MONHEGAN'S ENERGY FUTURE

For longer than there has been a power company on Monhegan, diesel generators have been a source of power for the island. While this equipment has provided the power Monhegan needs, it has had its drawbacks. Fluctuating diesel prices and increasing maintenance costs required to keep aging machines running have significantly increased the overall cost of generation on Monhegan. The environmental costs of diesel generation, fuel spills, air pollution, and climate change are also significant, and safety reliability continue to be a concern. Therefore, it is important to investigate what other options are available to Monhegan.

Although it is a small island, Monhegan has an abundance of renewable resources that could be harnessed for energy production. The wind resource on the coast of Maine is considered to be "good-to-excellent"[1], Monhegan has been singled out as one of the "most promising areas in Maine" for wave power development[2], and the island has a good solar resource which more or less lines up with seasonal electricity consumption patterns. These renewable resources, along with energy efficiency and conservation, could be viable options to move Monhegan away from diesel generation. However, it is important to understand the various pros and cons of each resource and technology, before deciding to pursue a renewable technology and its possible integration into the existing power grid.

The Monhegan Energy Planning Committee (MEPC) has been researching possible ways for the power company to adopt renewable technology. A central part of this process is gathering input from stakeholders, of which there are many for Monhegan. That is why we are holding "house parties": to gather input from you, our neighbors.

The purpose of the fact sheets in this packet is to help you understand what options are available for Monhegan to pursue. It includes information on the renewable energy resources available to Monhegan, current technology, and cost trends. This is a living document, which will be updated as better information is made available. Please read through it carefully, and be ready with any questions or comments that you might have.

Who We Are

The MEPC is a group made up of two year-round residents, two seasonal residents, and an Island Institute Fellow. We are tasked with creating a technical assessment of Monhegan's energy resources and possible technology options, and creating a plan to pursue options that the community is interested in. We are receiving technical assistance from the Island Institute and the US Department of Energy's Office of Energy Efficiency and Renewable Energy. Currently, we are working on creating a technical assessment, gathering community input, and creating a first draft of an energy plan.

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[1] "Maine's 50-Meter Wind Map." *US Department of Energy, Office of Energy Efficiency and Renewable Energy*. 2014 http://apps2.eere.energy.gov/wind/windexchange/maps_template.asp?stateab=me

[2] Kleinschmidt Group. "Maine Hydropower Study." *Maine Governor's Energy Office*. February 2015. 2-47.

Project Timeline

September/October 2014
Marian Chioffi travels to Samsø Island in Denmark with other islanders and College of the Atlantic students, in a trip sponsored by the Island Institute and the College of the Atlantic. The purpose of this trip was to learn about the island's transition to renewable energy.

October/November 2014
Marian and Zabet NeuCollins, a student at the College of the Atlantic, expand on previous energy efforts to conduct an initial assessment of energy systems on Monhegan, and research best practices for conducting community outreach.

February 2015
The Monhegan Energy Planning Committee (MEPC) is formed to create a plan for the future of energy on Monhegan.

June 2015
MEPC sends out a round of surveys assessing local priorities around energy.

July 2015
MEPC member Jack Partridge hosts the first 'house party' to discuss options for the future of energy on Monhegan.

January 2016 – April 2016
MEPC works on a draft energy plan. House parties will be held during this time, to discuss options for Monhegan's energy future

March/April 2016
A community meeting regarding the proposed Maine Aqua Ventus project is held, to discuss community benefits from the project.

June 2016
An informational meeting will be held with local energy experts, to discuss specific options and considerations for the future of energy on Monhegan.

June – August 2016
A second round of house parties will be held for summer residents to participate in in-depth conversations about the future of energy on Monhegan.

Fall 2016
A second draft of the energy plan will be created and circulated to stakeholders for comments.

Winter 2017
A final draft of the energy plan will be published.

Abbreviations

PV – Photovoltaic, electricity producing solar panels.

kW – Kilowatt, one thousand watts. Most potential energy projects on Monhegan are described in terms of kilowatts, which refers to the maximum amount of power that they can produce. For example, the land-based turbine that was proposed in 2009 was 100 kW, whereas the proposed Maine Aqua Ventus project be 6000 kW, or 6 Megawatts (MW).

kWh – Kilowatt hour, a metric that measures power output or consumption over time. Monhegan electricity bills measure kilowatt hours consumed.

