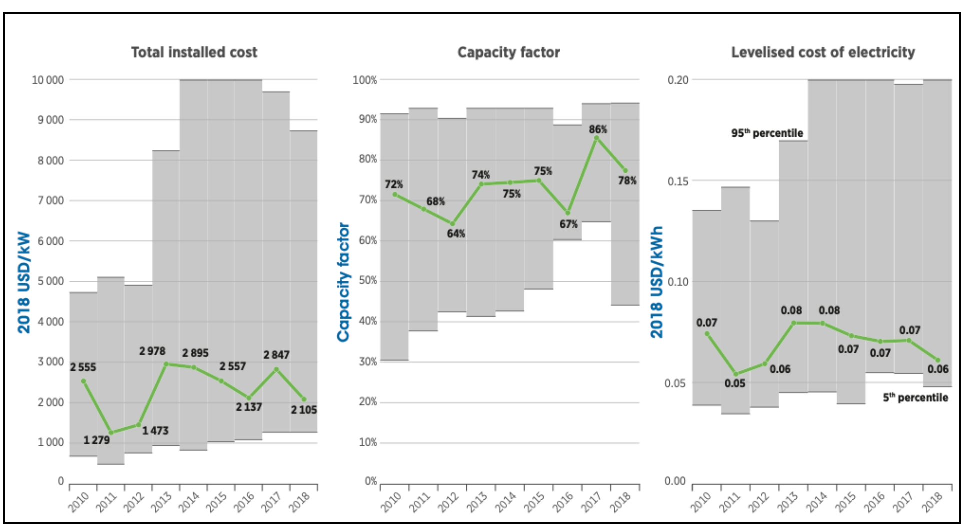
Project X

Mazn. Corporation

Marven Lapointe



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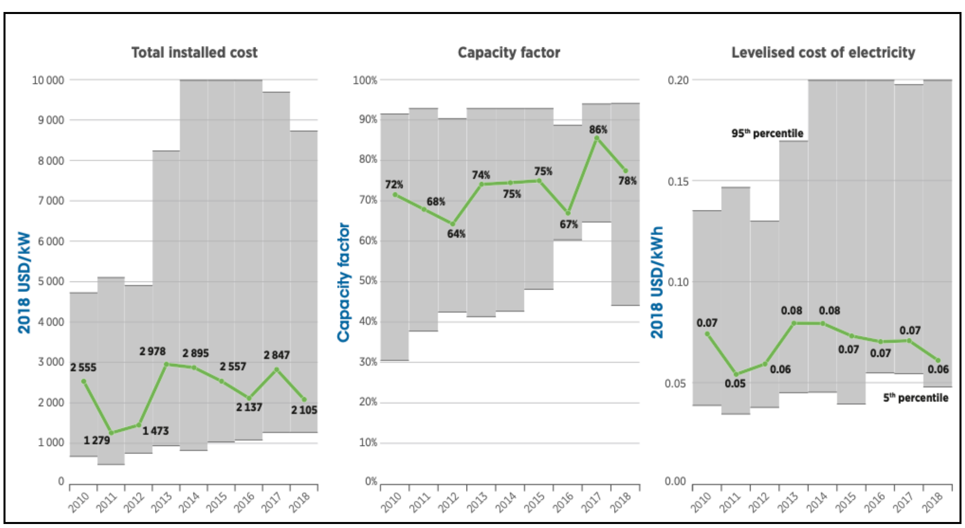

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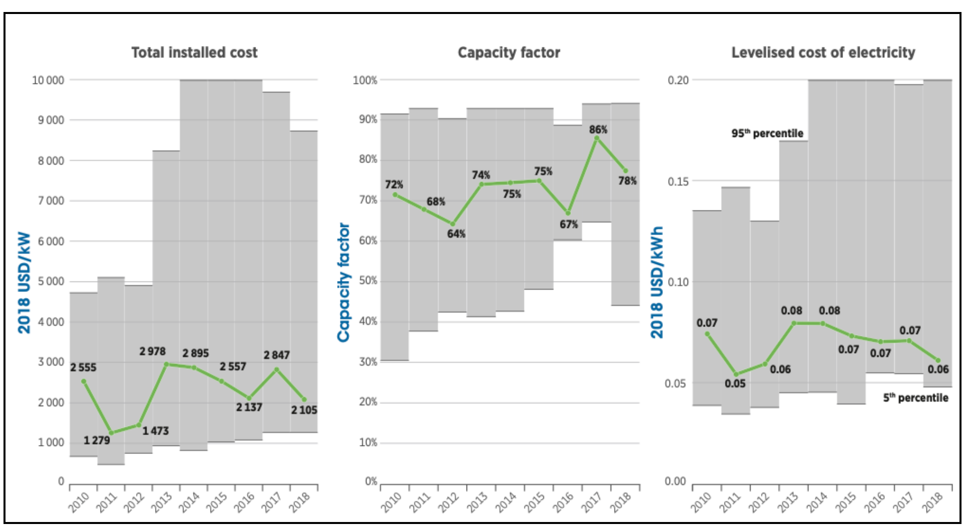
Mr. J.Fossilman:

We get to learn about lots of different ways for dealing with global warming. It is part of our job - climate change is the focus of our work at MAZN - and we would like to share with you our analysis of renewable energy options for our state, to achieve our goal of 100% renewable energy generation by 2050. We have picked four main renewable sources for Project X: Hydropower (H), Biomass (B), Wind (onshore) (W) and Tidal (T). In U.S Energy Information Administration (EIA) report (2019), for Maine, hydroelectricity, biomass and wind have powered three-fourths of our state's electricity. For that reason, we decide it is our best option to develop it on our foundation. Furthermore, we learn that technology in the tidal power sector is growing exponentially fast in recent years and the LCOE cost has been declining rapidly. For those reasons we have chosen HBWT for our Project X.

In Project X, we are urging the Governor of Maine to:

- Rebuild electrical grid system
- Build a massive biopower plant (5.7 GW) using *Belegian Eco Energy Model* in Ashland, ME
- Construct two underwater turbines arrays: One (106 MW) near Eastport, ME, and one (269 MW) near Cross Land, ME

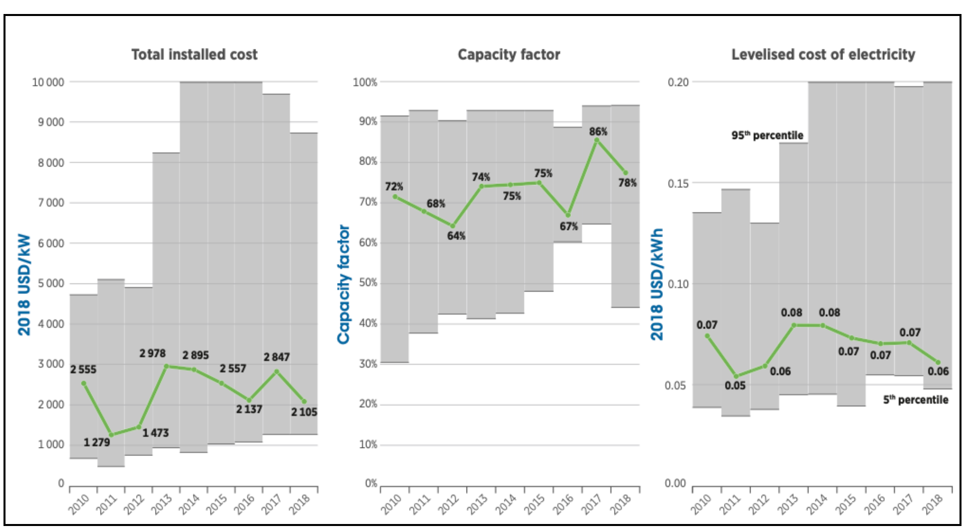


- Build a new Wind farm (50 turbines - 115 MW) on a coastline of Maine
- Rebuild hydroelectric dams specifically for hydropower generation
- Increase reliance on hydropower

Project X is designed as a long-term plan. When we reinvent our grid system to handle electricity surplus, we can power our homes 24/7 and sell the amount of electricity surplus across the states. This project will not only stimulate our regional economy, create more jobs, attract more tourists and create a positive impact on the environment, but also encourage others to dream big when building a green future. In the short term, the plan might increase tax rates for our residents, but if we can persuade our fellow Americans about the benefits and long-term goals, our future is limitless. We have a dream that one day, electricity shall be free and easily accessible to everyone. That is the future we are imagining and building at MAZN.

The future is ours!

MAZN Corporation

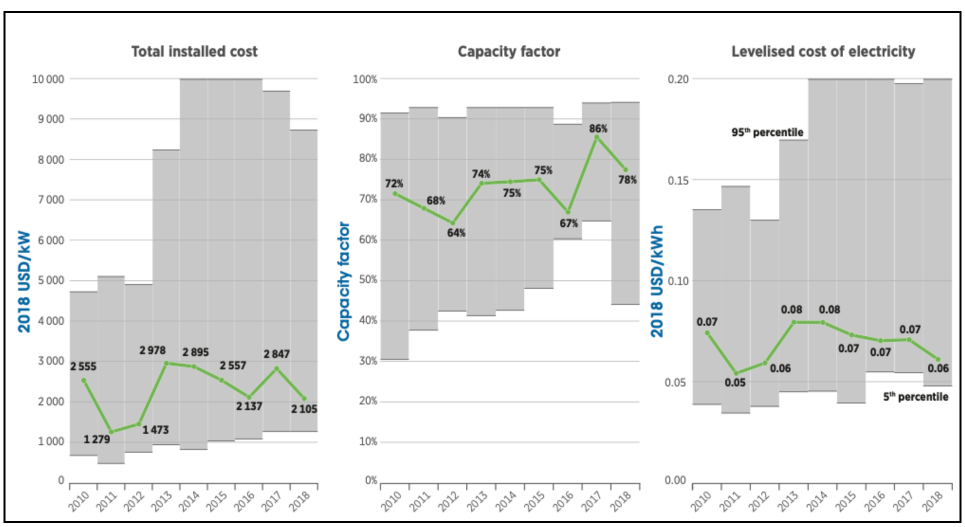


Short Summary

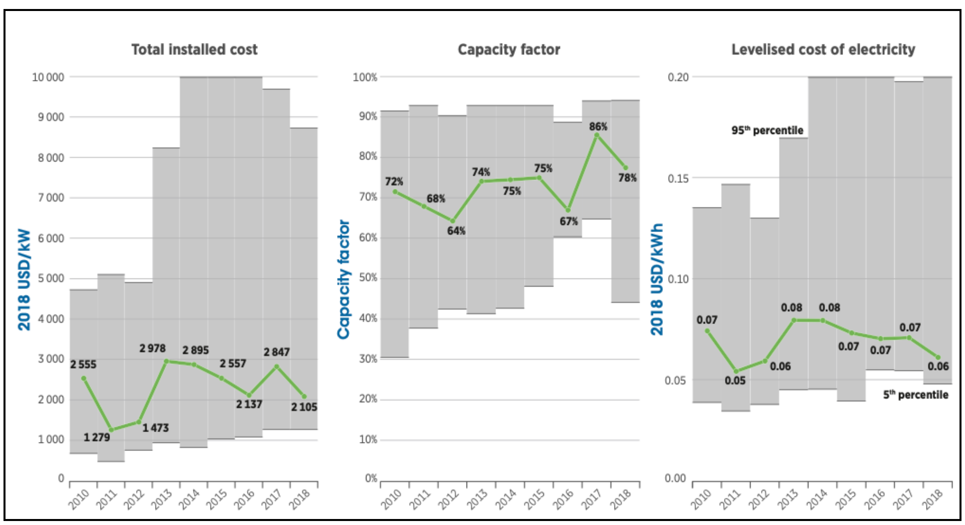
The future is bright for one who dares to imagine.

Let's build that future with our Project X. We aspire to power more than 700,000 households and 10,000 jobs for Mainers. And this is how each energy source will contribute to our common goal:

1) Hydroelectric power uses the flow of moving water to turn a turbine that powers a generator. It is one of the oldest methods of generating electricity used by man, allowing it to have been modified over the years to reach the point it is at today. Maine has seventy-three rivers that run longer than twenty miles, and spread throughout those rivers there are 107 hydroelectric dams (*Hydropower & Dams*). This is already an amazing defeat for hydropower, but given that the majority of these dams were built long before the 21st century for purposes other than hydroelectric power generation, they have a large capacity for upgrades. Though hydropower has its negative impacts such as changing ecosystems and harming fish, it is also cost effective, has low emissions, and is accessible energy. With an extremely varying capacity from 10% to 99% (*U.S. Energy)*, if perfected and used ideally it can be a huge asset to the 100% renewable energy goal.



2) There is a strong case to be made for bioenergy. It has the lowest cost of electricity per unit out of all ($0.062/ kWh) and that number has been declining in the past 5 years. Plus, the energy does bring positive impact on our environment and power more than 300,000 households after we install and run our most advanced 5.7 GW biopower plant. Most importantly, when we invest in biomass, we create more jobs in the forestry industry and other energy related sectors. Even though we do not yield total support from Mainers for biomass, we can solve the problem with high quality programs to educate our residents about our zero-emission sources. Looking toward the green economy, we need bioenergy.
3) Wind energy is one of the leading sources of renewable energy in the United States. The state of Maine is ranked 6th in the nation for acquiring energy from wind power and continuing to grow on wind energy can be very beneficial for Maine and its goal to reach 100% renewables by 2050. Maine is very suitable for wind power because it has an abundant source of wind along the ridge crests in the state's northwest and along its Atlantic coastline. By strategically planning on the location of the wind farms we can add to the 900MW of wind power already in the state.
4) Although still an emerging form of electricity generation, the harnessing of tidal energy is set to grow in popularity in the coming years. Hydrokinetic turbines, devices which can



convert energy from horizontally moving tidal currents similarly to wind turbines, show signs of being the next big advancement in the field of renewable energy. Much less impactful than previously considered tidal barrages, these devices can be installed on the seafloor in areas such as bay inlets where water rushes rapidly out to sea or into the bay as tides shift. Introduction of this technology at a commercial scale would make Maine the first U.S. state to achieve this, and thousands of jobs would be created by manufacturing and operating facilities within the state.

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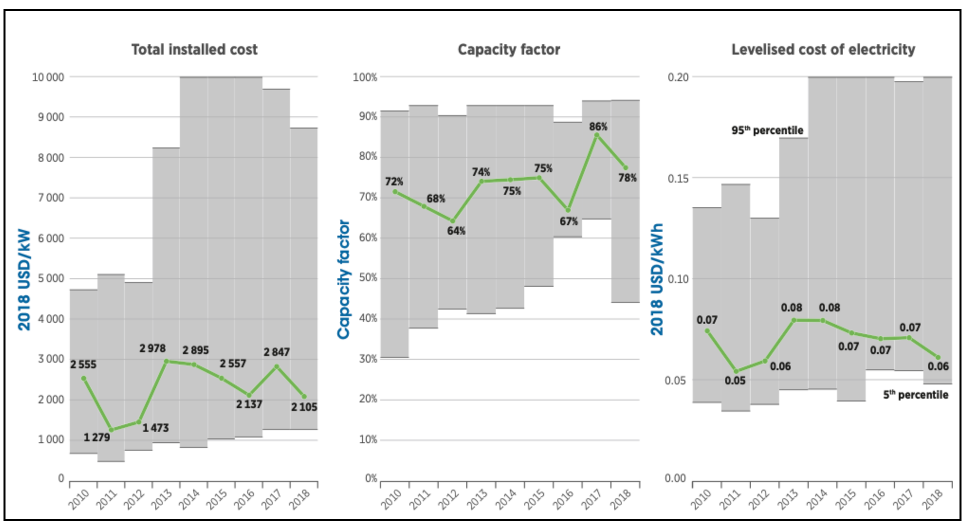
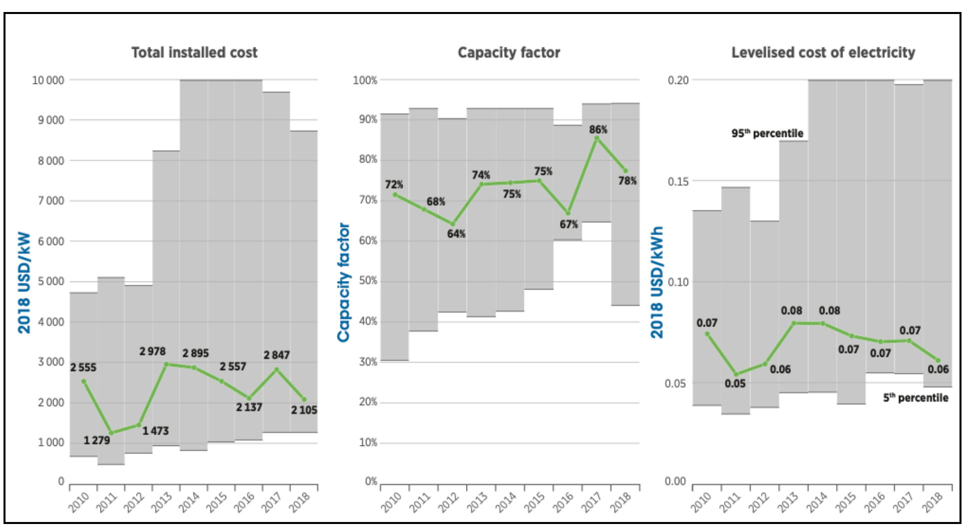


