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Investing In Sustainability: Making Portsmouth, New
Hampshire a Sustainable City

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Senior Thesis
ADMN 799H
Professor Lee Mizusawa
Spring 2013

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I. Introduction:

Scientific data suggests that we are headed into a warmer future primarily caused by human activity. Jared Diamond, author of the acclaimed novel, *Collapse: How Societies Choose to Fail or Succeed*, discusses what causes many societies to fail or succeed. Diamond writes, “Two types of choices seem to me to have been crucial in tipping the outcomes [of the various societies' histories] towards success or failure: long-term planning and willingness to reconsider core values. On reflection we can also recognize the crucial role of these same two choices for the outcomes of our individual lives.” We as human beings are not planning for the future, nor are we reconsidering our core values towards global warming. The evidence of global warming is evident and if you do not see it, you are contributing towards it.

II. Global Warming:

Global warming is the increase in temperature due to climate change. Currently, increased temperatures across our world are causing dramatic climate changes across the world. Evidence suggests that our world is heading into a future with warmer temperatures and one that is less habitable for the human civilization. This evidence is directly connected to the rise in greenhouse gases in our atmosphere. Greenhouse gases are gases such as carbon dioxide (CO_2), water vapor (H_2O), methane (CH_4), and nitrous oxide (N_2O), that absorb and re-emit radiation.

This is related to the greenhouse gas effect in which energy from the sun is sent to earth in the form of radiation. The earth absorbs some of this radiation while some of it is radiated back into space. However, due to the atmosphere, a very thin shield

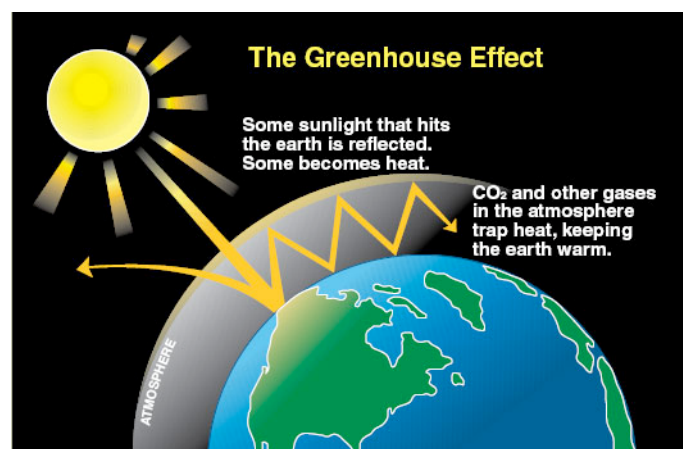


Figure 1.1: Greenhouse Effect (Greenhouse Effect)

over the earth that traps “some” reflected radiation, we are able to have a habitable planet. With the greenhouse effect, the planet is able to sustain an average temperature of 59° Fahrenheit or roughly 15° Celsius. Due to the increase in pollution and the rise in greenhouse gases, the atmosphere is getting thicker, capturing more escaping radiation and causing our planet to warm.

One of the most important people who first helped discover the impacts of CO₂ and its contributions towards global warming was Roger Revelle. Roger Revelle first began studying CO₂ in early 1958, sending balloons into the air to measure atmospheric CO₂ (Gore). Due to complications of air quality across the world, the Mid-Pacific Ocean was used for the location of

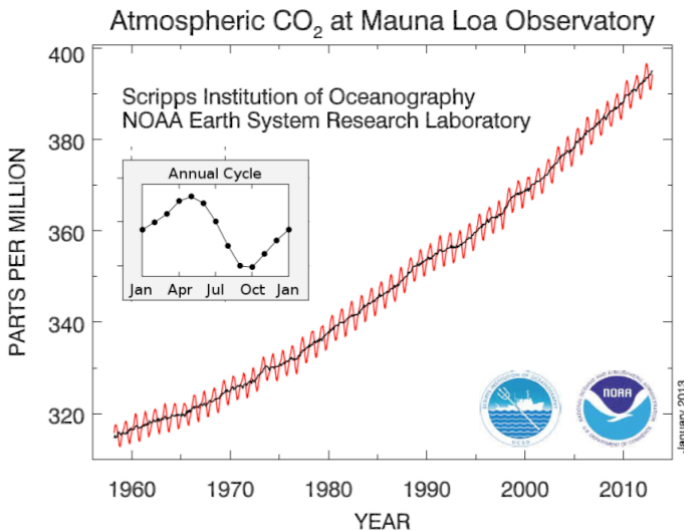


Figure 1.2: CO₂ atmospheric measurements from Roger Revelle until his death in 1991. Later information gathered by other scientists until present. (Revelle)

measuring due to its isolation from the rest of the world (Gore). After conducting many experiments, Revelle found that CO₂ increases and increases in temperature correlate one another. This startling fact was one of the first signs that global temperatures were warming. Based off of Revelle and other researchers’ findings, global

temperatures and CO₂ have increased significantly since 1958. Figure 1.2 depicts the data collected from Revelle and others up until modern day. The black line shows the increase in CO₂, while the red lines indict summer and winter.

Evidence of this increase in CO₂ and temperature can also be seen in ice cores. Ice cores are cylinders of ice that are drilled out of ice sheets. These cylinders of ice help scientist figure out past climates and changes that have occurred

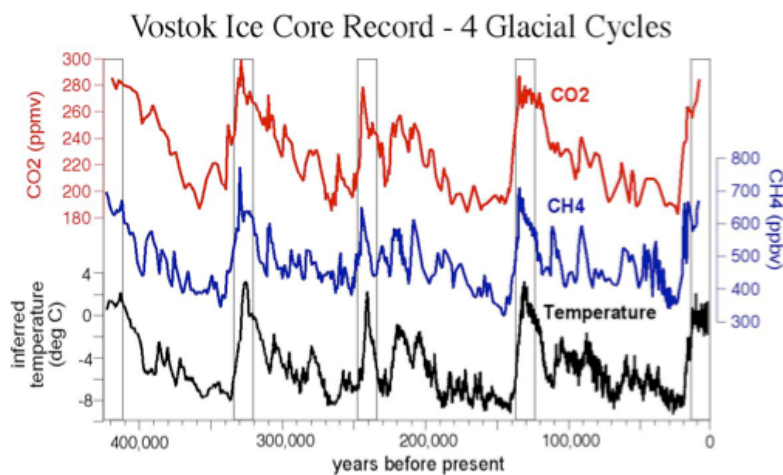


Figure 1.3: Vostok Ice Core Record. (Petit et al)

over thousands of years. Evidence of volcanic eruptions and isotope measurements can also be taken from the ice. Due to accumulation every year of snowfall, melting and freezing of ice, tiny