USDA – United States Department of Agriculture, which funds many rural electricity projects.

Definitions

Combined Heat and Power – Also called "cogeneration," the process of using waste heat from power generation to provide heating, cooling, or hot water.

Energy Storage – A mechanism that stores energy produced for later use. Usually used in renewable energy applications to better align demand and production. The most commonly used forms of energy storage are lead acid batteries, like what is in most boats and cars, and lithium ion batteries, which are found in laptops and cellphones.

Load – The amount of electricity demand at any given point in time.

Hybrid System – An electric power plant that incorporates more than one type of generation. On Monhegan, this would likely consist of diesel-fired microturbines, one or more renewable components, and a storage component. The benefit of this type of system is that it combines the reliability of diesel generation with the environmental benefits, and potential cost savings benefits, of renewable generation.

Microturbine – A machine that compresses and combusts a mixture of fuel and air to turn a turbine and create electricity and heat. These are similar to the large steam turbines used to generate electricity and heat from coal or natural gas, but smaller.

Microgrid – A small electric grid, such as Monhegan's with its own generation and/or storage. On the mainland, interest in incorporating microgrids into the larger electric grid has increased in recent years, due to the need to isolate or "island" a section of the grid to provide power in an outage

Peak Load – The greatest amount of load during a given time interval. For example, daily peak load is the load at the time of day when the most electricity is consumed. Also referred to simply as "peak."

Renewable Energy – Energy that is produced from a resource that replenishes at a rate faster than it is consumed, i.e. a renewable resource.

Switchgear – A series of automated switches used to match the load to the generators, synchronize the output of multiple generators running at the same time, restart the generators after an outage, balance phases, and provide an automatic shutoff in an emergency situation.

THE GRID

Monhegan's grid, which serves customers from Deadman's Cove to Lobster Cove, is unique for several reasons. First, it is very small, even for an island. In Maine, only Isle au Haut and Matinicus have fewer customers, and both have larger grids, in terms of area covered. Second, Monhegan's electrical lines are buried, which protects them from wind, lowering the number of weather-related outages on the island. The tradeoff is that this was very expensive to install and expensive to maintain as a cable has to be dug up to be fixed. Last, but certainly not least, Monhegan's grid is not connected to the mainland, and all electricity is generated on the island, using diesel-fired generators.

The unique qualities of Monhegan's grid mean that there are special conditions that must be taken into consideration when discussing energy development on the island.

CONSIDERATIONS FOR ENERGY DEVELOPMENT ON MONHEGAN

Small Scale

Monhegan's electric grid is very small, which creates challenges for the development of renewable energy. MPPD has a very small ratepayer base over which to spread its fixed operating costs, including overhead and grid maintenance. This is one of the main reasons electricity is so expensive on Monhegan. It also means that a renewable installation has to be fairly low cost to actually bring down electric rates on the island, because it will not offset any grid maintenance costs.

Financing

Renewable energy installations typically have very high upfront costs. However, they can be financed over the project lifetime, and grant funding is sometimes an option as well. An important consideration is whether the community will be better served by an installation owned outright by the power company, or one owned by an outside party, which would cover the upfront costs, and sell power to MPPD at a set rate.

Community Control

Local control over energy systems is a necessity for Monhegan. Due to the island's remote location, it is next to impossible for an outside entity to provide the proper level attention that is required to maintain an energy system.

Long-Term Planning

Most renewable installations have a lifespan of about 20-30 years. This means that possible changes to the size and characteristics of Monhegan's electric load should be taken into consideration.

System Components

Monhegan could adopt more than one kind of renewable installation. For example, wind and solar often complement one another; it may be windy when there is no sun, or sunny when there is no wind. Each renewable component should be no larger than required, in order to keep costs down. Additionally, if renewable energy makes up a significant portion of the island's generation, it will almost certainly need a storage component so that electricity production can be matched to the load in real time.

Environmental Impacts

Aesthetic impacts are very important to Monhegan residents, as well as tourists who play a large role in Monhegan's economy. Therefore the potential impacts of a renewable installation on the view and soundscape of Monhegan should be taken very seriously. Another important consideration is the amount of open space required for a renewable installation, particularly because much of the island is not available for development.