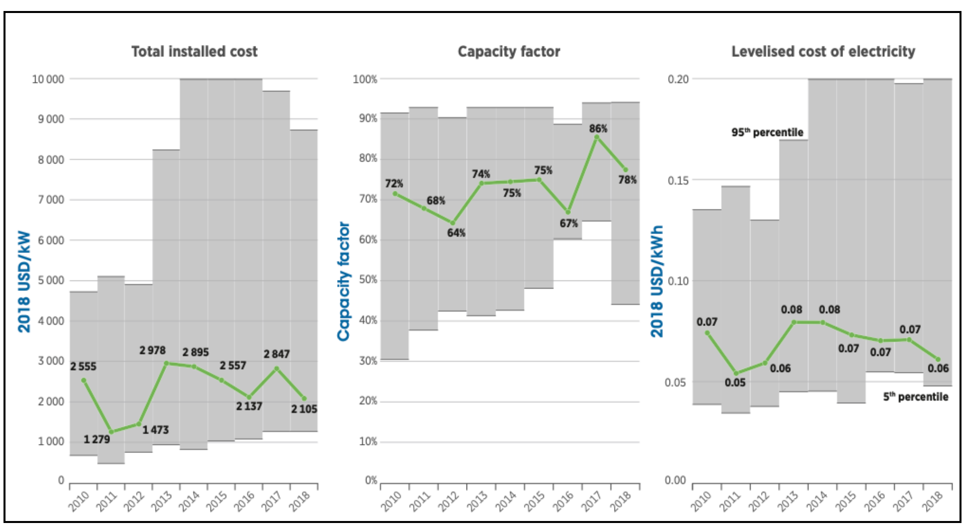


Total installed cost
2018 USD/kW
2 555
1 279
1 473
2 978
2 895
2 557
2 137
2 847
2 105
Capacity factor
Capacity factor
72%
68%
64%
74%
75%
75%
67%
86%
78%
Levelised cost of electricity
2018 USD/kWh
95th percentile
5th percentile
0.07
0.05
0.06
0.08
0.08
0.07
0.07
0.07
0.06

Introduction

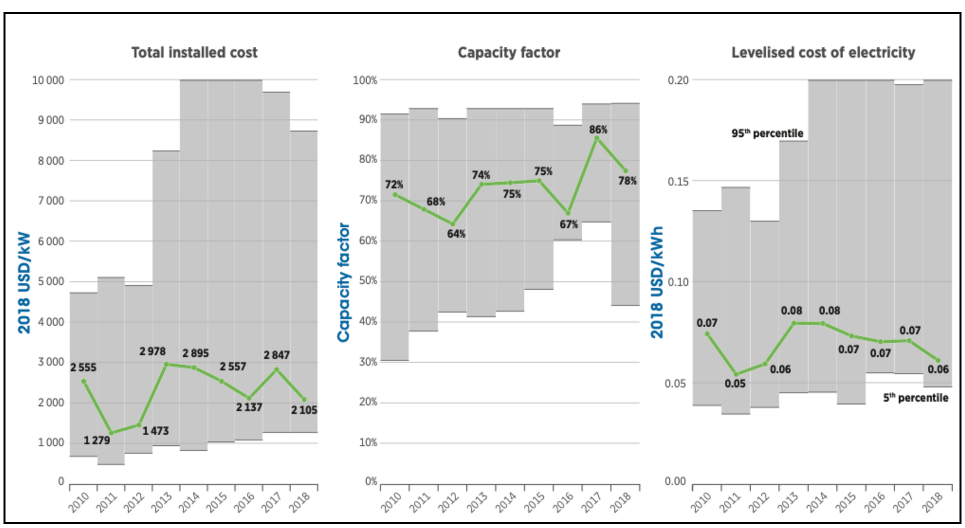
For bioenergy, our biggest concern is environmental impact. When we burn biomass (wood pellets, food-waste, house garbage, etc..), it releases greenhouse gases (carbon dioxide and methane) into the biosphere. But it is absorbed by plants through photosynthesis, and that will neutralize the amount of carbon in the atmosphere. But for methane, it remains a difficult challenge till recent years. Scientists from Japan have turned methane gas into a form of energy to power activity from methane biomass fermentation. The organic substances are turned into methane through anaerobic-digestion. It is a creative way to cope with climate change. (Klassen et al, 2017). The other concern is public perception. Our people have shown little to none understanding of how electricity is made from wood fuels. Solution for the problem is creating a learning environment for our residents about renewable energy. By educating our citizens, we untangle the misconceptions Mainers might have about biomass, and can push for a progressive plan (Hammond et al, 2019).

Hydropower is known to be one of the cleanest forms of renewable energy. The implementation of these requires a large enough flow of water in order to turn turbines, but these dams have adverse effects on ecosystems and wildlife. The largest concern with hydropower is to the fish and other organisms that reside inside. When a body of water is dammed, any life



attempting to follow its old route will be forced through the blades of the turbines and will likely be harmed or killed. But there is a solution to this, fish ladders attract migrating fish such as salmon with a flow of water which the fish swim up through a series of pools to surpass the dam (Noaa, 2018). The second greatest concern is that when an area has a drought, its water level and flow is minimized, which reduces or stops the generation of electricity that a dam creates with this flow. This issue can be prevented or reduced by creating a reservoir or storage system for the dam allowing it to run on previously stored water.

Though commercial-scale generation of electricity via tidal currents is presently absent in the United States, various countries have already been extracting this resource for decades through the utilization of tidal barrages. These barrages take advantage of large vertical changes in seawater elevation between tides, however this analysis is instead focused on hydrokinetic turbine technologies which rely on the horizontal movement of water as tides shift. Acting similarly to wind turbines, these devices are more economically and environmentally sound without the need for the construction of a dam (Maine Tidal Power). Challenges to deploying large-scale hydrokinetic power plants lie in current costs for the technology and limited current examples of the system. Overcoming these barriers is achievable by centralizing early development in the highest potential capacity areas and conducting more state-funded pilot



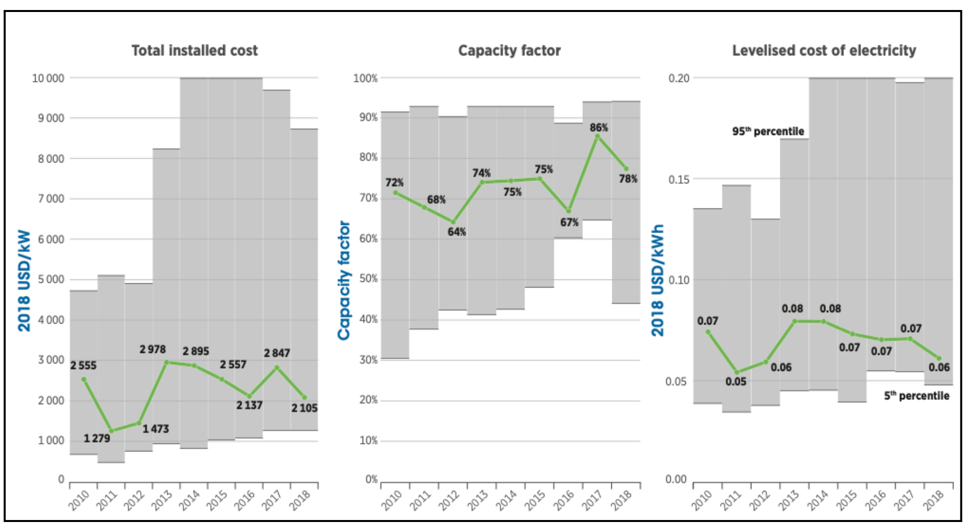
studies intended for the eventual construction of grid-connected commercial tidal power stations (Georgia Tech, 2011).

To evaluate our renewable energy sources, we use 7 different metrics: cost, environmental impact, capacity factor, number of households, job creation, policy and public perception.

Individual Resource Analysis

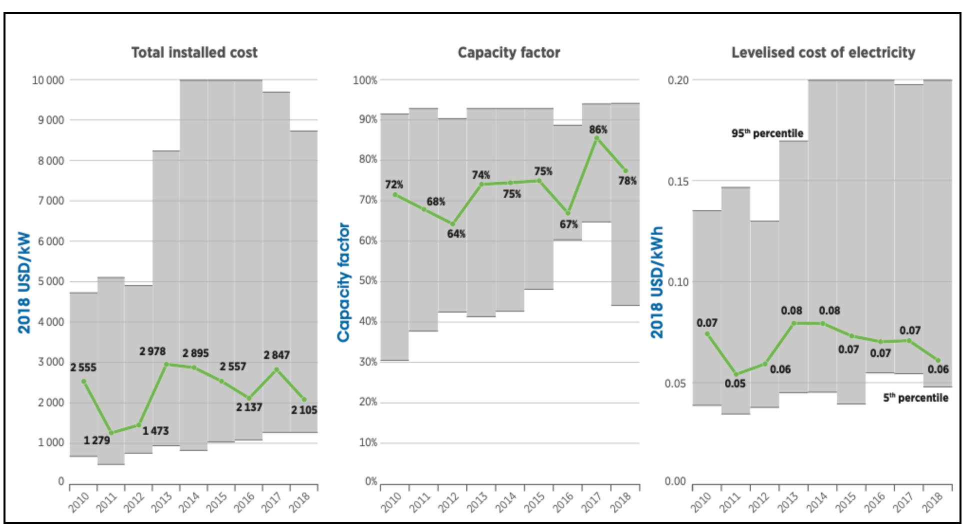
I. Hydroelectric

As part of an analysis of energy harvesting technologies to increase Maine's renewable energy generation to 100% by 2050, this paper will focus on Hydroelectric power. Hydropower is one of the oldest sources used to generate electricity by humans. It works by capturing the energy created by the flow of moving water. This is done by forcing it through a pipe, or penstock, aiming it to push against and turn the blades in a turbine that spins a generator to



produce electricity. Hydropower dams can be classified into three different types; low head, medium head, or high head. A low head dam gets its power through a run-of-the-river system and is often very wide and relies on a large volume of flow. A high head dam stores its water in a reservoir that is dropped from a high height with little flow through a small mouth to generate electricity. A medium head dam usually has characteristics in between high and low head dams but will always have a reservoir and is located at the thin point of a river. The factor that primarily decides which of these to implement is the height at which the water will fall.

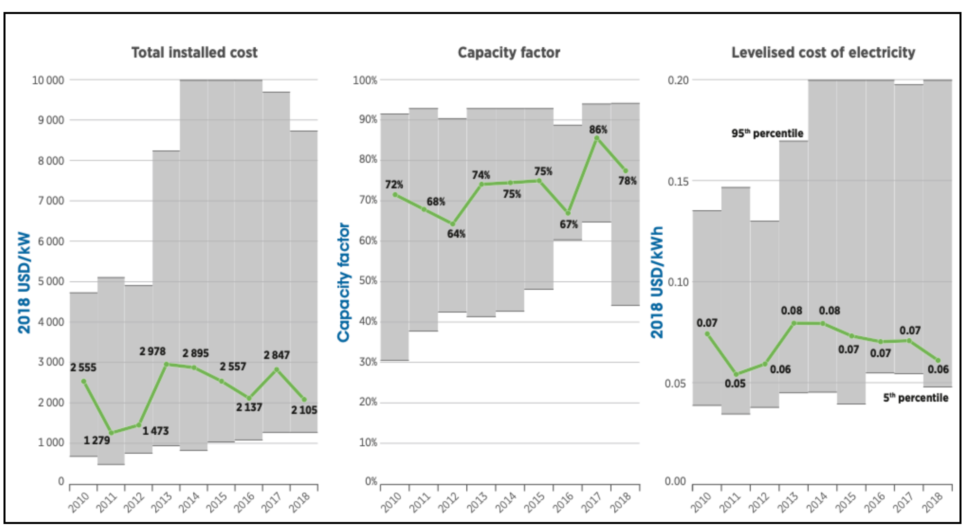
Hydroelectric power has benefits such as being low cost, low emissions, rewable, and is often locally available. Its deficits include reducing water flow, having negative impacts on ecosystems and the environment surrounding the dam, and reducing fish populations. Like all sources of energy it has its consequences, but its benefits have the possibility to outweigh those if implemented optimally. Today in the United States, hydropower accounts for about 7% of all utility scale electricity generation and is the country's largest single renewable energy source (*U.S. Energy*). The most recent data collected by the United States Energy Information Administration (EIS) for Maine electricity generation claims that about three-fourths already comes from renewable sources. More importantly they found that, “Almost one-third of the state's total net generation came from hydroelectric dams” (*U.S. Energy*). Maine has 107



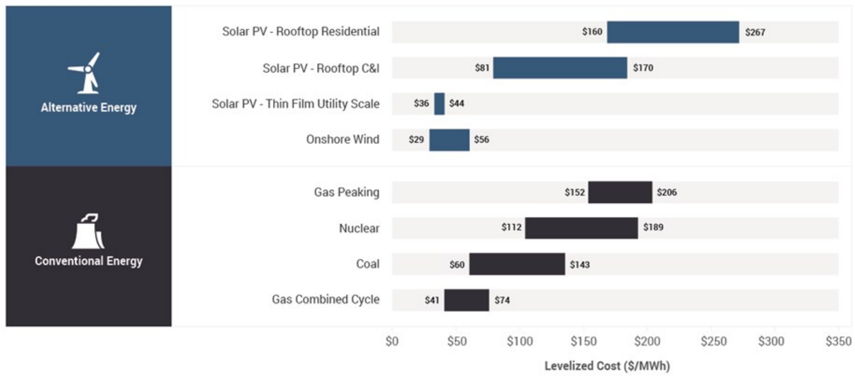
currently running along their vast amount of rivers (*Hydropower & Dams*). This proportion makes Hydropower the largest supplier of electricity generation for the state with biomass following behind at between 20 and 25 percent (*U.S. Energy*). With the goal of 100% renewable energy by 2050 in mind, there are a number of factors that attribute to which source or sources should be increased. This paper will analyze what our firm found to be the most important; number of households, cost, environmental impact, capacity factor, job creation, policy and public opinion.

Cost

Hydropower is one of the cheapest ways to generate electricity out of all renewable energy sources. It's costs can be generated by using the Levelized Cost Of Energy (LCOE) equation. This is done by finding the value of the total cost of building and operating each hydropower dam and then dividing that by the total electricity generation it will supply in its lifetime. The International Renewable Energy Agency (IRENA) found the weighted average LCOE for small hydropower projects created today to be between \$0.03 and \$0.115/kWh and for large hydropower projects to be between \$0.02 and \$0.06/kWh (*Hydropower Costs*). When converted to dollars per megawatt hour and compared to other sources seen in Figure 1, these numbers can be found on the lower end. Additionally, Maine imports more than one-fourth of its electricity supply from the Canadian grid which by implementing hydropower in the state itself,



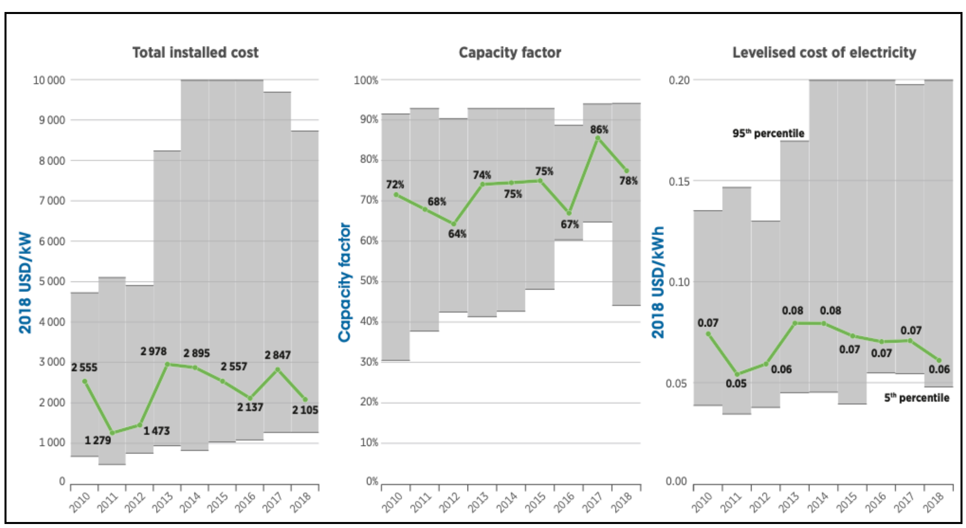
that would not have to travel a long distance or be purchased from an outside source, could greatly reduce costs (*U.S. Energy*).



