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Major Projects in the Massachusetts Renewable Energy Market

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ABSTRACT

This report describes the operation and current status of the Massachusetts renewable energy market and attempts to analyze three major projects that will have a distinct impact on the market. Cape Wind, the Maine Green Line and the Northeast Energy Link would all provide significant renewable energy to the market with a positive economic impact and minimal environmental damage. However, Cape Wind is no longer in feasible due to contract canelations and financial set-backs.

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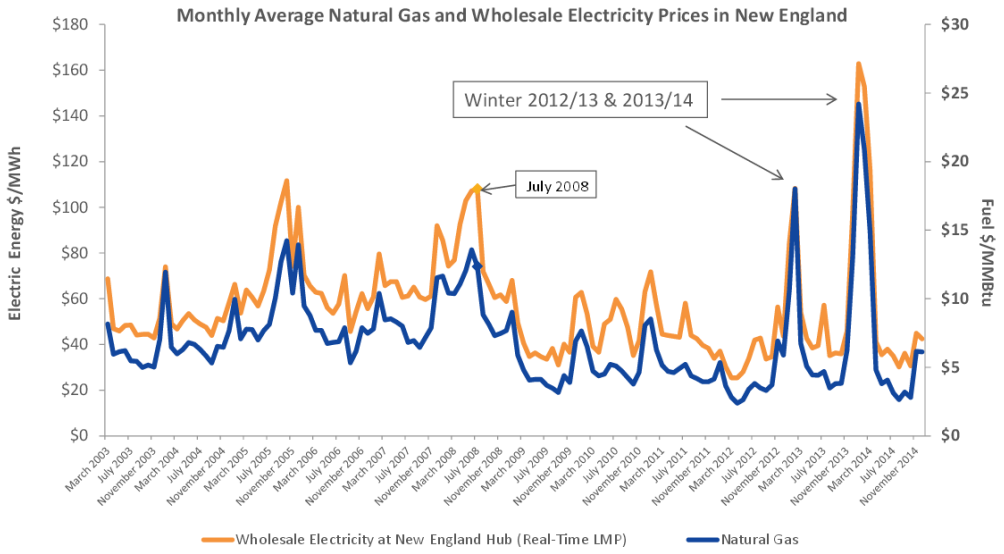
CHAPTER 1: INTRODUCTION

Massachusetts is at a pivotal moment in the history of its energy grid. Plagued by high energy prices for decades, the state has been trying to alleviate the price burden on consumers, all the while, trying to shift away from fossil fuels, as concerns of climate change and public support for green energy swells. Unfortunately, its actions have led to some new, unintended consequences. As it stands, if serious action is not taken, Massachusetts could see record energy price spikes that could cripple commerce and threaten not only the state, but the region as a whole.

The perfect storm that the Massachusetts' energy market faces has been slowly brewing over the course of the last decade. The big spoon stirring the pot has been the public and political push for cleaner energy. This first took the form of the Renewable Portfolio Standard (RPS), established by the Department of Energy Resources (DOER) in the late 1990's. It created a market system that attempted to put renewable energy sources on the same economically competitive level as their fossil fuel counterparts. More importantly, it mandated that a certain percentage of the electricity sold in the state to be from renewable resources, and that that percentage would increase annually. The next step on the road to crisis was the closing or scheduled closing of six coal, oil, and nuclear plants, leaving an increasing hole in the generation market. This forces a greater burden onto the remaining generator to meet the state's ever increasing electric load. Meanwhile, an increasing number of natural gas power plants began and connect to the system, due to an increase in natural gas supplies from hydro-fracturing and appealing to the public's desire for green energy by being advertised as 'cleaner than coal.' As more old plants were taken offline, the natural gas plants that replaced them needed to run at a

greater capacity and required more fuel. This paired with an increase in natural gas being used to heat homes, created an incredible demand for the fuel. These trends lead to record price spikes during the winters of 2013/14 when energy and heating fuel were at their highest demand.

Figure 1: Spikes in Energy Prices due to Natural Gas



Source: ISO-NE "State of the Grid" Gordon van Welie (slide 26)

This is the problem that the Northeast faces; it relies on natural gas for 41% of its electricity but it doesn't have the appropriate infrastructure to supply the natural gas it needs. This is because new pipelines will not be built without customer contracts for capacity. "Historically, natural gas generators have not entered into long-term contracts for pipeline capacity" (van Welie). Developers have proposed new pipelines or expansions to existing storage capacity, but the new capacity would be under contract to the local natural gas distributors and not the electricity generators. The issue there is, the local distributors "cannot contract for gas infrastructure expansion beyond the needs of their commercial and residential natural gas customers" (van Welie). This combined with "economic, legal and regulatory restrictions" hinder development of natural gas infrastructure. In essence, a pipeline has not been built because no one can answer the simple question "who will pay for it?" (van Welie).

Massachusetts is in desperate need of energy diversity. Both legal mandates and economic trends are begging for a market where one volatile fuel source doesn't control the electricity rates of six million people. This report looks to investigate three major energy projects that are attempting to solve this problem with renewable energy. We will attempt to analyze the environmental and economic impacts each project will have, as well as it effect on the renewable energy market in Massachusetts.