Reliability

The first priority for the power company is to provide reliable electric service to their ratepayers. Any generation technology that is adopted by Monhegan must align with this goal. This means that it has to provide the amount of power it is expected to provide and be relatively easy to maintain. Additionally, should any issues outside the scope of routine maintenance arise, there should be experts easily accessible to fix the problem in a timely manner.

CURRENT SYSTEM AND SCHEDULED UPGRADES

A 65 kW microturbine. Photo via Capstone

The Monhegan Plantation Power District (MPPD) currently uses three diesel generators to supply the island with power, including two larger 120 kW generators and a smaller 80 kW generator. These machines consist of a diesel engine attached to a generator, which turns mechanical energy into electrical energy. The switchgear that MPPD uses was installed by a company that went out of business shortly thereafter, and the unit hasn't functioned properly since, due to lack of qualified service technicians and parts.

MPPD has received a USDA High Energy Cost Grant to cover the cost of installing four 65kW Capstone microturbines and 10 kW of solar, which will replace the current generation system, including the switchgear. This system will be online in the summer of 2016.

<table>
<tr><th colspan="2">CURRENT SYSTEM</th></tr>
<tr><td colspan="2">CONCEPT: Two 120 kW Kohler diesel generators and one 80 kW Kohler diesel generator, combined with a switchgear from Northern Reliability.</td></tr>
<tr><th>PROS</th><th>CONS</th></tr>
<tr><td>• Provides power, 24 hours a day, 7 days a week
• Uncomplicated system, most maintence can be performed by someone with a basic mechanical/electrical skillset</td><td>• 80 kW generator is too large for the winter load, doesn't use fuel efficiently
• Switchgear does not function properly
• Increasing cost of operation
• Fuel spills pose an environmental risk
• Diesel emissions impose environmental costs
• Frequent outages
• Very noisy</td></tr>
<tr><th colspan="2">SCHEDULED UPGRADES</th></tr>
<tr><td>CONCEPT: Four 65kW diesel-fired Microturbines and 13kW of PV.</td><td>GOALS: Reduce diesel consumption, upgrade failing equipment, and begin to integrate renewables into the grid.</td></tr>
<tr><th>PROS</th><th>CONS</th></tr>
<tr><td>• Burns cleaner than diesel generators
• 65 kW microturbine is better suited to handle winter load
• Microturbines use fuel more efficiently than diesel generators
• Less maintence required
• Cost is covered by the USDA
• Built-in controls replace the current switchgear and can handle renewables
• Integrates some renewable capacity into the grid
• Has the ability to incorporate combined heat and power</td><td>• Still primarily dependent upon diesel fuel
• Requires Ultra-Low Sulfur Diesel, which is more expensive than the off-road diesel used by the old system
• A new technology, not as well understood as diesel generators</td></tr>
</table>

ON-ISLAND WIND TURBINE

Onshore wind turbines have been around for a long time, but have improved significantly in recent years. The average installed cost for land-based wind turbines is very low, particularly when compared with other renewable energy technologies[3]. Some of the issues associated with wind turbines include noise, bird and bat deaths, and unsightliness. These can all be mitigated (but not altogether eliminated) by proper siting.

100kW wind turbine at Camden Hills Regional High School. This is the same turbine that was proposed on Monhegan in 2009. Image via Portland Press Herald.

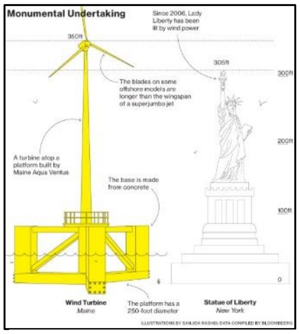
A 2009 model by AWS TrueWind, which was commissioned by MPPD showed that the median wind speed at 121 feet over Lighthouse Hill is 7.1 meters per second (m/s)[4].

Monhegan has considered an onshore wind turbine in the past. A 2009 study commissioned by MPPD examined the feasibility of a 100kW wind turbine on Lighthouse Hill. The project never came to fruition, but in the process a lot of research was done to find a good site, understand the economic impact, community concerns, the impact on birds and bats, the visual impact, and other environmental impacts. For more information on this project idea, visit www.monheganpower.com/windpower/.

