Jamaica Draft Energy Plan
December 2018

Importance of Enhanced Energy Planning

Introduction
Energy planning is important to Jamaica because, as concerned and responsible citizens, we recognize the need to reduce carbon based pollution (CO_2) of the atmosphere through a realistically executable energy plan, one that preserves the nature of our town prized by both our residents and many vacation home owners. We further recognize that advances in energy technology will offer significant cost savings to our citizens. The objective of Jamaica's Town Plan revised Energy section is to meet the requirements of ACT 174 which embodies the energy saving and sourcing goals of Vermont's 2016 Comprehensive Energy Plan in a manner that is consistent with Jamaica's long-standing Natural Resources, Land Use, and Economic Development policies.

Though Vermont's energy transformation may take years to implement, it will enhance the vitality of the state and local economy by reducing money spent on fuels pumped, mined or generated elsewhere, improve our health through reduced emissions and increased bicycle and pedestrian mobility options, and improve the quality of our local and global environment through reduced greenhouse gas emissions. This robust Energy Plan is used as a tool to advance the economic and environmental well-being of Jamaica, thereby improving the quality of life for its residents. Furthermore, these energy goals will reduce Jamaica's vulnerability to energy-related economic pressures and, in the long-term, climate change-related natural disasters, and promote long-term community resiliency in a variety of contexts.

The cost of energy in Jamaica, including residential, commercial and governmental use (for heating, electricity, transportation, etc.) is estimated to be $3,897,193 per year (see Energy Costs & Expenditures section below). Because a large majority of this energy is imported from outside of Jamaica and Windham Region, most of the money spent on energy does not directly benefit the local economy. Efforts to reduce the use of energy sources from outside the Town, or shift reliance to locally-produced energy, can improve household financial security and strengthen the local economy.

From an environmental perspective, petroleum and other hydrocarbon-dependent energy is a significant cause of localized environmental damage where those fuels are produced and refined, and the emissions from their use is responsible for human-induced climate change, related climate-change disasters, and ecological degradation. Moderate summer weather and snowy winters are major attractions to the tourists and vacation homeowners that are both essential to our economy and a major factor in our permanent residents' decisions to live here. Any efforts to reduce the use of non-renewable energy and shift to more environmentally-sound energy sources will benefit the Town's environment by contributing, however modestly, to the moderation of greenhouse gas-based climate change's effects on our local climate.

The primary objective of the Energy element of our Plan is to meet the Windham Regional Commission's (WRC) allocation of transportation and home heating energy savings and renewable energy sourcing targets in a manner consistent with preserving our town's rural nature, but consistent with the pace at which enabling technology and low-cost financing are available. Jamaica fully embraces the regional targets for renewable energy generation to be met by solar installations and residential wind generators, as well as the goals for energy conservation in home heating and transportation. Additionally, we will explore adding micro hydroelectric generation to our generation mix.

Preserving the Town's natural environment is essential to Jamaica's economy and tax base. Many visitors to our state and virtually all of the Town's residents value the area's natural beauty, including the state's most popular state park. For these reasons, industrial wind energy sources, which by their nature must be located on ridge lines, are not considered appropriate for Jamaica and are therefore prohibited under the provisions of this plan. While Windham Regional's plan does not presently assign a target for wind-generated renewable energy, it is Jamaica's policy to meet regional community renewable energy targets with solar, residential wind, and possibly micro-hydroelectric generation and to prohibit industrial wind development as inconsistent with long-standing Town policies. It is further considered that the regional targets based on current commercially-available technology may prove to be very conservative by 2050. Prohibiting industrial wind development does not interfere with the town's ability to reach its renewable energy targets.

A second objective is to develop a realistically attainable plan. By design, ACT 174 targets for key dates are aspirational. Several enabling technologies are necessary to achieve large-scale penetration of renewable energy generation into the power grid. These include energy storage, power electronics, and smart grid architecture and technology, including grid control. Vermont's current limit on net metering, 15% of base load, is a reflection of the difficulty in accommodating the variable levels of renewable energy source output in the current power grid. Technologies which deal with the variable nature of renewable energy sources and exploit their geographical distribution are necessary to achieve broad utilization of renewable energy sources. These technologies are in various stages of research and commercial development with unknown maturity dates. The cost of renewable energy continues to fall and is predicted ultimately to be much less expensive than fossil fuel-based sources. The combination of low-cost energy and the technology to deliver it to all domestic and industrial energy users will in turn spawn economic models with minimal capital expense and much reduced usage rates, enabling us to meet our goals. Our plan will include efforts to keep abreast of these much-anticipated technology and economic trends so that we may be able to take advantage of them as early as possible.