CHAPTER 2: BACKROUND

In the late 1990s New England became the first region in the nation to restructure its system that governed the wholesale and retail sale of electricity. The restructuring was driven, in large part, by the high energy prices that plagued residents and hinder businesses (Polestar). In November of 1997, the Massachusetts Legislature passed a bill requiring electricity deregulation to take effect in March 1998 (A History of Energy Deregulation). That legislation, the Electric Industry Restructuring Act of 1997 effectively dismantled the system of "vertically-integrated" utilities. These were companies that owned and operated the power plants where the electricity was generated and the lines that the power was transmitted over. This meant that if you lived in a certain area, chances were that you could only buy power from the company that owned the lines near your house. The Restructuring Act broke up this pseudo-monopoly that was charging high prices by taking the power generation out of the hands of the line-owners. This law not only separated the state's utilities from their power plants, but also laid the foundation for the state's renewable portfolio standard. Five years later "in April 2002, the Massachusetts DOER adopted the original RPS regulations" (North Carolina State University).

The Renewable Portfolio standard, as it exists in Massachusetts, is a "statutory obligation" that suppliers of electricity (utilities) within the state must acquire a set percentage of the total load they serve from qualified renewable resources. A qualified renewable resource or "Unit" is power plant that generates electricity from solar, wind, small hydroelectric, landfill methane and anaerobic digester gas, marine, geothermal or eligible biomass sources (Dept. of Energy Resources). Each unit is determined to be either Class I if the unit began commercial operation after 1998, or Class II if it began operation before that year. The RPS first went into

effect in 2003 mandating that 1% of electricity sold in the state should be from qualified units. The RPS also dictates that the percentage of renewable energy purchased will increment by 1% annually through 2020 when it will be 15%. The standard currently has no expiration date and would reach 50% by the year 2055, if left unamended. One percent in 2003 sounds like a modest start, but as Stan Blazewicz, Vice President of Business development for National Grid, pointed out in a recent press conference, with the 1% annual increment, the mandate requires a "250% increase in the state's renewable power between 2010 and 2020 (Krapels, Blazewicz)." That is certainly a challenge for an industry that is known to be slow to change and integrate new technologies.

Thankfully, the structuring of today's energy market is well designed to handle such challenges concerning both renewable energy, and the management, and sale of electric power in general. The two major players in the management of New England's electrical grid are the Independent System Operator in New England (ISO-NE) and the New England Power Pool (NEPOOL). After the electricity market was restructured, the ISO was created to operate and manage the electrical grid independent from corporate influences as a publicly accountable organization. ISO-NE's three main purposes now are grid operation, market administration, and power system planning ("Our Three Critical Roles"). NEPOOL was established back in the 1970's as a "central dispatch of generation in New England ("Our History")." It was designed to "handle settlements and billing; coordinate outages of transmission and generation equipment; undertake joint planning and other measures to improve system reliability and economics ("Our History")." Today, NEPOOL is responsible for the Generation Information System (GIS) that "issues and tracks certificates for all megawatt-hours (MWh) of generation and load produced in the ISO's control area, as well as imported MWh from adjacent control areas ("NEPOOL

GIS.")" This encapsulates one of the main challenge of the competitive market system which is tracking the purchase of electric power. The way the GIS system works is it creates a certificate for each MWh of power generated or flowing into the system (Springsteel). Utilities purchase these certificates for wholesale power according to the load they serve for their customers. The RPS works into this system by introducing Renewable Energy Certificates (RECs) into the market. A REC represents one MWh of renewably generated power. Utilities are required to purchase a number of RECs equal to that year's RPS percentage of the load they serve. For example, in 2015 the RPS Class I requirement is 10.0%, if Utility A is forecast to serve a load of 100 MWh, Utility A must purchase 10 MWh worth of RECs to fulfil that year's RPS requirement. If the utility does not, they must pay an Alternative Compliance Payment (ACP) for each MWh they miss the mark by. The utilities pay the ACPs to the DOER at a rate set by the DOER. The ACPs are priced to be more expensive than the market price of RECs and work as a cap to keep REC prices competitive (North Carolina State University).

This system has been fairly successful in bringing about significant progress in renewable energy generation in the past few years and the RPS has been the clear catalyst for this change by requiring companies to begin investing in renewable energy projects. The RPS has "created a reliable standard for development that allowed for companies to plan for the future," while promoting technologies and projects which are "more environmentally friendly and sustainable," said Howard Bernstein, the energy portfolio standards manager for the DOER. This allows for projects that would normally fall to the wayside, such as offshore wind energy and small scale hydro plants, such as small dams, come to the forefront and develop more quickly than before. In fact, "We are meeting the RPS after a couple of years being short on renewable energy for Class I. In 2013 it was increasingly being met by new wind projects... there is an increase in wind in

Massachusetts and Maine… and there are also wind imports from Quebec (Bernstein)." The DOER's most recent RPS Compliance report, found that "Massachusetts renewable generation rose by nearly 64% over 2012" and "The supply of 2013 RPS Class I RECs exceeded demand by 7%" in 2013. The Massachusetts renewable energy is currently succeeding in meeting the RPS, but the system operators must always be planning years ahead in order to keep up.