(*Ricci, Rita*)

Capacity

The capacity factor for hydroelectric power can be calculated by taking the total amount of energy that the plant produced and then dividing it by the amount it would have produced at full capacity. Based off of information collected by the EIS, over the past decade the average capacity factor for hydropower has remained around 40% but ranges between 10% and 99% (*U.S. Energy*). This large range could be for a number of reasons such as design and water availability. For design, a small plant on a large river will always have enough water to operate

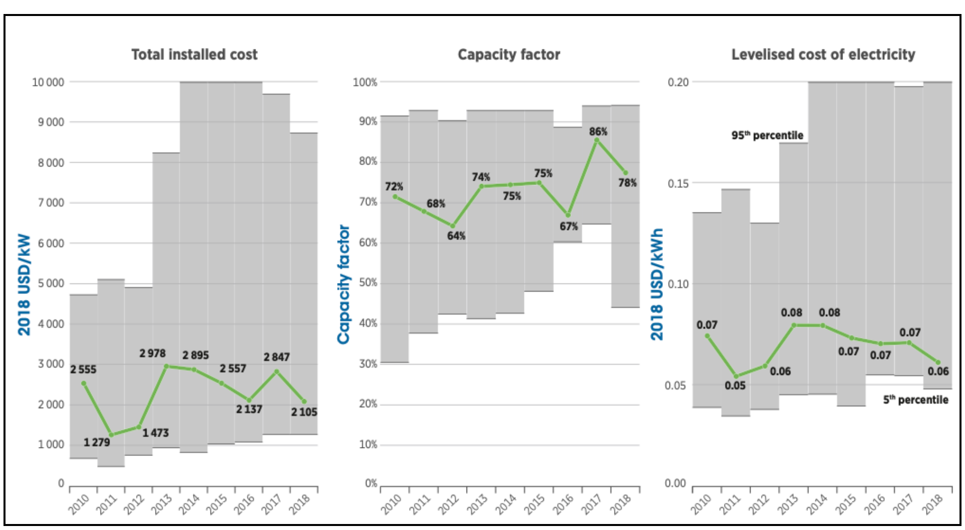


while a large plant may not. For water availability, a storage dam that has a reservoir may be able to operate at full capacity for several months in the case of a drought while a run-of-the-river dam would not. Regardless, a higher capacity factor is not as important as the production being equal to the necessity as to not waste excess energy. For that reason, it can be assumed that plants do not operate at a 100% capacity factor because they would be losing money by doing so. Furthermore, if the need for hydroelectric power were to rise as Maine reaches 100% renewable energy, its capacity factor could be increased.

Households

The next factor to be analyzed is the number of households that can be powered by this resource. According to the official government website for Maine, the states electricity used in 2018 was 4,601,826,035 kWh spread throughout the 518,000 homes (*Hydropower & Dams*). With the claim made by the EIS that 31% of Maine's electricity demand was filled by hydropower in the same year, it can be calculated that about 1,426,566,071 kWh and 160,580 homes were powered by that resource (*U.S. Energy)*. Looking back at the capacity factor for hydroelectric power plants being at about 40% on average, any increase on this number would supply a great number of homes and once again appears to be very possible (*U.S. Energy*).

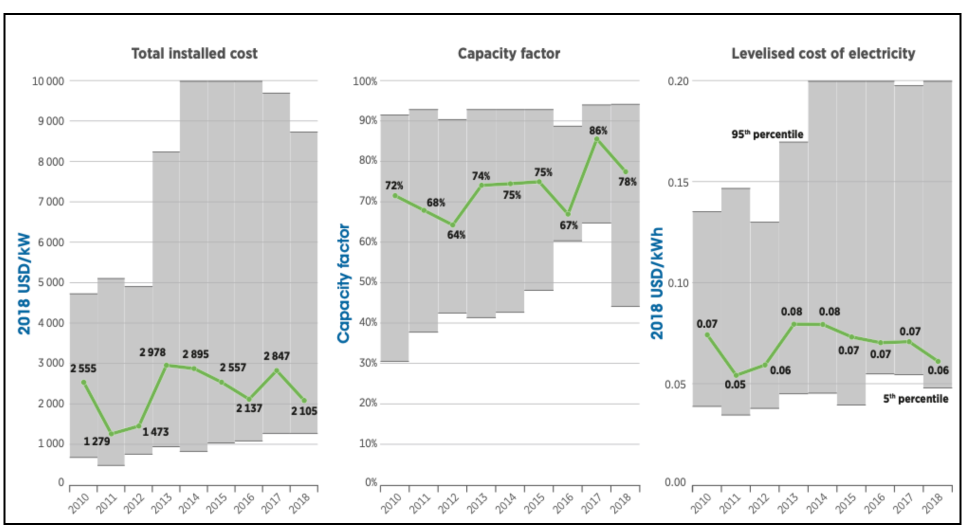
Environmental Impacts



Though the environmental impacts do not include constantly emitting greenhouse gasses or dumping pollution into the water, hydroelectric power does come with its effects. Although other resources may consistently emit harmful gasses, the only times that dams release a large amount of these are during its construction and destruction. Additionally, dammed reservoirs can be used for agricultural irrigation and flood control which are both ultimately beneficial for the environment (*Environmental Impacts*). On the other hand, dams also have the possibility of flooding which could kill people and wildlife and destroy ecosystems. They also can harm fish and other organisms that attempt to swim past the turbine blades, even with fish ladders and in-take screens they cannot all be protected. Like all resources, hydropower has its negative impacts, but those appear to be less concerning than those created by others.

Job Creation

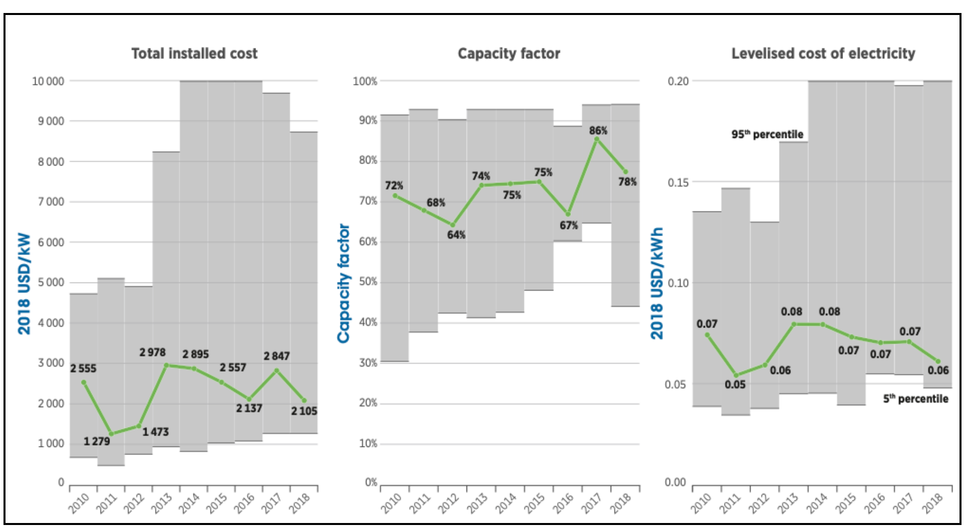
Hydropower has the possibility to create a number of jobs, a large amount of those would be temporary during the construction but it also creates a decent amount of permanent jobs. Temporary jobs would include a stupendous amount for construction workers among others, while permanent jobs would be for technicians, supervisors, and engineers. It has been estimated that even on the scale of micro-hydro, ten permanent jobs can be created each year per one MW installed, while solar pv would only create 3.3 per MW installed (*Meadway, James*).



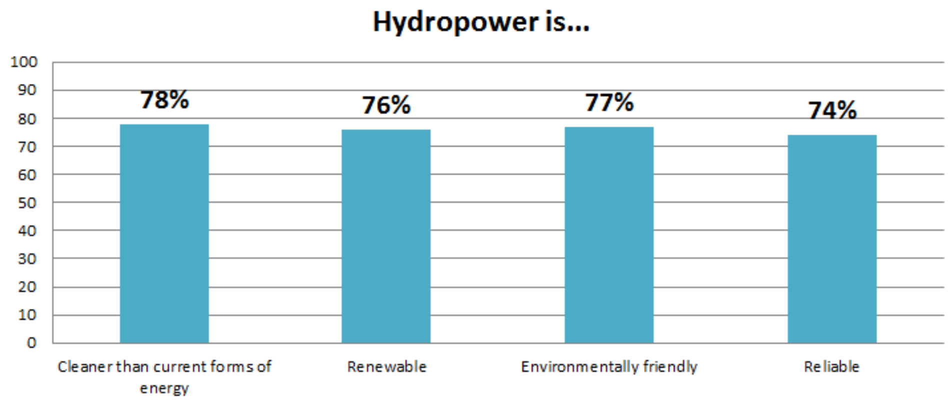
Additionally, most dams in the United States were originally created for flood control, municipal water supply, and irrigation water (*U.S. Energy)*. Although many of these now have hydroelectric generators, they were not originally made for the purpose of generating hydroelectric power. By developing these dams further, jobs could be created while increasing the production of electricity.

Policy / Public Perceptions

In Maine, hydropower plants are required to acquire an operating license from the Federal Energy Regulatory Commission (FERC) that is valid for between 30 and 50 years. This allows the federal government to determine how a hydropower facility's operations impact local environmental and recreational resources. With this, the relicensing process becomes an opportunity to look at the operations to decide if they can be better aligned with the current needs and values of the environment and the public. "Hydropower relicensing processes across the country have resulted in increased flows to support aquatic and riparian habitats, better access and services to support public recreation on rivers, and protection of cultural heritage sites" (*Hydropower & Dams*). Additionally, in state laws take into account economic, environmental, and energy impacts. The states website also allows the public to comment their opinions on the plans of the project along with its terms and conditions. Nonetheless, according to Figure 2

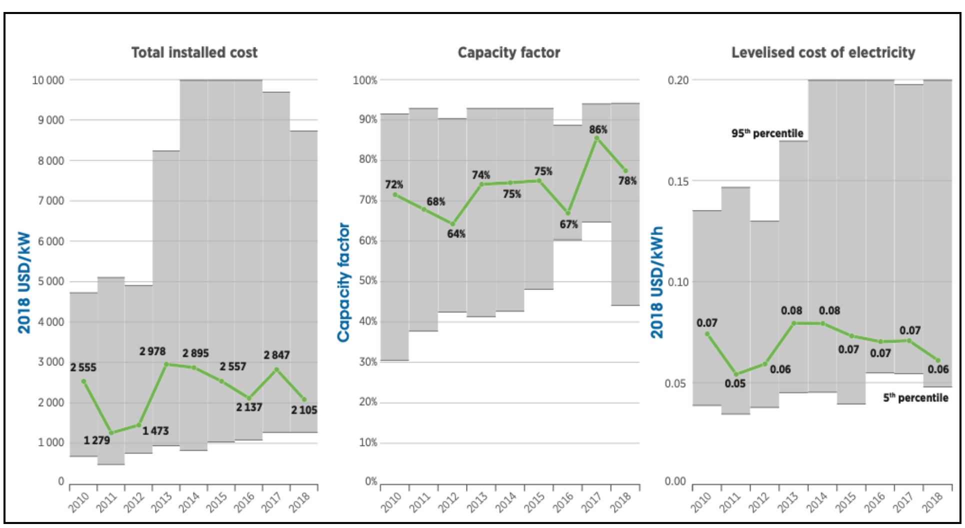


below, roughly three out of four Americans think highly of hydropower and show strong support for it.



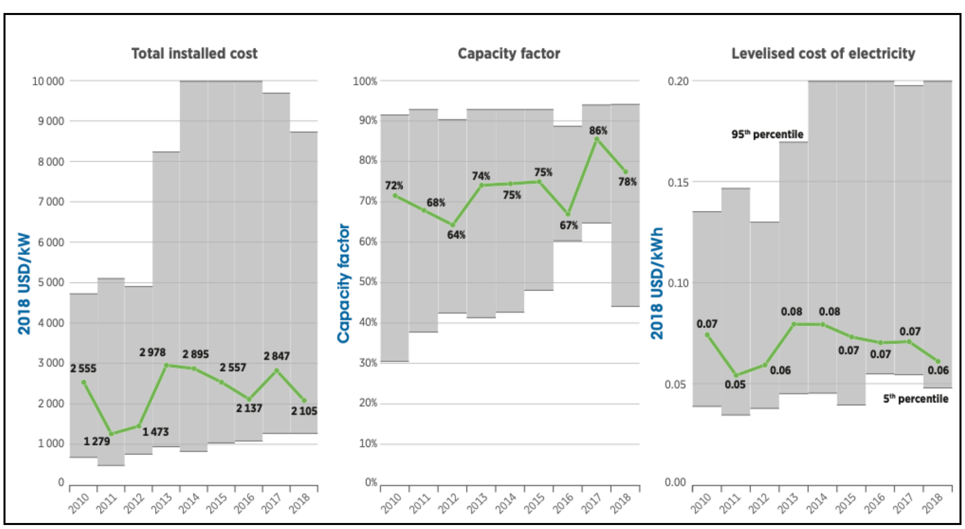
(*Broad Public Support*)

With the future of our planet on the line, Maine's goal of 100% renewable energy by 2050 is the first stance among many that will become crucial. Based on this analysis, hydroelectric power should be noted as a possible source to reach this goal.



II. Biomass

For many decades, we have used biomass as a source of energy. The term biomass refers to any organic materials that are from animals and plants, such as animal wastes, wood or living matter. Those biomass can be burned and converted into useful biofuels to run a motor in a vehicle or other daily uses. For hard biomass, they are burned to produce heat, which is converted to biogas or biofuels that is later burned for energy use. As of 2018, biomass fuels supplied 5% of total primary energy use in our nation. (EIA, 2018) Of that 5%, 10% come from municipal waste, 44% comes from wood and 47% came from biofuels. As part of a proposal to increase the State's renewable energy to 100% by 2050, we picked biomass as one of our four main sources. Because, as seen in *Figure 1*, more than one-fourth of Maine's electricity net generation comes from biomass. The energy plays a central role in powering hundred thousands



households in Maine. Gathering data and research, we conclude that there is a strong case to be made for bioenergy as one of four main renewable energy sources for our firm's proposal.

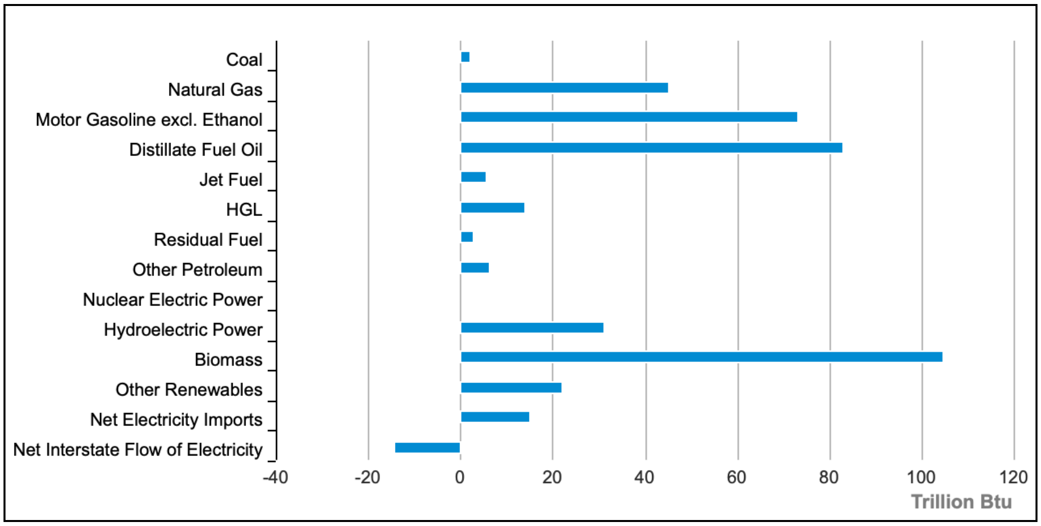
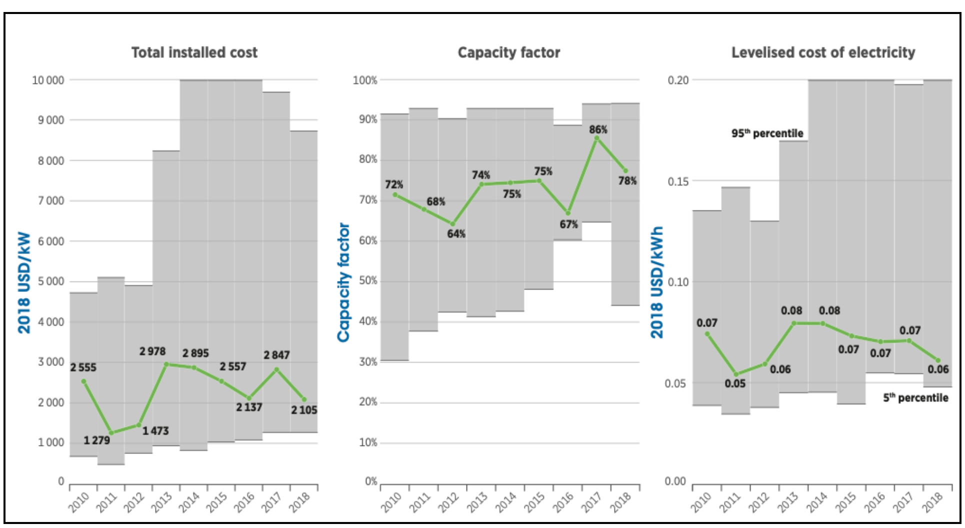


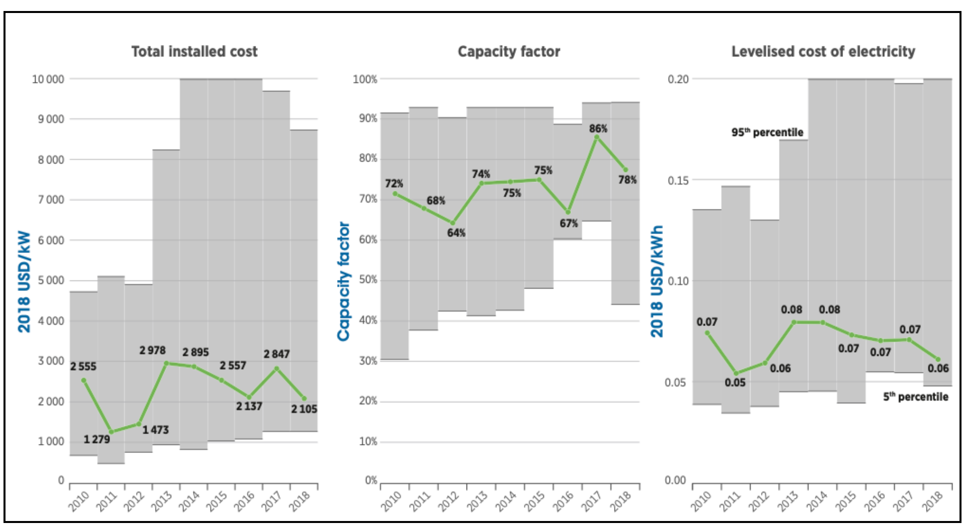
Figure 1: Energy Consumption from different sources in Maine as of 2017.