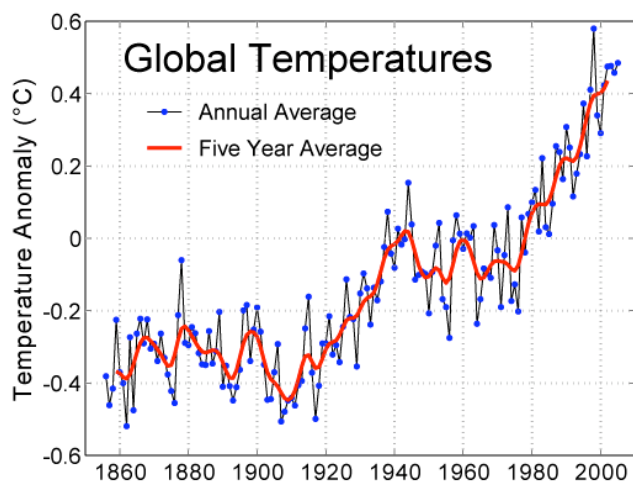


Figure 1.4: Global Temperatures. (Petit et al)

greenhouse gases are directly linked. Figure 1.4 shows global temperatures have been on the rise since recording began in the 1860's. Since greenhouse gases and temperatures are directly linked, the more greenhouse gases that are pumped into our atmosphere from pollution, the more world temperatures will increase. Further evidence of increased temperature can be seen from the recent images depicting melting of glaciers.

bubbles of air become trapped in each annual layer. These bubbles help give scientists a sense of the concentration of CO₂ for that particular year. Figure 1.3 shows the relation of carbon dioxide, methane, and temperature over the last 400,000 years until the present. The results obtained from the Vostok Ice Core indicate that temperature and

Glaciers are an important part of our world. Due to glaciers extensive mass, glaciers have been able to carve our world into what it looks like today from ice age after ice. One important aspect known to glaciers is its albedo. A glaciers' albedo is an important factor for the planet because it helps regulate the amount of radiation we receive. The albedo is the amount of radiation that is reflected back into space. Due to increased temperatures however, the amount of radiation being reflected back into space has been dropping and more glaciers are melting.

Images of glaciers from the past up until present have

shown dramatic changes. Figure 1.5 shows the dramatic changes at Glacier National Park, in

Montana. The top photo is from 1911 while the bottom is from 2000. Since 1850, Glacier

National Park has lost almost 125 glaciers. (Retreat of Glaciers in Glacier National Park) Today,

there are around 25 glaciers left at Glacier National Park, each estimated to be around 25 acres. It

was predicted in 2003 that by the year 2030, almost all large glaciers at the National Park would

completely disappear. (Retreat of Glaciers in Glacier National Park)

Since glaciers are melting worldwide and sea level is rising, flooding has also been an issue that many countries have been facing. During the Last Glacial Maximum, sea level was about 125 meters lower than it is today. (The Ocean) This is due to the fact that most of the fresh water was frozen into glaciers that covered most of the Northern Hemisphere. However, since the LGM, sea level has been on the rise. Cities such as Manhattan, Beijing, Shanghai, San



Figure 1.5: Glacier National Park From 1911 And 2000. (Braasch)

Francisco, and many others could face horrific devastation if the proper measures are not taken. It is estimated that sea level could rise as much as 2 to 6 feet by the year 2100 if global temperatures continue to warm. (The Ocean) This fact however does not consider the potential risk of the Greenland Ice Sheet completely melting. If the Greenland Ice Sheet were to melt completely by the year 2100, sea level would rise by 24 feet, completely submerging both London and Los Angeles. (The Ocean)

Since February 2nd, 2007, the United Nations panels of scientist had declared that, “evidence of a warming trend is "unequivocal," and that human activity has "very likely" been the driving force in that change over the last 50 years. (Gore) Things such as smokestacks, tail pipes to cars, burning forests, and much other man-made things have contributed heavily towards global warming. Since 1970, average temperatures have gone up three times the average since 1970. (Earth: The Operators Manual) The latest report from the United Nations Climate Panel predicts that temperatures will increase about 3° to 8° Fahrenheit in the century if carbon dioxide levels double that of 1750. (Earth: The Operators Manual) One year in particular that has shown clear evidence of global warming was 2012.

2012 was a year that many civilians across the U.S. realized that global warming was real. Based off of recent data, 2012 was marked as the hottest year on record in the U.S. since the recordings began during the 19th century. (Than) According to the National Oceanic And Atmospheric Administration, the average temperature was 55.3° Fahrenheit, one degree higher than the previous record set in 1998. (Than) Also in effect for 2012 was the fact that it was the 15th driest year on record, with an average precipitation total that averaged around 26.57 inches of ran or 2.57 inches below record. (Than) 2012 was also a year with some of the deadliest storms on record. 2012 ranked as the second “most extreme” year on record with 11 natural

disasters, including Hurricane Sandy. These storms averaged at least a billion dollars in losses.
(Than)

It is evident that climate change is happening us and we, as humans must take action to fight against it. Currently, many countries across the world are trying to move fast to decrease their greenhouse gas output. Much of this output is due to humans using energy, which is an everyday essential need. Governments are now trying to piece together a way to use renewable energy for their civilians' everyday uses. Renewable energy such as solar, wind, hydro, and others have the power to reduce greenhouse gas emissions substantially.

III. Sustainable Technology:

Currently, renewable energy is a popular subject in the United States. Recently, President Barack Obama addressed the nation and talked about how the government must take action to tackle global warming. In his State of the Union Address, President Obama said, "I urge this Congress to pursue a bipartisan, market-based solution to climate change, like the one John McCain and Joe Lieberman worked on together a few years ago. But if Congress won't act soon to protect future generations, I will. I will direct my Cabinet to come up with executive actions we can take, now and in the future, to reduce pollution, prepare our communities for the consequences of climate change, and speed the transition to more sustainable sources of energy."

(Reiners) With government support, the United States and other nations across the world will soon be searching for ways to decrease their carbon footprint.

a. Solar Energy:

One-way the world will be looking



Figure 1.6: Solar Energy (Solar Energy Contractors Directory)

to reduce emissions is by means of solar energy. Solar energy is the process in which technology harnesses the uses of the sun's solar power to use as energy. Today, only about 1/10th of the worlds' energy comes from solar power. (Earth: The Operators Manual) In recent estimates by scientists, the sun beams enough solar radiation on earth to satisfy the power needs for the entire world for one year. (Earth: The Operators Manual) Making use of this power would be very beneficial for the world.