ONSHORE WIND			
CONCEPT: One 100kW turbine located on Lighthouse Hill, combined with storage		GOALS: Reduce diesel consumption, lower electricity costs.	
PROS	**CONS**	**RISKS**	**ACTIONS**
• Proven technology • Takes advantage of a strong wind resource • Would reduce diesel consumption • Excess winter power creates opportunities for electric heating	• Visual impact • Potential noise impacts • Possible bird/bat deaths • Wind resource peaks in the winter, when the load is lower • Storage adds cost and technical complexity	• Legal or regulatory issues related to visual or auditory (sound) impacts	• Research funding options and permitting requirements for onshore wind turbines • Update research from 2009 study

[3] "Annual Energy Outlook 2015." US Energy Information Administration. June 2015.
[4] Baker, G. and Boynton, W. "Monhegan Island Community Hybrid Project." Island Institute/MPPD. September 2009. Page 10

FLOATING OFFSHORE WIND TURBINES



An illustration of the floating offshore wind turbine proposed by NE Aqua Ventus. Image via Bloomberg.

While onshore wind has been around since at least the eighties, floating offshore wind is a relatively new technology. Currently, most offshore wind installations are mounted directly into the seafloor, but floating turbines are moored to an anchor and float on the surface. This allows them to be installed in much deeper water. While onshore wind projects are relatively inexpensive, offshore wind is currently one of the most expensive forms of renewable generation.[5] The purpose of building floating offshore wind turbines is twofold: to take advantage of the good wind resource over the ocean, and to build turbines away from population centers, in order to reduce the impact on neighboring populations. However, there can still be drawbacks to floating offshore wind turbines, particularly if they are not sited properly. They can interrupt fishing grounds, cause bird and bat deaths, and be a visual nuisance.

The University of Maine recorded a median wind speed of 9.5 m/s at the offshore energy test site, located about 2.5 miles off Lobster Cove. NREL classifies this as a “superb” wind resource[6].

Floating turbines proposed by New England Aqua Ventus would sit in a state-legislated test site 2.5 miles off Lobster Cove, and be at least 364 feet tall. This project has received, and is continuing to seek federal funding

OFFSHORE WIND			
CONCEPT: Two floating offshore wind turbines sited 2.5 miles off Lobster Cove.		GOALS: Reduce diesel consumption, lower electricity costs.	
PROS	**CONS**	**RISKS**	**ACTIONS**
• Possibility of a fiber optic cable and free power supply, or payment in lieu of a cable • Takes advantage of a superb wind resource • Would essentially eliminate diesel consumption	• Visual impacts. • Possible bird deaths • Right-of-way concerns with cable coming ashore	• Dependence on a project largely out of Monhegan’s control • Could disrupt the fishing activity	• Continue ongoing conversations about benefits to Monhegan between the community and New England Aqua Ventus

[5] “Annual Energy Outlook 2015.” US Energy Information Administration. June 2015.
[6] “United States Wind Resource Map.” NREL. May 2009. http://www.nrel.gov/gis/pdfs/windsmodel4pub1-1-9base200904enh.pdf

COMMUNITY SCALE SOLAR

A community-scale solar installation on Naushon Island, MA.

Photovoltaic solar cells, often called PV, convert energy from the sun into electricity. While this was once one of the most expensive forms of renewable generation, prices have come down significantly in recent years. Larger solar arrays tend to be more cost-effective than small systems, but still slightly less cost effective than wind turbines.[7] Solar power isn't typically associated with many environmental problems, but it does require a significant amount of open space.

Monhegan's solar resource is not as strong as its wind resource, but it does have the advantage of better matching with the island's seasonal load profile. Monhegan receives proportionally more solar energy in the summer, during peak load, and less in the winter when it isn't needed as much.

A community-scale solar installation on Monhegan must be sited carefully. It would have to be open to the south, and would ideally be located in an area where it wouldn't interfere with any other land uses, or have unacceptable visual impacts.

<table>
<tr><th colspan="4">COMMUNITY SCALE SOLAR</th></tr>
<tr><td colspan="2">CONCEPT: One 100kW solar installation, with storage incorporated</td><td colspan="2">GOALS: Reduce diesel consumption, lower electricity costs</td></tr>
<tr><th>PROS</th><th>CONS</th><th>RISKS</th><th>ACTIONS</th></tr>
<tr><td>• Solar resource matches island's load profile
• Installation is modular, panels can be added if the load increases.
• Would reduce diesel consumption</td><td>• Installation would take up a lot of space, and Monhegan does not have much open space available
• Visual impact dependent upon siting
• Storage component adds cost and technical complexity</td><td>• Unforeseen technical problems</td><td>• Meet with Monhegan Associates and other landowners to discuss possible project locations
• Conduct resource assessments at possible sites.</td></tr>
</table>

[7] "Annual Energy Outlook 2015." US Energy Information Administration. June 2015.