The three major energy projects we investigated that attempt to keep the grid supplied with renewable energy are the Maine Green Line, the Northeast Energy Link, and Cape Wind. Cape wind was a wind project that was planned to be located off the shore of Nantucket Sound. It was proposed by Cape Wind Associates and entailed having approximately 130, 3.8MW windmills arranged in rows (FAQ) ("Our Three Critical Roles"), which would be the largest offshore wind project in America. As of January 2015, National Grid and Eversource Energy have chosen to cancel their power purchasing plans with Cape Wind (McNamara).

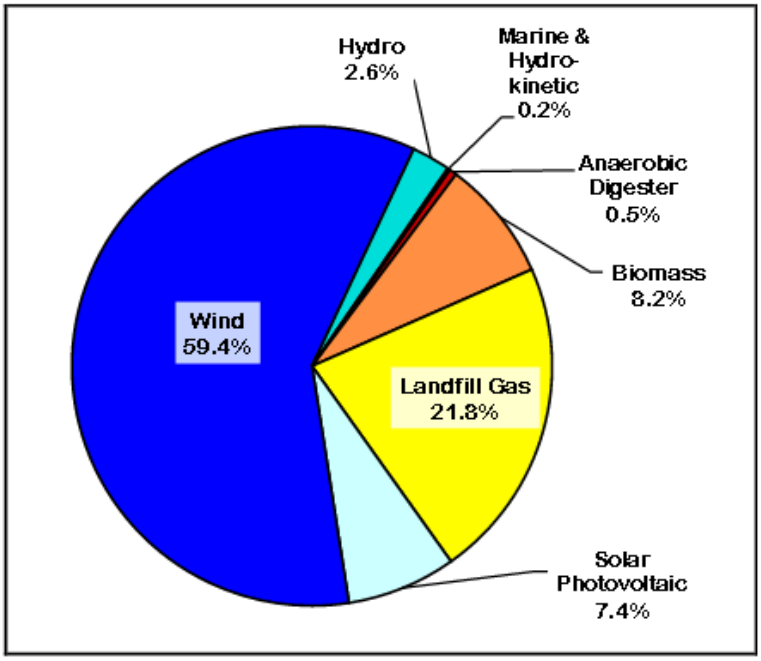
The Maine Green Line is a 1000 MW undersea High Voltage Direct Current (HVDC) power line. The Green Line's proposed route goes off the coast into the Gulf of Maine, through the Atlantic, and resurfaces in the greater Boston area. The Green Line has been proposed by the newly formed partnership between Anbaric Transmission and National Grid. Also working on the project are a team of design companies including, New England Independent Transmission Company, LLC , the Cianbro Companies and Power Bridge, LLC ("Maine Green Line").

Similar to the Maine Green Line is the Northeast Energy Link (NEL) is power line proposed by Emera Maine and National Grid. The main difference between NEL and the Green Line is that NEL is an underground cable that will be buried along interstate highways in Maine, New Hampshire and Massachusetts ("Home"). The proposed route is a 230 mile stretch that will run "from northern and eastern Maine and eastern Canada into southern New England ("Home").

It is expected to carry the wind energy generated by projects in northern Maine and hydroelectric energy generated in Canada down to Massachusetts. These are the renewable projects we chose to analyse.

As a group we decide to focus mainly on projects that involved the generation or transmission of wind power for Massachusetts. However this doesn't mean that we don't acknowledge other sources that contribute to Massachusetts' renewable energy supplies. We chose to focus on wind because about 60% of the RPS is met by wind power as of 2013 (Department of Energy Resources). But it should be noted that solar-voltaic, Landfill gas and biomass resources make up a combined 37% of the renewable energy that met the RPS that year.

Figure 1: 2013 RPS Class I Compliance by Generation Type*



* Includes the Solar Carve-Out, all SRECs

Source: DOER Massachusetts RPS & APS Annual Compliance Report for 2013

The success of solar in Massachusetts can be attributed to expansions made on the original RPS called the Solar Carve-Out initiatives. The Solar Carve Out was a new regulation

added to the RPS in 2010 that supported distributed solar, as a means to meet the ever growing Class I requirements. So far, the Solar Carve-Out has been quite successful as its original goal of 400MW of solar capacity has been met and the program is now in its second iteration, the Solar Carve-Out II initiative, which began in April of 2014 and whose goal is 1600 MW of new solar capacity by the year 2020, (North Carolina State). However, in September of 2014, the DOER announced that it was not setting aside any capacity for utility scale solar power (generation greater than 650kW). "The amount of capacity in that sector was already going to fill up earlier than expected... there were more incentives to develop sources for rooftops, and less incentives for large scale solar power plants (Bernstein)". This reflects the DOER's interest in promoting distributed solar. Although solar can help Massachusetts reach its RPS goals our group decided not to focus on solar for our project. The main reason our group chose not to look into solar projects is because they make up only 7% of the energy used to meet the RPS (Dept. of Energy Resources) as of 2013. We wanted to focus on projects that could help Massachusetts reach the RPS goals on a large scale level. The transmission projects and offshore wind projects that we have looked into would have a larger impact to New England and Massachusetts in regards to the RPS. That is the main reason why we focused almost exclusively on wind.

