency in laboratory studies.

Although this is a very

far leap in efficiencies from the earliest days of photovoltaic research, it is not reflective of what is in the current market. Typical photovoltaic panels on the market today have approximately 12-20% efficiencies. This may appear to be a low level of efficiency to a consumer, but in fact it is not. According to the U.S. Energy Information Administration, in 2014 the average annual electricity consumption for a U.S. utility customer was 10,932 kWh (EIA 2014). Even at 15% efficiency of your solar panels, there is often enough space on the roof of a single family home to install enough solar panels to fit a load of that size. Improvements in the ability for solar panels to absorb more than the visible light spectrum, such as longwave absorption and UV absorption, has led to increased efficiencies in solar panels. Panels that have a higher number of P-N



junctions are the most efficient. Market ready monocrystalline solar panels also tend to be higher in efficiency than polycrystalline or thin-film solar panels at this stage.

Solar panels have also increased in popularity because of their steep decrease in price over the past decades. As you can see in figure 2, the price of solar cells has decreased from a prohibitive seventy six dollars per watt to a much more affordable thirty six cents per watt. As is

true in most capitalist ventures, economies of scale lead to decreased cost of production which is often, at least partially, passed onto the consumer to gain a competitive market advantage. In countries that have higher rates of solar energy usage than the U.S.,