According to a recent report from the U.S. Energy Information Administration (EIA), for Maine, three-fourth of the state's electricity is powered by renewable energy sources, 31% of which is hydroelectricity, 22% is biomass and 21% is wind. There are a lot of potential in biomass that we can unlock, especially in wood and wood waste sector. There are three wood pellets manufacturing plants which produce more than 230,000 tons of pellets annually that can be burned and converted into heating fuel that is used for home and commercial heating. The



pellets are a great alternative for home heating oil given its cost is rising. There is another form of biomass that does contribute a decent amount- biodiesel, an essential energy source for millions of Mainers, is recycled from cooking oils. The biofuel has stimulated forestry-focused businesses, been increasing thousands of jobs and most importantly, restored our forestry to its original state.

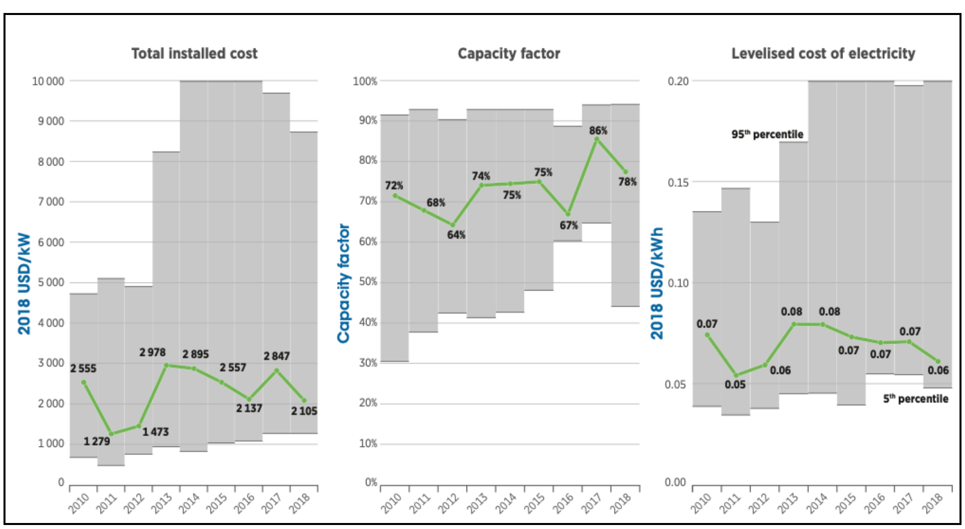
In ways of evaluating our energy, we use 7 crucial metrics: cost, environmental impact, capacity factor, households, job creation, policy and public perceptions. We also further recommend two important tasks to help us achieve our goal, specifically, for biomass: to build a massive biopower plant (5.7 GW) and reinvent the national grid system. (Keller, 2017). Otherwise, the details of the metrics - how they are measured- are mentioned following. For cost, we use levelized cost of energy (LCOE) as a measurement. For environmental impact, we scale it to positive, neutral or negative impact based on how our plant and mechanical process affect the environment we are living. For capacity factor, we use EIA evaluation on the technology to indicate thes percentage-the higher the percentage it is, the more efficient the technology is. For households, we calculate the actual expected annual bioenergy output to give an estimation for numbers of household For job creation, we use International Renewable Energy Agency (IRENA) to give an estimation on job creations when we employ biomass. For policy scale, we



shall look for laws that support our energy source and restrictions we might face on the road. And lastly, for public perception, it is rated on a scale of a binary system: 1 for support, 0 for reject.

First is cost. There are two parameters for LCOE that are technology cost and performance. Our LCOE of biopower plants are affected by installed capacity costs and heat rate difference. In *Figure 2*, as of 2018, the cost of electricity per unit bioenergy was low ($0.062/kWh) which was 14% lower than it was in 2017. We have not been able to obtain 2019 data, but we predict that LCOE might be $0.05, since the line shows a declining slope by 0.01. Even though the number has been consistently declining in the past 8 years, we need to make more investment in biopower sector so as to stimulate technological advancement - increasing our biopower plants's optimal performance. According a report from the National Renewable Energy Laboratory, *Figure 3*, the capital expenditure has shown a tendency to decline, meaning a business might have to pay less to maintain or grow the biomass company. Therefore, there will be more funding or investment in improving the technology performance.

Figure 2: LCOE, Capacity factor and total installed cost as of 2018. Extracted from DOE report



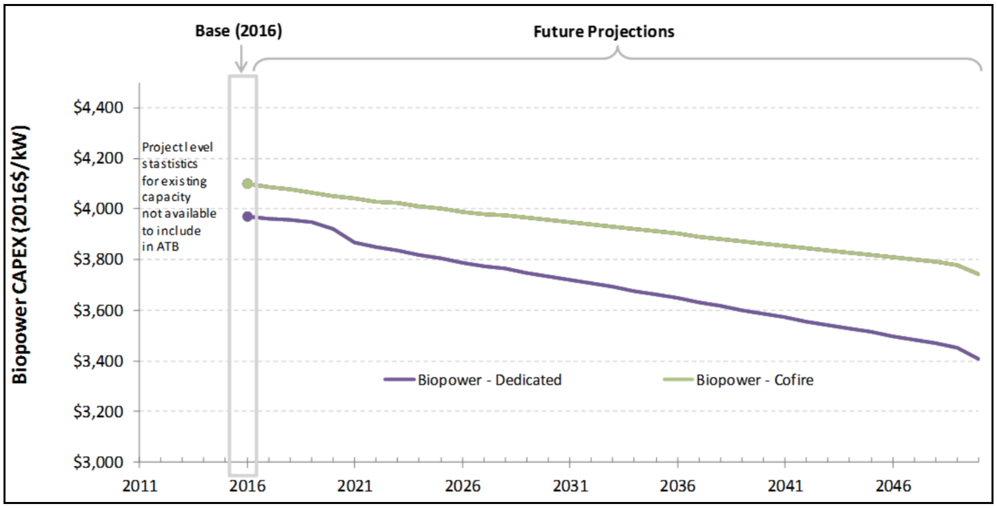
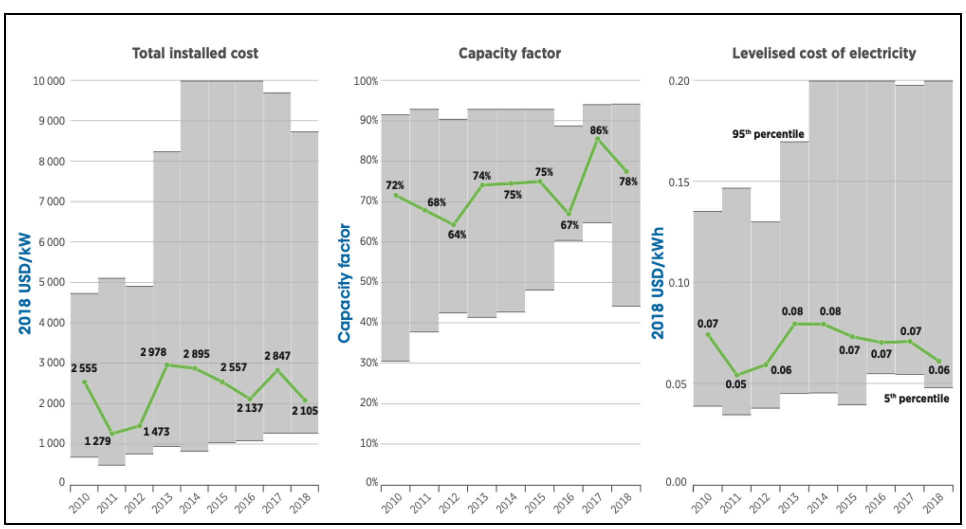


Figure 3: Capital expenditures (CAPEX) historical trends for biopower

Second is capacity factor. Bioenergy has a constant capacity factors (~57%) throughout the years since biopower plant is known to perform approximately close to its optimal performance. There are four factors affecting the number: system design of the biopower plant, expected downtime and energy losses. We can decrease the energy losses in next 5 years when we implant new technology. It is predicted that the capacity factor can be increased to 86% by IRENA report (Figure 2).There is an emerging technology, 5.7GW of new bioenergy electricity generator which has been used in Europe, so it is possible we can improve the capacity factor of biopower plant by 20%.(IRENA, 2019) In order to see how much difference a higher capacity



factor can make, we advise readers to continue reading through household metric that we estimate the amount of households in Maine that bioenergy plants can power.

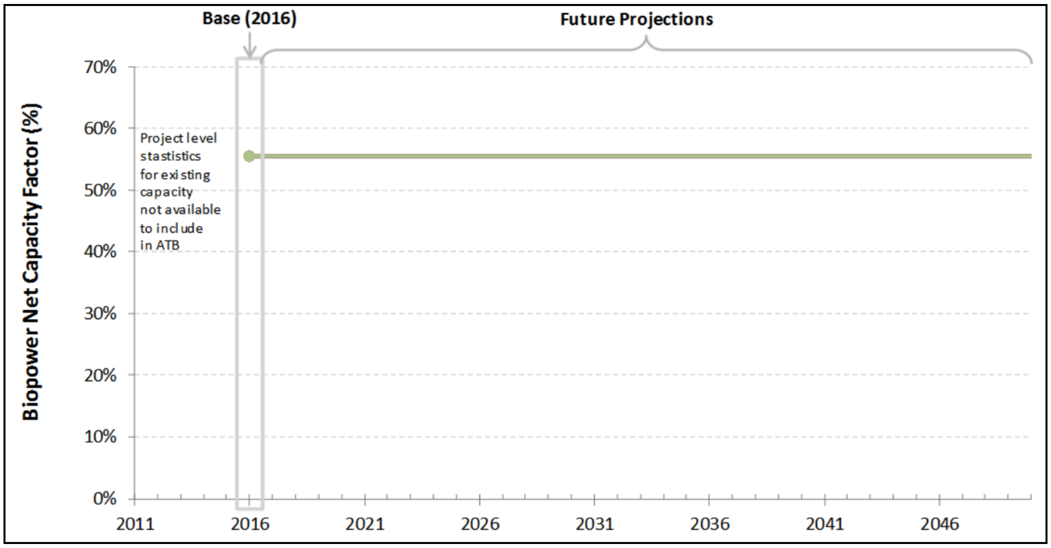
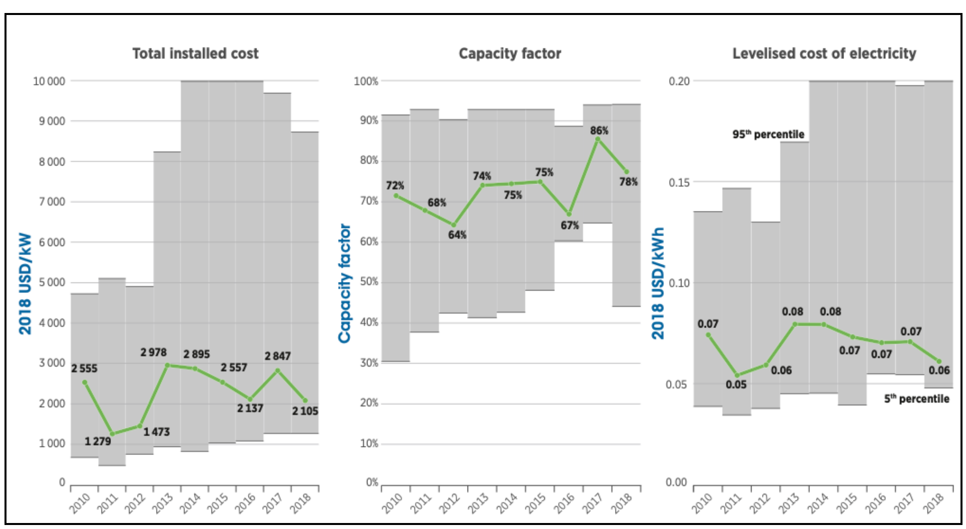


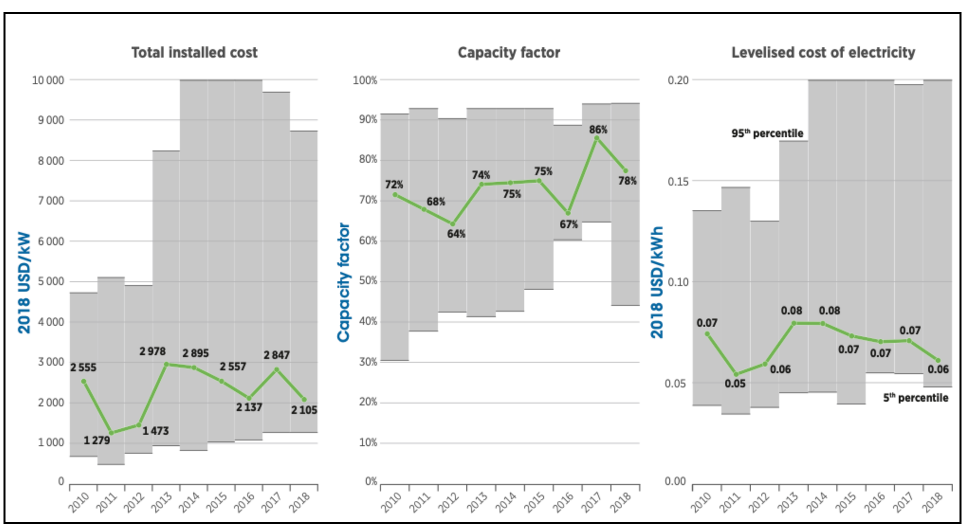
Figure 4: Biopower net capacity factor. Consistently, it stays at 57%.

Third is environmental impact. There are some concerns when burning biomass because of the release of carbon dioxide, a greenhouse gas. However, those amounts of CO_2 are absorbed by biomass plants through photosynthesis process. That makes biomass a carbon-neutral energy source. There is another challenge for biomass sector. People harvest the wood at a faster rate than planting trees so we need to encourage Mainers to plant fast-growing trees to slow down the deforestation and improve our ecosystem. For waste-to-energy plants, burning waste can produce

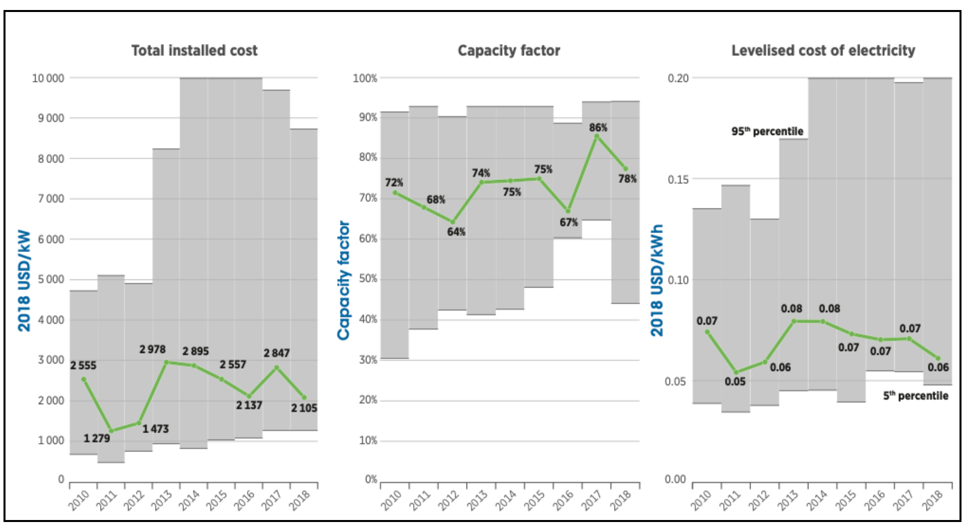


air pollution and release toxic substances into the air. Therefore, the U.S Environmental Protection Agency (EPA) had to announce a new strict rules specifically designed for waste-to-energy plants that require the plants to use specialized devices to capture air pollutants by spraying a liquid into the combustion engine to neutralize the acids in the substances. Furthermore, we burn biomass at high temperature (1,800 F) to breakdown every compound of toxic chemicals into less harmful particles. At last, there is a controversial argument we need to listen to, which is that we use food crop land to grow plants for biofuels. We agree with scientists that we do not yield much energy in return from ethanol so we do not advise Mainers to plant corn for ethanol production. Otherwise, corn might not be a popular choice to grow in such a constantly changing weather of New England. Overall, bioenergy brings positive impact on the environment.

