100% Renewable Energy

SUSTAINABLE HUDSON VALLEY

ecc

Marbletown Environmental Conservation Commission

ACTION PLAN FOR MARBLETOWN, NEW YORK

Created by the Marbletown Environmental Conservation Commission

With Sustainable Hudson Valley and the 100% CT Project

Contents

1. **Introduction**

Why This Project

The challenge of shifting to 100% renewable energy captured the imagination of the Marbletown Environmental Conservation Commission (ECC), a group of skilled professionals appointed by local government to address environmental challenges and enhance the quality of life in town. That interest was shared by Sustainable Hudson Valley, a regional organization devoted to accelerating the shift to renewable energy through local innovation. Both partners understood energy as an issue that profoundly affects household and business economics and quality of life, and as an arena for involving the entire community in a process of positive change.

Governments and businesses around the world are making commitments to 100% renewable energy. Major players include the city of Atlanta, the state of Hawaii, nearly 50 countries, and 140 major companies including IKEA and Swiss Re. California, the 5th largest economy in the world, is committed to 100% renewable electricity by 2045. And these efforts are showing up in smaller communities like Burlington, Vermont and Greensburgh, Kansas as well. Some of these efforts are moving fast. Uruguay, for example, is already getting 95% of its electricity from renewables after a ten year push.

New York has passed the Climate Leadership and Community Protection Act (CLCPA), committing the state to achieving 100% renewable electric power by 2030, and an 85% reduction in greenhouse gas emissions by 2050. The CLCPA provides for any remaining greenhouse gas emissions in 2050 to be reduced to zero by purchasing carbon offsets, thus achieving a decarbonized economy statewide by 2050.

With its large solar array to power municipal operations, Ulster County is already getting 100% of the electricity for county operations from solar power, and aims to do more.

In 2018, Marbletown became the first municipality in New York's Hudson Valley to tackle this transition as a community.

The Partners -- Marbletown ECC and Sustainable Hudson Valley

The Marbletown Environmental Conservation Commission is an appointed local government body. The ECC monitors local environmental issues, works on projects as a Climate Smart Community, and advises the town government on policy and programs. Its members include professionals in finance, business management, architecture, and communications. Marbletown has already created a strong local policy framework for renewable energy including land use guidelines.

Sustainable Hudson Valley is a regional nonprofit organization whose mission is to speed up, scale up, *jazz up* and leverage action to combat climate change in the Hudson Valley. The organization plays the role of expert researcher, strategist, facilitator, and advocate. SHV focuses its work on cities, towns and villages as places that are big enough to matter yet small enough to influence. SHV has studied effective processes for creating actionable plans for the transition to 100% renewable energy around the world, and wanted to stimulate this work in the Hudson Valley by demonstrating the potential with a trusted pilot partner.

Why Marbletown

Marbletown is a stable community with a 2017 population of 5,514. It's a unique town with spirit and a population of innovators. Marbletown has several special circumstances that make it a strong demonstration site for a 100% renewable energy transition plan. Energy costs are generally high, due in part to lack of natural gas infrastructure. Thirteen percent of residents live below the poverty line, while the rest are financially stable to affluent. This makes it realistic for many residents to invest in renewable technologies for buildings and transportation, and for the community as a whole to seek creative ways of making it possible for the rest.

A Climate Smart Community, the Town has strong political commitment to environmental protection, and to the preservation of the historic, small-town character of its hamlets. There are already laws in place to prevent the siting of energy facilities on prime farmland or forests. The ECC works well with elected officials and municipal staff, and has strong support from the Town Board. Centrally located in Ulster County, this community is positioned to serve as a dynamic laboratory of possibility that can demonstrate possibilities to surrounding towns.

How we created this plan

Our goal was to create a highly actionable plan – a set of strategies and commitments that can be implemented in a coherent and cost effective sequence, resulting in the community's use of renewable energy to meet 100% of Marbletown's needs for power, heating and cooling, and mobility. We wanted to accomplish as much as possible over the coming decade.

The first step in the action plan was to study the existing energy needs and infrastructure in town. One of the most cost-effective and environmentally friendly sources of energy is efficiency. The planning process paid special attention to ways of promoting efficiency and conservation, and connecting it with financial savings for the community.

One of the most impactful ways to improve energy efficiency is to shift from combustion of fuel to electrification, since electric devices are almost always more efficient. The action plan therefore includes strategies for supporting the transition away from fossil fuel combustion for space and water heating, and away from fossil-fueled transportation as well. Renewable power, heating and cooling strategies are at the heart of this action plan, along with three important ways of reducing gas-powered transportation: electric vehicles, mass transit, and greatly increased walking and cycling.

Marbletown's 100% Renewable Energy Action Plan began with a focus on electric power supply as the most straightforward option for large-scale change in the short run. The community was able to begin sourcing electricity from an innovative supply option recently enabled by New York State, Community Choice Aggregation (CCA). While the Town took immediate action to enroll in a regional program with Hudson Valley Community Power, the planning team also assessed local options for additional renewable energy siting, including suitable land for large scale solar facilities, the potential of small hydro sites, and the hydroelectric capacity of the local High Falls generating station.

The assessment included the capacity of the electric grid to accommodate renewable power, which will be a limiting factor in the short term. That discovery led to an expanded consideration of renewable technologies for heating and cooling, including biomass (which already plays a

significant role in Marbletown space heating) and solar hot water, which remain options in the future.

To imagine and encourage the widespread shift to renewable technologies for transportation, heating and cooling, the Marbletown team created a multi-year strategy to educate the community and create incentives for households and businesses to adopt these clean technologies. This strategy begins with overcoming barriers to change, building awareness and increasing capacity – for example, making sure that there is plenty of public EV charging, and that service providers like car dealers and HVAC contractors are well prepared to meet growing demand. Even before this formal Plan was finalized, the ECC and SHV had begun to lay groundwork through community education, policy efforts, industry training and group purchase programs.

Marbletown has 2756 buildings, 3684 vehicles, and 3113 electric meters. In 2018, residents and businesses spent a little over $13 million for electric power, heating and cooling, and transportation fuel. The ECC estimates that 90% of electricity demand is currently being met by in-state renewables through the Hudson Valley Community Power Community Choice Aggregation. The renewable electricity is mainly from hydroelectric plants in the Mohawk Valley. Combined with renewable biomass (primarily wood) used for heating, this amounts to approximately 29% of total energy demand met by renewables. Much of the wood used is sourced locally by residents, but some is trucked in from out of town.

The ECC estimates that fully harnessing the opportunities for efficiency and electrification could cut total energy demand by at least 40%. The reductions in cost that result from increased efficiency are an important possible source of funding for the building and vehicle upgrades needed for the transition.

For in-town solar generation, there are over a dozen viable sites. Combining these with a 3.1 MW run of river hydropower generator at High Falls, the Plan would meet existing power demand while taking every possible action to reduce it. The Plan goes on to map year-by-year adoption of renewable heating and cooling technologies, and transportation approaches, including electric vehicles, transit, and people-powered transportation.

The Path Forward

Marbletown's 100% Renewable Action Plan was developed from mid-2018 through early 2020. The conceptual plan was completed in a few months, followed by an in-depth focus on how to translate vision into action. At first, we looked at 2030 as a target for deep reductions in greenhouse gas emissions that is widely embraced by climate scientists, and tried our best to imagine Marbletown achieving a complete transition to renewable energy in that period. At the same time, we were committed to keeping our recommendations realistic - that is, making assumptions about human behavior that recognize how differently people will respond to this ambitious set of goals. So this report includes a discussion of several scenarios for the scaled-up adoption of renewable electricity, heating and cooling and transportation technologies:

- a baseline "business as usual" pathway;
- a scenario assuming enthusiastic community engagement;
- a "least cost," economically optimal scenario, which assumes all replacements of equipment and vehicles are electric or renewable starting in 2024; and

- a scenario which combines the least cost path with enthusiastic community engagement leading to earlier replacement of some equipment and vehicles.

We recognized that the path forward will be impacted by factors beyond our control as a town, including the ripple effects of the pandemic as well as state and federal policy and broader energy trends. Regardless, we focus on what we can do locally.

This effort is designed as a call to voluntary action. Some in town will not choose to participate. As we move ahead, we will identify sources of in-town greenhouse gas "sinks" (such as soils that are farmed using regenerative techniques). These can compensate for any fossil fuel emissions that remain, so that the town can achieve net zero emissions regardless.

This plan is a road map that the community will need to learn how to navigate. The pace of change will depend on the leadership and creativity that is brought to bear. It begins with immediate actions that local government can take on behalf of the community, including public education, subscription to renewable electricity by the town, and a review of local policies to identify changes that would make it easier for everyone to go renewable.

In 2019, the town adopted policies that will encourage the shift to renewables:

- prohibiting fossil fuel infrastructure such as power plants and natural gas metering and compression stations as permitted activities in the town, formalized in the zoning code,
- adding energy storage to the zoning code,
- reducing and simplifying building permit fees for roof-mounted solar to encourage installations, and
- committing the Town to researching the availability and economics of electric or renewable alternatives before buying any vehicle, equipment, or device that uses fossil fuels.

Other policy innovations under consideration are:

- the adoption of New York's new "stretch" building energy code that sets higher standards for new construction and major remodels, and
- changes to the building permit fee schedule to promote energy efficiency and building electrification.

Power supply was identified as the first priority on the timeline, thanks to the availability of Community Choice Aggregation (CCA) to provide renewable electric power to all meters in town (except where customers opt out). As this plan was being finalized, the Town Board approved participation in Hudson Valley Community Power's CCA program for this purpose.

We were just finalizing this plan in early 2020, when the covid-19 pandemic hit the news. This combined crisis of public health and economy has injected a great deal of uncertainty into all our lives, and into these efforts. From oil prices to population shifts to job losses, we are in a new reality that is evolving rapidly. The many second homes in Marbletown have suddenly turned into primary residences for our neighbors from

metropolitan New York, potentially creating conditions for population growth. Small business closings have made our community more economically vulnerable, and the overwhelming of the social safety net has created stresses for our farms.

At the same time, many residents are sheltered at home and paying fresh attention to the comfort levels and economics of their homes and lifestyles. People are more receptive than ever to online education, as well. In light of the long-term economic benefits connected with energy efficiency and renewable choices, we believe the community benefits of the transition to renewables are greater than ever. What is more, the covid crisis brings home the human costs of environmental degradation and reinforces the importance of action to tackle climate change. While the work of implementing this plan will require extra adaptiveness in these times, our commitment to it is unchanged, and so is the foundational strategy of community education.

From the beginning of the planning process, we were actively educating the community about the vision and the many ways to participate. The ECC and SHV held a community forum in September 2018, a Clean Power Expo in June, 2019, and a comprehensive webinar about the project in May 2020. Additional workshops have promoted Community Solar subscriptions and a framework for households and businesses to take "Ten Cost-Effective Steps" for shifting to renewable energy when they replace appliances, equipment and vehicles.

In virtual or face to face mode, we are well prepared and eager to continue working with the community to translate this vision into action.

2. **Marbletown's Energy Use**

Buildings

There are 2,756 buildings in Marbletown -- mainly single family homes. The top sources of heating fuel are oil (1842), propane (431) and electric resistance (222). There is also considerable use of wood as a secondary fuel. We estimate that these buildings use about 178,247 mmBTU (millions of British Thermal Units) of energy for heating and hot water.

Marbletown has over 400 historic structures from the 18th and 19th centuries, making it one of the most concentrated collections of vintage and historic properties in the country. Historic buildings can be especially challenging to insulate due to thin and non-existent wall cavities, aged materials and other factors. Typical historic buildings in Marbletown are built of stone and have small rooms. Insulating outside the stone walls would destroy the historic appearance of the buildings, while interior insulation would use already scarce indoor space and in some cases would compromise the exterior masonry.

These buildings also require care in designing solar arrays, so that they fit well with the aesthetics of properties and neighborhoods. However, there is a great deal of precedent and technical guidance available for this, from reputable sources such as the National Trust for Historic Preservation and the National Park Service. The ECC is committed to making sure that new technologies are installed in harmony with the existing architecture and streetscape.

Thanks to advances in materials and building science, all buildings, including historic ones, can be retrofitted to use much less energy than they did originally. New York State provides low to no cost energy assessments for residents and businesses, and very cost-effective services for building energy upgrades. In Marbletown as in every community, many more people are eligible for these benefits than the fairly small numbers who have used them. Air sealing and insulation help to reduce both heating / cooling and electricity demands. And as the efficiency of lighting and appliances increases every year, it is more and more economical to upgrade with high-efficiency and renewable alternatives.

Today it is possible to improve the efficiency of buildings by replacing fossil-fueled heating and cooling with renewably powered heat pumps and heat pump water heaters. It is also possible to switch to renewably powered electric appliances and tools including lawnmowers, snow blowers, weed wackers, small tillers, etc.