Our third objective is to reduce our citizens' energy expenses. As mentioned above, prices for renewable energy, wind, and solar have continued to decline and are expected to bottom out well below those of fossil fuels. This will allow our town to make significant savings of the $3,897,193 annual energy bill mentioned above. The future cost spread between fossil fuel and renewable sources will be sufficient to finance the upfront capital costs of installations within usage rates and still offer users considerably less expensive energy usage rates than are currently possible. Both these developments, low usage rates and low capital conversion costs, will align our residents' economic self-interest with our citizenship interest of reducing CO_2 emissions. We believe that our citizens will be motivated to act in their economic self-interest, i.e., take advantage of energy cost savings and low capital financing plans. Therefore, we will promote conversion to renewable sources, emphasizing the financial benefits, as soon as technology and economics enable.

While Jamaica can do little to shift the broader state or federal policies, we can influence energy use and production on a local level. In this energy plan, we hope to address Jamaica's local actions for increasing our energy efficiency and promoting renewable energy generation, and overall pathways to become more resilient. We will adopt policies to meet our specific goals as technology and economic developments permit.

Long-Term Vision & Petroleum Dependence

There is a trend toward factoring the "societal costs" into the price of energy; society pays for health costs associated with pollution, environmental clean-up, military protection of petroleum sources, and the continued failure of the Federal government to address the disposal of radioactive wastes. In the long-term, communities who depend on fossil fuels are vulnerable to risks associated with their price and production volatility.

These challenges may significantly increase the cost of conventional energy sources within the next ten to twenty years. As a result, Jamaica will seek to establish reliable energy resources for townspeople and municipal operations in order to hedge against the increasing volatility of hydrocarbon prices, and to reduce the environmental impact of our energy use. Should societal costs be added to energy from conventional sources, the spread between fossil fuel and renewable energy will increase, providing increased market pull for the technologies enabling large-scale renewable energy grid penetration, i.e. 100% net-metering, and business models making it more affordable. The role of clean, alternative energy sources will be expanded and supported.

The Windham region has been assigned goals for efficiency improvements, use of alternative fuels, and generation of renewable energy for the benchmark years 2025, 2035, and 2050. The Windham Regional Commission (WRC) has in turn apportioned these goals to each town. This plan commits Jamaica to meeting the goals assigned to it within the constraints imposed by the pace of introduction of enabling technologies. They are summarized in Table E1 below.

Category	2025	2035	2050
Efficiency Targets at Benchmark Years			
Residential Thermal: Estimated number/percent of houses to be weatherized to meet efficiency goals	94 / 9%	184 / 17%	377 / 36%
Commercial Thermal: estimated number/percent of commercial establishments to be weatherized	3 / 9%	6 / 16%	10 / 30%
Electricity: Estimated number/percent of kilowatt hours to be conserved annually and percentage of building upgrades	561,700 / 42%	917,900 / 68%	1,342,600 / 100%
Fuel Switching Targets			
Residential and Commercial Fuel: Estimated number of new wood pellet stoves and high efficiency wood boilers	280	266	266
Residential and Commercial Fuel: Estimated number of new heat pumps	87	172	24
Transportation Fuel: Estimated number of new electric vehicles	60	424	896
Transportation Fuel: Estimated number of new bio-diesel vehicles in town	92	176	304
Use of Renewable Energy			
Transportation: Percentage of total BTUs consumed	13%	31%	90%
Heating: Percentage of total BTUs consumed	56%	67%	93%
Electricity: Estimated number of MWh to be produced from residential and commercial solar, residential wind, and small hydroelectric generators	308	492	1,231

Table E1

Summary of Jamaica's commitment to meeting allocated energy goals

Jamaica's Current Energy Use

The following paragraphs describe Jamaica's current estimated energy demand in detail. These current use estimations provide a starting point from which the town can develop informed energy policies that directly address its current context and opportunities going forward.

In order to provide a more accurate picture of the energy planning requirements in Jamaica, energy consumption, generation targets, and efficiency targets need to be broken down into three distinct energy sectors. Those sectors are electricity, transportation, and heating.