CHAPTER 3: METHODS

In order to obtain a complete picture of our research question, we decided to interview professionals in the power industry. This method complemented our traditional research of Internet based searches by giving us a human and up-to-date view into today's energy market. Interview subjects were chosen for their relevance to various renewable energy projects in Massachusetts. The interviewees were first contacted by e-mail in an attempt to schedule a phone interview. In the e-mail, the option was presented to answer the interview questions via an e-mail question and answer session if an interview could not be scheduled or is otherwise impractical. The email also asked if the subject could refer us to anyone else that they think would be helpful for our research topic. This allowed for the possibility of interviews with more subjects who may be relevant.

The interviews were conducted via telephone with the interview subject during normal business hours. The interviews were initially conducted in a Gordon Library Tech Suite with the interview subject on speakerphone, but was shifted to the SSPS Conference room for greater convenience and clarity of sound. During the interviews, one student would conduct the interview with a list of prepared questions for the subject. Another student will be taking notes on the interview. Interviewees were asked if we could take an audio recording of our interview, all of which agreed. The interview questions varied depending on the individual but all questions followed the theme of the research question: "How will X-project impact the Massachusetts renewable energy market?"

We chose to interview company representatives that had a direct stake in the current energy market in Massachusetts, representatives from the three major projects that we were

investigating, and any major organized opposition groups. For example, we spoke with Steve Conant, the senior vice-President of Anbaric Transmission, a company that announced a partnership with National Grid to help design the Maine Green Line project. We also spoke to Howard Bernstein of the Department of Energy Resources for Massachusetts to gain a better understanding of the RPS's origins and effectiveness so far. For a look at the opposition opposing Cape Wind, we spoke to Aldra Parker, who is a leader of the Alliance to Protect Nantucket Sound. We also interviewed Michael Durand of Eversource Energy, and Ian Springsteel of National Grid to understand the perspective of state's two largest utilities on the RPS and the renewable energy market.

Our interview approach did have some weaknesses. Not all the companies we contacted resulted in an interviews. We attempted to speak with Cape Wind, ISO-NE, and Hydro Quebec, none of which panned out. Hydro Quebec had no comment about any plans to expand to America, Cape Wind had no desire for an interview, and ISO-NE simply did not get back to us. Using these interview strategies and paired with our Internet research, we believe we have compiled a comprehensive analysis of three major energy projects that will affect the future of Massachusetts' renewable energy supply.

CHAPTER 4: DISCUSSION

Cape Wind

Cape Wind was planned to be first offshore wind project in America. The wind capacity offered by Cape Wind would have significantly expand the renewable energy market in Massachusetts and allowed for a more local option as opposed to importing renewable energy from other states. It was expected to generate 468 MW of RPS qualified energy, which was expected to be able to cover 75% of all energy demand in the Cape Cod area (FAQ) (Overview). The power generated by Cape Wind was going to be sold in Massachusetts, with the intention of fulfilling RPS standards. In September of 2014 it was estimated that Cape Wind would be operational and at full capacity by the end of 2017 (Penn Energy). Operating at 468 MW we can approximate that Cape Wind would generate around 4,099,680 MWh a year by multiplying its capacity by its capacity factor and the number of hours in a year. If we take that estimate and compare it to the DOER projection of a 6,521,138 MWh of renewable load obligation in the year 2018, we see that Cape Wind could have supplied 23% of the total Class I requirement for 2018.

Figure 2: Cape Wind Energy Statistics

Project	Cape Wind
Completion date	2018
Capacity [MWh]	468
Capacity Factor [%]	38
Annual Renewable Output [MWh]	1,557,878
Completion Year's projected Class I Obligation [MWh]	6,521,138
Percentage Contribution [%]	23.9

Source: DOER Massachusetts RPS & APS Annual Compliance Report for 2013

In addition to the boost to Massachusetts' renewable energy resources, Cape Wind also had some notable economic impacts as well. The power would have been generated in-state which would have achieved more energy independence for Massachusetts, which in 2013 purchase 82% of its renewable energy from other states (Dept. of Energy Resources). "Massachusetts will also receive 27% of the royalty payments Cape Wind will pay to the Federal Government" ("Project Benefits"). In addition, $9 million would be given to the nearby town of Yarmouth, over time, as a form of compensation. It was expected to create between 600-1000 jobs during its construction, 50 permanent jobs to maintain its upkeep, and possibly more jobs by creating tourism through creating ferries routes that would be closer to the windmills to look at them ("Project Benefits"). Cape Wind's many economic and renewable energy impacts make it an attractive project, however, its environmental impacts also need to be taken into account.

A number of environmental reports and studies were conducted on the Cape Wind Project. All reports were then verified during the review required by the National Environmental Policy Act (NEPA). There was a clear consensus from the reports that there would be no significant impact on the surrounding environment posed by the location or the size of Cape Wind, meaning that, according to multiple sources, Cape Wind's effect on local ecosystem was negligible (BOEM). The reports include; the BOEM's Environmental Assessment of Cape Wind, the National Oceanic and Atmospheric Administration's (NOAA's) National Marine Fisheries Service Environmental Assessment, the NOAA's National Marine Fisheries Service Biological Opinion, the Department of the Interior's Record of Decision, the BOEM's Final Environmental Impact Statement, and the U.S. Fish and Wildlife Service's Biological Opinion. Despite its positive energy and economic impacts and passing multiple environmental surveys, Cape Wind was not without its detractors.