Power

Electric power is distributed to Marbletown's 3113 electric meters by Central Hudson Gas & Electric, a subsidiary of the Canadian company Fortis. The majority (2640) of Marbletown meters are residential, 326 are classified as small commercial, and the

remaining 147 as large commercial/ institutional. These large facilities include the campus of SUNY Ulster, part of the state university system which has made a commitment to moving toward zero carbon by 2040. While commercial energy use, at 3.7 GWh annually, is not a large segment of Marbletown's total annual 27.8 GWh demand, these users have the opportunity to get out in front by generating their electric power onsite with solar energy and supporting larger-scale renewable installations in the public interest.

In New York's deregulated system, customers may select the supplier of their choice. In 2019, the town took a giant step towards 100% renewable electricity by selecting Hudson Valley Community Power, a provider of clean energy through Community Choice Aggregation, as the default energy provider for residential and small commercial customers.

Vehicles

Marbletown's population of 5,514 owns a total of 3,684 vehicles. Most of these are passenger cars and light trucks, which we estimate have an average fuel efficiency of 26 MPG. An average driver logs around 10,000 miles per year in this country. Taking the rural nature of the town into consideration, we estimated average miles traveled per year a bit higher, at 12,000. That means the average driver uses roughly 461.5 gallons of gasoline per year, and the town population consumes 1.7 million gallons.

Beyond passenger cars, Marbletown residents have pickup trucks, tractors, snowmobiles and specialty vehicles. Renewable and electric options to meet these needs are coming into the marketplace.

Industry and agriculture

Industry is a relatively small segment of Marbletown's energy use, but it is critical economically. Shifting the largest and most visible workplaces in town to renewable power is a valuable strategy for demonstrating business leaders commitment to alternative energy and helping educate their employees who can take similar actions at home. Shifting industrial and commercial buildings to renewable power is straightforward. Specific industrial applications will have specialized needs; however New York State's Energy Research and Development Authority has a well developed program for technical assistance and financing that can aid these businesses in stepping up.

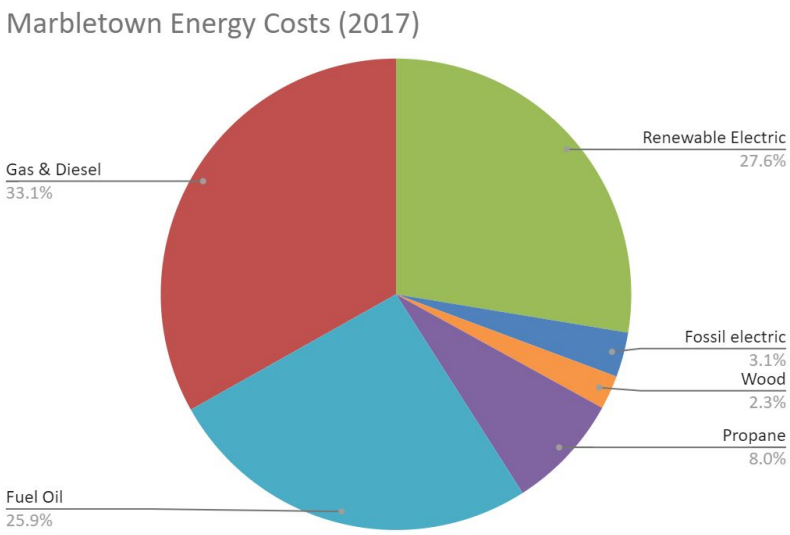
Agriculture is a signature industry in Marbletown. Though they are economically pressed, farmers in the Hudson Valley are organized and innovative. In recent years, farmland loss has slowed and there is a lively influx of new farmers and value-added agribusiness in the area. Agriculture needs reliable energy throughout the year, but especially during the period from spring through fall when solar energy is most abundant. New York State has an active program of technical and financial assistance for energy conservation and renewables in the agricultural sector, which will be a valuable resource for our efforts. At the same time, every farm's needs are unique, and

every farmer is challenged to make their business work. This sector deserves careful and customized outreach and support to participate in the shift to renewables.

Farming practices also have significant potential to reduce greenhouse gas emissions and even sequester carbon. Strategies such as no-till planting, biochar, and regenerative grazing have all shown great potential to remove atmospheric and sequester it in the soil. Although beyond the scope of a renewable energy plan, giving farmers incentives to adopt these practices has the potential to support local agriculture while offsetting greenhouse gas emissions.

Energy uses and users

We converted these figures into a common measure, million British Thermal Units (mmBTU), to create an estimated target for the renewable energy supply needed: 446,533 mmBTU per year. This is the energy needed by the community, business and local government to travel to work and play (and for the sizeable population of part time residents to get to and from Marbletown). It's the energy needed to light, heat and cool buildings, to power computers, lawnmowers, snowblowers, farm equipment and more.



This current load meets the needs of a socioeconomically diverse population and supplies buildings that range from recently built to pre-Revolutionary. The community covers a spectrum from affluent and comfortable to disadvantaged. According to 2019 data:

- 13% of Marbletown residents lived at or below the poverty level;
- and 17% of the population or about 700 people self reported as non-white;
- there were 61 minority-owned firms;
- there were 270 women-owned firms.

In developing this plan, we thought seriously about the needs and contributions of this entire population, and ways to work with population segments such as these, in order to ensure that the changes we recommend are realistic and comfortable for the community, and that the benefits of our effort were accessible to all.

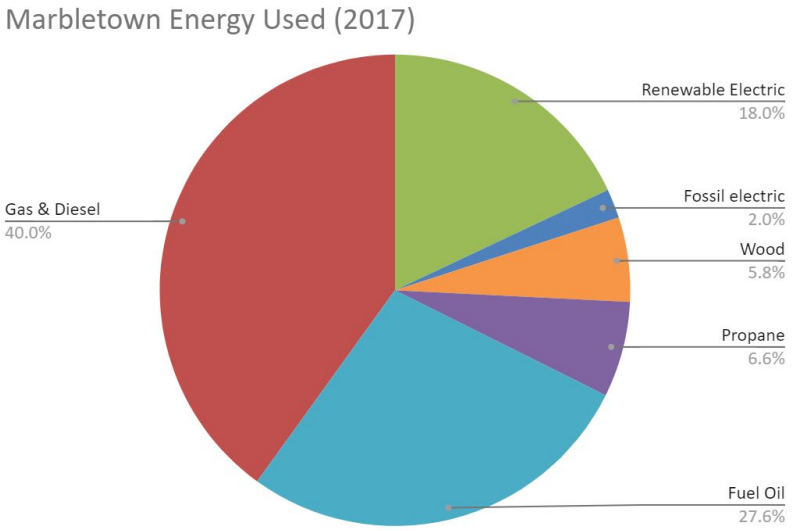
3. Energy Resources

Though it is heavily forested, Marbletown has a variety of resources for siting and supporting renewable energy supply, from small scale to large.

Rooftop solar. Most buildings in the Northeast were constructed without any attention to taking advantage of solar power, so many are poorly oriented. Overall, 20 – 25% of building roofs in the Northeast are a good fit for solar based on their orientation, condition and ownership. Because of the local tree cover, we estimated Marbletown's percentage at 15 – 20%. Still, many more buildings could go solar than have done so. A Solarize program of public education and group purchasing in 2017 laid a foundation of community education.

Renewable power generation sites in town. Marbletown has taken proactive steps to protect forests and farmland from energy development by law. Still, there are more than a dozen viable sites for solar installations on the order of 100 kW or more. Two or three may accommodate a megaWatt or more, on public and private lands.

High Falls is home to a run-of-river hydroelectric site on the Rondout Creek. Owned by Central Hudson, the plant's capacity is 3.238 MW.



Community Choice Aggregation now supplies electric power to nearly everyone in Marbletown. Around 15% of this power is sourced from run-of-river hydroelectric plants in the Upper Hudson Valley. The rest comes from the purchase of Renewable Energy Credits, largely from upstate New York hydro and wind power.

Community Solar is an additional subscription option, available to everyone who pays an electric bill and does not have rooftop solar. Some residents have taken advantage of this option by subscribing to facilities around the Hudson Valley, and more recently the New Beginnings Solar Farm has been constructed right in Marbletown.

Electric vehicles are showing up around town, though they are still a very small part of the mix for passenger transportation. With over 40 makes and models on the market as of early 2020, the EV marketplace is growing rapidly though chaotically.

Charging infrastructure is in place at the Town offices, Community Center, Stone Ridge Library, the SUNY Ulster campus and a private gym, all high-traffic areas. Private building owners such as workplaces and educational institutions can also contribute to EV capacity by installing chargers on their properties. At least five area car dealerships began to feature EVs in 2019, and their staff have been trained by Sustainable Hudson Valley to sell EVs' features and benefits.

Renewable heating and cooling powered by electricity is far more efficient than burning fossil fuels. The primary electric approach to renewable heating and cooling is the heat pump. This broad category includes air source heat pumps, also called "mini-splits"; ground source heat pumps (geothermal), and heat pump water heaters.

These renewable heating and cooling technologies are developing rapidly. Air source heat pumps are suitable to serve as the sole heat source in cold climates like New York's. Incentives from New York State and the electric utilities reduce the cost of installing them. Sustainable Hudson Valley's HeatSmart program works in partnership with these organizations to educate the public and identify quality contractors. Heat pumps and heat pump water heaters are one of the more cost-effective renewable technologies you can install, because they pay for themselves in savings early in the ownership cycle.

This Marbletown home demonstrates two forms of renewable heating: an air source heat pump and biomass heat from wood.

Because there are currently grid constraints to renewable power generation, the ECC also looked into two non-electric approaches to renewable heating and cooling: solar hot water and high-efficiency biomass stoves.

Solar hot water is most suitable for niche applications with high water use, including hospitals, restaurants, gyms, laundromats, and large housing complexes -- unfortunately a small part of Marbletown's energy demand. Some residents may have success using solar hot water at home, but we are not "pushing" this option for homeowners generally, unless technology improves and momentum develops.

Biomass technologies interested the ECC because of their potential for a local industry with careful forest management. We have observed wood smoke from chimneys and stacked cordwood in all parts of the town, but especially in outlying areas. One local

business heats its service area with a pellet stove that burns corn which would otherwise be wasted, keeping things toasty at nearly zero cost for the business. Residents appreciate wood heat as an economical alternative to fuel oil or propane; many residents enjoy gathering wood themselves. As a heat source that works during power outages, wood increases community resilience. Therefore, we recognize wood as part of the renewable mix.

However, even the most efficient modern stoves still pollute. To the extent that wood burning continues as part of the mix, the ECC recommends developing strategies for increasing the heat captured from a given amount of wood, while minimizing the emissions. The most important of these strategies will be encouraging the replacement of older wood stoves, which are many times more polluting than stoves meeting the 2020 EPA guidelines. Encouraging early wood gathering and proper dry storage helps as well. Environmentally responsible use of wood requires, at a minimum, two protections: harvesting the wood resource no faster than it can be replenished, and addressing the air pollution from even the best wood stoves. Many households that heat with wood have been doing so for a long time. This probably means that many woodstoves in use are older models and there is likely an opportunity to develop a program that supports upgrading.

Summary

Marbletown has all the resources it needs for renewable power supply, building heating and cooling, and mobility. Its biggest constraints are the capacity of the electric grid, and the complexity of these large-scale changes in consumption and production. Ambitious improvements in energy efficiency are the key to supplying as much of the Town's energy needs as possible locally, and to reaping the greatest rewards from cost savings. The work ahead is to match resources to demand, take full advantage of the opportunities for efficiency, and educate and inspire the community to participate.