Solar energy is transferred into electricity by means of solar panels. Solar panels are made of semi-conductor material, much like the material found on spacecraft, handheld calculators or



Figure 1.7: Solar Energy. (Making Your Home Solar Energy Ready)

computer chips. (Solar Energy) As sunlight hits these panels, electrons are knocked loose from their atom, producing electricity as the electron moves through the cell. (Solar Energy) Other solar power techniques include heating water by means of the sun's heat, which helps create steam to drive turbines to

create electricity or focusing mirrors on a tower with a receiver, which heats the molten salt within a receiver to drive a turbine. (Solar Energy) In all, solar energy is something that can be enhanced and used in terms of energy. Also solar energy is virtually noise and pollution free. Solar energy, however, does have real disadvantages to it.

As night approaches, solar energy is virtually useless because there is no sunlight to create electricity. Also, clouds create a problem as well as they block sunlight from reaching the earth's surface. Another disadvantage many people have realized is the expense of solar energy. Due to the high costs of buying and installing the solar panels, as well as the challenge of finding a large

enough area to install them, many people tend to look towards cheaper alternative ways of getting their energy. On the other hand, due to many states' new tax credit systems and rebates, solar energy is becoming cheaper for many Americans and beneficial in the future. This is because initial start-up costs are high, but the system's will begin to pay for itself and savings would accumulate. In more recent studies, solar costs tend to pay for themselves in five to ten years. (Chernova)

Currently, human beings use around 15.7 terawatts, while the sun produces about 173,000 terawatts daily to earth's surface. This is almost about 15 times larger than current human use. (Earth: The Operators Manual) Places such as the United States Southwest deserts have enough land to supply 80% of the world's current use of energy alone. (Earth: The Operators Manual) Today, many nations across the world have started to use solar energy in hopes of reducing their carbon footprint and their dependency on fossil fuels. In the last 15 years, there has been a 20% surge every year in the use of solar energy because of falling prices and gains in efficiency. Japan, Spain, Germany, and the United States are major countries for solar energy.

b. Wind Energy:

Another renewable energy source that has been growing is wind energy. Wind energy is the creation of energy through wind movements. Wind energy has been used as a source of energy for at least a thousand years and has recently been making a comeback in the recent decade. (Wind Energy) Energy is made from wind by means of wind turbines. These tall structures have blades at the top which turn when the wind blows against them. As these blades turn, a turbine is turned, producing electricity. (Wind Energy) Most of these windmills have

three large blades, with the generator contained in the tower that is parallel to the blades. Most of these towers are about 200 to 300 feet tall and are painted white for visibility for aircraft.

To create large amounts of energy, these wind turbines are usually built in groups called wind farms. Wind farms usually consist of 100 or more turbines, on hundreds of acres of land. (Wind Energy) One of the largest wind farms in the world is located in Jaisalmer, India. This wind farm produced about 1,064 megawatts of electricity in 2012. (Wind Energy)

Windfarms are usually built in places that experience large amounts of air flow. One place in particular in the United States is the Midwest. The Midwest, also known as the windbelt, consists of hundreds of wind farms. From Texas, all the way up towards the Canadian border, this 2,000 mile stretch consists of some of the strongest winds in the world. This area consists of hundreds of wind farms, which tower over crops in places like Iowa, Texas, Nebraska, and Kansas. (Earth: The Operators Manual) In Texas alone, wind turbines have produced about 10,000 megawatts of electricity. (Earth: The Operators Manual) If Texas were a country, it would rank sixth in the world in wind energy.

Other technologies, such as hovering wind turbines, are being produced to capture the strong winds in the higher altitudes. (Wind Energy) Jet streams that move throughout the stratosphere at about 32,000 feet contain strong enough winds to produce large amounts of electricity. (Wind Energy) These wind turbines would hover over the earth, much like a kite, and capture the large amount of jet streams for electricity.

Although wind energy has many advantages



Figure 1.8: Wind Energy. (Washington Free Beacon)

including being relatively cheap, generating no carbon emissions, clean source of energy, ability to capture wind all over the planet, there are still drawbacks to it. One drawback in particular is the wind itself. Since weather is random and some days may not be as windy as the next, wind energy is unreliable at times. Also wind farms must require a significant amount of land. Building these farms can cover hundreds of thousands of acres. Wind energy also has a high initial cost. This is due to the fact that many of these wind turbines are privately made and require large amounts of labor to have them working effectively. Until recently, the U.S. and other nations have created tax incentives and rebates, similar to those for solar energy, for those who purchase wind turbines as an energy source. (Wind Energy)

In a recent study, the U.S. Department of Energy has said that wind energy could supply 20% of Americans' electricity by 2030. (Wind Energy) Also, new offshore wind farms could also produce roughly 43,000 new jobs in the U.S. and create \$200 billion in revenue for the U.S. Altogether, wind energy produces about 1,256 terrawatts daily, which is about 78 times the average human usage. (Wind Energy) Currently, countries such as the United States, Germany, China, and Spain are leading the way for wind energy. (Wind Energy)

c. Hydro-Energy:

Hydropower is a renewable source of energy that many nations across the world currently use. Hydropower is energy produced by means of moving water. When rain or snow occurs, runoff water forms in hills and mountains, creating streams or rivers. (Hydropower) This moving water creates a large amount of energy that can be harnessed.

Hydropower has been around for centuries, mostly



Figure 1.9: Hydro Energy (Hydro-Electricity)

being used for farming and other practices in the early centuries. In the late 19th century when the first hydropower plant was built. (Hydropower) In 1879, the first hydroelectric plant was built in Niagara Falls, powering street lamps and providing electricity to local residents. A typical hydro plant usually consists of three different parts: the electric plant where the electricity is produced, a dam that controls the water inflow, and the reservoir where the water is stored. (Hydropower) As the water through the dam flows, they push on blades which spin a turbine. The turbine then spins a generator to produce electricity. The amount of electricity that is produced mainly depends on how much water is flowing and how far the water drops. (Hydropower)

Currently, hydropower produces about 1/5th of the world's electricity. The highest producers of hydroelectricity are Brazil, China, Canada, United States, and Russia. (Hydropower) One of the largest plants in the world is located on China's Yangtze River. This dam is about 1.4 miles wide and 607 feet tall. In the United States, the largest hydro plant is located in northern Washington, along the Columbia River. (Hydropower)

Hydropower is currently the cheapest way to produce electricity. This is due to the fact that once dams are built and equipment is installed, the energy source, water, is a free source of energy. (Hydropower) Other than the fact that hydropower is cheap, they are available right away. Since engineers can control the dam and the amount of water that flows, electricity can be



Figure 1.10: Columbia River Dam. (SimCenter)

made through turbines on demand. Also, since dams are a big part of how hydropower works, the reservoirs that dams create can provide outdoor activities, such as swimming and fishing, for civilians. (Hydropower)

Although hydropower may have benefits,

there are also disadvantages as well. Due to the fact that dams create reservoirs, flooding of neighboring ecosystems may destroy or hurt habitats. Also, dams can prevent fish, such as salmon and others, from moving upstream and spawning. (Hydropower) However, because of recent advances in technologies, things like fish ladders help fish migrate upstream and continue to populate their habitats. Lastly, hydropower may cause low oxygen levels in streams since no new water is continually flowing through the stream. This will decrease the fish populations and water ever else is in the river. (Hydropower)

d. Tidal Power:

Tidal power is one of the new sustainability technologies of the future. Due to their its to harness power through tidal movements, tidal power provides a great source of energy. Tidal power is produced when large turbines are put into places with strong and high tidal movements. (Hydropower) As the ocean tides create high and low tides, the kinetic energy that they produce move the underwater turbines.