The major opposition to Cape Wind came in the form of the Alliance to Protect Nantucket Sound. Their opposition was based on worries that Cape Wind might harm local wildlife, such as fish and birds, and that it could harm the local tourism-based economy because the windmills would making the skyline less attractive (see Figure 5). According to the Alliance, only a few permanent jobs would be created, which would not compensate for the loss in revenue via tourism (Parker). Using these points, the Alliance have file multiple lawsuits challenging Cape Wind.

Figure 3: Simulated View of Cape Wind from Shore

Source: "Graphic Map and Visual Simulations" Capewind.org

Cape Wind's deals with National Grid and Eversource Energy, previously Northeast Utilities, fell through at the beginning of January. Cape Wind formed a contract with National Grid and Eversource Energy stating that Cape Wind would ensure that their finances were in order and progress was being made towards its completion, in exchange the utilities would give a

loan to Cape Wind, and ultimately buy power from them. Upon Cape Wind's failure to obtain financial backing as specified by the contract, both utility companies chose to withdraw from the contracts. This means that the future of Cape Wind is rather bleak. They have stopped renewing land leases, and have not given any explanation to the public as of yet (Abel). Cape Wind's failure was highly unanticipated, and has now left many utility companies in a bit of a scramble to fill the large hole in their long-term renewable plans and find new ways to satisfy their RPS obligations. For example, Eversource energy, previously known as Northeast utilities, has "Just now terminated that contract, and are now looking for a way to replace it (Durand)." It is currently unknown why Cape Wind chose to not renew its leases and the contract, but it is theorized that they were unable to keep up with the costs associated with the various lawsuits set against them by locals, and grassroots opposition groups (McNamara).

The Maine Green Line

The Maine Green Line project is a 1000 MW underwater HVDC transmission line. It plans to depart off the coast of Maine and resurface in Massachusetts to connect in the greater Boston area. The project is being designed by a newly formed partnership between developers Anbaric Transmission and New England utility, National Grid, who formed the Green Line Infrastructure Alliance. Currently, little is publicly known about the project, as it is still in the "pre-permitting stage" (Conant). The advertising suggests that the new transmission line will allow for new wind energy developments in northern Maine as well as imported hydropower from Canada to be seamlessly integrated into New England's grid. Through our research we've identified key aspects regarding the Green Line's projected environmental impact, economic impact and effect on the Massachusetts renewable energy market.

At the time of writing this report neither Anbaric Transmission nor any of its partners have applied for an environmental impact study to be done, so conclusions on the project's environmental impact can only be drawn from similar cases of underwater transmission lines. The Convention for the Protection of the marine Environment of the North-East Atlantic (or the 'OSPAR Convention') did a general study on underwater transmission lines in 2009. In their study they found that the construction of the line caused only a temporary disturbance in marine life and the most significant impact comes from the long-term presence of the line. The line may create a habitat flora and fauna that are not native to the region (Merck). The study was also concerned with the thermal and electromagnetic radiation that could come from the lines and their apparent impact on local marine populations. Thermal radiation from heat dissipation is more prevalent in alternating current lines and therefore would be a significant consideration for the Green Line. Electromagnetic radiation which is produce with greater intensity by direct current lines may have an effect on fish migrational patterns, the study concluded. The trait that makes the Green Line special is that it is a two wire, bi-polar system. This means that one of the parallel wires carries current in one direction and the other's current flows in the other direction. This has the special property of cancelling out most of the electromagnetic effects around the wires so net effect could be less than background noise (Conant). During the interview with Steve Conant, Senior Vice President of Project Development, he described the lines being "the size of two tissue boxes stacked on top of each other, coupled with a fiber-optic line." Needless to say that the undersea cable, that will be buried, is anything but bulky.

Environmental considerations aside, the Green Line project offers a few interesting advantages simply by being an underwater transmission line. First, because the majority of the distance is traversed under the Atlantic, the Green Line avoids numerous complications from

trying to set up overhead terrestrial lines through state forests and private properties. The Northern Pass Project, a proposed transmission line that is set to run the length of rural New Hampshire, is all too familiar with this challenge as it has attracted the scrutiny of both private landowners through which its lines would cross, as well as organizations like the Conservation Law Foundation ("Northern Pass"). Conant agreed that the Green Line, because it's in its early development stages is "flying under the radar" at the moment.

Another consideration that was part of our research was the economic impact of projects like the Maine Green Line. The Green Line is estimated to have a $2 billion economic impact (Conant). Looking through the lens of job-creation Green Line and transmission projects like it don't offer much by themselves. Transmission lines require construction that usually goes through a specialty contractor that could be based in Missouri or Manhattan. The construction would last a couple years and employ on the order of 2,000 to 3,000 construction workers (Conant). Once the line is built, other than occasional maintenance by a similar specialty contractor, and monitoring or the system, transmission lines don't create permanent jobs in a particular place the way a power plant does. However, one should also consider the jobs created indirectly at the hydro plants in Canada or maintaining wind farms in Maine to major transmission projects like the Green Line. This is implying that the wind farms and power plants were built or will be expanded upon because of the new availability of transmission capacity provided by these projects. It is fair to say that jobs like these are created partially because of the Green Line, although no new generation projects are currently linked with the Green Line. Whether or not you can count these jobs as being created due to the Green Line, there is no way of telling if any of the jobs created directly or indirectly from the Green Line will appear in Massachusetts. One economic impact the will partially affect Massachusetts is the increased tax

revenue in the townships that its converter stations will be built. Because the line is HVDC, the electricity will have to be converted from alternating current before the line enters the ocean and after it resurfaces. This will require converting stations to be constructed, from which towns will gain income from the property taxes. Overall the Maine Green Line offers a significant economic stimulus to the private sector and to a few municipal coffers, but little in the way of Massachusetts job creation.