4. **Efficiency and Electrification: A Strategy for Reducing and Managing Demand**

Going electric – the key to efficiency

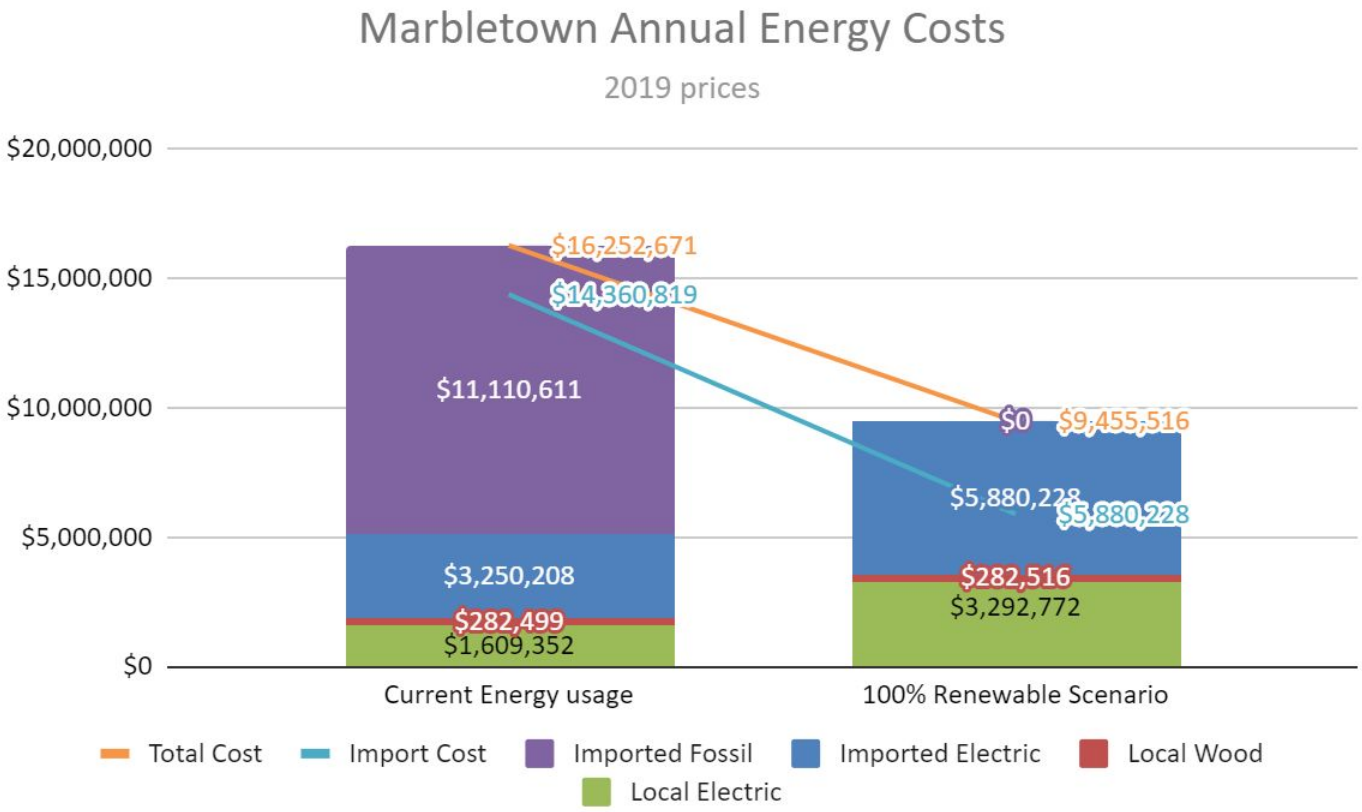
To make the 100% shift realistic, sharp increases in energy efficiency and productivity are needed. Marbletown's energy load could be reduced by as much as 40% through

aggressive energy efficiency and conservation efforts in buildings, transportation and electricity use, combined with a shift from equipment that burns fuel to more efficient, electric versions. One of the highest-impact ways to get more out of the available energy is to shift from combustion based technologies to their electric counterparts, such as heat pumps and electric vehicles, which are far more efficient by their nature. For example, the following chart shows the "coefficient of performance" (COP) of electric heat pumps (an efficiency rating) compared to biomass, fossil fuels and electric baseboard heating. The COP of a heat pump is defined as the ratio of useful energy output to the work required to produce it. The last line shows costs for the same amount of heating and cooling benefit, based on current estimated fuel costs.

ELECTRIC or COMBUSTION	ADVANCED WOOD STOVE	FUEL OIL BOILER	CONDENSING PROPANE FURNACE	ELECTRIC BASEBOARD	AIR SOURCE HEAT PUMP	GEOTHERMAL HEAT PUMP
COP	**0.65**	**0.85**	**0.90**	**1.00**	**2.92**	**3.89**
Efficiency	**65%**	**85%**	**90%**	**100%**	**292%**	**389%**
Yearly Cost	**$1,500**	**$2,992**	**$3,232**	**$4,000**	**$1,370**	**$1,028**
Fuel Price	**$200/cord**	**$3/gal**	**$2.73/gal**	**$0.14/kWh**	**$0.14/kWh**	**$0.14/kWh**
BTU/unit	20000	115000	91500	3412.14	3412.14	3412.14
$/mmBTU	$10.00	$26.09	$29.84	$41.03	$41.03	$41.03
$/mmBTU delivered	**$15.38**	**$30.69**	**$33.15**	**$41.03**	**$14.05**	**$10.55**

Like heat pumps, electric vehicles are moving into the mainstream marketplace as cost-effective options. With forty makes and models available to choose from, the electric vehicle market is growing 50 – 60% per year. Many models are cost-competitive with gas powered cars. Air source and ground source heat pumps are in more common use than ever. Recent advances in these technologies allow them to be used as the sole source of heating in most well-insulated homes in upstate New York.

So a fundamental feature of this Plan is a coordinated shift from burning fuel to using electric power from renewable sources, and in the process making our buildings and technology as efficient as possible. The following chart shows expected savings of dollars and energy use as we get closer to 100% renewable energy, and lays out the mix of local and imported power sources we expect to draw on. The more we are able to rely on local or nearby sources, the more we will keep dollars circulating in the local and regional economy.



Shifting from fossil fuels to electric heating and cooling technologies, and shifting wood use to modern equipment, brings a significant added benefit: reducing air pollution. When this electricity comes from renewable solar, wind, or hydropower resources (like most of the electricity used in Marbletown) electrification leads to the complete elimination of emissions.

Building efficiency

Building efficiency is a foundation for renewable heating, cooling and power. Fortunately, the field of building science has given rise to highly effective ways of upgrading the energy performance of a building through common measures like air sealing, insulation, appliance and HVAC upgrades. Air sealing and insulation are particularly important because they improve building comfort and resiliency in addition to delivering financial benefits.

Even though these upgrades pay for themselves quickly, only a minority of New Yorkers have taken advantage of them. Inspiring the public to take these steps requires concerted education and outreach that speaks the language of home and business owners. We will provide consistent, ongoing and engaging education for the community, while at the same time creating policy incentives. Electrifying heating and cooling can help all Marbletown's residents and businesses save money in the long run and -- with

renewable power supply -- improve the community's energy security by getting off fossil fuels.

Air source and ground source heat pumps, and heat pump water heaters are increasingly popular. Marbletown will work with Sustainable Hudson Valley and NYSERDA on a series of HeatSmart education and group purchase campaigns to promote these technologies with competitively selected contractors. The ECC has also taken leadership in experimenting with negotiating group purchase discounts with SHV's HeatSmart contractors.

Obviously, this transition will be a multi-decade process. However, it has begun already, driven by early adopters who are curious and interested in demonstrating new technologies. As group purchases interest more and more residents, economies of scale will increase and drive prices down, making it progressively easier for more people to get on board.

The electric vehicle transition

Electrifying transportation will also be a multi-year effort, as gas powered private vehicles are replaced with EVs and as electric options become viable for buses, trucks, and specialty vehicles. New York is part of the Zero Emission Vehicles Coalition with eight other Northeastern States and California; together these states have set a goal of having 12 million EVs on the road by 2030. But this market is still in its infancy. AAA's annual survey of driver attitudes about electric vehicles shows in 2019 that 16% of drivers are ready to switch to an EV with their next purchase. Range anxiety is waning, but concerns remain about access to convenient, affordable charging. And there is still confusion in the marketplace about driving features and how to compare EV and gas powered vehicle costs. Similar questions exist among car dealers; three separate "secret shopper" studies in the US and Europe found that most car dealerships were discouraging interest in EVs through limited supply, lack of promotion, and by sending signals that the vehicles were not really ready for the market.

To address these issues, Sustainable Hudson Valley is providing consumer education and dealer training under its Drive Electric Hudson Valley program, which has already trained most of the dealerships near Marbletown. As battery costs fall and electric vehicles become more profitable to produce, we expect the auto-makers to be more active partners in ensuring plentiful EV supply, well informed dealers and promotional support.

A realistic transition to 100% renewable energy requires sharp increases in efficiency for every energy use type of user. Energy efficiency programs and services, such as those that are funded by the state and sponsored by the utilities, have engaged a segment of the population but not at the scale or pace that will be required by 2030. New sources of motivation, such as community pride, will be essential, and so will local champions representing the entire community. There will be value in innovative models like "Weatherization Week" in coastal Maine, an annual group purchase and sweat equity extravaganza for getting homes weatherized.

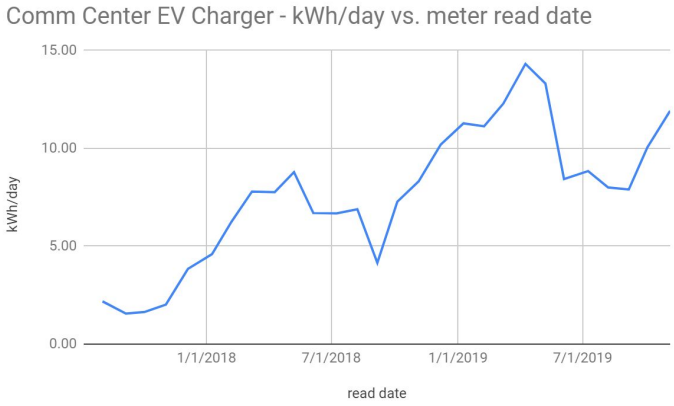
The power grid is presently a major constraining factor for Marbletown's ability to generate renewable electricity locally. Without substation upgrades or significant investments in energy storage, the two substations serving Marbletown have the capacity to host only 6 to 8 MW of solar photovoltaics. The incorporation of energy storage has the potential to accommodate additional solar. As of the date of this publication, one 2 MW solar farm is complete, and a 5 MW solar farm is to be built in 2MW stages, possibly in conjunction with 2 MW of energy storage now in the late stages of permitting. At least two smaller commercial solar installations between 100 kW and 1 MW are in the late stages of permitting, and look likely to be constructed in 2020.

In addition to these late stage projects, approximately 1 to 2 MW of hosting capacity is available at Central Hudson's High Falls substation, which serves the town's commercial and business districts in the hamlets of Stone Ridge and High Falls.

By law, grid upgrades to accommodate new energy supply are the responsibility of the utility if demand growth is demonstrated. Otherwise, private users wishing to change their energy source (or private developers) are required to pay for the upgrades needed to do so. Electricity demand in the area has been generally flat to declining in recent years, so significant upgrades to these substations should not be anticipated until after town electrification efforts have progressed significantly.

Handling load growth and changing usage patterns from electrification. If Marbletown achieves its ambition of rapid electrification of heating and transportation with heat pumps and electric vehicles, electric load growth in the area will likely exceed the utility's forecasts. However, this load growth will be much higher in the winter months, while local renewables will make their greatest contributions in the spring, summer, and fall.

Electric vehicles typically get 20 percent to 30 percent worse mileage in cold weather, leading to higher winter charging loads. This trend is clear in the graph of the average daily electricity usage at Marbletown Community Center electric vehicle charging station in addition to the general upward trend in overall usage.



As these winter peak loads increase, they can be somewhat mitigated through improved building envelopes, and the priority conversion of homes that currently use conventional electric heat to heat pumps. The use of local sustainable wood resources for supplementary heat can also mitigate winter peaks, if the emissions are addressed.

Creating the conditions for success

In addition to promoting efficiency, several other steps are needed to lay the foundation for scaling up electrification of heating, cooling and transportation. These involve preparing and organizing suppliers of services and products, and making sure that charging infrastructure is fully accessible.

1. Supply and service considerations:
    - trained and certified heat pump contractors for installation and repair;
    - well informed middle-persons such as hardware stores and banks;
    - car dealership staff with thorough understanding of electric vehicle technologies and with commitment to maintaining an inventory onsite;
    - expertise on the details of these technologies within local government (such as an ECC subcommittee).

2. Infrastructure for electric vehicle charging:
    - The town has made it a priority to install public charging stations in Marbletown's two downtown commercial districts, so far including the Community Center, library, and a popular gym.
    - The ECC and SHV have begun to develop group purchase options for home charging equipment, by itself or in conjunction with solar arrays.

3. Long term capacity building by creating new infrastructure and industries to handle emerging needs and opportunities.
    - As more and more fossil fueled vehicles and appliances are replaced with renewable options, it is important to be sure they are not simply passed on to other consumers to pollute in other communities. Disassembly and recycling could be appropriate at the county level to serve surrounding communities as well as Marbletown. In the case of vehicles, there may be an opportunity to develop a local industry converting conventional vehicles to electric.
    - As the users of wood heat consider their options for upgrading stoves and managing their emissions carefully through early wood purchase or collection and drying, we will help them with education at a minimum. As we discuss options with these neighbors, we may figure out ways to support upgrading wood stoves such as group purchasing.
    - While we encourage full participation in this transition and its benefits, some members of the community may not choose to do so. To achieve net zero greenhouse gas emissions regardless, the ECC and SHV will explore ways of increasing options for sequestering greenhouse gases in soil or water, such as regenerative agricultural practices.

Encouraging alternative modes of transportation -- including transit, carpooling, walking and biking wherever possible -- can also greatly reduce energy use while reducing traffic congestion and improving the health of residents. The Town and the ECC are looking at

a number of ways to expand our walk-bike trail network. Working with a local gym, we expect to open a new trail connecting the hamlet of Stone Ridge to the SUNY Ulster campus. We are also exploring multiple possible off-road connections between the hamlets of Stone Ridge and High Falls, expanding the trail network in High Falls using Town property to extend existing paths from the center of High Falls up to Mohonk Rd, and are negotiating with a property owner to create a short branch of the O&W rail trail, which would connect the Rondout Municipal Center which houses the offices of both the towns of Marbletown and Rosendale with the existing O&W Rail Trail. A new educational program called Marbletown Walk and Learn will also give residents who might not have otherwise used the existing trail network a reason to get outside and familiarize themselves with what the town already has to offer.