Fourth is the number of households. According to a report from Maine Electricity Rates, the average electricity use of a Maine household is 6.372 MWh. (Electricity Local, 2019) And we can produce 230,000 MWh annually with a capacity factor of 57%. (EIA, 2018) That means we can power more than 36,000 out of 518,200 households in Maine. But if we increase the capacity factor to 86%-using the new technology from Europe, 5.7GW of new bioenergy electricity generator- we can increase the number of households we can power to 54460. That



way helps us double the amount of households power plants can power. Otherwise, there are six operating biomass power plants in Maine. It is our recommendation to build another biomass power plant to power more households. At our current state, we are using 32 megawatts of electricity (*ReEnergy Ashland power plant*), but that power can be magnified to 215 megawatts of electricity by building a massive biopower plant, using *Belegian Eco Energy model*. In the model, we increase the performance of power plant by applying more pressure to the steam. (*Figure 5*) By building a massive biopower plant in Maine, we will add 250,138 households to the record. To sum up, we can power up to 304,600 households just by building a 215 megawatts biopower plant. Doing that, we help create more jobs for Mainers.



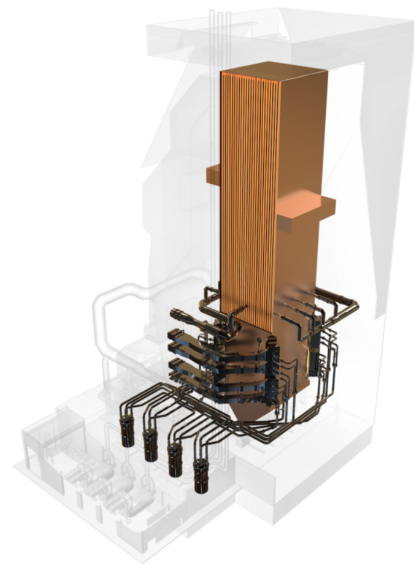
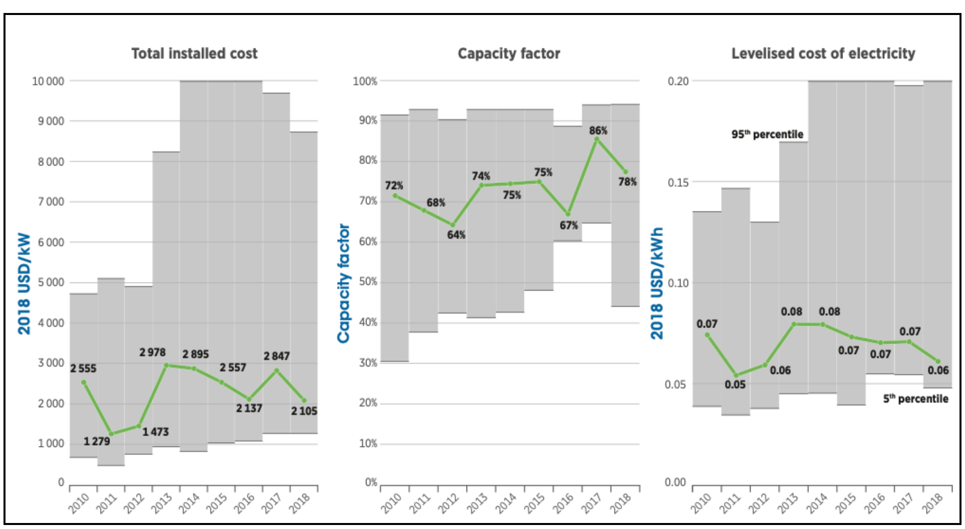


Figure 5: By increasing pressure and temperature, water turns into a supercritical fluid; that helps the turbine operating more efficiently.

Fifth is job creation. As mentioned above, we create more green jobs if we go 100% renewable energy. On March, 2019, the National Association of State Energy Officials and the Energy Futures Initiative released two reports that biomass industry alone can put 6.7 million Americans to work; that is 2.3% increase in employment nationwide, meaning, on average, 600 jobs in bioenergy industry alone for Mainers. (Census Data, 2019) That is a considerable amount



given a small population of Maine. The number will triple or even quadruped when we build the new massive biopower plant in the state. We need to bring policy makers together to make it happen.

Sixth is policy. United States legislators have encouraged us to move toward a green economy by introducing legislations that help us become independent of foreign oil and set a goal of moving our nation toward a sustainable future. They introduced Title IX, Subtitle D: *Agricultural biomass research and development program*s to stimulate research development in biofuels and biobased products. Furthermore, this part of legislations remove barriers in technology by authorizing funds for the research programs. That is the most important federal law that can accelerate us to a sustainable future.

Seventh is public perceptions. It is a resounding 0[1], unfortunately. Even though the majority of Americans support renewable energy plans, the public illogically do not support zero-emission sources. When were given surveys, Americans ranked woody biomass lower than fossil fuel or natural gas. (Farhar, 1999) The reason for that is that people are not familiar with how electricity is made from wood fuels. It was shown that only 12% of American passed a quiz

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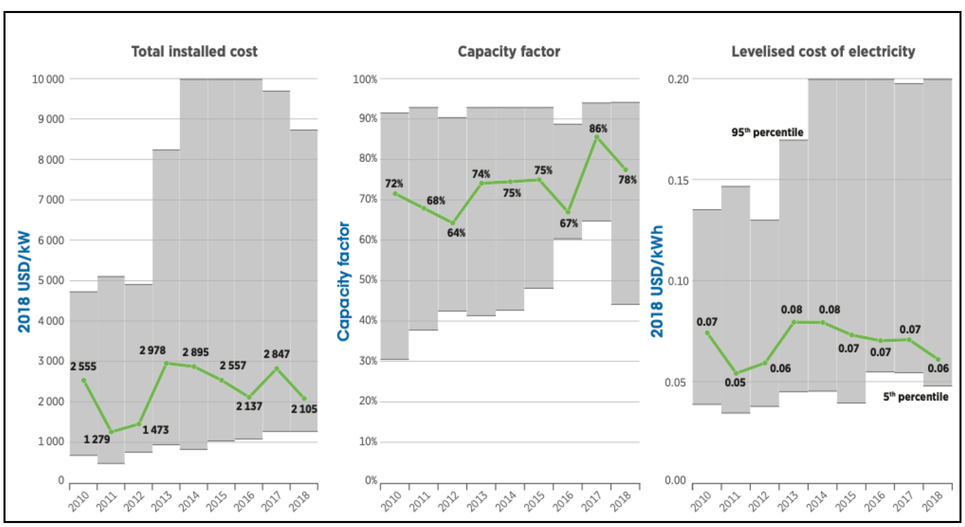
[1] For public perception, it is rated on a scale of a binary system: 1 for support, 0 for reject.

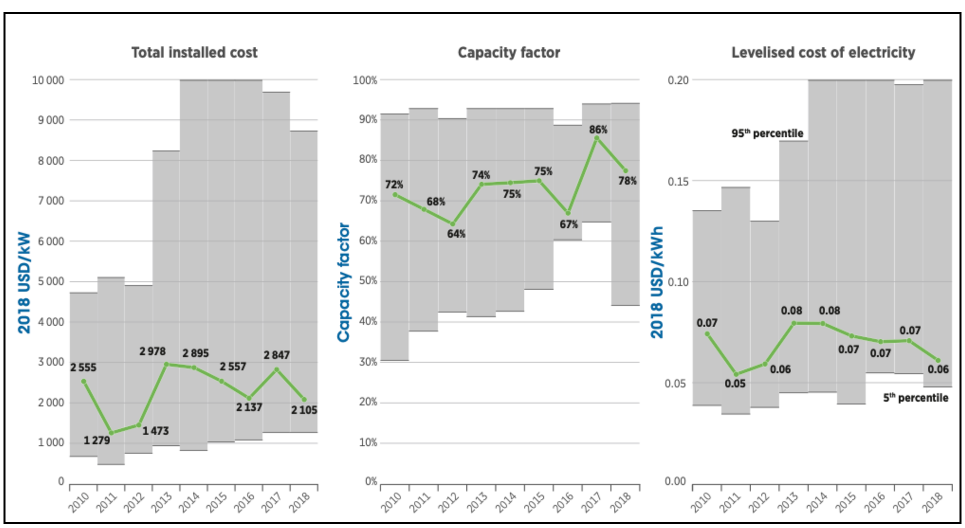


which tested basis knowledge of renewable energy. (NEETF, 2002) The solution is simple. We shall create more programs that educate residents about renewable energy, specifically biomass. We can exchange money or gift card for their time to learn. By untangling the misconception of biomass, we can push for more progressive plans. Education is the key to solve this issue, public perceptions..

Those information painted the full picture of our energy, biomass. But, there is a problem we shall pay attention to. It is the grid-one of the greatest engineering inventions of human history. We need to rebuild our nation grid system since the current system cannot handle energy surplus from a massive biopower plant (215 Megawatts). We must rethink how we build our grid completely. When we succeed in reinventing the grid system, we can power for households across the states. This might be the single most important puzzle we need to solve now if we want to move toward a 100% renewable future. The future is bright for one who dares to imagine.

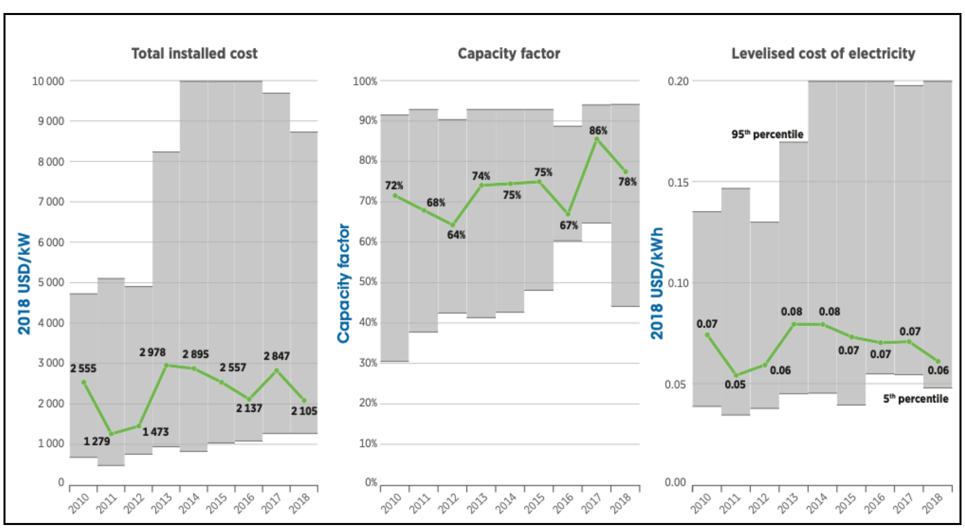
III. Wind (On-shore)

Wind energy is the process of creating electricity using the wind, or air flows that occur naturally in the earth's atmosphere. Wind energy is one of the most popular and growing forms of renewable energy.Modern wind turbines are used to capture kinetic energy from the wind and



generate electricity. Wind energy is divided in to land and offshore wind. The way turbines work to generate electricity is fairly simple. When wind blows past a wind turbine, The long blades of the turbine captures the wind’s kinetic energy and rotate, this creates mechanical energy. This rotation turns the internal shaft connected to a gearbox, which then increases the speed of rotation by a factor of 100. Electricity is created because of that spin. Maine is already a leading state in acquiring energy from wind power so developing more wind farms and continuing to grow the potential from wind power is crucial to meet that goal set by the state of Maine. Maine leads New England in wind-powered generation and is ranked 6th in the nation for its energy obtained from wind power. In 2018, Maine's wind turbines produced more than one-fifth of the state's total net generation and accounted for two-thirds of all wind-powered generation in New England. Maine had more than 900 megawatts of installed generating capacity from nearly 400 wind turbines at the beginning of 2019. Most of the new plans to generate renewable electricity by wind are planned to be built in New England and Maine is one of the top candidates due to its landscape.. The state of Maine’s best wind resources are along the ridge crests in the state's northwest and along its Atlantic coastline.

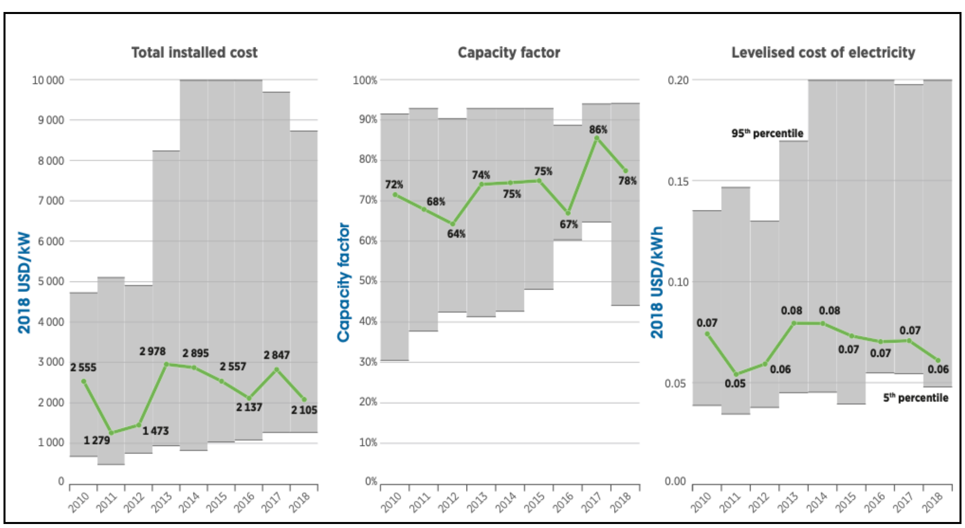
Before going ahead in starting new wind energy projects in Maine we need to look at several criteria. To achieve the state of Maine’s goal, new renewable energy development must



strive to first avoid and then minimize impacts to wildlife, take into account how the public will see the project and many more criterias that will allow the project to commence. Back in 2015, a wind project was halted because of concerns about the impact of wind turbines on tourism, property values, and the environment. By strategically planning and meeting our criteria we can achieve 100% energy from renewables starting with wind power.