The most important question in our research for each energy project was to measure its impact on the renewable energy market in New England Energy market. Because the energy sources that will use the expanded transmission capacity of the Green Line have not been chosen, speculation can only be drawn from the most recent press release from the Green Line Infrastructure Alliance. In the press release both Ed Krapels, the CEO of Anbaric Transmission and Stan Blazewicz stressed that Off-shore wind from Maine and Canadian Hydropower were a "winning combination" that would provide both a new surplus of REC sources but also a price relief for consumers. If we analysing this statement, we can see some truth to it. With the 1000 MW of line capacity, new wind developments in northern Maine can supply qualified renewable power to the Massachusetts energy market and generate the RECs needed for utilities to meet the RPS mandate. To give 1000 MW a sense of scale, in 2013 the Class I RPS was 7.713% and the total retail load for that year was 49,252,929 MWh meaning that the utilities needed to purchase 3,799,402 MWh of renewable power. In the 2013 RPS Compliance report, it projects that by 2018 the Class I requirement will be 6,521,138 MWh. If the Green Line is built by then and 25% of its capacity is used to transmit wind energy then it will add 2,190,000 MWh to the energy market which is 33% of the total obligation for 2018 and 80% of the MWh that will need to be added to the market between 2013 and 2018 using these estimates (Dept. of Energy Resources).

It should be noted that this is all based on projections, estimates and round numbers, but the point is that the Green Line will add a considerable portion of the capacity needed to keep meeting the RPS obligations.

Figure 4: Green Line Energy Statistics

Project	Cape Wind
Completion date	2018
Capacity [MWh]	1000
Possible Percentage of Wind Energy [%]	25
Annual Renewable Output [MWh]	2,190,000
Completion Year's projected Class I Obligation [MWh]	6,521,138
Percentage Contribution [%]	33.6

Source: DOER Massachusetts RPS & APS Annual Compliance Report for 2013

The Green Line will also help the market creating capacity for hydropower to be sold in Massachusetts. Although only 'small hydro' (25 MW capacity or less) built after 1997 qualifies for the Class I RPS, having more hydropower in the energy market will add much needed diversity (Stori). Diversity helps the market by helping suppressing the overall price of energy when certain sources produce less or fuel prices spike like with natural gas. For example, when demand for natural gas rises in the winter, if there is enough wind, hydropower and other resources connected to grid, they can ramp up operation to try to lessen the amount of power the natural gas plants need to contribute to the system (Conant).

There was a project similar to the Maine Green Line that was also an underwater transmission line that intended to supply the Boston area with much need capacity. The project was called Sealink, and it was planned to run a "68-mile underground/undersea transmission cable" and supply up to 520 MW of capacity "to the Mystic Substation in Everett, Massachusetts, which is the heart of the Boston transmission network (New Hampshire Transmission)." The Sealink project was in competition with another terrestrial AC transmission

line called Greater Boston and Southern New Hampshire Reliability Project and was put forth by National Grid and Eversource Energy. On February 12th, 2015, the ISO announced that they would endorse the AC plan and not Sealink citing a $260 million dollar difference between the projects as well reliability of the overhead lines (Newsham). When asked about this recent decision by the ISO and how it reflects on the Green Line's chances Steve Conant pointed out that the New Hampshire Reliability project versus Sealink was competition decide by the ISO that revolved around grid reliability for the greater Boston area. Green Line on the other hand, is more of a business venture that is looking to be funded by investors, and is not for the sake of grid reliability (Conant).

The Northeast Energy Link

The Northeast Energy Link (NEL) is a transmission project that is being developed by National Grid and Emera Maine. It is a proposed transmission project that would supply 1,100 megawatts of renewable energy from Maine and Canada to Massachusetts and other states in New England ("Home"). The current plan is to build an underground transmission line that would run through interstates 95, 295, and 495. This underground transmission line would run for roughly 230 miles from Orrington, Maine to Tewksbury, Massachusetts ("Home"). The main objective of the Northeast Energy Link is to help utility companies and states in New England achieve their RPS goals. One could compare the Northeast Energy Link with the Maine Green line as they are both HVDC transmission lines from Maine to Massachusetts. HVDC is preferable to HVAC because it can transmit more power over longer distances ("Introduction HVDC"). Transmitting more power over greater distances saves money because there are fewer transmission lines needed to transmit the energy (HVDC). HVDC lines lose less energy than

HVAC lines because they are easily controlled and extremely stable (HVDC). The underground lines in the Northeast Energy Link would have all of these advantages. Studies conducted by Energy Security Analysis Incorporated (ESAI) have shown that the NEL would be a cheaper option for renewable energy in Massachusetts ("Home"). If implemented, the Northeast Energy Link could be a very helpful project in regards to the RPS for the states in New England, specifically Massachusetts.