Figure 2.1: Tidal Power (Jackson)

(Hydropower)

There are currently three different sources of tidal power that are produced: tidal streams, barrages, and lagoons. Tidal power from streams is the basic flowing of water from the movement of tides. As tides go in and out, the turbines are turned and generate power. (Hydropower) Unlike wind, stream tidal power provides a constant and predictable source of energy. Barge tidal power is produced when a dam is constructed and tidal flow spills over the dam, turning generators to create electricity. This type of tidal power can be harnessed through rivers, bays, and estuaries. (Hydropower) Lastly, the lagoon tidal power is similar to the barge,

but is constructed along the coast of an ocean. This is primarily due to the fact that lagoons are created when the ocean fills the lagoon with water as the tides move shoreward and empty when the tides move seaward.

Today, there are two large tidal power facilities located in La Rance, France and Nova Scotia, Canada. There is currently a third facility that is being built in Russia, but is still in its experimental stage. Although the United States is working at creating tidal power plants, there are no plants being built yet. (Hydropower) However, other places, including England, are in the stages to begin building of one.

Though the United States has been working at creating tidal power plants, many legal and financial issues have challenged implementation. Some legal issues in the United States include environmental impacts and underwater land ownership. Since many people care for the environment, having underwater turbines could potentially destroy some of the ecosystems from the moving blades. Also, many investors are not willing to put money towards tidal power because it is not guaranteed that it will be a strong energy source and benefit consumers. (Hydropower) Engineers are currently working at improving the turbines so that the amount of energy increases, the impact on the environment decreases, and there is a way that investors will benefit from the project. (Hydropower)

e. Geothermal Power:

One way we can harness some of earth's heat is through geothermal power. Geothermal power is energy produced from beneath the earth's crust. The energy that is harnessed sits in the rocks and fluids beneath the crust. For thousands of years, man has always used geothermal energy as a source of power for cooking, heating, and other tasks. (Geothermal Energy)

The underground reservoirs of steam from the hot molten rock, provide a great power source to produce electricity. A geothermal pump, which draws from the steam miles deep in the crust, has the advantage of providing heat to buildings during the winter and extracting that heat to be put back into the earth during the summer. (Geothermal Energy) Some cities also use geothermal energy to heat water pipes that run under streets to melt snow during the winter. (Geothermal Energy)

Currently, there are three different types of geothermal power plants: dry steam, flash, and binary. Dry steam takes steam from fractures in the earth and uses the steam to turn turbines and create electricity. This strategy is the oldest when capturing energy geothermally. (Geothermal



Figure 2.2: San Francisco Geothermal Site. (LaGesse)

Energy) Flash plants pull hot water deep from the crust of the earth and mix it with colder water to create steam. This steam is then used to create electricity. Lastly, the binary process is when hot water from the earth's crust is brought to the surface through pipes. These pipes then pass by a

secondary fluid that has a much lower boiling point

than water. This then creates steam to turn turbines and produce electricity. (Geothermal Energy)

Geothermal energy is currently being used in 20 different countries across the world. One of the leaders in geothermal energy is the United States. Because of the geysers in Northern San Francisco, the United States is able to harness the energy from this area and turn it into useful electricity. (Geothermal Energy) Also, another worldwide leader in geothermal energy is Iceland. Iceland has many active volcanoes, geysers, and hot springs that help heat many buildings and swimming pools in the country. (Geothermal Energy)

There are many advantages when using geothermal energy. First geothermal energy can be taken from earth without burning fossil fuels, unlike oil, coal, and gas. Geothermal plants also produce only 1/6th of the carbon that a natural gas power plant produces. (Geothermal Energy) Also, geothermal energy is a reliable source of power, unlike wind and solar energy. (Geothermal Energy) Also, geothermal energy is relatively cheap and available 365 days of the year. (Geothermal Energy)

Although geothermal energy has many upsides, there are some disadvantages that go along with it as well. First, geothermal energy releases a gas known as hydrogen sulfide, which smells like rotten eggs. This plays a big role because it can cause controversy with the surrounding communities. (Geothermal Energy) Also, geothermal waste is another issue. Once geothermal water has been used completely, a small percentage of the water contains some toxic materials. Lastly, some areas may begin to cool down down eventually after decades of usage. (Geothermal Energy)

As our world continues to move towards sustainability, renewable technologies will soon be a big contributor towards the world energy demand. However, new sustainable policies will have to be made by governments to fight the current climate change.

IV. Sustainable Policies:

Today, many countries are taking steps towards creating sustainable policies. Countries such as Sweden have put policies into place to be more sustainable. During the 1980's, Sweden developed policies to create the first eco-municipalities. This movement helped start the Local Sustainability Development, which was presented at the Rio Summit in 1992. (Furlone) As of 2010, Sweden currently has around 79 local eco-municipalities that make up around 30% of the municipalities in the country. (Furlone) In 2006, Sweden also announced that it was going to

create an energy and transportation economy that ran free of oil, reducing most of the countries carbon footprint. (Montague) This action was first laid out during the 1980's by the Swedish government and has since been taken into affect. It is predicted that by the year 2020, Sweden will be emissions free for its energy and transportation sectors. (Montague)

Other countries, such as the United States, have also adopted ideas like eco-municipalities and reducing dependence on oil. Currently, the United States is working on turning many of its large cities into eco-municipalities. Portland, Oregon and Santa Monica, California, are on the breaking edge of becoming eco-municipalities. City officials have come up with major plans to convert these cities into more sustainable and greener environments. (Montague) Like Sweden, many cities in the world that are converting to eco-municipalities, follow a four-step approach. This includes: 1.) Concentrations of substances extracted from earths crust, 2.) Concentrations of substances produced by society, 3.) Degradation by physical means, and 4.) Basic society needs are met. (Montague) This breaks down into meaning that we should minimize the harm to the earth and human health, while still promoting reductions of carbon emissions. Also, cities should focus on producing renewable energy, while still maintaining basic humans needs such as shelter, food, and others.