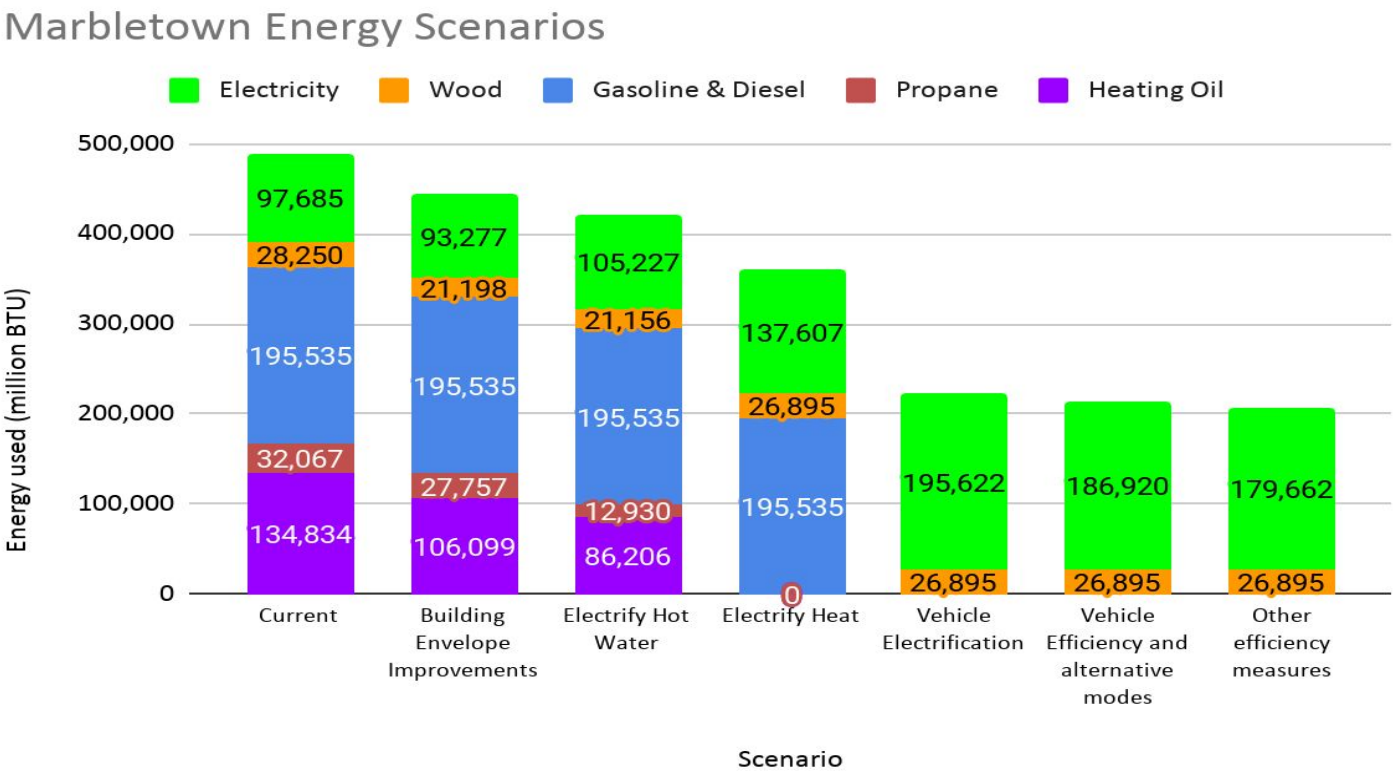
Extensive outreach will be critical to build on this foundation and actually achieve adoption of energy efficiency and renewable energy use at a town-wide scale. Year by year, as prices fall and the technologies become more commonplace, the scale of participation could rise exponentially. Residents with lower income will be able to participate by timing the replacement of fossil fuel equipment to the end of its useful life, and by taking advantage of energy efficiency opportunities to save money. The ECC will monitor progress and course-correct as needed. Sustainable Hudson Valley will continue to assist with implementing the Marbletown 100% Renewables Plan and make every effort to replicate the model in the next wave of communities.

5. Putting it All Together

Strategic vision

Marbletown is a receptive community for experimentation and learning on environmental and energy innovation. It has been an early adopter of state environmental programs such as Clean Energy Communities and Climate Smart Communities. Thanks to political support for innovative local policies, the ECC has been able to experiment with new policies, programs and strategies, and does so in careful consultation with elected officials and staff. The community effectively functions as a test bed for local laws and programs to address climate change and environmental concerns. The 100% Renewable Action Plan was created by the Marbletown ECC as a scenario of possibility, and shared with the community informally for feedback throughout its development. Now, with publication of this statement of vision and strategy, the community is invited to amp up participation, share lessons learned, and generate local pride as well as economic advantage by taking leadership to implement this plan.

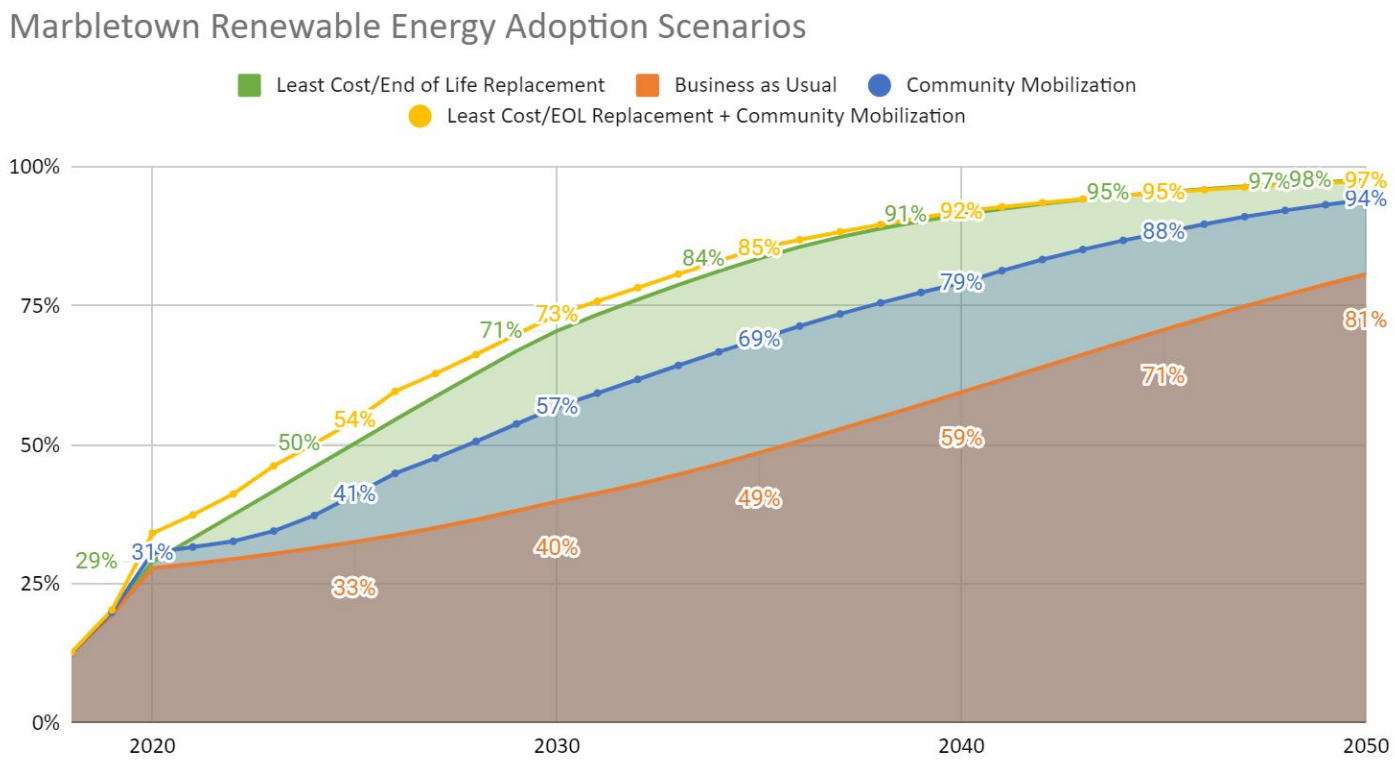
For both residents and businesses, long term cost savings and controllability of expenses will be an incentive to participate. At the same time, significant investment is needed for high levels of energy efficiency and the switch to renewable heating/ cooling and transportation. The smartest financial strategy for managing the necessary changes is investing, first in building efficiency, and then replacing building systems with electric and renewable options when they need to be replaced anyway. This approach creates initial savings that can be used to help cover the up-front costs of the next investments. The chart below demonstrates just how much the overall energy demand can be reduced.



An immediate and ongoing source of funds will be community solar subscriptions. These make it easier to build up capital for future investments. In addition, the costs of renewable energy and storage have been falling sharply, making renewable options more competitive for replacing heating and cooling systems, and for vehicle purchases, every year. By encouraging residents and businesses to make the transition in their own ways, at their own pace, the Marbletown vision makes it realistic to conceive of a large-scale shift in consumption patterns without hardship.

Reality check: Modeling progress

To be sure we are setting achievable goals, we considered the kinds of year-by-year scenarios of progress that would be needed. We created models of the pathway to 100% renewable energy, looking separately at each of the three main parts of Marbletown's energy use: electricity, building heat and hot water, and vehicles.

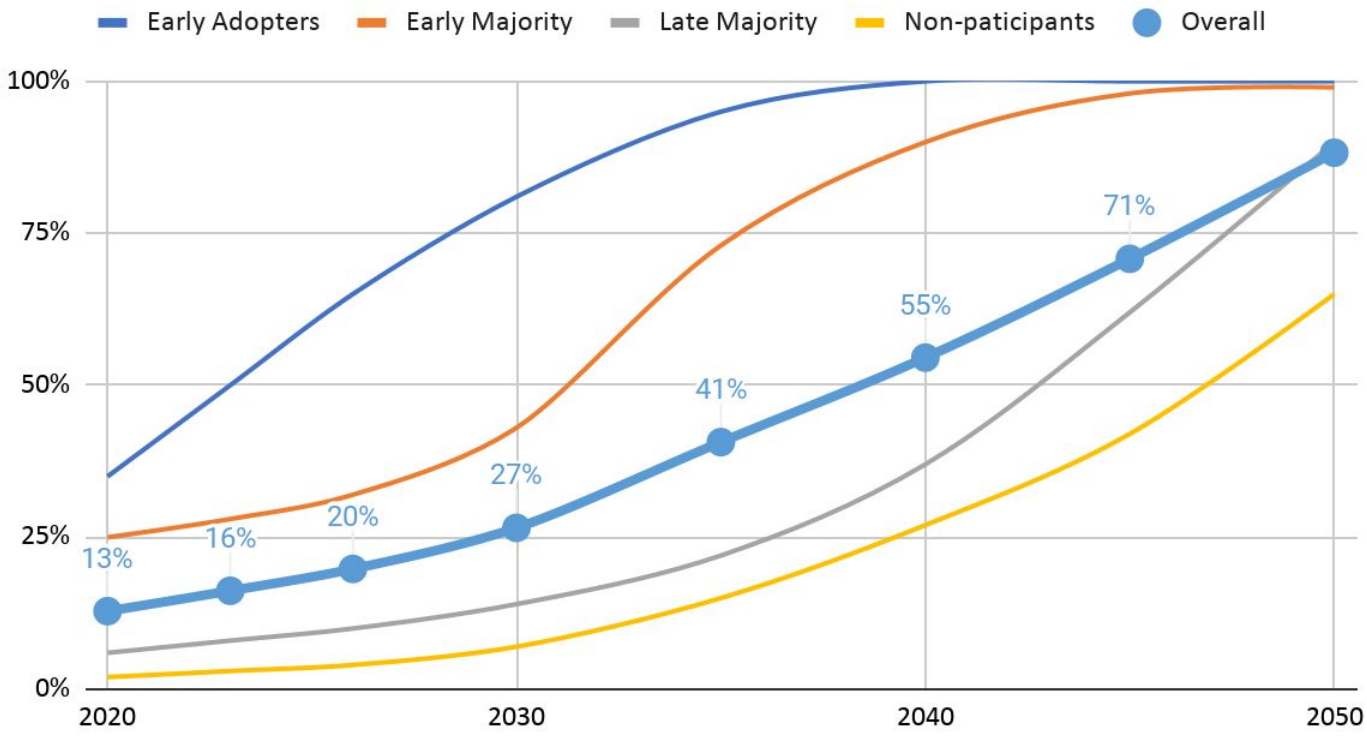


The first is "**Business as Usual**," with modest but steady adoption of renewable options to replace fossil fueled equipment. Technologies for homes and businesses like solar panels, electric vehicles and heat pumps are rapidly falling in price and often have superior performance than their fossil fueled equivalents. The technologies are proving their durability, and the companies that produce them are marketing more and more actively. As this happens, more people will naturally make the switch, especially since the high cost of fuel oil and propane for heating make them a good value in Marbletown.