It is unknown how much of the 1,100 megawatts of renewable energy from wind and hydropower in Maine and Canada would help Massachusetts meet the RPS, however, it is made clear that some of the energy transmitted by the NEL will qualify as renewable under Massachusetts' RPS ("Home"). There is not much opposition to the NEL because it is an underground transmission project so it will not greatly affect the look of the terrain above ground. Environmentally, similar to the Green line, the transmission line will not negatively affect the local environment the lines will be buried underground along interstates corridors. Having the transmission lines next to the interstates is advantageous to the environment because it will require far fewer trees to be cleared compared to a brand new transmission right-of-way being cut. Thus this underground HVDC line will not disturb any new areas in state parks or private property, again, giving it an edge over the Northern Pass. Much like the Green Line, the overall environmental impact will be positive because the energy being transmitted and sold is clean wind and hydro energy that is both renewable and generates no greenhouse gas emissions (National Grid).

In addition to being environmentally friendly, experts believe that the Northeast Energy Link would have a positive impact on the economy. A recent research performed by ESAI, an energy research and consulting firm, goes more in depth as to why NEL would have a positive

economic impact (National Grid). First and foremost, the study showed that the renewable power supplied by the NEL would be extremely cost competitive compared to other renewable energy alternatives (National Grid). The NEL also has the potential to lower market prices in New England by an estimated $7.3 billion over 30 years (National Grid). The Northeast Energy Link would also provide jobs for people in New England (National Grid). It is estimated by 2018 that the total spending on wind power in Maine will be around $1.28 Billion dollars. The investments of $1.28 billion will have created or supported 1,560 jobs a year from 2006 to 2018. In 2015 it is estimated that over 4,200 jobs will be created due to Maine wind power (Projects).

Another positive economic impact of the Northeast Energy Link has to do with the taxes generated with its creation. In addition to the HVDC lines there would also be AC/DC converter stations on each end of the line. An AC/DC converter can convert energy from one form to another, as well as change the voltage and frequency of the energy (Home). The converter stations will need to be built on land which will generate property taxes for the towns the stations will be built in.

A major utility involved in the NEL is First Wind Holdings which is now a part of Sun Edison. First Wind Holdings is a renewable energy utility located in Boston, MA. It is a major player in the NEL project because it has plans to build wind farms in Maine that would be a great deal of the energy transmitted by the Northeast Energy Link. Nearly 1,000 megawatts of wind power planned by First Wind would help New England states meet the RPS (National Grid). It is unclear, however, how much of this renewable energy would be sold in Massachusetts. The company currently has five wind projects that have been completed in Maine, and one project that is in development. First wind has completed projects such as Mars Hill Wind, Stetson Wind I, Stetson Wind II, Rollins Wind, and Bull Hill Wind in Maine. These five projects have a

combination of 219 MW capacity. There is also the Oakfield wind project that is currently in development (Projects). These wind farms are in a perfect position to supply energy that could be transmitted by the NEL as well as the Green Line.

Maine Wind Projects

As stated before the wind farms listed above provide a great opportunity for the NEL and the Green Line. Due to the similarity in location of these two transmission projects the wind farms in Maine could be a valuable energy resource to Massachusetts.

Mars Hill Wind is a wind energy project that was completed in 2007. The wind farm as a whole has 28 turbines and produces over 127,000 megawatt hours of electricity in a standard year (Projects). Mars Hill Wind powers an estimated 18,000 homes in New England and has a CO2 offset of 47,900 tons (Projects). There is opposition for the Mars Wind project, as seen before in other large wind projects. The opposition was mainly concerned with the noise and the overall attractiveness of the wind turbines. One of the citizens in Mars Wind Maine stated that "the wind turbines changed my life forever (Solar)". There was a lawsuit regarding the noise of the Mars Hill wind turbines, however the judge dismissed the case.

Stetson Wind I and Stetson Wind II are combined to be one of the largest utility-scale wind farms in New England (Solar). With 53 wind turbines Stetson Wind powers an estimated 30,000 homes in New England and has a CO2 offset of 73,000 tons (Projects). The wind farm is located in Danforth Maine and seen a relatively positive acceptance within the community. Rollins Wind farm is a project that was completed in 2011 (Projects**)** It consists of 40 wind turbines and powers 16,900 homes in New England (Projects). The last current Wind farm that

First Wind Holdings operates in Maine is Bull Hill wind, which consists of 19 wind turbines and powers 16,800 homes in New England (Projects).