Besides adopting energy policies from different nations, the U.S. has developed policies of its own to combat climate change. Recently, John Kerry met with Japan's Foreign Minister to discuss future action against climate change. Both the United States and Japan feel as though, "human-caused climate change represents a threat to the security and economic development of all nations." (U.S., Japan, G8 Commit to Climate Change Action) The United States has recently designed a three-pillar approach to combat climate change, post 2020. This includes cooperation to advance low-emissions development in the world and to construct climate-resilient societies.

(U.S., Japan, G8 Commit to Climate Change Action) Both countries also discussed plans to combat climate change at the recent G8 Foreign Ministers meetings, in London, England. There countries from around the world pledge to put forth a plan to make life more sustainable and reduce the carbon emissions. The plan created by the G8 meetings includes: 1.) Agree to a new climate change agreement by 2015, 2.) Increase renewable incentives for homes and businesses, like Climate and Clean Air Coalition, and 3.) Raise \$100 billion per year to help mitigate climate change. (U.S., Japan, G8 Commit to Climate Change Action)

Unfortunately, the United States has fallen behind in its funding to help combat climate change. Recently, Congress announced that it has cut some of the budget for climate change action. In the last fiscal year, the government dedicated \$858 million to help combat climate change. (Schmidt) In April of 2013, the government announced it would cut that budget by 2.5% (\$837 million). (Schmidt) This came to a shock to environmentalists, as we live in an age where there is a growing need for clean energy, extreme weather conditions, and deforestation across the world.

Due to recent budget cuts by the United States, pressure amounts on local municipalities to become more self-sufficient in being sustainable. Places like Portsmouth, New Hampshire, will have to raise more funds on its own to create a more sustainable society.

V. Portsmouth, New Hampshire:

One of the largest cities in New Hampshire is Portsmouth. With an approximate population of 20,000 people, Portsmouth is a relatively large New Hampshire city. Aspects to the city, such as the Piscataqua River, provide the city with a renewable power source, ready to be harnessed. Sustainable City Coordinator, Peter Britz, has been working on ways to improve the city's sustainability and the amount of waste that can be recycled. According to Mr. Britz, Portsmouth

uses a methodology, known as the bottom-up approach, when conducting eco-friendly projects. In 2006, the city worked with government officials in finding out the amount of greenhouse gas emissions produced by the city. (Britz) The figure that government officials were able to calculate was around 600,080 tons, with 15,000 tons of that number coming from city municipal buildings and cars. Since then, the city has been working at improving these figures. (Britz) Although, many of the sustainable features that Portsmouth is looking to put in place are long term projects, some short term projects have been set-up to already improve the cities sustainability.

One short-term project, LED lighting, has been helping to improve the sustainability of the city of Portsmouth. LED light bulbs, or better known as light-emitting diodes, use less of the amount of energy that normal fluorescent bulbs use and also have a much longer life span. (Britz) Portsmouth has currently been placing many of these light bulbs in places such as the city library, firestation, and the drinking water treatment plant, to save energy usage and money. (Britz) Many city officials have also been encouraging residents to switch over to these new energy and money savers. Besides including the usage of LED light bulbs, the city has also been working on making many of their municipal buildings “Certified High Performance.” (Britz) One building in particular, according to Mr. Britz, is the new middle school the city building. This school would become one of Portsmouth’s Certified High Performance buildings and would be a stepping stone towards a better future in making more sustainable buildings throughout the city. (Britz) The city is currently working with the state of New Hampshire in accessing grant money for this project. Other buildings, such as the library and firestation, are already high performance buildings, with the police station on the way to become certified.

Since many of the sustainable projects initial costs are very high, Portsmouth has been making many of their sustainable projects long-term. This includes applying for grants, such as the Regional Greenhouse Gas Incentive or RGGI. (Britz) Started in April of 2012, RGGI is the United States first, “market-based effort to limit greenhouse gas emissions in the U.S.” (Regional Greenhouse Gas Initiative) States such as Connecticut, Delaware, Maryland, Rhode Island, Vermont, New Jersey, New York, Massachusetts, Maine, New Hampshire, make up this program. These states work together in creating a single fund which would be used in creating sustainable projects in each state, in hopes of creating a more sustainable future. (Regional Greenhouse Gas Initiative) Currently, the city of Portsmouth has applied for some of this grant money in hopes to make buildings like City Hall, more sustainable.

Another project which the city is hoping would create a more sustainable future, would be to widen roads and create bike lanes for bikers. By creating bike lanes throughout the city, officials are hoping that greenhouse gas emissions would decrease, due to the flow of more bike riders throughout the city instead of using cars. (Britz) However, due to regulations on how wide side walks have to be according to state regulations, this project could not be completed without large grants from the state. (Britz) Another idea the city has started to think about was creating a trolley system, which would be able to carry passengers to different parts of the city. This form of public transportation would limit car use in the city and provide residents with a way to more effectively move throughout the city. (Britz) This type of trolley transportation system is similar to ones used above ground in both Boston, Massachusetts and San Francisco, California. Although these cities have much wider streets, the type of transportation system is very similar to the one Portsmouth would like to create. (Britz)

Another large scale project that town officials are looking towards starting is implementing solar panels to power parts of the city. Today, Portsmouth officials have been looking at places, such as the land near the Portsmouth Drinking Water Treatment Plant, to place solar panels and help improve the cities sustainability. Due to the fact that solar panels take up many acres of land, many officials, such as Peter Britz, believe that the land around the treatment plant would be ideal for solar panels. However, due to the initial costs of solar panels and also the unpredictable weather patterns in the Northeast, solar panels may be too expensive and to hard to maintain. (Britz) As an alternative, one energy source which officials are also looking to create a more sustainable city has been tidal and current power. (Britz) Due to the fact that the Piscataqua River runs through Portsmouth, much of this energy can be harnessed and turned into power for the city. One project in particular that has been making headlines and is making steps towards tidal and current power is the Memorial Bridge Project. (Britz)



Figure 2.3: Memorial Bridge. (Baldwin)

The Memorial Bridge of Portsmouth, which connects both Portsmouth and Kittery, Maine, has been vital to the city ever since it first opened in 1922. Throughout history and up until the the present, the bridge has been important in enhancing trade and commerce, tourism, community life, and the historic character of both communities. However, by 2011, the bridge had finally been shut down due to safety regulations. Since then, many officials and Ocean Engineers, have been working together in creating the worlds first living bridge. The idea of a living bridge means a constant energy supply that the bridge produces and use's for its own use.