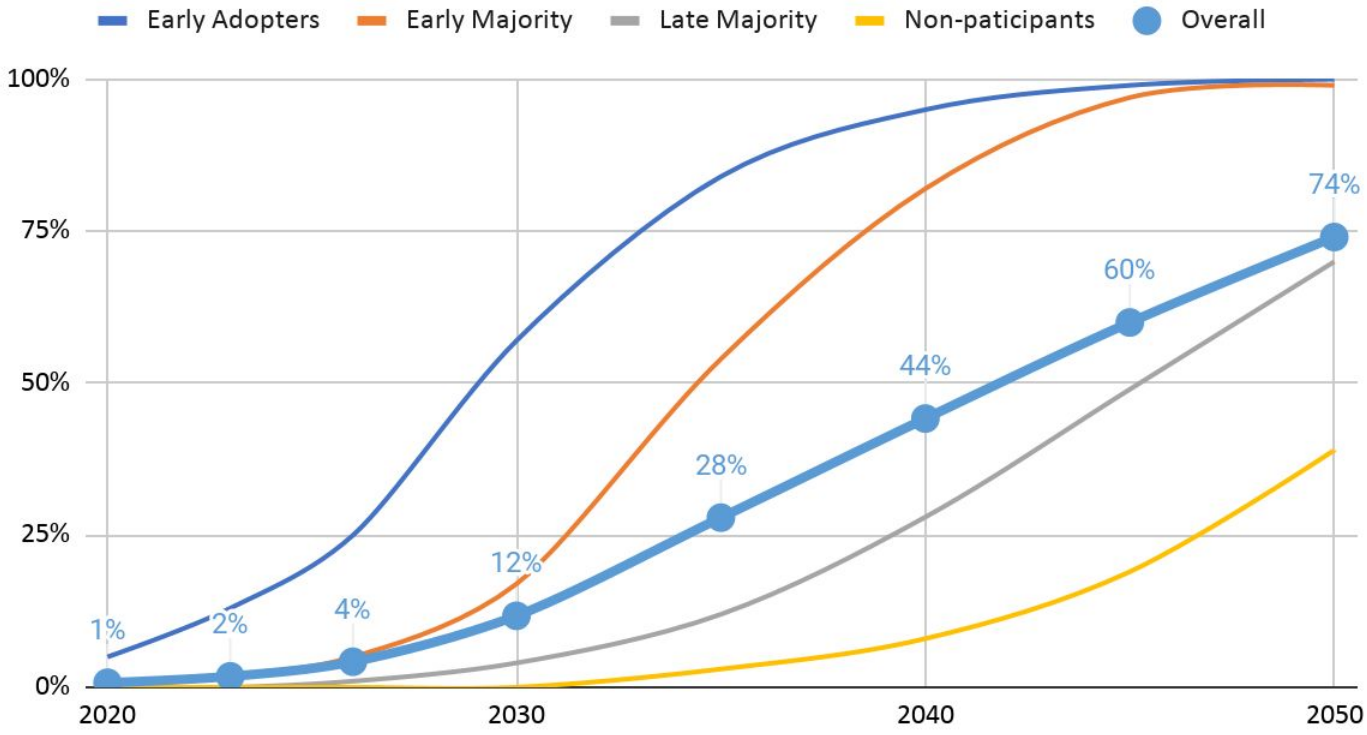
We developed this scenario using a social diffusion model, with the population divided into four groups: "Early Adopters" have an affinity for adopting new technology and compose 10% of the population. "Early Majority" are open to new things, but like to know someone else who has tried it before adopting it themselves. They compose 25% of the population. Late Majority will adopt new technology and ways of doing things when they know several other people who have already made the change and benefited from it. They compose 45% of the population. Finally, "Non-participants" prefer traditional ways of doing things, and will generally stick with them until that becomes more difficult than adopting a new standard. Non-participants compose 15% of the population.

For each of these groups we developed a separate adoption curve for both vehicles and building systems. Charts showing these adoption curves are included below:

Business as Usual Building Electrification



Business as Usual Vehicle Electrification



We combined all these curves along with a curve for the percentage of renewable electricity starting at 90% in 2020 and rising linearly to 100% in 2030 to develop an overall percentage of renewable energy used by the Town's residents and businesses in the Business as Usual Scenario.

The second "**Least Cost/Full End Of Life Replacement**," makes the assumption that residents, as rational economic actors, will replace their building systems and vehicles at the end of their useful lives with renewable or electric equivalents at the end of their useful lives. Since both electric vehicles and air source heat pumps have lower total cost of ownership than their fossil fueled equivalents, rational economic actors will always choose electric vehicles and heat pumps or biomass based heat such as efficient wood stoves when replacing old equipment at the end of its useful life. In this scenario, we assumed all new vehicles and building equipment would be renewable or electric starting in 2024.

There are a number of market barriers to this Least Cost scenario in pure form. When building equipment breaks, the building owner seldom has all the possible replacement options available to choose from, and often also lacks critical information. This often leads to the most expedient decision not being the least cost decision, such as when a building owner replaces a broken oil boiler with another boiler during a cold snap.

Similarly, although the types and availability of new electric vehicles is increasing rapidly, there is currently a shortage of all wheel drive, work truck, minivan, and SUV options, and even when suitable electric or plug-in electric vehicles exist at a competitive price, lack of knowledge among both customers and dealers, as well as lack of inventory and misaligned incentives for sales staff often leads to the purchase of a fossil fueled vehicle despite a higher total cost of ownership.

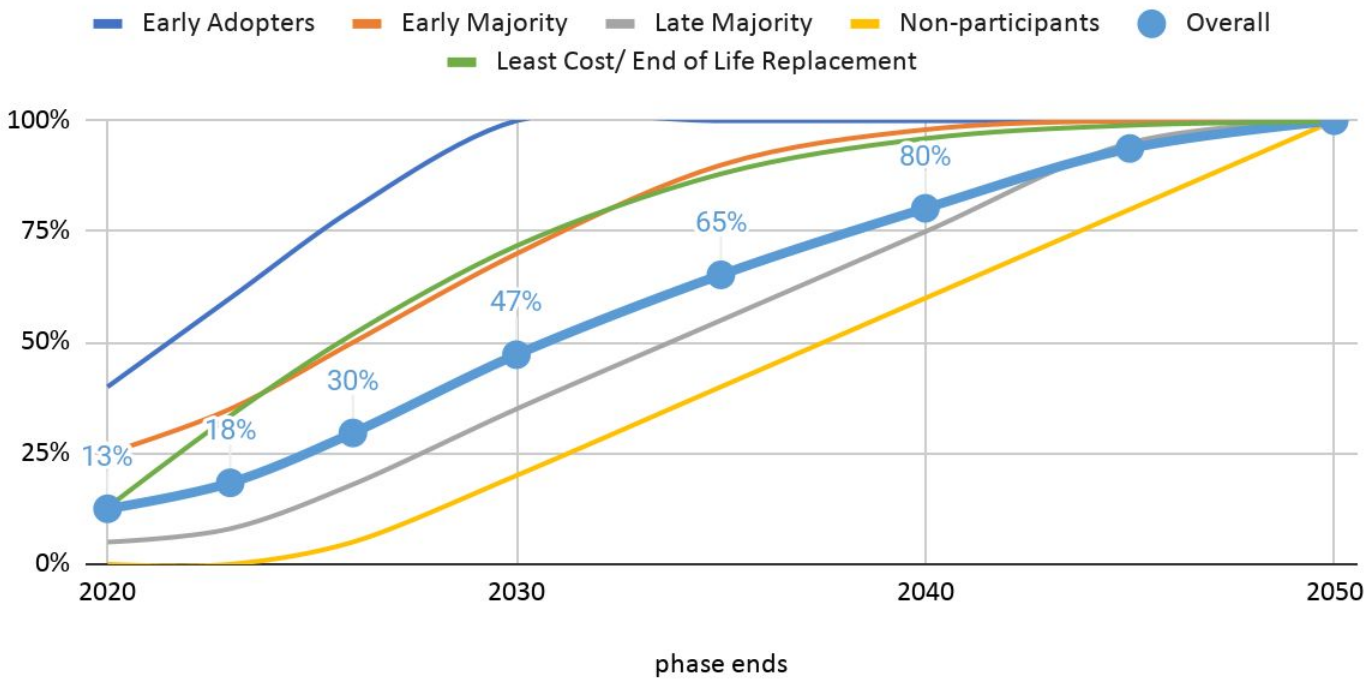
Because of these market barriers, this Least Cost scenario is unlikely to play out without significant local policy changes, which might be incentives, regulations or a mix. If the community sees the value of a rapid yet cost-effective transition and politically supports these, this scenario accelerates progress while minimizing costs.

The third scenario, "**Community Mobilization**," illustrates the potential of an ambitious outreach campaign to mobilize the community and inspire more residents to replace their fossil fuel equipment with renewables as soon as they are able. Achieving this vision will require passionate involvement of many people, strong leadership, technical and financial support to make the opportunities widely available. We aspire to create a culture change as early adopters of renewable energy influence friends and neighbors with their enthusiasm.

Like the Business as Usual scenario, we modeled this using social diffusion between the four population segments. The following two charts show the adoption rates we modeled for each of these segments for buildings and vehicle electrification. The Least Cost / Full End of Life Replacement adoption rate for buildings and vehicles is included for comparison.

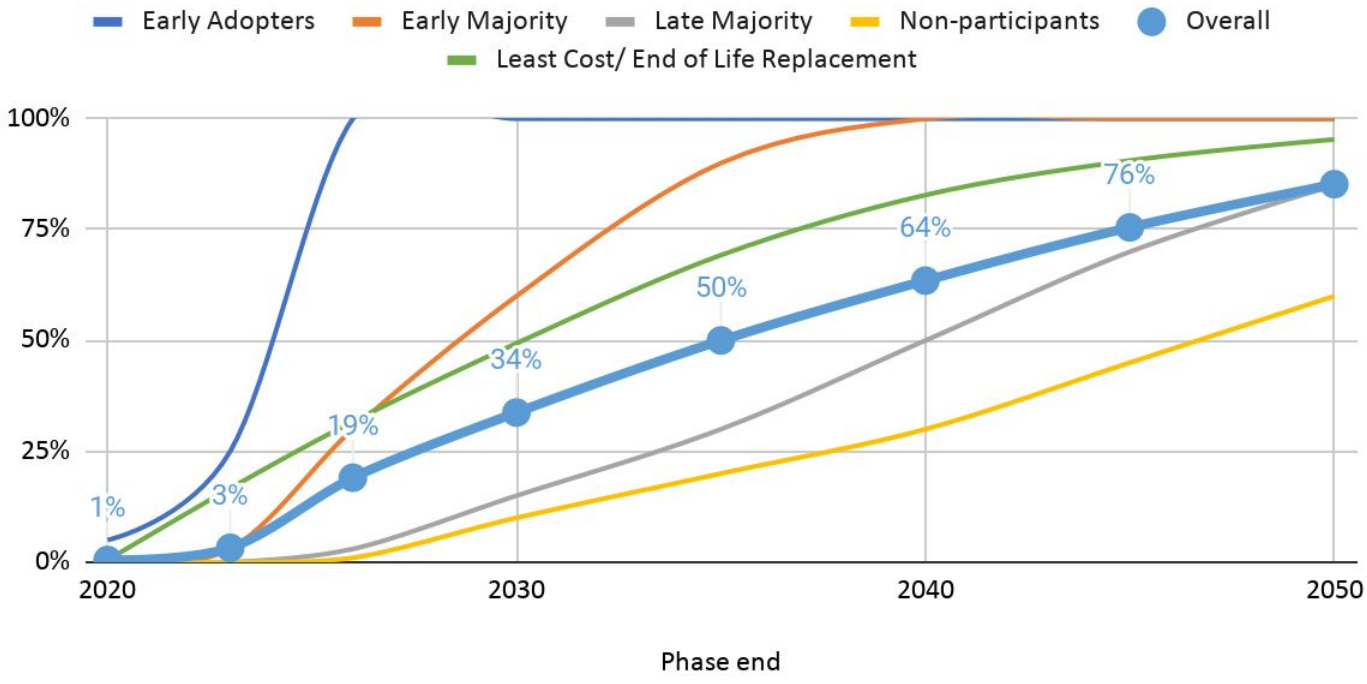
Building Electrification with Community Mobilization

vs. Least Cost/Full End of Life Replacement scenario



Vehicles Electrified With Community Mobilization

vs. Least Cost/Full End of Life Replacement scenario



The final scenario "Least Cost/Full EOL Replacement + Community Mobilization" combines ambitious community mobilization techniques with full end-of-life replacement to show the maximum progress toward 100% renewable energy that we consider possible. It takes advantage of the fact that early adopters are often willing to replace equipment before the end of its useful life, but assumes that other segments of the populace behave as economically rational actors seeking to minimize overall costs. This scenario achieves a 30% increase in penetration of renewable energy by 2040 – a result we consider to be worth serious commitment.

Roles and responsibilities

The ECC has been creating conditions for implementation of this effort by building a wealth of partnerships within and outside Marbletown. These include independent experts and contractors, agencies, finance providers, educators and advocates. Within its existing mandate, the ECC is well positioned to coordinate the creation of policies and programs – and to engage the community in reinventing its approaches to heating and cooling, mobility and power.

As Ulster County has done, Marbletown has begun by incorporating renewable energy planning into its purchasing policy. Over time, this will ensure that all Town government operations are renewably powered, including buildings, fleets, and public works operations.