The existing and proposed wind projects by Sun Edison in Maine show that wind energy has a big future as a renewable energy resource. Wind seems to be the primary focus of the utility companies**.** About 60 percent of the Massachusetts Class I RPS obligation was met by wind energy in 2013 (Dept**.** of Energy Resources). It is also apparent that the future of wind energy is bright as seen by the projects popping up all over northern Maine. One can assume that the Maine wind farms built by Sun Edison will provide a great deal of the power transmitted by the Northeast Energy Link. We can assume this because National Grid and Emera Maine are partners with Sun Edison. National Grid and Emera Maine are attempting to implement the NEL while Sun Edison has and is building wind farms in Northern Maine. It is not clear how many megawatts of the wind farms in Maine will provide to Massachusetts through the Northeast Energy Link and Green Line because both projects are in the planning stages.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

From our research, we were able to draw a number of conclusions on the market, the state, and the researched renewable projects. A realization we came to early on in our research was that Massachusetts is not a lone actor in the operation of its electric grid or its progressive march toward renewable energy. Although, in this report, Massachusetts was our main focus in terms of policy and energy consumption, it might have been just as appropriate to look at New England as a whole. Each state in the region does have its own laws and energy needs but all of them have programs that promote renewable energy and all but Vermont have actual RPSs. They also share connections to the same grid operated by the same organization and they all face similar challenges stemming from the climate (cold winters) and an over dependence on natural gas.

Our research also gave us insight into the objectives of the renewable portfolio standard and allowed us to measure its effectiveness at meeting those objectives. The RPS's objective is to promote the sale of renewable energy in Massachusetts. As such, the RPS has been a driving force behind the creation of renewable energy sources in a market that is normally slow to change. However this investment has been limited to the resources that are already economic viable like wind energy. While there is more of a focus on creating wind energy sources, less conventional sources of renewable energy, such as tidal power, and anaerobic digestion, have not seen the same kind of investment. This is because the RPS is a market mandate and not a government subsidy. It supports renewables by requires utilities to purchase renewable power but does not tell them exactly which ones to choose. It is us up to the utilities and investor put money into the renewable energy sources that are most economically feasible, and right now that

title is held by wind and landfill methane power. Without technological breakthroughs or other renewable energy policy, wind and landfill methane energy seem to be the two sources that will dominate renewable energy in Massachusetts, controlling 81% of the market (see Figure 2).

A related question about the RPS that came up in our research was the question of Hydropower's limited inclusion in the RPS. Hydropower is usually seen as a fairly environmentally friendly source of electricity. However, Class I of the RPS only allowed for small hydro and incremental hydropower sources and Class II did not include any at all Hydropower. We found ourselves asking, was this just? This part of the policy meant that the Northern Pass, another transmission project we looked into early on, would not have any impact on the Massachusetts because the energy it is planned to transmit is predominantly power from Hydro Quebec's large dams. After speaking with Howard Bernstein of the DOER we gained a better understanding of why the RPS is written that way. Hydropower plants that began commercial operation before 1998 (Class II) tend to have long-term power purchasing contract and do not need the support of the RPS. The reason that large hydropower plants don't qualify for Class I is because they tend to destroy the environment around it, leading it to be less environmentally conscious contradicts one of the main goals of the RPS. The inclusion of small or incremental hydro resources acknowledges that hydro is a renewable resource worth investing in without promoting environmentally irresponsible expansion or economically aiding a part of an industry that doesn't need it.

Another important thing we learned was just how valuable each project is to the necessary expansion of renewable energy market, and how each project needs to go through many hoops and hurdles in order to become a reality. The big example is Cape Wind. It was planned and billed as a huge boon for the northeast and Massachusetts in particular, and its

failure leaves a huge hole that utilities were not expecting. This sudden gap is making utilities like National Grid and Eversource Energy try to invest in new projects to purchase the required renewable energy for their RPS obligations. In addition, it may discourage other companies to invest in offshore wind energy, as seen by the lackluster bidding on the Martha's Vineyard off-shore plots. Martha's Vineyard is area divided into plots of land, located far offshore. It was considered a prime location for offshore wind energy generation, and there was expected to be a fierce bidding war over the area to secure plots for windmills to be placed. After bidding was finished, only two companies chose to bid anything, only the minimum amount, for relatively small plots of land (Springsteel). This may shift wind investor's attention to future projects in Northern Maine.

At the start of our research we thought we were going to be able to pick which project was the 'best'. What we found was that the question wasn't that straightforward. We very supportive of Cape Wind but over the course of our project, Cape Wind went from 'the future renewable energy' to belly up. We were then left with the Green Line and the Northeast Energy Link, which are two projects that are trying to accomplish the same thing, but this doesn't mean that they are mutually exclusive. Acknowledging that they are both in the early planning stages, both seem feasible and worthy of investment and at this point, it's a question of which one can secure the necessary financial backing and make it through permitting. Both projects also need approval in the court of public opinion, lest they suffer a similar fate to Cape Wind, bogged down by lawsuits.

Future Recommendations

Our project presents a solid starting point for a plethora of other research endeavours in the energy policy area of study. An early concept in our research was to attempt to compare Massachusetts' RPS and its execution to other states in the US that had similar standards. Massachusetts proved to be enough for us but IQPs in the future could certainly try to tackle this analytical comparsion. Other projects could also further examine other parts of the Massachusetts RPS that this report didn't focus on such as the Solar-Carve Out or the Alternative Energy Portfolio Standard. The Solar-Carve Out could make for a facisnating project because it would focus more on another major trend in energy that this report didn't mention, distributed generation. It is also very possible to simply continue the research in this report. Both the NEL and the Green Line will develop further in the next couple of years and their feasibility and impact in the market may change with development. Their development cycles could also provide similar lessons to energy investors that Cape Wind did about public opposition and the importance of having secure financial backing.

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