DISTRIBUTED SOLAR

Solar panels on rooftops in Hawaii. Image via NYTimes.

Solar panels can work in a single large installation or as a lot of smaller installations spread out over a larger area - what's known as "distributed solar", "distributed PV", or "rooftop solar." While this type of generation is growing in popularity, it is considerably less cost effective than larger, centralized solar arrays.[8] Distributed solar is often installed on rooftops, which lessens some of the spatial impacts of solar technology. In order to support a solar installation, a roof must face to the south, and be able to support a significant amount of weight for up to twenty years.

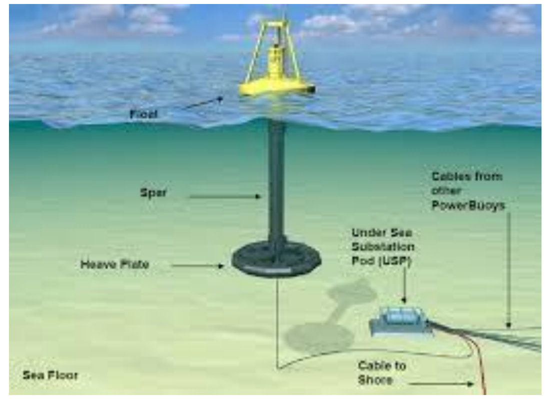
There are several Monhegan-specific challenges to developing distributed solar. On the mainland, distributed solar is usually financed through a utility program called "net metering", which pays customers for the electricity that they generate but don't consume, usually at above-market rates. However, MPPD is a small quasi-municipal utility which cannot afford to pay customers for generation that may or may not be useful, and has long been exempt from the state of Maine's net metering law. Furthermore, there are significant technical barriers that make the integration of distributed solar into the Monhegan very difficult.

<table>
<tr><th colspan="4">DISTRIBUTED SOLAR</th></tr>
<tr><td colspan="2">CONCEPT: Several small solar installations spread throughout the island.</td><td colspan="2">GOALS: Reduce diesel consumption, lower electricity prices, lessen land use impacts of solar.</td></tr>
<tr><th>PROS</th><th>CONS</th><th>RISKS</th><th>ACTIONS</th></tr>
<tr><td>• Lower land use than community scale solar
• Solar resource matches island's load profile
• Installation is modular, panels can be added if the load increases
• Would reduce diesel consumption</td><td>• MPPD would have to create a program to pay for solar generation
• Difficult to implement equitably
• Technical barriers, including grid saturation, phase imbalance, and voltage mismatch
• Visual impact dependent upon siting</td><td>• Unforeseen technical barriers to solar grid integration</td><td>• Research grid integration costs for distributed solar deployment on Monhegan
• Conduct resource assessments at possible sites</td></tr>
</table>

[8] Conca, James. "Which is Cheaper – Rooftop Solar or Utility-Scale Solar?" Forbes. http://www.forbes.com/sites/jamesconca/2015/07/30/which-is-cheaper-rooftop-solar-or-utility-scale-solar/

WAVE POWER

Wave power generation uses the vertical movement of waves to generate electricity. This is an emerging technology that has not yet commercially available to the same extent as wind and solar. However, the industry continues to grow and develop around the world, with projects in Washington State, as well as Europe and South America. As is typical with emergent technologies, the costs associated with wave power are very high, but are expected to come down as the technology develops. Possible negative impacts of wave power include interference with marine life and fishing activity.



A diagram of a "PowerBuoy," a technology developed by Ocean Power Technologies, Inc. Image via jagadees.wordpress.com.

Monhegan has been identified as one of the best sites in Maine for wave energy development by the Governor's Energy Office (GEO).[9] This designation is based on the wave resource measured at the designated offshore energy test site (where the proposed Aqua Ventus offshore wind project would be located), and the high cost of energy on Monhegan. Like the wind resource on Monhegan, the wave resource is mismatched with the electric load on the island. Waves are typically stronger in the winter, when less people are on the island consuming electricity.