Environmental Impacts

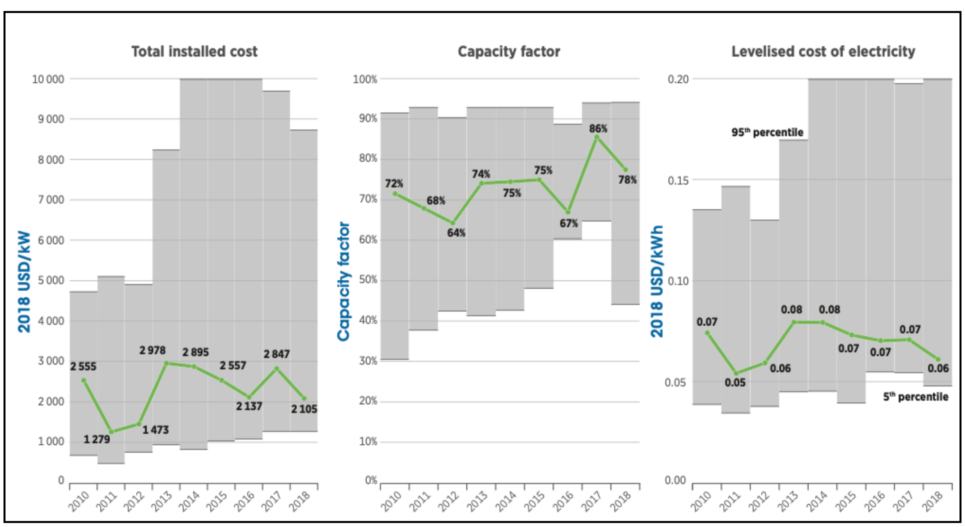
There is a couple environmental impacts associated with wind power or the turbines to be specific that would affect animals or the environment in Maine. First off the turbine would affect birds and bats. With the loss of habitat that comes with constructing a turbine , land based wind turbines can result in high collision risks to bats and birds moving near the turbines. Birds and bats during migration in the fall and in the spring are at greatest risk, as well as birds and bats moving during bad weather where visibility is lessened. Some birds and bats can be attracted to wind turbines due to type of construction, lighting, colors, and patterns and when they get near the turbine they undergo a suction that kills them. Birds get sucked in by the turbines where they experienced death from impact of the humongous blades or the blade speed creating air pressure and affecting their breathing. Although turbines cause some deaths, they are the lowest cause of bird and bat deaths annually in the U.S causing the deaths of about 140,000 birds. There are



considerable measures that can be taken to cope with habitat loss and bird deaths from turbines. For habitat loss we can avoid sensitive habitats, including important wildlife movement corridors, connecting wildlife populations separated by human activities or structure, and highly resilient landscapes. For animals we can do research to identify and understand local wildlife habitats and potential impacts for a wind project

Cost

Wind power can either increase or decrease the price consumers pay for electricity. Long-term contracts can lower electricity rates for consumers in Maine if the contract prices turn out to be below the market price over the contract term. The total amount of the expenditures, under market cost, would amount to 1 million dollars with just with power itself compared to the 1.613 million dollars reported in 2018 from both renewable and nonrenewables in Maine. This means that switching to 100% has a possibility to drastically decrease the amount spent on electricity. Under market cost, wind power is looking at a max capex(capital expenditure) of $1,610. Wind power also has a range of calculated energy cost from $30-$143. In terms of cost to build a wind turbine, it varies in size and capacity. The bigger the turbine the higher the cost. The costs for a utility scale wind turbine range from about $1.3 million to $2.2 million per MW



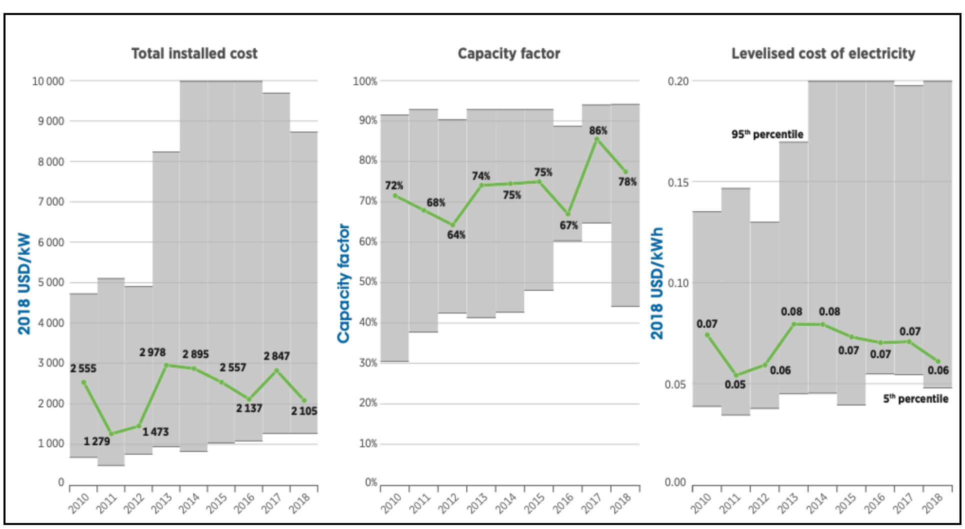
of nameplate capacity installed. Most of the commercial-scale turbines installed today are 2 MW in size and cost roughly $3-$4 million installed.

Capacity Factor

With taller wind turbines, more than half of the total land cover of Maine, which is 59%, has the potential for commercially viable wind resources. The wind speed distribution of available wind resources with most of the available wind power concentrated at the lowest viable wind speeds 87% at each height, at wind speeds between 6.5 and 7.5 m/s. Maine's currently has installed capacity of 923 MW of wind power and 21% of Maine's energy comes from wind power. With such high output of energy, wind power has the potential to power most of Maine's households. Maine has the potential to reach 3000 MW by 2019 with a continuous development in wind energy. The goal of 100% power from renewables can be achieved starting with wind power generating more energy. At a 21% capacity factor, wind power would be able to power about 29,000 homes.

Public Perception

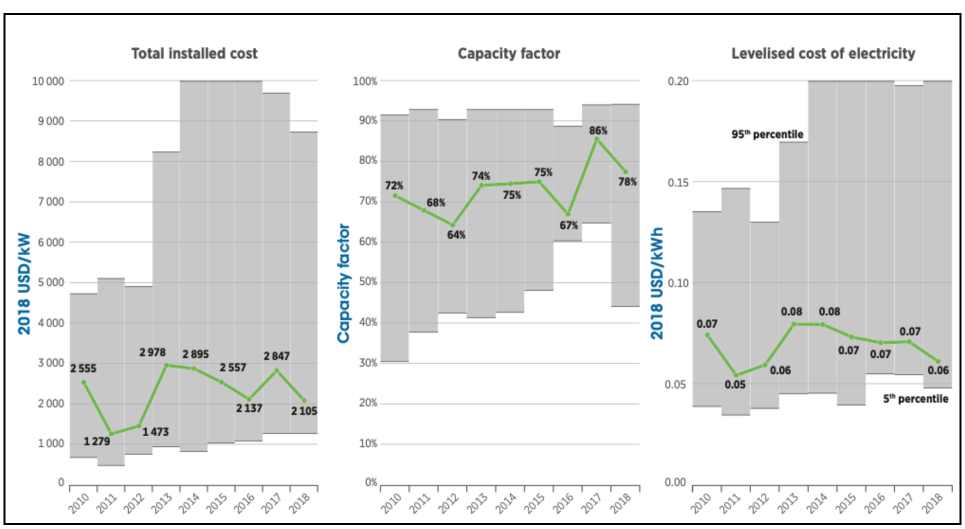
Based on a survey taking on June 14, 2018 most off the public opposed to the project. 84 residents of Maine and 10 organizations responded in the survey. The results were as follows:



Positions	Number of Responses	Percentage of Responses
Opposed to further wind development	76	81%
Support Further wind development	11	12%
Mixed or Unsure	7	7%

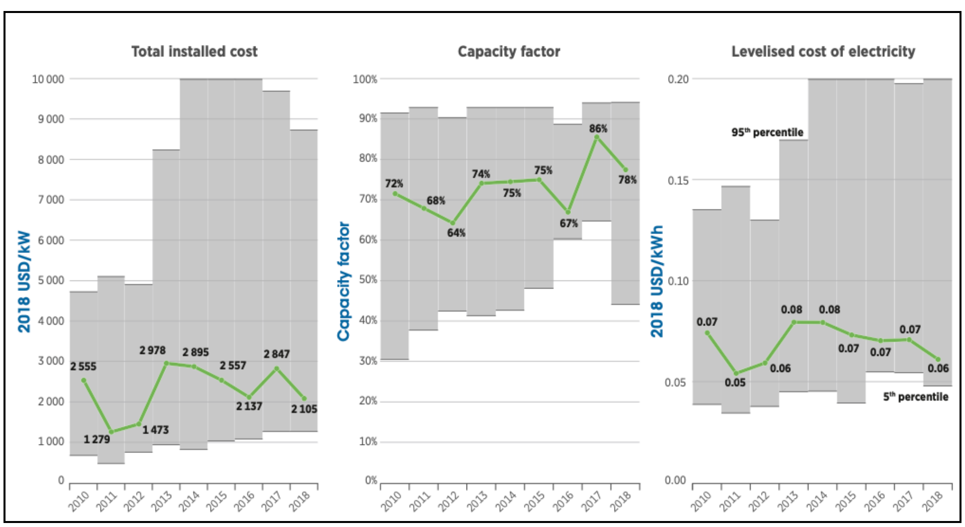
Table I: Survey from the public

The public were opposed because a bunch of factors. Some of them are, potential loss of scenic views or Natural resources, negative impact on the environment, noise or negative health effects, and potential impact on tourism. These are all factors we would take into account in construction new turbines. There are also incentives to actually to continue the project. One of them is the potential for positive impact on the economy. Constructing new wind turbine or wind farms will require workers which would create more jobs for people in the area. Wind is also an indegenous resource that will last many lifetimes so the availability of the resource and the potential for economic growth supports the plan to expand wind energy in Maine.



Policy

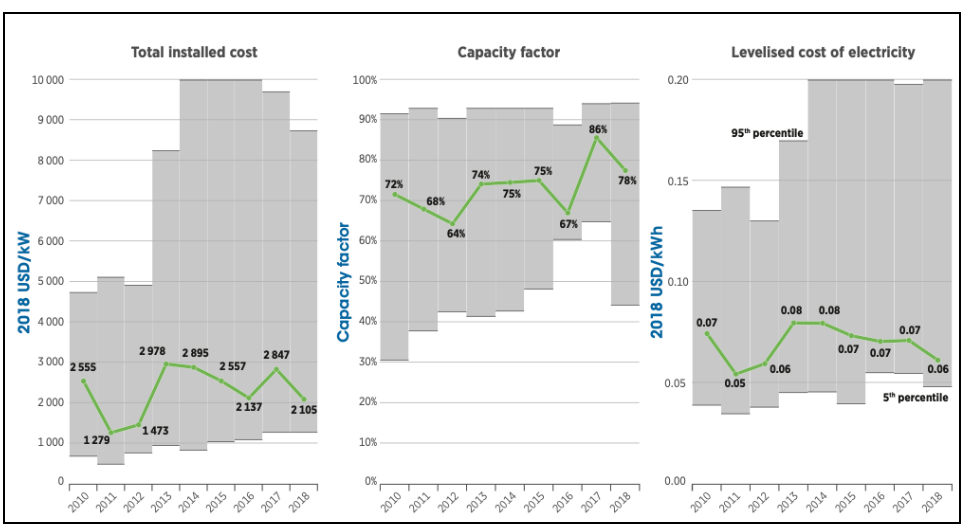
The main policy to follow is how wind energy will impact wildlife. Projects must strive to first avoid and then minimize harm to wildlife and wildlife habitats, but areas where the imapcts can not be avoided they must be rewarded or compensated for. The compensation must address all the species or the habitat that's being affected. Renewable energy developers should strive to create projects that have little to no harm to the environment and provide a net benefit for wildlife. This means addressing landscape-scale impacts caused by fragmenting features like transmission lines that come from the turbines and accounting for impacts to both common and uncommon species and habitat types.



IV. Tidal

Tidal power is a renewable energy source which has been gaining popularity in recent years with notable efforts to expand the industry being found in the United Kingdom, France, and China, where technological improvements continue to smooth out problems associated with earlier designs. The concept of harnessing energy from oceanic tides involves converting the kinetic energy in horizontally moving tidal waters to electricity via the use of turbines attached to generators. Extraction of this predictable, reliable energy source began with the construction of tidal barrages which act similarly to a hydroelectric dam, creating a head as tides rise and recede (15). As of late however, attention has been shifted toward the development and installation of underwater hydrokinetic turbines which do not require the damming of waterways, and the number of operational hydrokinetic turbines and the amount of electricity generated by such devices has been increasing each year. They act more similarly to wind turbines, however the power is much greater given the density of water compared to air, providing a much higher output per unit area than solar arrays or wind turbines.

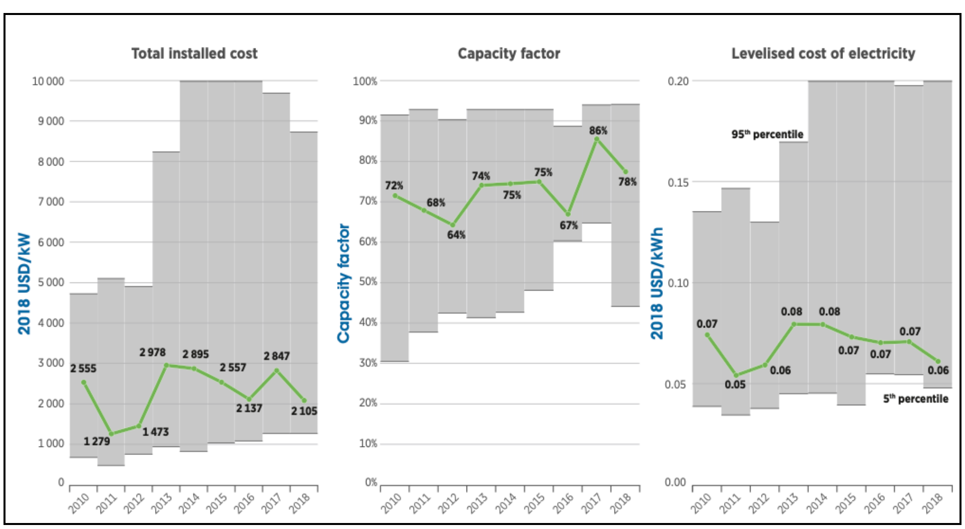
Harnessing energy from the shifting tides is an idea that has been present in Maine for nearly a century. A site of interest since the 1930s has been Passamaquoddy Bay along the border between the state of Maine and Canada (15). Plans were originally made for the



construction of tidal barrages, but this was abandoned for economic and environmental concerns. Within the past few decades, efforts have been made toward the development of hydrokinetic turbine technologies with various groups such as ORPC designing, manufacturing, and testing underwater turbines (16). Successful testing projects in the United Kingdom have produced facilities with enough power to supply electricity to 850 homes (17). There are currently no tidal energy plants supplying energy to the Maine power grid, however there is considerable potential for expansion. Below is an analysis of tidal energy potential as it applies to the state of Maine and a goal to achieve 100% renewable energy generation. Cost, environmental impact, capacity/output, public perception/job creation, and current policy are the categories which this analysis has been broken up into.

Cost

A summary published by the U.S. Department of Energy in 2016 estimated the levelized cost of energy for tidal power to be about 130 to 280 $/MWh for commercial facilities (Figure 1)(19). While costs are comparatively high, the studies claim that costs are expected to decrease substantially as technology advances further and renewable energy grows more desirable. The Cobscook Bay Tidal Energy Project was funded by a $10 million investment and is estimated to



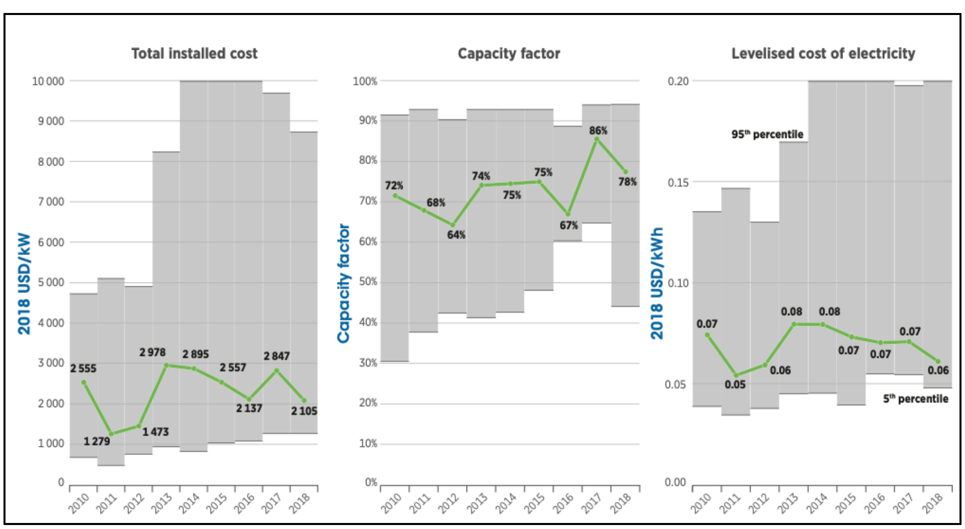
have injected around $14 million into the local economy while also introducing job opportunities (18).

Deployment Stage	Variable	Wave		Tidal	
		Min	Max[1]	Min	Max
First array / First Project[2]	Project Capacity (MW)	1	3 [3]	0.3	10
	CAPEX ($/kW)	4000	18100	5100	14600
	OPEX ($/kW per year)	140	1500	160	1160
Second array/ Second Project	Project Capacity (MW)	1	10	0.5	28
	CAPEX ($/kW)	3600	15300	4300	8700
	OPEX ($/kW per year)	100	500	150	530
	Availability (%)	85%	98%	85%	98%
	Capacity Factor (%)	30%	35%	35%	42%
	LCOE ($/MWh)	210	670	210	470
First Commercial-scale Project	Project Capacity (MW)	2	75	3	90
	CAPEX ($/kW)	2700	9100	3300	5600
	OPEX ($/kW per year)	70	380	90	400
	Availability (%)	95%	98%	92%	98%
	Capacity Factor (%)	35%	40%	35%	40%
	LCOE ($/MWh)	120	470	130	280

Figure 1. Data published by the U.S. Department of Energy from a 2016 study detail the levelized cost of energy, capacity factor, and various other statistics related to tidal energy projects in various stages of development.