Current Electricity Demand

Jamaica's current electric energy supply comes from Green Mountain Power. Electricity consumption data from Efficiency Vermont was produced for each town in the state, and is the primary source of this information. This data set combines the energy supplied from all potential electricity providers to that town. It also separates the usage for both the residential and commercial or industrial sectors. (See Figure E2 below)

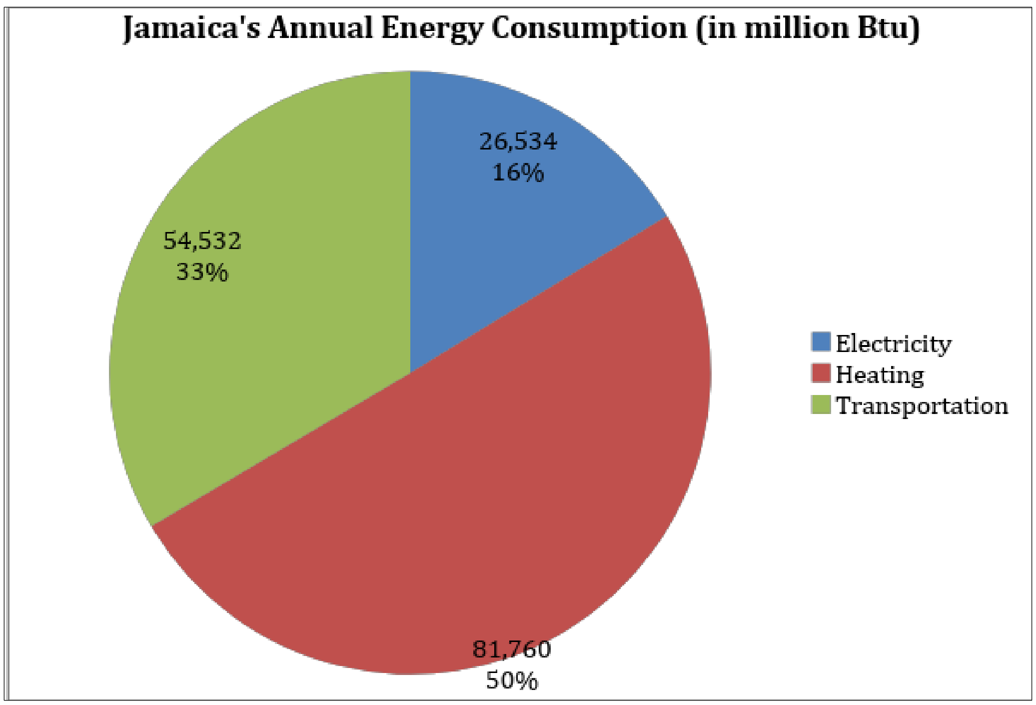

Figure E1

Figure E1 shows how energy consumed in the town is divided between these sectors. The sections below break down the calculations and describe the assumptions made to arrive at these final demand figures.

Since the rural nature of Jamaica is characterized by Jamaica Village residences and geographically-dispersed full-time and vacation residences, residential electricity needs far exceed commercial and industrial use. Because of this, current residential use is the greater factor in our planning. To translate this energy demand into dollar amounts, we can estimate a cost of $0.1435 per kilowatt-hour (Vermont state average for electricity costs across all sectors in 2015). Based on the above data, residences in Jamaica paid over $955,500 in 2016 for 6,656.277 kWh. Commercial and industrial facilities paid just over $160,000 for their 1,120,056 kWh of electricity.