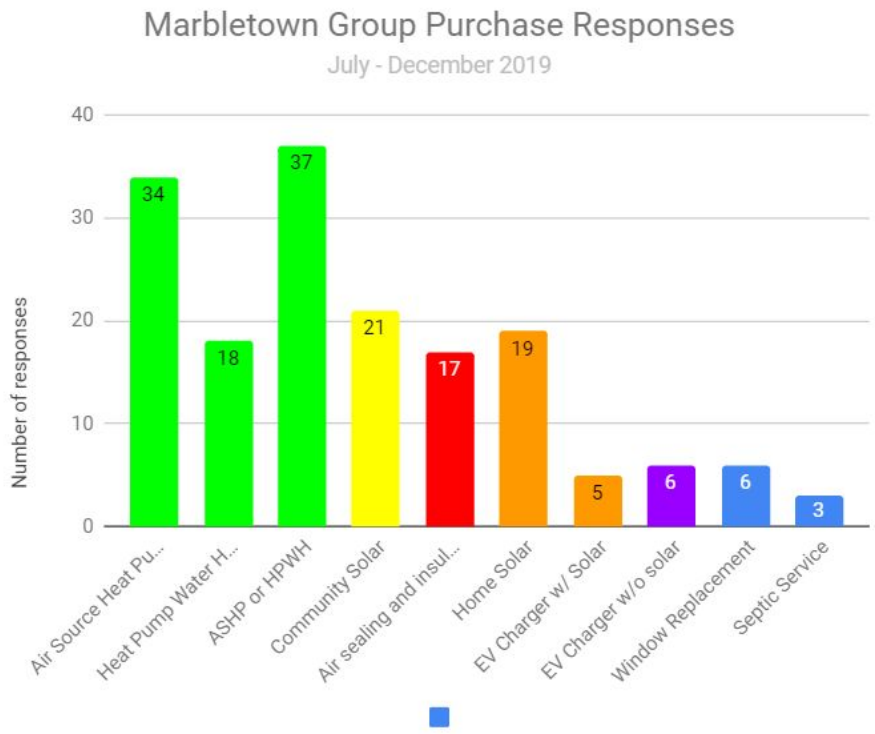
Leading by example will be essential, but not sufficient. This far-reaching plan will require much broader involvement and investment than most projects that a small community might consider. The Town Board will be invited to pass a resolution formally adopting this Plan. That resolution designates roles and responsibilities for stakeholders:

- Local staff will be responsible for implementing the municipal aspects of procurement and facilities management, and administering local laws and codes.
- Elected officials will be spokespeople and champions, building awareness and understanding in the community.
- State and county agencies, including NYSERDA and the New York State Office of Climate Change, will be essential partners to provide technical and financial resources; as we gain momentum and see results, we hope these agencies will also help to share and replicate this model.
- Businesses and economic development agencies will play a particular strategic role in implementing this plan. Businesses can be the most visible, often large-scale users of renewable energy and can develop profitable ventures in technologies that support the transition. Local and county economic development agencies will find Marbletown a receptive partner in identifying opportunities for business attraction and development that support the clean energy transition.
- Nongovernmental partners will be essential to support the outreach and technical assistance efforts that will ensure the success of the transition to 100% renewable energy. Sustainable Hudson Valley is committed to walking along this path with

Marbletown to support and document the process and refine the plan when needed.

Public Outreach

The ECC is developing a public outreach campaign based on the same principle of replacing vehicles, appliances, and HVAC systems with electric and renewable fueled options as they reach end-of-life or before. The campaign will include education about electric vehicles, air and ground source heat pumps, heat pump water heaters, electric induction cooking, and electric equipment such as lawn mowers and snow blowers. Product-neutral technical assistance resources will be available to make participation easy and rewarding. The ECC and SHV will work with members of the community, as they are ready to participate, offering support such as technical assistance and group purchase discounts.



The ECC has begun building capacity and increasing the adoption of renewable technologies by organizing group purchase programs for solar power, community solar, renewable heating and cooling technologies, water heating, and building envelope and insulation, which attracted over fifty participants in six months.

The guiding principle of Marbletown's public outreach campaign is a personalized commitment, the "100% Renewable Pledge":

"I pledge to shift my energy use to 100% Renewable Energy, as quickly as I am able. I will save money immediately with community solar or install solar on my building. I will learn about electric and renewable alternatives so that I am prepared to replace a fossil fueled vehicle, appliance, or tool. I will keep at it and share lessons learned in the community."

This is a significant commitment. We do not expect that the entire community will be ready to take that stand right away, or will approach it in the same way. But as we explore the ways to make the shift - as a community - we will learn together. That is why the Pledge is designed to begin with a commitment to learning. This ensures that community members are ready and know what to buy when it is time to replace their fossil-powered technologies -- even if they have to make the switch in a hurry, such as when a boiler breaks in the middle of winter or a car is totaled. Businesses taking the pledge will commit to providing the educational resources their customers need to fulfill the pledge with respect to any types of equipment they sell.

For some households and businesses, it will be exciting and timely to step up to make these changes when the opportunity presents itself. Others will want to think, learn, plan and see how it goes for the first movers. When financial resources are a limiting factor, renewable replacements for equipment and vehicles can be timed to coincide with the end of the equipment's useful life or when it breaks. By calling for planning and learning, rather than only focusing on immediate action, the Pledge is designed to be economically realistic for people at every income level. The ECC and SHV will work with all segments of the community based on their readiness and values; we expect waves of participation and will learn new ways to respond to the concerns that each one brings.

The planning process has been informative for the ECC and SHV, as we have considered the possible barriers to this transformative change. Renewable technologies are rapidly becoming cost-competitive, so the biggest barriers are not economic. They have more to do with attitudes and perceptions of the opportunities.

Since participation is strictly voluntary for households, businesses and institutions, the Town must create a compelling mix of incentives and supports to promote participation. New local policies may be needed in some areas. Fortunately, the Town has already demonstrated its commitment to working closely with citizens to formulate new environmental policies that have strong public support.

Economic Development and Employment Potential

As Marbletown and the whole Mid-Hudson region develop their capacity to shift to 100% renewable energy, numerous economic and business opportunities will come into focus. There are growing industries in sustainable forestry, energy efficient building materials, appliances, equipment, software and services, vehicle retrofitting, and many other areas of technology.

Given the town's rural nature, sustainable forestry and clean energy installation are likely growth industries within the town's borders. Sustainable construction and building materials are another area of opportunity that may expand if the rural population swells with people leaving more urbanized areas. And the switch to electric vehicles creates a particular opportunity for technology entrepreneurs in connection with Marbletown's ambition for getting fossil fueled cars off the road (not just out of town); there is potential for a local industry in converting gas and diesel powered cars to electric.

The Mid-Hudson region as a whole will see the full set of job opportunities within a short electric vehicle or mass transportation commute. Ulster County sees this opportunity as well, and funded a Green Careers Academy with significant scholarship and tuition reduction programs at SUNY Ulster in Marbletown, launching in 2020. This provides an exciting opportunity to encourage the young people and displaced workers of the community to become experts in these new technologies.

The estimated savings of approximately $9 million spent on imported energy (from outside the town) annually is also likely to be a significant boost to local residents and businesses, with lower income residents receiving relatively greater benefits as a proportion of their income. These savings amount to approximately $1,800 per resident, or $4,700 per household per year. That is approximately seven percent of the $62,635 median household income in Marbletown. To the extent that the increased disposable income is spent locally, economic activity will be further increased.

Conclusion

We have taken a deep dive into Marbletown's energy use patterns and strategies for reducing it through efficiency. We have identified sources of renewable power that are immediately available through Community Choice Aggregation, and others that could be cultivated as the grid is modernized over the coming years. We have used reasonable estimates of the order of magnitude of energy demand and supply. We have looked thoughtfully at the nature of the path to 100% renewables through modeling and scenarios, while recognizing their inherent uncertainty. Modeling is inherently imprecise, and the scenarios are quite general. We cannot fully predict how the community will change as it embarks on this process. Still, several principles are clear:

- Marbletown residents spend a higher proportion of their income on energy than the average New Yorker or American citizen due to the Town's relatively cold climate, lack of natural gas infrastructure, rural nature leading to more automobile dependence, and older building stock.
- New technology with rapidly falling costs presents Marbletown with an opportunity to transition to renewable energy and dramatically cut energy costs with modest additional investment beyond normal equipment replacement.
- The greatest barrier to this transition is probably not financial, but instead is lack of awareness, knowledge and motivation.
- As we overcome these barriers, this transition will also bring local health and economic benefits.

The main driving force for this transformative agenda is interest and excitement that it generates in the community. By being part of this transformation, Marbletown's creative, engaged citizens can find a worthy set of challenges for education and experimentation. Marbletown is a cohesive, tolerant community, with high levels of talent in its elected officials and volunteers. By taking up this transformative challenge together, everyone stands to learn something about how to create positive change for their loved ones, the community and future generations.

6. References and Resources

Corvidae, Jacob; Laurie Stone, Matt Jungclaus, James Mandel, Angela Whitney and Peter Bronski (2018) The Carbon-Free Regions Handbook. Snowmass, CO: Rocky Mountain Institute.

Energy Information Administration, 2015 Residential Energy Consumption Survey. https://www.eia.gov/consumption/residential/data/2015/

Energy Information Administration, Household Energy Use in New York, a closer look at residential energy use. https://www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/ny.pdf

Gable, Christine and Scott, "13 Electric Vehicle Conversion Companies," Thoughtco.com uploaded 5/27/2020 at: https://www.thoughtco.com/electric-vehicle-ev-conversion-companies-85249. 1/23/2020.

Goodstein, Eban and L. Hunter Lovins, "A Pathway to Rapid Global Solar Energy Deployment: Exploring the Solar Dominance Hypothesis." Energy Research and Social Science 56 (2019) 101197.

Hydroworld 2019, High Falls Hydro Plant summary, retrieved 9/10/19 at: https://www.hydroworld.com/ferc/2900-3899/high-falls-hydro-electric-2951.html#gref

M. Z. Jacobson, R. W. Howarth, M. A. Delucchi, S. R. Scobies, J. M. Barth, M. J. Dvorak, M. Klevze, H. Katkhuda, B. Miranda, N. A. Chowdhury, R. Jones, L. Plano and A. R. Ingraffea, "Examining the feasibility of converting New York State's all-purpose energy infrastructure to one using wind, water, and sunlight", Energy Policy, 2013, 57, 585–601. US: http://web.stanford.edu/group/efmh/jacobson/Articles/I/USStatesWWS.pdf

National Park Service, Technical Preservation Services, "Solar Panels on Historic Properties," downloaded 9/10/2019 at: https://www.nps.gov/tps/sustainability/new-technology/solar-on-historic.htm

Rogers, Everett (2003). Diffusion of Innovations, 5th Edition. NY: Free Press.

Scenic Hudson: Clean Energy, Green Communities: A Guide to Siting Renewable Energy in the Hudson Valley https://www.scenichudson.org/sites/default/files/renewables-siting-guide_web.pdf

Scott, Mike, "Economics of Electric Vehicles Means Oil's Days as a Transport Fuel are Numbered," Forbes 9/2/2019. Downloaded at: https://www.forbes.com/sites/mikescott/2019/09/02/economics-of-electric-vehicles-mean-oils-days-as-a-transport-fuel-are-numbered/#7eec85385102

US Department of Energy "Wood and Pellet Heating" https://www.energy.gov/energysaver/heat-and-cool/home-heating-systems/wood-and-pellet-heating

Ulster County and Marbletown Economic data from Data USA:
https://datausa.io/profile/geo/ulster-county-ny/#economy

New York State Wood Heat Report, April 2016
https://www.nyserda.ny.gov/-/media/Files/Publications/Research/Biomass-Solar-Wind/15-26-NYS-Wood-Heat-Report.pdf

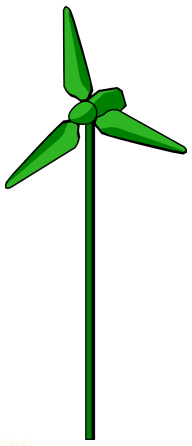
Appendix 1: Inviting Participation with the 100% Pledge and Technical Assistance

While the town can lead by example with its own operations and by providing easy access to renewable electricity, it's the community that will create Marbletown's 100% renewable future. Residents, businesses, and institutions -- taking the actions that make sense to them -- will be the force behind Marbletown's progress. To inspire this movement, we created the 100% Pledge:

"I pledge to shift my energy use to 100% Renewable Energy, as quickly as I am able. I will save money immediately with community solar or install solar on my building. I will learn about electric and renewable alternatives so that I am prepared to replace a fossil fueled vehicle, appliance, or tool. I will keep at it and share lessons learned in the community."

The good news is that there are steps, and an orderly progression to make this shift economically sensible and manageable for ordinary people. The ECC will be supporting the community throughout the process, which we've organized for cost-effectiveness.