Environmental Impact

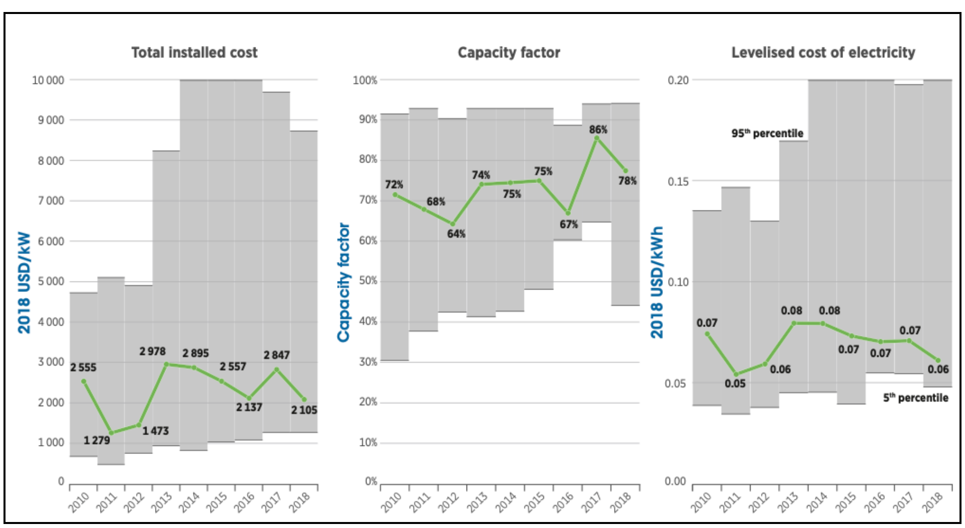
Since hydrokinetic systems are not yet widely used, environmental responses are largely unknown and can be largely specific to a project's location. A common concern is benthic



disturbance such as loss of foraging grounds caused by the anchoring of structures to the sea floor (20). The movement of the turbine blades may also result in auditory disturbance and other harm to wildlife via violent currents very close to the spinning blades. Changes may also be made to sediment transport and deposition patterns, which can impact marine species which are sensitive to suspended particles and depend on specific water conditions. More research is needed before definitive decisions are made regarding the environmental safety of hydrokinetic devices, so further experimentation and implementation of turbines will resolve this issue further. Compared to the burning of coal or natural gas, harnessing tidal energy appears to have significantly less pollutive aspects with no greenhouse gas emissions during operation.

Capacity/Output

While there are currently no tidal power plants providing energy to the Maine power grid, there are numerous locations in the state which pride suitable environments for commercial scale operations. Figure 2 is taken from a 2011 assessment performed by Georgia Tech Research Corporation which outlines potential locations for future tidal energy generation (21). As part of a plan to satisfy our goal of 100% renewable energy, development should take place south of Eastport and east of Cross Island. Developing both of these areas to their highest potential would have a combined potential capacity of 375MW. Assuming the applied technology has a capacity

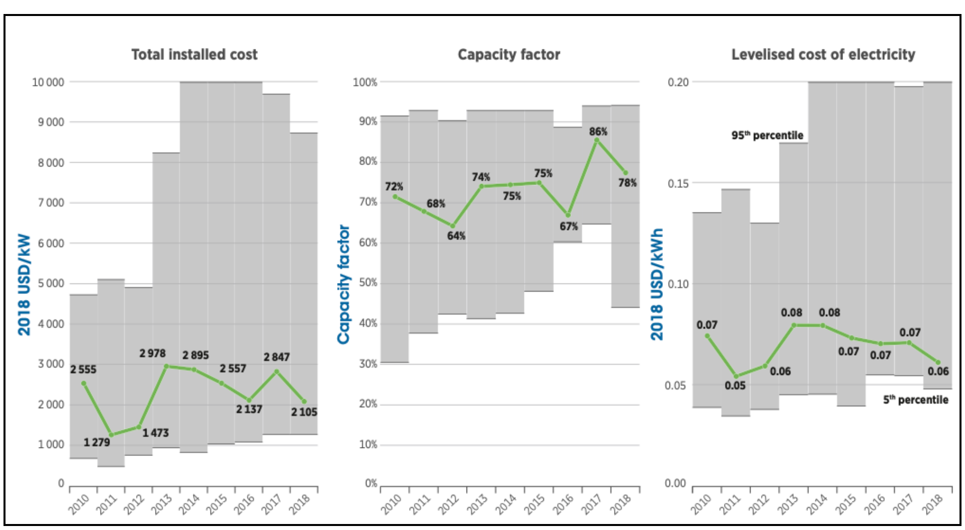


factor of about 35% (19), approximately 1,149,750MWh would be generated annually, which is enough electricity to power around 180,352 homes. Most of the time the turbines would not be running at maximum power, however they serve as a reliable source of power during ramp up periods. The data is also drawn from a study performed in 2011, so technology in this field has advanced significantly since then. It can be expected that with more detailed surveys and further developments in technology, the maximum potential output would be expected to increase.

Latitude (deg)	Longitude (deg)	Width (m)	Mean depth (m)	Max depth (m)	Name	State	Maximum Power (MW)
44.8889	-66.9908	1499	15.8	26.3	S of Eastport	ME	106
44.9364	-67.0465	374	1.2	1.4	Bar Harbor	ME	4
44.6198	-67.2786	765	6.5	7.6	N of Cross Island	ME	26
44.5940	-67.5486	1362	6.6	15.3	NE of Roque Island	ME	32
44.5915	-67.3949	943	4.0	7.3	Btwn Starboard and Foster Islands	ME	21
44.5905	-67.3551	7008	29.1	56.6	E of Cross Island	ME	269
44.5249	-67.6161	582	8.3	10.5	S of Jonesport	ME	22
44.5148	-67.5655	813	3.6	5.5	Btwn Sheep and Head Harbor Islands	ME	15
44.5688	-67.7583	628	2.8	3.1	Channel Rock	ME	9
44.3851	-67.8845	2826	6.3	8.4	Btwn Southwest Breaker and Green Islands	ME	68
44.1332	-68.3631	2036	10.5	15.1	Btwn East Sister and Crow Islands	ME	61
44.2756	-68.6756	459	1.4	1.4	Deer Isle	ME	3
44.5517	-68.8007	470	4.0	4.0	E of Verona Island	ME	10
43.8503	-69.7152	627	17.3	19.8	NE of Mac Mahan Island	ME	10
43.7909	-69.7857	619	12.5	12.8	N of Perkins Island	ME	19
State Total						**ME**	**675**

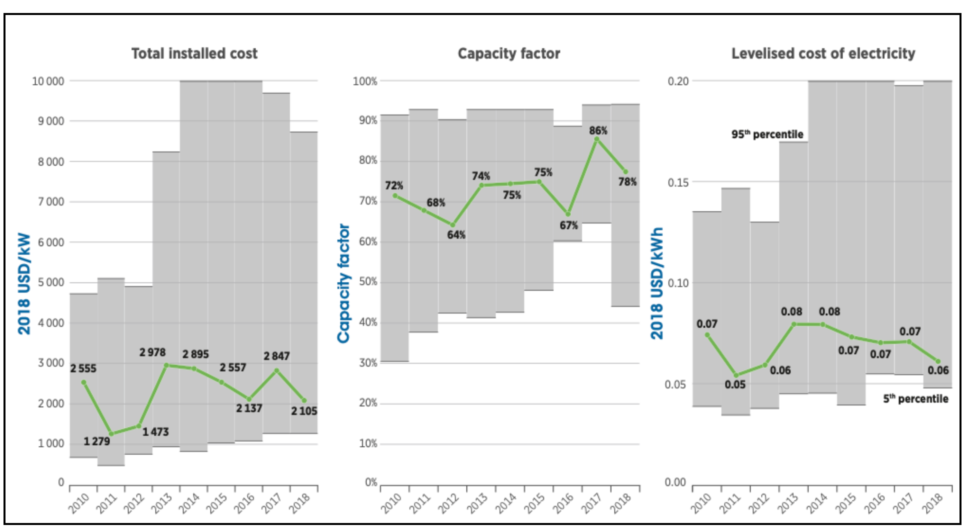
Figure 2. Data from a Georgia Tech Research Corporation study identifies areas of high potential for tidal energy development.

Public Perception/Job Creation

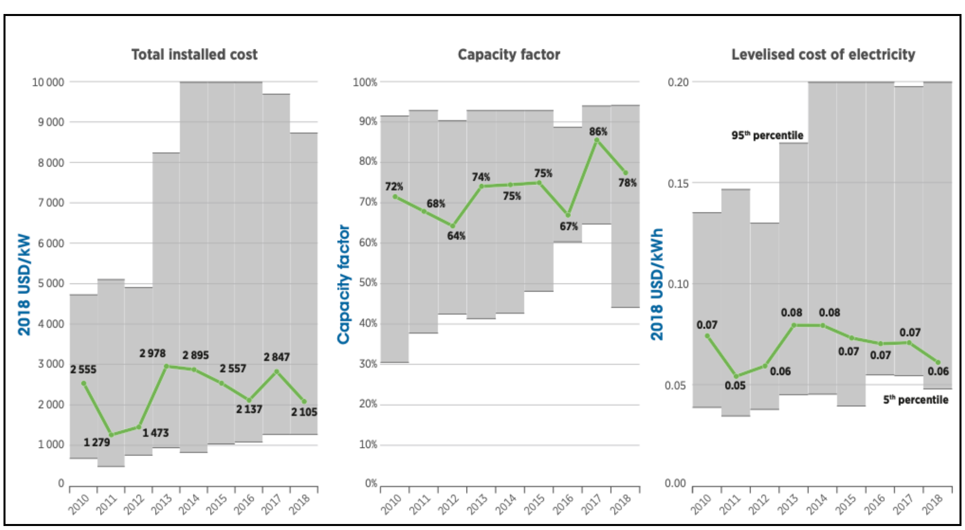


Various groups have shown interest in harvesting tidal energy in areas like the Passamaquoddy Bay since the Quoddy Project in the 1930s (15). Over the years, politicians, engineers, and even some indigenous tribes have contributed toward and supported the research and development of such technologies. Many hydrokinetic turbines conceal most if not all of their structure underwater, so scenic views are left unobstructed as opposed to offshore wind energy plants. Various licenses have been granted for demonstration projects designed to research the potential output and associated impacts of hydrokinetic turbine operation, and pilot projects have been met with little public resistance. The Ocean Renewable Power Company (ORPC) is currently promoting its hydrokinetic turbines for both tidal and river currents. The ORPC has completed demonstrative projects of its turbines in the Cobscook Bay near Eastport, ME and became the first commercial source of tidal energy in the country, supporting over 100 jobs with one project (18). With 100 jobs being supported by a project which provided energy for 75-100 homes, it becomes clear that large, utility-scale tidal power projects would provide a multitude of employment opportunities for thousands of Maine citizens.

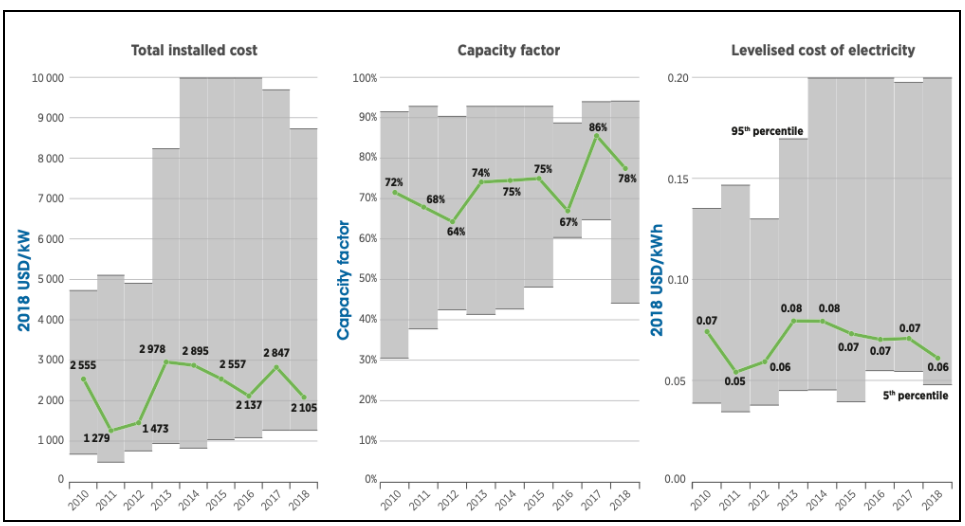
Policy



With recent heightened concern about climate change and the desire to eliminate dependence on fossil fuels, federal legislation has been put in place with the goal of diversifying renewable energy supplies and furthering development in renewable energy infrastructure (22). In terms of federal regulation, a license to develop must be issued by the Federal Energy Regulatory Commission (FERC). Developments must also be issued a permit by the U.S. Army Corps of Engineers (COE), ensuring that it is in compliance with Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. Moving on to regulations put in place by the state of Maine, under the Maine Waterway Development and Conservation Act (MWDCA), developers must acquire a permit from the Department of Environmental Protection (DEP). The permit follows an evaluation of compliance with Section 401 of the Clean Water Act as well as various economic and environmental impacts including public safety, impacts on fish and wildlife, energy generation, and public access. In 2009, the governor of Maine signed into law *An Act To Facilitate Testing and Demonstration of Renewable Ocean Energy Technology*, which led to the introduction of a stream-lined pilot project licensing process which grants permission to construct small-scale projects for the purpose of testing hydrokinetic technologies. These pilot projects are designed for demonstration purposes and are provided a given amount of time to operate before they are either issued a commercial license or the structures are removed with the

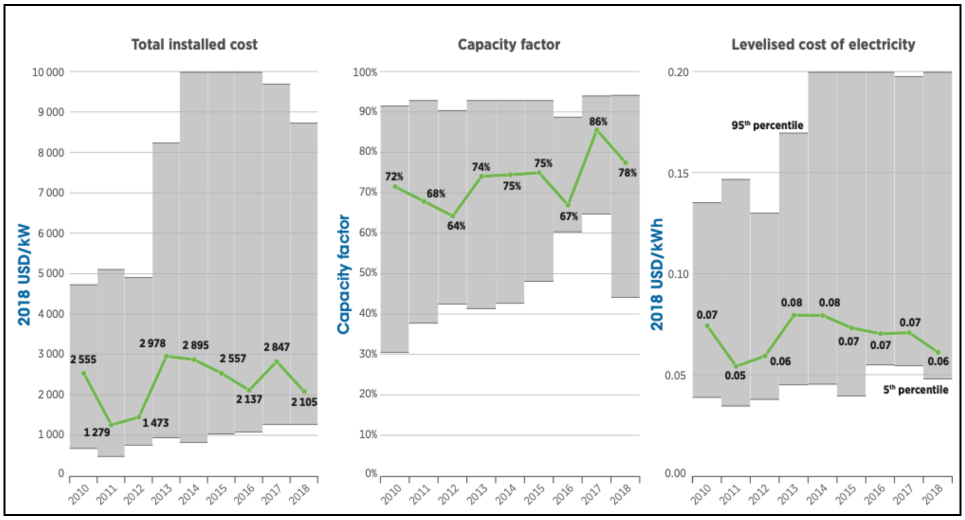


site restored. A year later in 2010, *An Act To Implement the Recommendations of the Governor's Ocean Energy Task Force* was enacted, providing economic incentives for development of hydrokinetic projects and to overcome other economic, technical, and regulatory obstacles. Among other things, this law directed the Public Utilities Commission to solicit long-term contracts to supply installed capacity and renewable energy from tidal energy projects and also directed the Maine Port Authority to assess port facilities and make recommendations to the Legislature regarding areas which prove to be viable locations for ocean energy development.



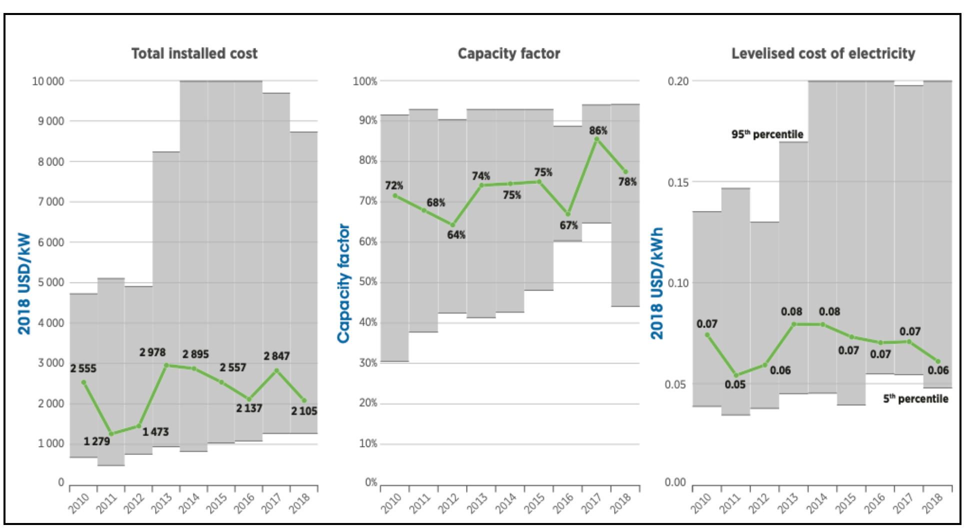
Conclusion

With such a large area for growth, the state of Maine should look into its current hydropower dams. The majority of its dams were created for the purpose of flood control, municipal water supply, and irrigation water, with generators only being added as an afterthought (U.S. Energy, 2019*)*. This opens the capability of restructuring these dams in order to be for the specific purpose of effective hydroelectric power generation. Next, with an average capacity of 40% with an actual range of 10% to 99%, there is a large possibility of improving each dams capacity. The issue with many dams is that the generation relies on the direct flow of the river, this generated energy can be wasted if there is no demand for it at that moment, which is a possible factor as to why the capacity is significantly lower than what it could be. If more dams utilize a storage systems, allowing previously stored water to be used in unison with its demand, and If more demand is placed on hydropower electricity in general, its capacity will likely increase. Currently electricity from hydropower fills the demand of 31% of Maine's total electricity use. This powers an estimated 160,000 homes *(*EIA, 2019*)*. If the capacity was increased to its most effective 99%, the amount of homes supplied could be upwards of 400,000, with any increase in capacity powering a large number of homes.