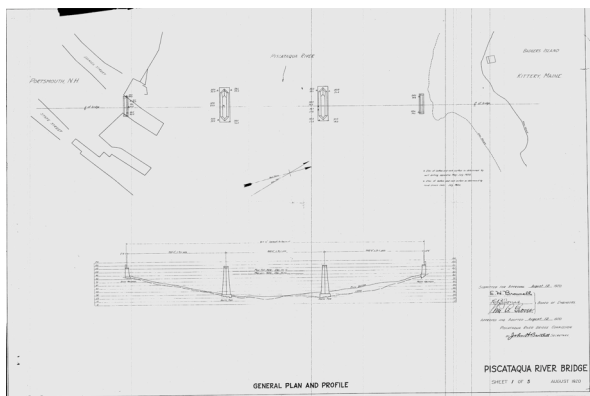


Figure 2.4: Memorial Bridge Plans. (Baldwin)

The Piscataqua River and the Memorial Bridge would be the best place to first create this bridge on a small scale.

UNH Professor of Ocean Engineer, Ken Baldwin, is one of the heads of this revolutionary projects. Over the past few years, Mr. Baldwin

and members of his team have been working together in making this bridge possibly. Figure 2.3 gives a glimpse at what the future Memorial Bridge may look like. Since the day the Memorial Bridge was created, many different engineering techniques were put into place to combat the fast moving current that occurs at the bridge's base. Figure 2.4 shows a glimpse of some of the first initial plans when first developing the Memorial Bridge. (Baldwin) Over time, engineers began to realize the potential benefits to the tidal power that sits below the bridge. Tidal power is the most predicted renewable power source available currently.

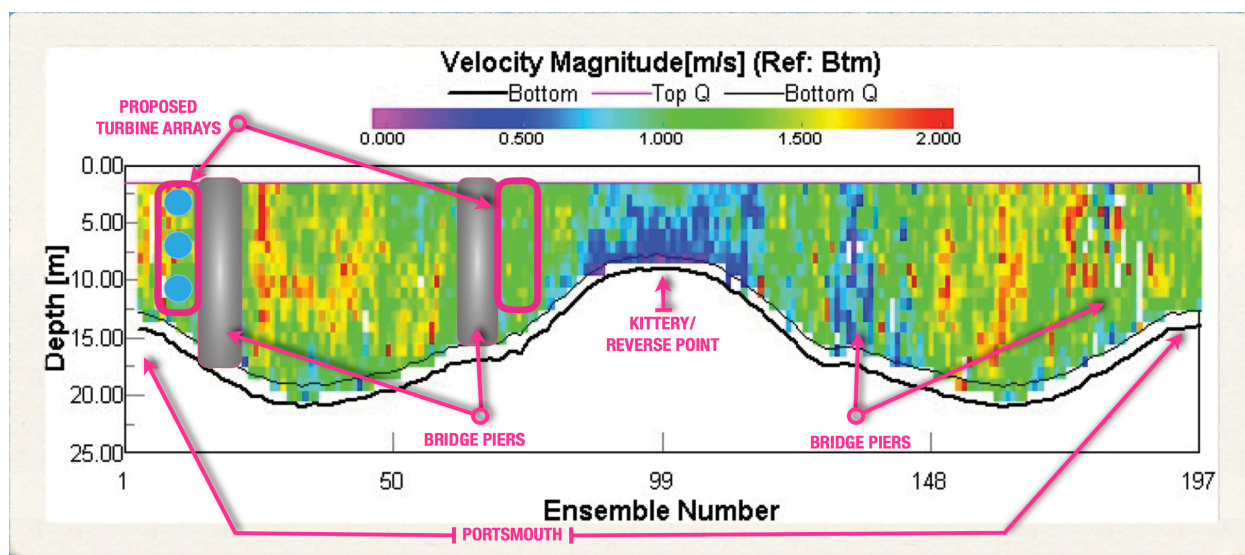


Figure 2.5: Piscataqua River Velocity. (Baldwin)

Due to its reoccurrence, tidal power defined by centuries and is independent of any local weather patterns. This is mainly due to the fact that the Moon will always be around and we will

always have tides going in and out. (Baldwin) The Piscataqua River is a tidally driven current that has tides flowing in and out of the harbor about four times a day. The maximum velocity that is seen from these currents is around 2 M/S (metres per second) and averages around 1.7 M/S. (Baldwin) For a turbine to be put in place, it would take around 1 M/S to keep it

moving and producing enough electricity to power a bridge. (Baldwin) Figure 2.5 shows the high velocities of the river. Because of shipping regulations, the tidal turbines cannot be too close to the middle of the boating lanes under the bridge. This is a major problem when trying to gain the maximum efficiency from the turbines, due to the fact that the major velocity of the water is under the middle of the bridge. Figure 2.5 shows that the major velocities are under the mid-point of the bridge, indicated by the dark-blue color.

If the Memorial Bridge were to have tidal turbines, it would produce enough electricity to power the bridge and some of the surrounding areas. However, there are some challenges that engineers will face while trying to construct these sustainable energy sources. First the turbines can pose a risk to the biological life. Species, such as fish, may be killed by the dozens from the spinning turbines. This can also have an effect on fishing as well. If more fish are killed by the turbines, less fishing will occur, posing a threat to the fishing community. Another threat from the turbines would be noise from the machines. If the turbines were to be sitting above water partially during low tide, the noise from the machines may disrupt the community around it. Lastly, construction of the turbines can also cause delays in shipping and pollution from spills. If the turbines were to break, shipping lanes may be delayed during the process of fixing the

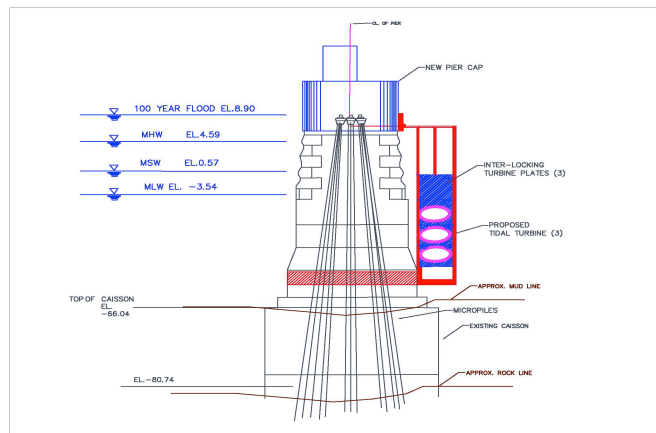


Figure 2.6: Memorial Bridge Turbine. (Baldwin)

turbines. Also, pollution from construction materials or mistakes during the process of implementing the turbines, can cause serious consequences for the surrounding areas.