WAVE POWER			
CONCEPT: A wave power pilot project connected to the Monhegan grid.		GOALS: Reduce diesel consumption, lower electricity prices.	
PROS	**CONS**	**RISKS**	**ACTIONS**
• Very little visual or spatial impact • Would reduce diesel consumption	• Resource does not match load • Very high associated costs • Interference of cable with fishing activity • Right-of-way conflicts associated with a cable coming ashore	• Significant possibility of technical issues due to the undeveloped nature of the technology • Possible unknown environmental impacts • Possible impacts on fishing conservation zone • Would require a partnership with an outside developer	• Actively advertise offshore energy test site to wave power developers • Research subsidies available for wave power development

[9] Kleinschmidt Group. "Maine Hydropower Study." The Maine Governor's Energy Office. February 2015.

TIDAL POWER

Tidal power is another common form of ocean energy production and, like wave power, is not yet at the commercial stage of production. There are several demonstration projects underway in the United States, including a grid-tied project by the Maine-based developer Ocean Renewable Power Company (ORPC) in Cobscook Bay. There is some risk to marine life with tidal power projects, which can be mitigated with proper siting and project design.

ORPC's TidGen tidal power unit being installed in Cobscook Bay, ME. Photo via ORPC.

According to model data from Georgia Tech[10], the mean tidal power density in the water around Monhegan is under 50 Watts per square meter (W/m^2). In comparison, the mouth of Cobscook Bay has a mean tidal power density of over 1,000 W/m^2, 20 times the Monhegan resource.

TIDAL POWER			
CONCEPT: A tidal power pilot project located in the waters off Monhegan.		GOALS: Reduce diesel consumption, lower electricity prices.	
PROS	**CONS**	**RISKS**	**ACTIONS**
• Very little visual or special impact • Installation would likely be the first of its kind on the East Coast (Good optics, press, etc…) • Would reduce diesel consumption	• Resource is extremely limited • Very high associated costs • Interference of cable with fishing activity • Right-of-way conflicts associated with a cable coming ashore	• Significant possibility of technical issues due to the undeveloped nature of the technology • Possible unknown environmental impacts • Possible impacts on fishing activity	• Actively advertise offshore energy test site to tidal power developers • Research subsidies available for wave power development

[10] Haas, K. "Assessment of Energy Production Potential from Tidal Streams in the United States." Georgia Institute of Technology, Savannah. Savannah GA. 2011. http://www.tidalstreampower.gatech.edu/

MAINLAND GRID CONNECTION

Many islands in Maine are connected to the mainland grid, and purchase their power from either a utility or a wholesale power provider. The cost of the power they purchase is often much lower than the cost of generating power on-island. However, the cost of a cable to service Monhegan is generally prohibitive because of the long distance to the island and the small customer base over which to cover the cost of a cable. Based on research done to assess the viability of an on-island wind turbine, the cost of a cable to Monhegan would be about $1,000,000/mile, which could raise rates on the island over $1/kWh. An undersea cable could also have adverse impacts on fishing activity around Monhegan.

CABLE			
CONCEPT: A submarine cable linking Monhegan to the mainland.		GOALS: Reduce diesel consumption.	
PROS	**CONS**	**RISKS**	**ACTIONS**
• Diesel would no longer be needed, except as a backup • Cable could also be used to bring fiber to the island	• Very high upfront cost • Cable would disrupt fishing grounds • Right-of way conflicts with cable coming ashore • Electricity from mainland grid is not completely from renewable/clean sources • Possibility of outages from mainland, or wear and tear on the cable	• Possible impacts on fishing activity	• Talk to other islands that have a cable about maintenance costs, other considerations

FEEDBACK

Thank you for taking the time to review these fact sheets, your input is very important to us. Please provide any feedback you have in the space provided below, and return it to the Monhegan Plantation Power District at:

MPPD
PO Box 127
Monhegan, ME 04852

You may also email your feedback to Ben Algeo at: balgeo@islandinstitute.org, or Marian Chioffi at bookkeeper@monheganpower.com.

Thanks again, we look forward to hearing from you!

Sincerely,

The Monhegan Energy Planning Committee
Marian Chioffi, Ben Algeo, Jack Partridge, James Balano, and Winnie Murdock