Energy Sourcing

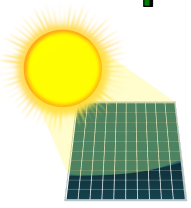


1. Green Electricity

a. If your Town (Marbletown has) has joined a Community Choice Aggregation (CCA) to buy 100% green electricity, usually at reduced cost, you are already enrolled if you have not previously chosen a different energy provider (in which case you should opt back in for the savings.)
b. If your town is not in a 100% renewable CCA, let your Town Board know that you want them to.

2. Solar or Community Solar

a. By signing up for community solar, you can get nearly 10% savings on your electricity bill at no up-front cost and no termination fee. Anyone who pays an electric bill who does not have solar on their roof is eligible.
b. If you have a suitable roof and you can benefit from the tax credits, home solar is a great investment.



Energy Efficiency

DIY home energy audit:
https://www.energy.gov/energysaver/home-energy-audits/do-it-yourself-home-energy-audits

3. Basement and Attic

Where accessible, I will insulate and air-seal the critical areas like the rim joist around my basement or crawl space and my attic.

4. Opportunistic Insulation and Air Sealing

a. When I replace my roof, I add insulation and air sealing under the new (preferably non-fossil based) roofing material if I cannot add insulation my attic.
b. When I replace or add siding, I will add continuous insulation under the siding.
c. Whenever any work is done on an exterior wall of my building, I will take the opportunity to reduce air leakage and add insulation if possible.

5. Efficient Electrics

a. I will only use efficient LEDs in high use lighting areas
b. When buying appliances, I will look for Energy Star appliances, and compare annual usage between models.

Electrification

6. Transportation

a. **EV Ready.** The next time I have electrical work done, I will ask the electrician to also install an electric vehicle charger or electric vehicle charger-ready circuit (50A 240V) with a NEMA 14-50 outlet near my parking space(s).
b. **Electric Vehicle:** The next vehicle I purchase will be an electric vehicle (EV) or a plug-in hybrid electric vehicle (PHEV). If there is not currently an EV or PHEV that meets my needs or budget (i.e. I need a pickup truck), I will use my old vehicle or purchase only used vehicles until suitable EVs or PHEVs are available. When buying used vehicles, I will look for more fuel efficient options, such as hybrid cars and trucks. If new EVs or PHEVs are too expensive for my budget, I will investigate the purchase of a used EV or PHEV.

7. Building Heating and Cooling

My next home heating systems will be a 100% renewable alternative.

a. If I install or replace an air conditioning unit, I will do so with a cold climate rated air source heat pump or geothermal heat pump.
b. If I replace a boiler or furnace, I will do so with a cold climate rated air source heat pump, geothermal heat pump, or an EPA rated wood or wood pellet furnace or heater.
c. If I use a fireplace or wood stove more than 10 years old, or a gas fireplace, I will only replace it with a EPA 2020 qualified wood stove or wood pellet stove.
d. If I use wood for heat, I will store my wood with protection from rain and snow, and obtain wood well in advance so that it has time to dry fully.

8. Hot Water

When replacing my hot water heater, I will replace it with a heat pump or hybrid water heater, electric on-demand water heater, solar hot water, electric tank hot water heater, or an auxiliary heater off a wood or wood pellet furnace.

9. Small tools and power equipment

When considering the purchase of fossil fuel powered tools and equipment such as lawnmowers, snowblowers, generators, chainsaws, etc. I will research and purchase electric (corded or battery powered) options whenever they are available and meet my needs.

10. Helping others

I will share what I have learned with friends and neighbors and help them to transition to 100% renewable energy as well.

Typical Cost-Effectiveness of the 10 Steps

Actual cost effectiveness will vary depending on individual circumstances, but measures are color coded according to the typical cost-effectiveness in most circumstances.. The most cost effective measures with instant payback should be taken at every opportunity. Measures with paybacks of four years or less will be cost effective even if financed at credit card interest rates. Measures with paybacks of 10 years or less are attractive investments compared to financial securities such as stocks or bonds. Measures with paybacks over 10 years are difficult to justify based on the financial benefits alone, but other benefits often make them worth doing for those who can afford them.

No.	Step	Measure	Up-front cost	Extra cost over traditional option	Annual Savings	Rebates /Incentives	Payback	Other benefits
1	Green Electricity	CCA	None	None	+/- $50/yr		instant	green electricity
2a	Solar	Community Solar	None	savings	$120/yr		instant	none
2b	Solar	Home Solar	$21,000	$21,000	$1,120.00	$10,500	7-12 years	green electricity
3	Insulation & Air sealing		$5,000	$5,000	$700	varies	1-10 years	Home comfort; less mice and other vermin
4	Efficient appliances		$1 and up	$0 and up	$1 and up		varies	
4	Efficient wood stove		$2,500	$1,500	$500		3+ years	less smoke; healthier air
5a	Vehicles	EV Ready	$100 to $1000	$100 to $1000	none	maybe	N/A	Quick home charging
5b	Vehicles	Used EV	$7K and up	$0	$750	no	Instant	Used EVs are often cheaper than comparable used gas cars
5b	Vehicles	New EV	$30K and up	$3K to $10K	$750	up to $8000	2-5 years	great acceleration, fun to drive, lower maintenance
5b	Vehicles	Leased EV	$200-$500/ mo	$50/month	$0	up to $8000	instant	Gas savings should pay for higher lease cost compared to gas vehicle
6a	Heating and Cooling	Air Source Heat Pump instead of A/C	$3000 and up	$500	$300	$250/unit	1 year	back-up heat in case your boiler/furnace breaks
6b	Heating and Cooling	Air Source Heat Pump instead of Furnace	$3000 and up	$1,000	$300	$250/unit	3 years	Air conditioning
6b	Heating and Cooling	Air Source Heat Pump instead of Furnace AND A/C	$3000 and up	$500+ savings	$300	$250/unit	instant	Zoned heat and cooling with minisplits
6b	Heating and Cooling	Geothermal instead of furnace	$15000 and up	$10,000	$1,000	$1500/ton + annual incentive	5-6 years	Some also supply hot water.
6b	Heating and Cooling	Geothermal lease	$0	$1,000	$1,100	unknown	instant	
6c	Heating and	Efficient	$2,500	$1,500	$500		3 years	less smoke; healthier

	Cooling	Wood stove						air; saves wood
6c	Heating and Cooling	Pellet stove	$3,000	$2,500	$300	$1,500	3 years	no smoke; healthier air, saves wood
6d	Heating and Cooling	Cover wood & Buy wood early	$20 (tarp) + $200/cord	$0	$50	no	Instant	less smoke; healthier air; less hauling wood
7	Hot water	Heat Pump Water Heater	$3,000	$1000	$200	$1000	Instant	dehumidification around water heater
8a	Cooking	Induction hot plate	$50 and up	$50 and up	small	no	long	better temperature control than gas, can cook outside in summer
8a	Cooking	Induction range	$1000 and up	$250 or more	$20	no	13 years	better temperature control than gas, no carbon monoxide
8a	Cooking	Electric range	$250 and up	$0	none	none	instant	OK if you don't cook much
9	Outdoor equipment	Walk behind mower	$300	$0	$12	no	instant	lighter than gas mower, quiet, no gas spills, easy start
9	Outdoor equipment	Riding mower	$4,000	$1,000	$50	no	20 years	No gas spills, quiet
9	Outdoor equipment	Snow blower	$300 and up	$0	$5	no	instant	easy to start. Many are underpowered, though... keep a shovel handy
9	Outdoor equipment	leaf blower	$50 and up	$0	$2	no	instant	quiet
9	Outdoor equipment	Chainsaw	$80 and up	$0	$2	no	instant	quiet, light
	Assumptions	Electric	Heating fuel (fuel oil or propane)	Gasoline				
	Ann. Budget	$1,200	$2,000	$1,500				

Appendix 2: Technical Considerations

In scoping out a pathway for the shift to renewables, we have made efforts to be both rigorous in our analysis and accessible in our discussion of the overall path so that the entire community can appreciate the possibilities before us. In this section, we provide detail underlying three key discussion points: how we made the initial estimates of load and the savings that will be connected with electrification; how we are planning for expansion of in-town renewable power supply in the context of electric grid constraints and utility plans for upgrades; and how we have addressed the balance of benefits and risks connected with one locally abundant renewable energy source: wood.

DATA

Data sources and interpretation

The Marbletown ECC and Sustainable Hudson Valley have based this strategic plan on estimates of energy demand, and available energy resources, that we gathered from authoritative sources when we began this project in 2018. Our primary sources of data for estimating energy load are:

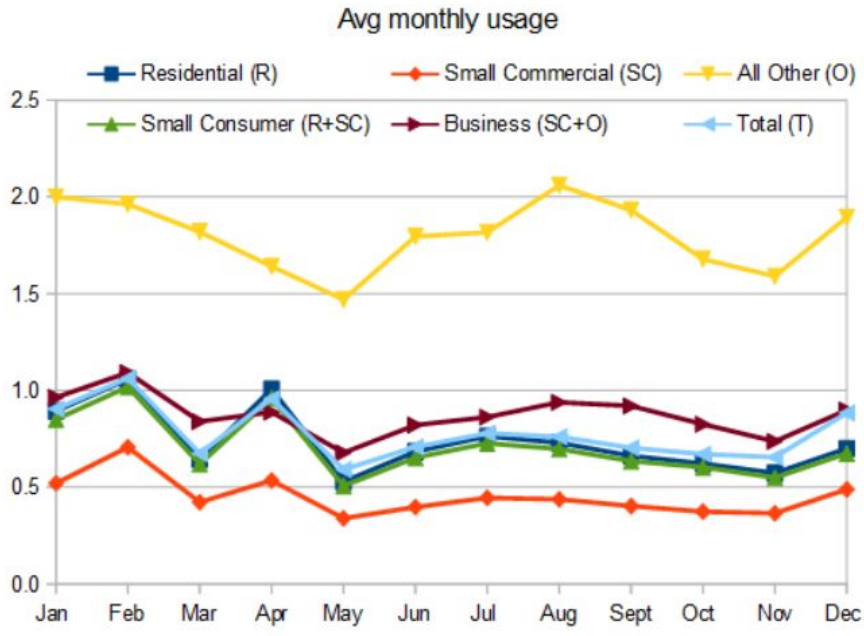
- Ulster County Tax record data for building square footage and primary heating fuel type, which includes dates of construction and heating sources, obtained in 2018;
- New York State DMV 2018 vehicle registration data for vehicle makes, models, year, and zip code (for High Falls and Stone Ridge, which constitute more than 90% of Marbletown);
- New York's Utility Energy Registry (UER) for January 2016 through June 2019 provided electric power usage for every meter in each utility's service area. Data maintained by the New York State Energy Research and Development Authority (NYSERDA).
- Ulster County's parcel-scale land use maps, supplied by the County's Department of the Environment, provided us with a pool of potential renewable energy sites to consider, obtained in 2018.
- The New York State Wood Heat Report, published April 2016, provides estimates of current wood use for heat, and the emissions and economic impacts of converting conventional fuel oil heating equipment to advanced wood heating using locally sourced wood products. Wood pricing is based on the author's experience buying cordwood locally in 2019.

Our estimates contain significant uncertainty because the data are limited (e.g. driving habits) or privately held (e.g. heating bills). Despite this, we believe these estimates are

sufficiently accurate and detailed to help guide the development of this strategy because they provide the most essential information: the magnitudes and types of the major energy uses that must be addressed.

We know that these numbers, and the surrounding conditions will change as we progress. The Covid-19 pandemic is one such conditional change. The shuttering of an estimated one fifth to one quarter of total US output in the second quarter 2020 continues to distort markets. Energy usage has fallen as work from home edicts have largely eliminated daily commutes in many municipal statistical areas across the country. As a result, PM2.5 emissions in New York City have dropped 15.11% in the last ten days through the 25th of May. At the same time while car registrations across western Europe were dropping by almost a third through the end of the 1st quarter, EV registrations rose 56% for the same period. Meanwhile, consumer spending, about 70% of total US GDP output, has declined dramatically with stay-at-home mandates promulgated by state governments. Consumer spending on durable goods fell 16.1% and on services fell 10.2%, with overall GDP output falling 4.8% through the end of the 1st quarter. Second quarter GDP is widely projected to fall even further, meeting the technical definition of a recession, namely, two consecutive quarters of negative growth. During the month of April, gasoline sales fell 13.3%, electronics and appliance store sales fell 17.4%, clothing sales dropped 37.4% while food services and bars saw a drop of 16.6% in sales year-over-year. A full 36.5 million workers have applied for unemployment benefits since mid-March. Nationally, the unemployment rate stands at 14.7% in April, with Nevada at 28% leading the country in jobless workers due to the state's dependence on hospitality and tourism. New York unemployment stands at 14.5% for the period. US emergency pandemic spending is already at $2.3 trillion, just over 10% of US GDP, and likely to go higher moving forward.

Of course, this economic picture will influence overall energy use. The impact of Covid-19 has led to many businesses rethinking the very nature of the office as more work is done remotely. Thereby shrinking the footprint of offices, but expanding energy demands in the homes of remote workers. And one of the greatest influences on energy use levels will be the success of our efforts to promote radical efficiency through smart lifestyle choices and investment in high-efficiency electric systems to replace fossil fuel combustion. We have



launched this project with measurable targets in mind, so that we can evaluate changes and course-correct when necessary; but we are also tracking progress in qualitative terms, by the enthusiasm and participation of the community.