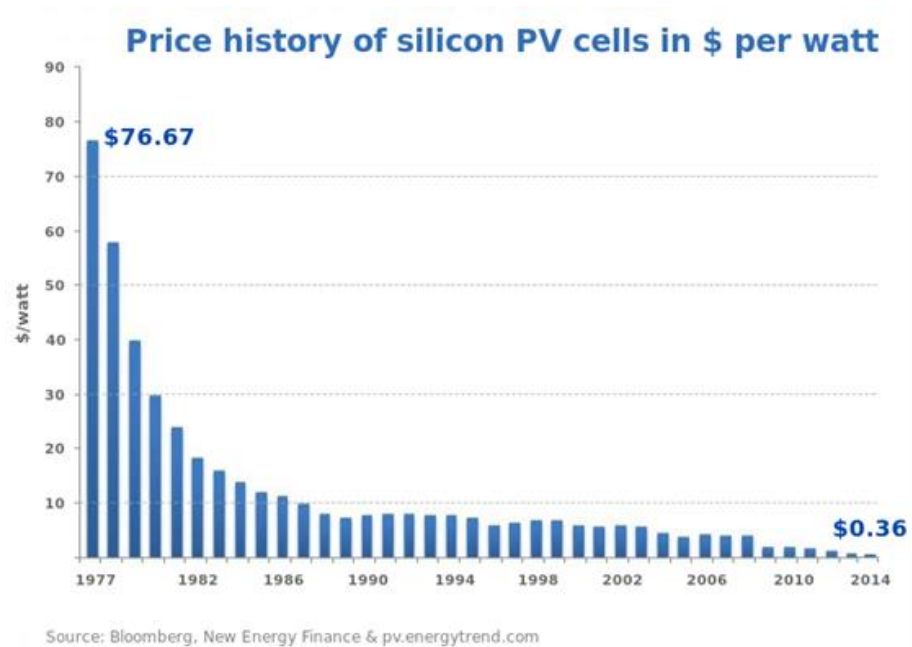


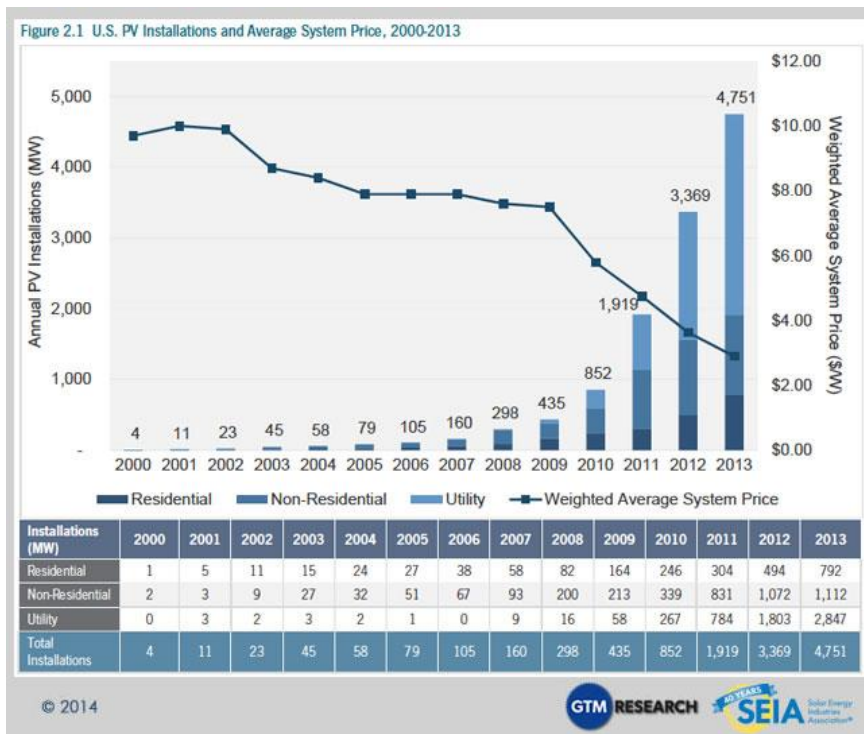
Figure 2, Historical decreasing in prices of PVs

such as Denmark or Germany, the cost of having solar photovoltaic systems in homes is less expensive. This is misleading, however, because the costs of the solar panels are actually quite comparable. The differences in costs actually arise from something called the soft costs. These are things such as labor, installation costs and repair costs. These are all prices that also have the potential to be reduced as economies of scale for these grow. The investments that private residents make when they decided to install solar photovoltaics on their homes are steep. They often take decades to pay off and require residents to take on debt.

Net metering laws have been pivotal in growing the solar panel market for private homes in the U.S. These mandate that utility companies buy any excess solar power from private homes at market price at in that moment. This allows private residences to potentially make money on their investments or at least compensate for a small portion of the debt that they incurred by taking out loans for private PV systems. Obviously, this is not ideal for utility companies as they lose money on these interactions. This accounts for the strikingly small percentage of solar energy that makes up utility electricity production. This year, net metering laws were put up for a vote in Massachusetts and were voted to raise the net metering cap even higher to allow for the production of new solar PV projects. This is not great news for the utilities, however, because it reinforces the limiting of solar PV technologies to private generators for their own consumption needs. There has also been discussion of a ceasing net metering in Massachusetts which would be catastrophic and could easily undermine the growth of solar PVs. Each state has their own laws for net metering, so changes in Massachusetts laws don't have a huge direct effect overall, but it is important to remember that Massachusetts and California tend to be leaders and front runners in pro-environmental policies. So it is likely that Massachusetts laws would indirectly affect other states.

Since so much of the solar energy in America is privately owned by residents and businesses, it ensures that only those who have private homes and can afford to accumulate such debts are the people using solar. This technology cannot be utilized by the poor or people who don't own private homes. According to the Solar Energy Industries Association (SEIA) utility scale solar projects have also been increasing as prices are reduced (figure 3). A further expansion of utility scale solar must happen in order to keep this trend moving forward. Without net metering laws, even those private single family residents who could still afford solar projects

would do it because it makes less financial sense. In this country, it is often true that those



organizations and groups with the most money tend to have the loudest voice at a table with law makers. Sadly, their voices tend to be louder even than the people that the law makers usually serve.

According to a review of the

photovoltaic industry done by Parida et al

(2011), solar photovoltaics have the potential to meet future energy demands of certain cities by the year 2025. To do so, the photovoltaics must achieve advances and ideas for material usage and reliability technologies as well as a continual increase in their efficiency levels. Increases in efficiencies and decreases in market pricing of solar panels is very likely to occur if they remain to be a popular and well known form of renewable energy.

The necessary shift from reliance on carbon based fuels to a renewable energy profile is critical to combating potential worsening of the changing climate. We must decline in use of liquid fuels and move towards an electricity economy backed by renewables in order to have a chance at reducing the effects of climate change from what they are currently projected to be. The market is continuing to get more and more advantageous for solar photovoltaics in private

homes and businesses as long as efficiencies continue to grow and prices continue to fall.

Cooperation of public utilities in indirectly funding these projects allows for increased ability of individuals to own systems like this, but currently it is only easy for semi-wealthy owners of single family homes to invest in projects like these.

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