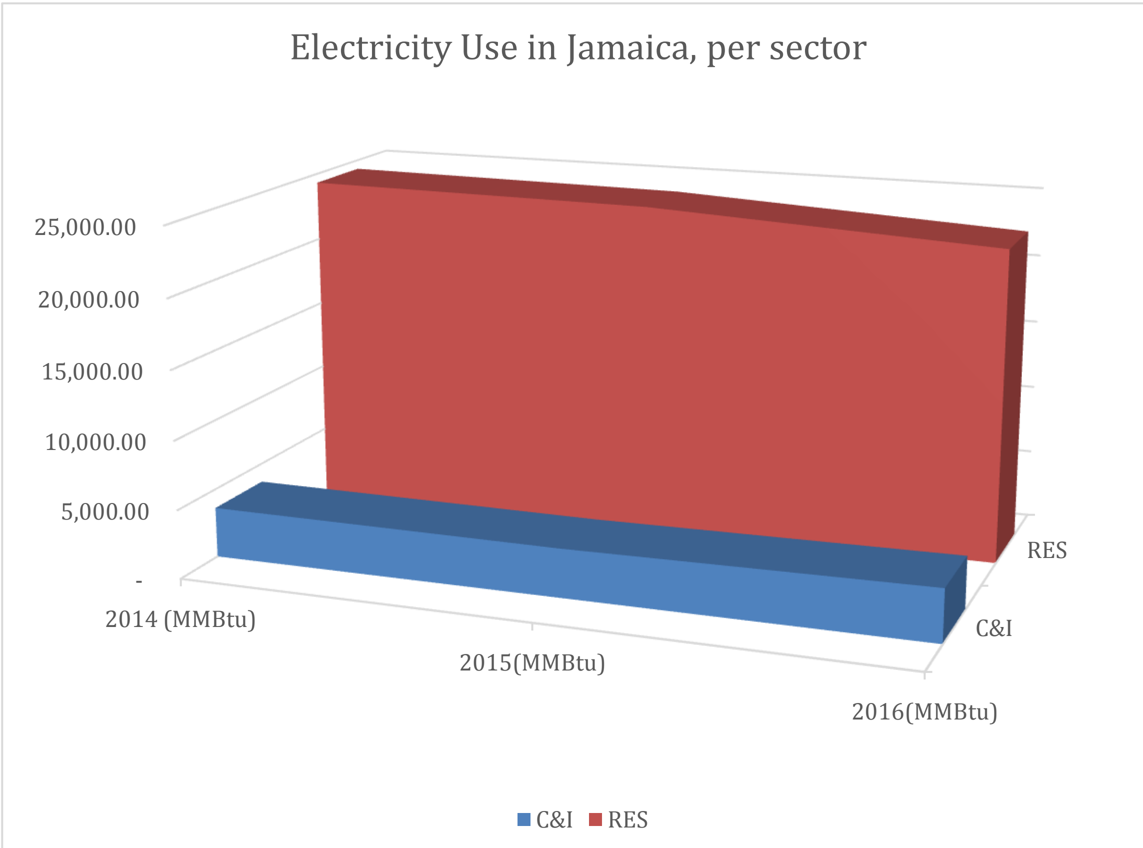

Figure E2

Figure E2 shows the electricity consumption by Jamaica Residential and Commercial / Industrial sectors.

Current Transportation Use

According to 2010 U.S. Census Bureau data, Jamaica has 790 primary housing units (not vacant or used for seasonal / recreational purposes). Based on that number of households, it can be estimated that there are 1,356 light-duty vehicles on Jamaica's roads, which consume 927,504 gallons of fossil fuel each year. Below is a table summarizing the averages and estimates used to arrive at those figures.

790	Number of primary housing units.
1356	Number of fossil-fuel burning light-duty vehicles (LDV).
11,356	Estimate of the average annual number of miles travelled by an LDV in the area (For Vermont as a whole, total vehicle miles traveled per registered vehicle was around 12,500. The vast majority of LDV in Vermont can safely be assumed to drive between 9,000 and 15,000 miles annually).
22	Estimate of the average fuel economy of fossil-fuel burning LDV fleet in the area, in miles per gallon (statewide average fuel economy).
408,373	**Estimated number of gallons of fossil fuel consumed annually, calculated from the values above.**
121,259	Number of BTUs in a gallon of fossil fuel, computed as a weighted average of the individual heat contents of gasoline (95%) and diesel (5%).
62,591	**This is the estimated total annual energy consumption of internal combustion vehicles in the area, in millions of BTU.**

Table E2

Summary of Jamaica's Transportation Energy Use

To estimate the cost of this consumed energy, we assumed a cost of $2.34 per gallon (Vermont state average in 2015). In Jamaica, consumers spent over $955,692 on transportation related fuel costs alone.