Currently, the state of the turbines rests in the hands of budgeting committees. Proposals are being made to come up with funding for the turbines for the Memorial Bridge. Also, structural design for the turbines is also currently pending. The image shown in figure 2.6 shows the current concept model for the turbines. (Baldwin) If the Memorial Bridge were to be fitted with these turbines, it would open up future projects for bridges, such as the Sarah Long Bridge, also in Portsmouth. (Baldwin)

VI. The University of New Hampshire:

One local University that Portsmouth can benchmark, when trying to become sustainably efficient, is the University of New Hampshire. Currently, the University of New Hampshire is the one the most sustainable universities. Due to UNH's strong commitment to sustainability and green-energy, the University is now a sustainable leader for other schools in the U.S. UNH sustainable coordinator, Jacqueline Furlone, shed light on what UNH does to be a leader in sustainability.

One aspect of the UNH community, that makes it a leader in sustainability is the Ecoline (methane gas pipe) that runs underground from Rochester, New Hampshire, to UNH. This Ecoline is the first of its kind for a university. Constructed in 2007, this pipeline contains methane gas that comes from a landfill site in

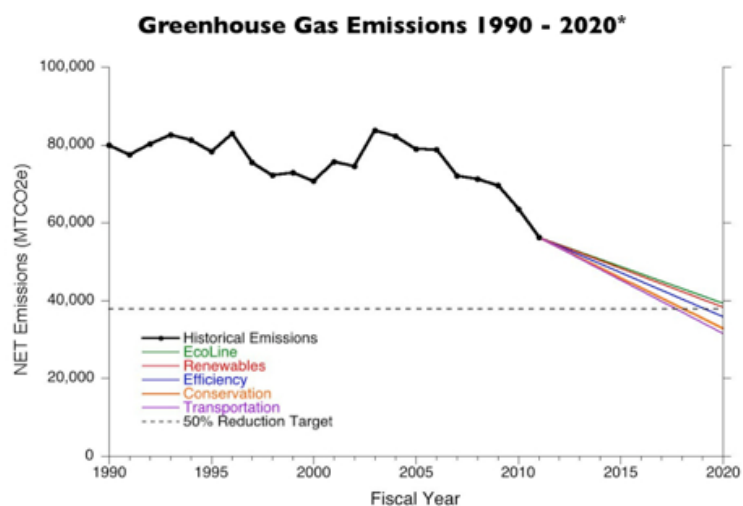


Figure 2.7: UNH Greenhouse Gas Emissions. (Furlone)

Rochester. This material is used to power the entire university campus. The cost of this project was initially around \$49 million, but has an estimated payback of about 10 years or less.

(Furlone) This aggressive plan of implementing an Ecoline was part of UNH's approach to cut greenhouse gas emissions substantially. It is estimated that UNH will cut its carbon emissions by 50% in 2020, 80% in 2050, and have carbon neutrality by 2100. (Furlone) Figure 2.7 shows the current downward trend of gas emissions at UNH.

Another integral part of UNH's sustainability is its cogeneration plant. In 2006, the cogeneration plant began operation and cost \$28 million, with a payback period of about 20 years. The cogeneration plant is used to take wasted heat from the production of electricity and turn it into energy. (Furlone) In 2006 alone, the carbon reduction from 2005 was around 21%. Currently, this plant operates at full capacity, supplying power to the five million square foot campus. (Furlone)

Some other aspects to UNH's campus, which help it be sustainable, are its use of LED lights and the new hydration stations. Currently, UNH uses LED in almost every building at UNH. This has been part of UNH plans to save money and cut energy costs. So far, as Jacqueline Furlone put it, "the LED lights are an important part to UNH's process of being sustainable and have help cut some energy costs substantially." Although the LED lights are an important element of UNH's sustainability, the new hydration-stations have also been an important aspect as well. UNH began installing these new water stations in the fall of 2011. (Furlone) The main purpose of these new stations is to encourage students to use cleaner and fresh fountain water, instead of drinking from plastic bottled water. Today, bottled water is consumed heavily and causes pollution problems for the environment. Unless a plastic water bottle is recycled, it sits around in an environment and takes centuries to decompose. Another aspect to the new water

stations is to re-recycle water, which may be wasted at the stations. This ensures that no water is wasted and everything is recycled. Currently, all of UNH's dining halls have a ban on plastic water bottles and instead, encourage people to use their hydra-stations. (Furlone)

Another major part of UNH's sustainability is their food. One of UNH's main goals is to become completely dependent on locally grown food one day. Currently, around 22% of UNH's dining budget is spent on locally grown food. This means, UNH gets around 22% of its food from local vendors, within a 250-mile radius. (Furlone) This help ensures that everything is fresh and saves on gas emissions produced through transportation. The UNH Dairy Bar, which is located next to the train stop, is an energy efficient and sustainable food stop. Almost all of the food served in the Dairy Bar is local and the building is equipped with energy efficient appliances. UNH has also been encouraging students to check out local farm vendors, in hopes that students will buy locally more often. This encouragement can be seen through promotions that will occur in the dining halls and by stating where the food came from on tags, next to the prepared items.

UNH has also been heavily involved in the transportation aspect of sustainability. Today, 25% of UNH's gas emissions are from vehicles that are owned and operated by UNH. However, since 2008, UNH has been lowering its vehicle gas emissions. From July 1st, 2007 to July 1st,



Figure 2.8: UNH Transportation. (Furlone)

2008, UNH lowered its vehicle emissions by 21,000 tons. (Furlone) One-way in which UNH is lowering its vehicle emissions is by encouraging sustainable transportation on campus is through the use of bicycles. Currently, donors from Space

Allocation and the Repairs and Renovation Committee (SARRC) are estimated to spend around \$40,000 on new bike racks throughout the UNH campus. Also, UNH has been working on expanding certain roads throughout campus, to allow bike lanes. In 2007, the re-construction of UNH's Main Street was completed. This \$2.2 million project was to create bike lanes and improve bike traveling along the streets. (Furlone) This project also widens sidewalks, to encourage more students to walk to classes. Another project, which was completed in 2010, opened up bike lanes, connecting West Edge to the Field House. This \$500,000 project, widened roads and improved bike traveling outside the main part of campus.

UNH's focus on using sustainable vehicles has also been significant. Today UNH's vehicles consist of 10 gasoline-electric cars, 3 plug-in hybrids, 10 100% electric vehicles, 17 compressed natural gas vehicles, and 56 high bio-diesel vehicles. UNH has also been able to expand its re-fueling stations, due to funding from the state. (Furlone) In 2011, the state helped finance a massive fueling station for UNH's fleet of vehicles. This helped expand the sustainable natural gas stations and the biodiesel stations as well. (Furlone)

Lastly, UNH's focus to always recycle also makes the campus very sustainable. Today, UNH focuses on making its waste 100% recyclable. Paper, plastic, and other recyclable material are recycled throughout the UNH campus. (Furlone) In many areas throughout the campus, people can easily throw away material that can be recycled. This also includes printer ink. Just recently, UNH started using recyclable ink-cartages all over the campus. This insures that no ink is wasted and the cartages are re-used. (Furlone)

UNH has taken many steps to make it a leader in the field of sustainability. Many of the steps taken have secured a bright future for the university and will also save the campus money over the years to come. UNH also is a good example of what Portsmouth, New Hampshire, could

accomplish if the right funds and personnel were available. Taking approaches towards sustainability and a greener future, could save the city money and make it a better community for years to come.