ESTIMATING ELECTRICITY USE

Utility Energy Registry data provides monthly electricity usage for several classes of customers: Residential, Small Commercial (non-demand meters), and Other (demand meters). This data is available going back to January 2016, but unfortunately contains some errors, such as several months where the number of accounts included was only one tenth of the normal number of accounts, and many more months where most of the data is withheld, ostensibly for privacy reasons. For Marbletown, the UER contains useful data for 2016, 2017 and the first half of 2018.

Average electricity usage was calculated by month and account type. The usage was then averaged across multiple years (where the data was available) for each calendar month. Finally, total annual electricity usage was calculated as the sum of the twelve average calendar months. usage. The town uses approximately 28.6 million kWh or 28.6 GWh of electricity annually.

Note that the electricity usage per account is after the production from net metered solar customers. Unlike other customers, net metered solar customers are billed on a bi-monthly, odd-month basis. Such customers only seem to show up in the data when they are billed for energy, which happens in winter and early spring (December through April) when solar production is less than consumption. The UER data for residential and small commercial customers shows higher electricity average electricity usage in the months of February and April, but slightly fewer accounts in these same months. This anomaly may be accounted for if more solar customers are billed in odd numbered months than in even months.

This hypothesis is reinforced by the fact that we do not see a similar pattern in the energy usage of demand metered (All Other) customers. These customers show a more typical electricity usage pattern, with higher usage in winter due to higher heating and lighting needs, and in summer, driven by air conditioning.

ESTIMATING VEHICLE FUEL USE

DMV vehicle registration data was used to estimate the number of vehicles registered in Marbletown, and their average fuel economy. Vehicle registrations are unfortunately listed by zip code, and Marbletown contains parts of four zip codes: All of 12484 (Stone Ridge), most of 12440 (High Falls) and small parts of Accord, Kingston and Cottekill zip codes. We decided to approximate in-town vehicle registrations by using the registrations in the 12440 and 12484, about 70% of Marbletown addresses.

Vehicle registrations were then painstakingly sorted by make, model, and production year and matched with their EPA estimated average fuel economy to calculate a weighted average vehicle fuel economy for Marbletown vehicles of 26 MPG. Assuming 12,000 average annual miles for each of the 3,584 non-electric vehicles, we concluded that Marbletown residents use approximately 1.7 million gallons of gasoline and diesel annually for transportation.

If these vehicles are replaced with comparable electric or plug-in electric models, we expect that each gallon of gasoline or diesel would be displaced by approximately 10 kWh of electricity. In other words, we estimate that the average gas vehicle that currently gets 26 mpg will be replaced with an electric vehicle that gets 2.6 miles per kWh. While most electric vehicles currently on the market get much higher miles per kWh (3 to 4 is typical) larger electric vehicles will naturally get lower mileage. This assumption is quite conservative because it assumes no efficiency gains in electric vehicles between now and when the gas vehicles are replaced.

ESTIMATES OF ENERGY USE IN BUILDINGS

According to Ulster County property records, Marbletown has the following buildings, organized by primary heating fuel:

Primary Heating Fuel	Number of Buildings	Average Sq. Footage
Coal	1	1,134
Electric	222	1,575
Geothermal heat	8	2,051
Natural Gas	4	1,540
Oil	1,842	1,834
Propane/LPG	427	1,729
Solar	1	1,200
Wood	9	1,546
None/Unknown	242	226
TOTAL	2,756	1,654

For the purposes of the study, we assume that the building listed as heated by coal actually uses wood heat, since coal is no longer commercially available. We also assume that the four buildings listed as having natural gas heat are actually heated by propane, since there are no natural gas pipelines in Marbletown. According to the Energy Information Administration's 2009 and 2015 Residential Energy Consumption Surveys, we estimated that the typical building requires 17 million BTUs for hot water and 50 to 80 million BTUs of heating fuel depending on building size and the expected efficiency of heating equipment.
We also assumed that 15 to 20 percent of building heat is provided by wood for buildings with primary heating fuel listed as oil, propane or electric. The use of wood for heat is especially prevalent in Marbletown's older and historic buildings, all of which were built with fireplaces and chimneys that have often been retrofitted with wood stoves or fireplace inserts. Homes that use wood heat may lack sufficient insulation and have higher heating requirements. The use of wood heat in these older and less efficient homes also makes sense given that wood is much less expensive than other heating fuels in Marbletown. Many town residents own several acres of wooded land and can provide for their own heating needs solely through their own labor. Commercially, a delivered cord of mixed hardwood costs approximately $200, or $10 per million BTU, approximately a third to a quarter of the cost of fuel oil or propane.

Based on these assumptions and the building data, we conclude that the town uses approximately one million gallons of fuel oil, three hundred thousand gallons of propane, two thousand cords of wood, and eight million kWh (8 GWh) of electricity for building and water heating per year. The 8 GWh of electricity used for heat and hot water are included in the 28.6 GWh of total electrical usage derived from UER data.

BUILDING ELECTRIFICATION

To calculate the amount of electricity required to fully electrify Marbletown buildings, we made the following assumptions:

1. The efficiency of existing electric water heating would increase by a factor of 1.8 as most of these were replaced by heat pump water heaters. The efficiency of electric space heating would double as heat pumps replace resistive heating would improve by a factor of 2.
2. The efficiency of wood heating would increase by a factor of 1.2 as many fireplaces and wood stoves were replaced by modern wood stoves and pellet stoves.
3. We estimate that 93 percent of space heating currently provided by oil and propane would be replaced by heat pumps, with a 2.3x increase in the efficiency of delivery. The remaining 7 percent would be provided by wood, with a 0.7x decrease in the efficiency of delivery.
4. Water heating by fuel oil and propane would be converted to electric with a 2.2x increase in efficiency.
5. Building insulation and air sealing would be improved sufficiently to lower space heating demand by 25%.

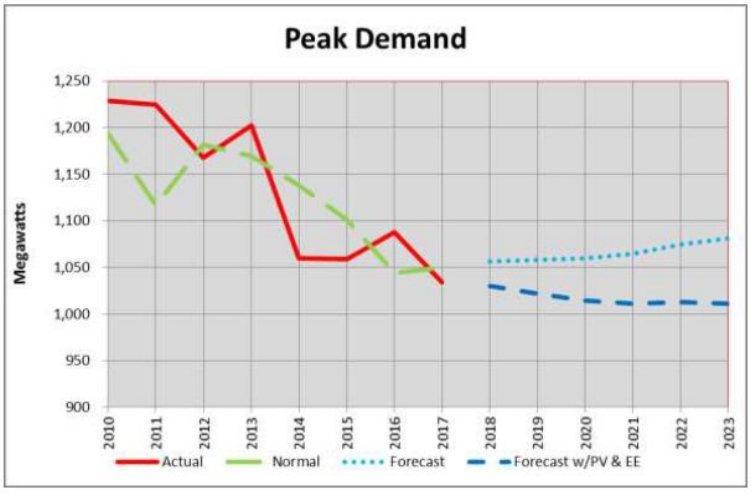
After conversion, the town would require 20 GWh of annual electricity for water and space heating (40 GWh total) and 2,100 cords of wood, or an increase of 12 GWh of electricity and no net change in current wood consumption.

Electric grid constraints and modernization

As discussed in Chapter 3, a large-scale shift to renewable energy sources will increase demand on the electric grid, but those increases will vary seasonally with highest load in the winter and the most abundant renewable energy resources in the spring, summer and fall.

The extra revenue available to developers from the local capacity zone makes Marbletown a potential market for both national and international developers of solar and electricity storage projects. This development is limited by available grid capacity, and the limited number of locations which are not either prime farmland or completely forested.

Near term grid upgrades are unlikely until electrification causes the new winter peak to significantly exceed the current summer peak. The area is served by Central Hudson Gas and Electric, a subsidiary of the Canadian firm Fortis. Like most utilities, Central Hudson has long range plans in place for ongoing upgrades to the grid based on conditions and demand. These plans can be accessed through the utility's distributed generation web portal (www.cenhud.com/dg) and the Joint

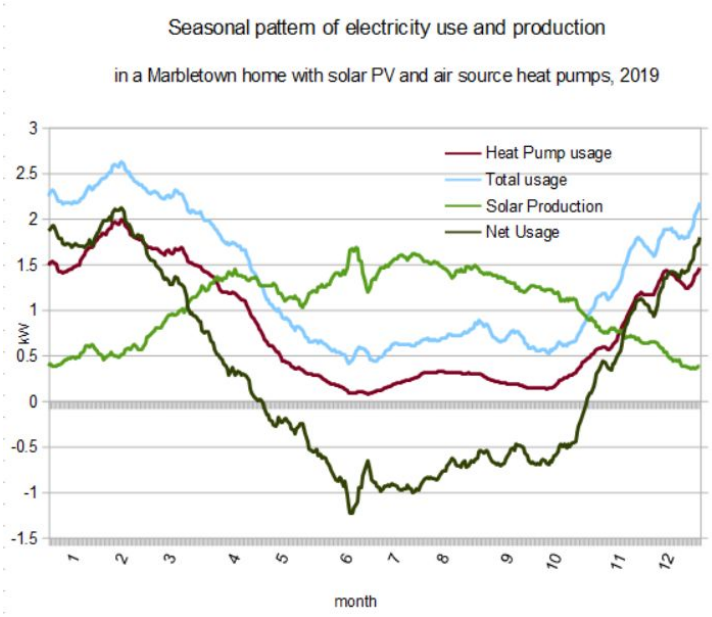


Utilities of New York (jointutilitiesofny.org) web portal.

By regulatory statute, Central Hudson is responsible for upgrading the grid in response to specific growth in power demand. Any additional upgrades or more proactive investment in grid capacity must be paid for by the requester.

According to Central Hudson's plans referenced above, peak load at the Hurley Avenue and High Falls substations remains well within their design capacity. The ratio between peak demand and capacity is 73% and 50%. The utility expects peak load to continue to decline at the Hurley Avenue substation and grow at only 0.4% per year at High Falls. These forecasts imply that the current infrastructure will be adequate for the foreseeable future, unless efforts to electrify heating and transportation increase demand beyond current projections. advance much more quickly than utility predictions.

Renewable heating and solar are unlikely to increase summer electric peak, especially in combination with short-term smoothing using battery storage. Winter heating demand is roughly five times summer cooling demand, while electricity generated from solar is roughly three times as high in summer as in winter.



The shift to renewable electricity for heating and transportation, combined with increased solar installations has the potential to shift peak electric loads from summer to winter, starting at relatively low levels of penetration. Current summer system peaks are driven by air conditioning demand. Although cold climate air source heat pumps are typically considerably more efficient as air conditioners than those installed in many Marbletown homes today, the roughly five-fold difference in heating demand and cooling demand could lead to a rapid shift from summer to winter peak demand. We can expect the shift at such a time when the number of buildings heating with air source heat pumps reaches approximately one fifth of the number of homes using summer air conditioning, or 10 to 15 percent of all buildings. Wider adoption of solar and electric vehicles will accelerate the trend further. A complete transition to renewable energy will likely involve significant wind energy imports in winter through the electric grid, and exports of solar electricity in summer. It will be necessary to work closely with our local utility to coordinate and communicate demand and grid modernization needs. These needs are likely to include grid upgrades, and energy storage to accommodate increased solar penetration and winter demand due to electrification of heating and cooling.

Woody biomass opportunity and risk analysis

In light of uncertainties connected with upgrading the electric grid to allow for rapid expansion of in-town renewable power supply, we also considered the potential of renewable heating through a non-electric means, wood heat. If all of the town's forests were to be sustainably harvested, this would produce enough wood to displace all the town's space heating needs at least twice over.

Given the constraints of land ownership, accessibility, and preservation for wildlife habitat, only a fraction of this potential sustainable harvest is practical, but we believe it would be possible to increase sustainable wood harvesting significantly. A three-fold increase in wood harvesting would provide half of the town's space heating needs with local wood resources. This scenario is meant to illustrate possible future policy options; further research into policies to increase sustainable wood harvests and pollution impacts are necessary before any such policy should be implemented.

While its impact on natural resources would have to be carefully managed, the increased use of local biomass holds significant promise for local economic development and local jobs. It would result in an additional $600,000 per year being spent on local wood harvests, and $1,200,000 less being spent on imported renewable electricity. This change would increase local employment by ten to forty jobs over the baseline scenario, depending on the size of the local multiplier effect. With approximately 3190 people of working age, the High Wood Scenario could boost the local employment rate by approximately 1% compared to the base 100 percent renewable scenario, which itself would be a strong engine for job growth and economic development.

Environmentally responsible use of wood requires, at a minimum, two protections: harvesting the wood resource no faster than it can be replenished, and addressing the air pollution from even the best wood stoves. Many households that heat with wood have been doing so for a long time, which means that many wood stoves in use are older models. There is an enormous difference in the particulate pollution from older wood stoves and 2020 EPA approved models.

Emissions from various residential wood heating technologies, as a percentage of fuel oil boiler emissions

Source: NY State Wood Heat Report