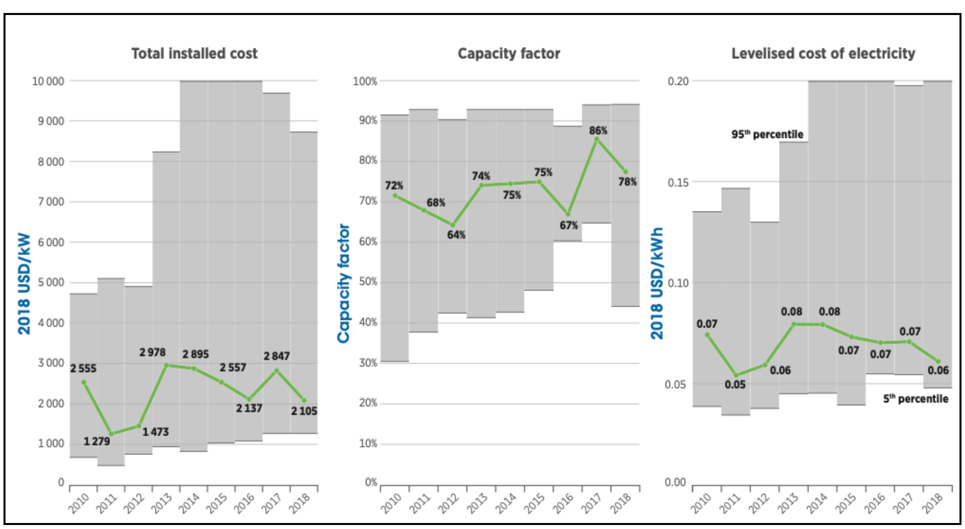
In order to build the massive biopower plant, we need to change public perceptions on biomass with educational programs. Furthermore, we must rebuild our grid system because our current grid network cannot handle a great amount of electricity coming from the biopower plant. We need to implant and expand high-voltage direct current transmission technology to help us integrate our energy to our power plant (Gates, 2019).

Wind energy has the potential to meet the states of Maine's demand for an increase in renewable energy. The state of Maine is already known for its wind energy source that has a capacity of 21% and a total output of 923MW. The plan to meet the states renewable energy demand is to build a new wind farm.. The state of Maine’s best wind resources are along the ridge crests in the state's northwest and along its Atlantic coastline. Implementing a new wind farm consisting of 50 turbines with a total output of 115MW is the start of a new plan of action to reach the stated goal of 100% renewables by 2050. Wind power has the potential to reach 40% capacity being able to power 53,600 homes. It can also create a numerous number of jobs strengthening the economy of Maine. By taking into account the factors that would affect the approval like environmental impact, capacity factor, plus cost and by strategically planning the location of our new wind farm with can be an aid to real the states goal.



It is important that the state of Maine adopts tidal energy as a source of electricity in order to successfully diversify its energy portfolio. In correspondence with our plan, the construction of turbine arrays in the two areas deemed to have the highest potential would maximize the production capacity when development advances from pilot testing to commercial operation. The projects proposed would be built off of the southern coast of Eastport, ME and off the eastern coast of Cross Island, ME with a combined output sufficient to power approximately 180,352 homes in the state. As has been the case with numerous other renewable energy sources, costs are expected to be relatively high at the start of development. Over time, as the application of tidal technology becomes more widespread and understood, the effort required to manufacture and develop projects as well as the costs involved will decrease. Bordering one of the most tidally active places in the world, the Bay of Fundy, Maine is positioned to lead New England as well as the rest of the country in tidal energy advancement.

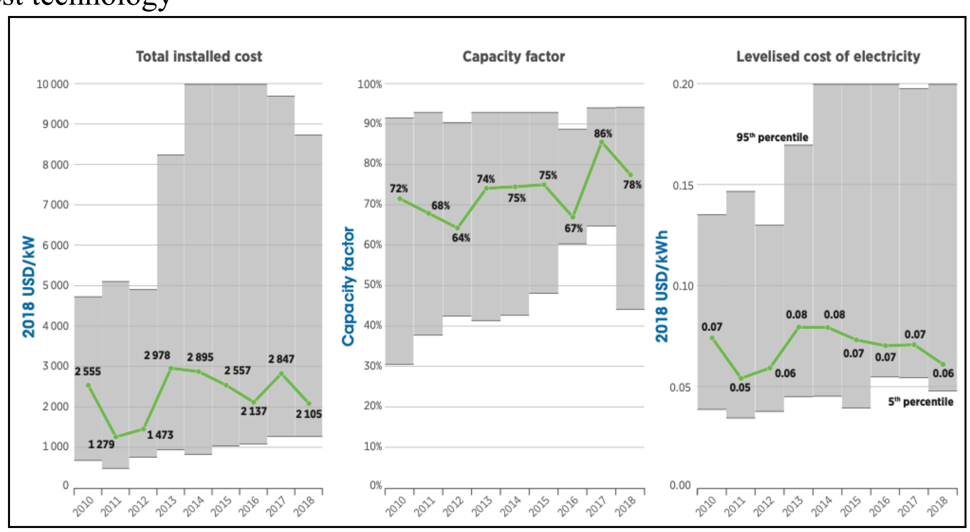
	Cost: LCOE ($/KWh)	**Environmental Impact**	**Capacity Factor (%)**	**Number Of Household**	**Job Creation**	**Policy**	**Public Perception**
Hydroelectricity	0.02-0.06	-/+	40	160,000-	4,200	Support	1



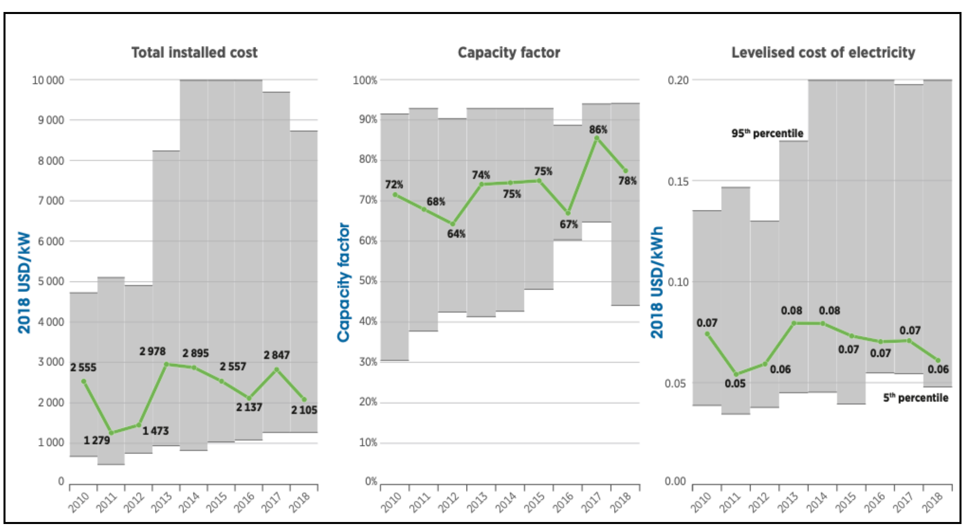
				400,000			
Biomass	0.062	+	87[2]	304,600	1,800	Support	0
Wind (On-shore)	0.0278	-	39%	53,600	4,143	Support	0
Tidal	0.13-0.28	-/+	35-40	180,352	1,000	Support	1
HBWT				**698,552 - 938,552**	11,143		

Table X: Summary of four renewable energy sources and 7 metrics. For cost, LCOE is used to evaluate the costs of electricity per unit. For environmental impact, + for positive, - for negative, +/-: equal impact. For number of households, we calculate it based on electricity output annually capacity factor and average electricity use of a Maine household. For job creation, we use IRENA report to give an estimation on job creation. For policy column, we look for rules and laws that might allow or restrict our energy. For public perception, rated on binary system (0 for

[2] Updated from latest technology



no support, 1 for support), we withdraw a conclusion from scientific research in which people collected surveys from citizens.



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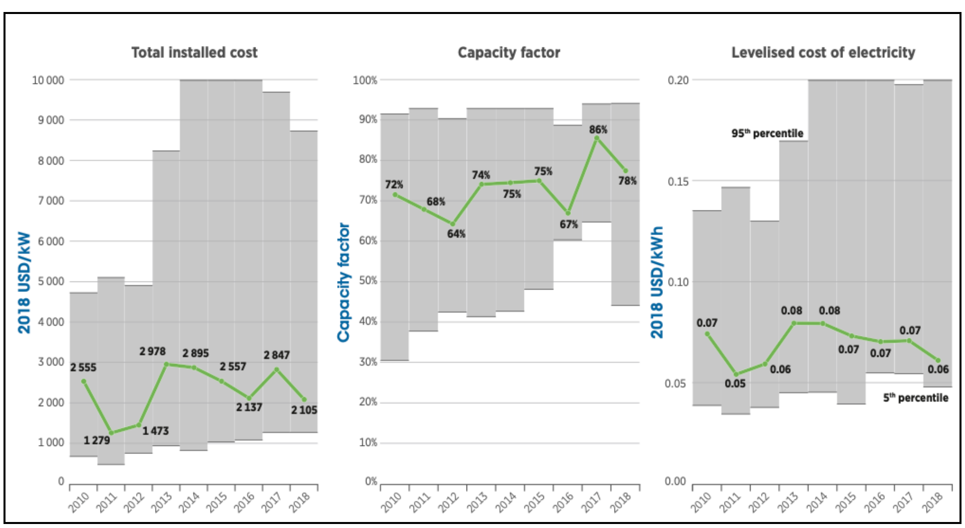

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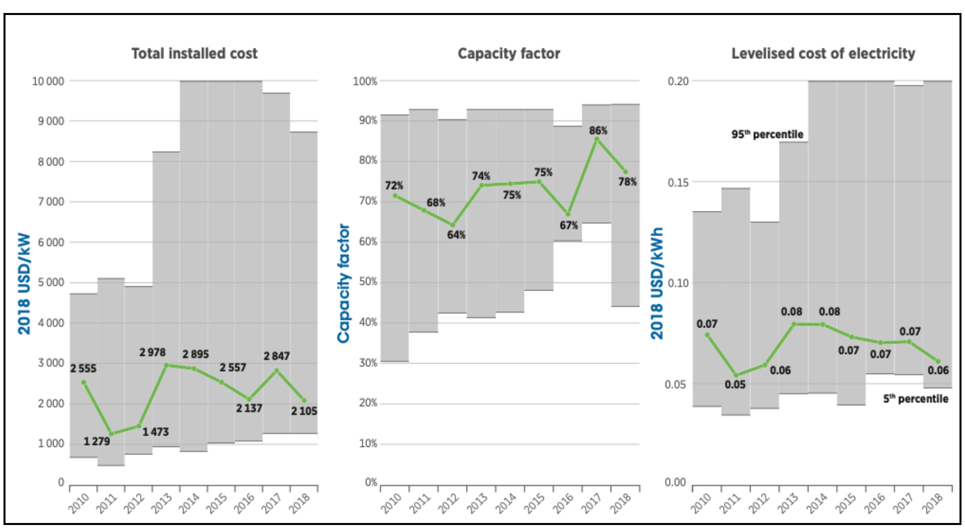

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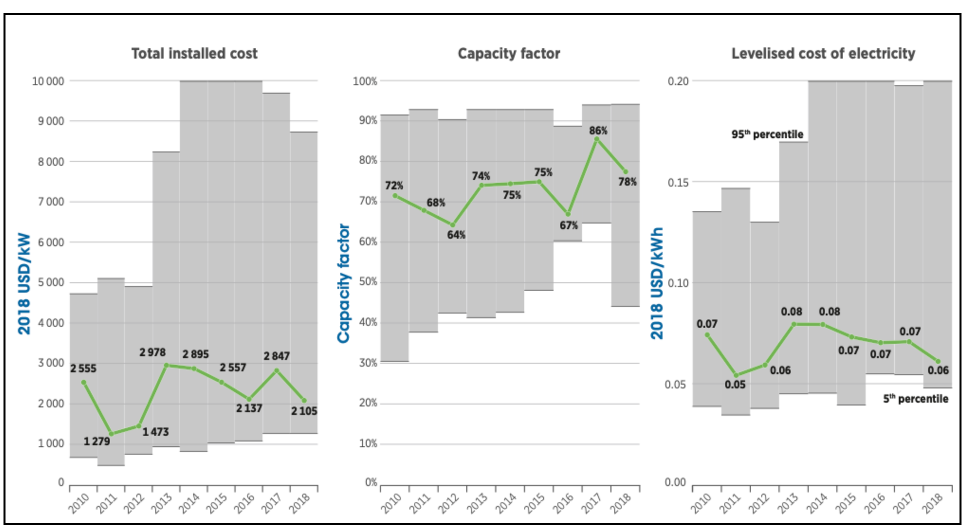

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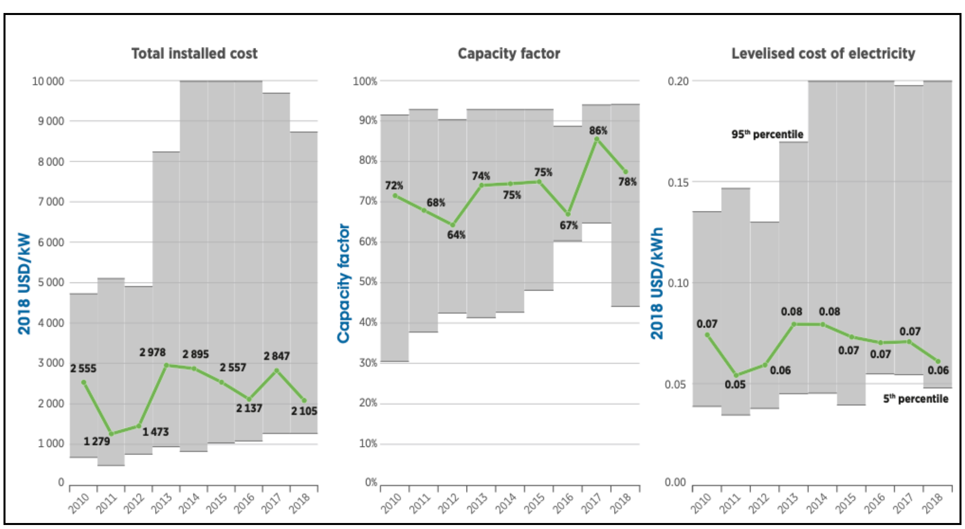

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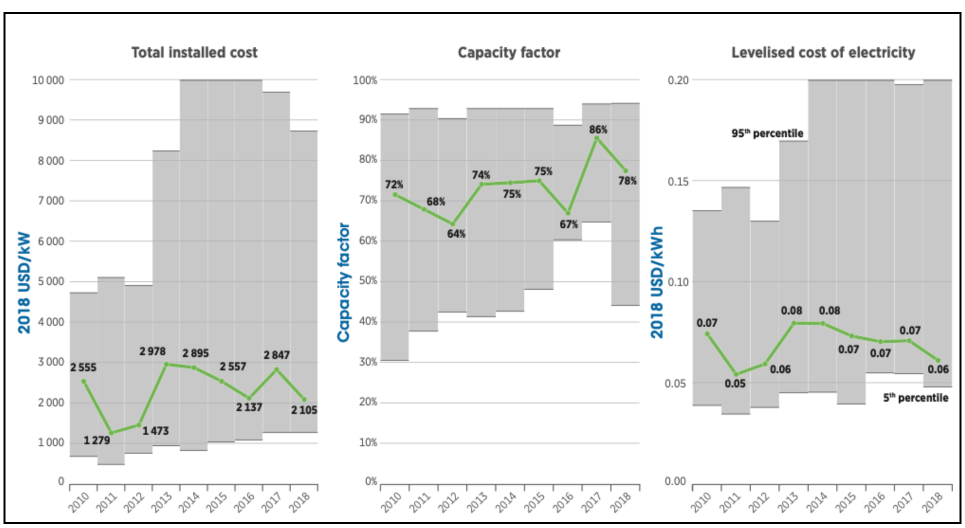

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