VII. Recommendations For Portsmouth:

For Portsmouth to have a greener future, there are some vital steps and procedures it must put in place, to become more sustainable. Although these recommendations cannot take place unless funds are available, it is important for Portsmouth to focus on what it can for the future.

Using UNH as a benchmark for Portsmouth, it is clear that there are many small and large projects that Portsmouth can take up. First, expanding the amount of recycling areas throughout the city would help. By having more paper and bottling recycling areas, the city would see less trash scattered in the city and more sustainability. Currently, most of the streets in the downtown Portsmouth area have at least one recycling area. Increasing the number of recycling places can benefit the city.

Like UNH, Portsmouth should also promote local food throughout the city. Having farmers markets more often and pioneering local food consumption can have a large impact on the community. More people would buy locally, which would benefit the community. Also, transportation emissions would drop substantially. Another idea that also involves the food industry would be to have incentive programs in the city for restaurants that use composts for their wasted food. Due to strict regulations, much of the food that comes from restaurants cannot be donated. By having more composts throughout the city for food waste, the city could re-use the fertilizer and soil matter that is produced. This would be very big for local food vendors who strive to have everything they produce “home grown.”

Another project Portsmouth should consider is installing new hydration-stations throughout the city. These new machines are \$2,400 a piece and provide the community with fresher and recycled water. (Furlone) This also helps cut down on the amount of plastic bottles that people throw away.



Figure 2.9: Portsmouth Lampposts. (Broccolo)

Having these hydration-stations available in the most populated parts of the city and also installing them in many of the municipal buildings would be a good start for Portsmouth to become more sustainable. Places such as the local library and city hall are good places to first install at least one new hydration-station. If local staff and others see an increase usage in these stations, I would recommend more to be installed.

Another key project that could help the city, would be to invest in more LED lights all over the city. These lights would provide the city with more sustainable lighting and help cut down costs on energy. Portsmouth currently has LED lighting in some of the cities municipal buildings, but many other areas of the city should also be considered for LED lighting. Places such as downtown Portsmouth, could be ideal for LED lighting. Having to upgrade the lampposts in the downtown area would be very costly, but would be beneficial for the future. A LED light bulb can typically cost between \$12 to \$50, depending on how many and the size of the LED bulb. (Britz)

Portsmouth municipal vehicle fleet could also be upgraded as well to be more green efficient. Like UNH, Portsmouth can invest in a more hybrid fleet. In 2006, the municipal buildings and vehicle fleet of the city, give off about 15,000 tons of carbon. If the city were to invest in more

efficient vehicles, this number could eventually be lowered. Since hybrid vehicles can cost between \$18,000 and \$50,000, depending on model, I would recommend starting with two small hybrids. (Britz) After one-year of usage, the city can see the amount of carbon and money saved compared to the other vehicles being used. If the savings are beneficial, I would invest in more sustainable vehicles if there is enough money in the budget.

Larger projects that Portsmouth has for consideration, like the Memorial Bridge turbines and solar panels, are very beneficial projects that the city should invest in. These two projects could open up more doors for future sustainable projects in Portsmouth. One future investment that would also be beneficial for the city would be to have its own methane pipeline. Similar to UNH's pipeline, Portsmouth could invest into a pipeline system that would re-use the left over waste from the city at a landfill sight. This would be able to power part of the city or even the whole city if the landfill sight were large enough. Although this project would be larger than UNH's Ecoline, it would also be very beneficial for the city and have a certain number of years that would payback the initial costs. The Portsmouth Ecoline project would initially be higher than the \$49 million UNH paid. This is because Portsmouth is a large city so the pipeline and operational plant would have to be relatively larger than the one used at UNH. Also, the payback period would be longer as well since the cost of the project would be higher. As an estimation, off of UNH's costs, if an Ecoline for Portsmouth cost the city \$100 million, the payback period could be about 20 years. Currently, UNH's Ecoline payback period is about 10 years from its \$49 million project.

Another large-scale project that town has proposed is widening the streets of Portsmouth, to allow for traveling of bikers. This would open the door to let more bicycles travel throughout the city and lower the amount of vehicles. Being able to widen the streets downtown Portsmouth



Figure 3.1: San Francisco Trolleys. (San Francisco Cable Car)

would be ideal because of all of the congestion from traffic. By widening the streets, this can also allow for a more sustainable travel system to be put in place. Like the trolley system in San Francisco, being able to have a sustainable public transportation system in the downtown Portsmouth area would bring more tourists to

the city and cut-down on the traffic in it.

VIII. Challenges For Portsmouth:

There are some lingering challenges that Portsmouth will face when trying to become a more sustainable city. First would be the cost. Many of the projects that Portsmouth could do to make their city more sustainable, come with a higher initial cost. These initial costs are what make some sustainable projects too expensive for cities. Also, maintenance costs for some of these projects can be very high. For Portsmouth to combat these costs, it will have to apply for grants from different government organizations and also raise money for its own. Organizations like RGGI allow for the city to apply for grants that primarily focus on sustainability.

Another challenge that the city would also face is strict regulations from both the state and nationally government. Projects such as, widening the streets, can cause controversy with real estate and handicap accessibility. The city will have to maintain and keep a close watch on the guidelines they must follow, without breaking any laws. The slightest mistake when executing a project could cost the city financially.

Lastly, one of the biggest challenges that the city will face is the behavioral aspects of the community. If local residents do not want to be more sustainable and follow what the city is

trying to accomplish, this may cause many problems. Today we see this more with many people across the U.S. who will not follow the sustainable approach that the country is trying to take. This is due to the fact that this could mean higher taxes for those who live in a certain region that wants more sustainable projects. By having more town meetings and promoting a more sustainable life style, more residents would understand the importance of what the city is trying to accomplish.

IX. Conclusion:

Realizing that we need to change our habitats as a world is the first step towards a more sustainable future. Due to the current rises in greenhouse gas emissions, our world is facing a climate change never experienced by humans before. President Obama has unveiled plans, which will change the course of the United States future to be more sustainable. Like many other countries across the world, the United States hopes to change the current rises in temperature before it is too late. As a city, Portsmouth has the opportunity to be a leader in sustainability as we enter into the future. Using the University of New Hampshire as a benchmark and using ideas from the UNH campus can help Portsmouth both economically and environmentally. Although there may be challenges financially, politically, and locally from residents, being able to be a sustainable city will be important for the future of United States.

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