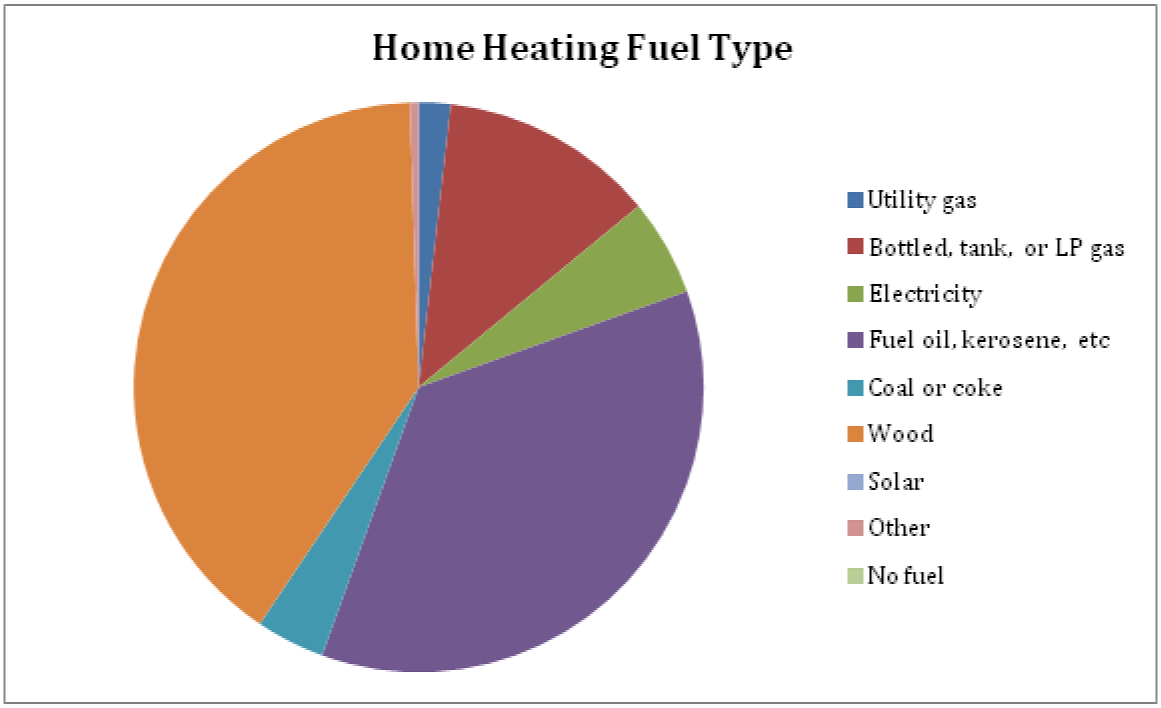

Figure E3

Use of home heating fuel in Jamaica by type

Current Heating Demand

To account for the different building types and their respective uses, the following estimates divide thermal energy demand by either residential or commercial use (industrial building thermal demand is not included).

For residential buildings, it was assumed that average annual heating load of area residences is 110MM BTU, for both space and water heating (Vermont state average). With 460 residential housing units, 23 commercial buildings, and 585 vacation homes in Jamaica, the state average usage yields an estimated 81,760 MMBTU annual total heat consumption.

Furthermore, census data also provides information on the home heating fuels used for both owner-occupied and renter-occupied housing units (both are considered "occupied"). Figure E3 above shows the percentage of fuel use by fuel type.

For residential and commercial buildings, an estimated total of just over $1.8 million was spent in home heating (roughly $1.67 million from home owners and $330,000 from renters). In Jamaica, 44% of housing units are primary/"occupied" homes, while 56% are seasonal/"vacant" homes. Based on the energy model projections from the state (created by the LEAP, or Long-Range Energy Alternatives Planning model), it can be assumed that seasonal homes only use about 15% of the energy of a primary home, due to more occasional use and a presumed higher energy efficiency. As such, seasonal homes in town are estimated to consume about 7,590 MMBTU annually (compared to the 50,600 MMBTU for primary residences).

For commercial establishments, it is estimated that the total heating load is 650 MMBTU each year. For the state, the average is in the range of 700 MMBTU to 750 MMBTU per year, but the average for any given area is very likely to be significantly higher or lower, as the mix of businesses from region to region is highly variable. Based on the types of commercial buildings in Jamaica, the heating load was calculated to be less than state average. With 23 commercial establishments, there is an estimated thermal energy demand of 21,500 MMBTU. These businesses pay about $770,000 each year in heating expenses.

Total Energy Costs

In sum, Jamaica pays a staggering amount in energy across the three use sectors. The total estimated cost to the town's residents for electricity, heating, and transportation is roughly $3.9 million dollars each year. There are real financial incentives for the Town to move toward energy efficiency, on behalf of both residents and business owners (see section 4 "Jamaica's Energy Targets and Conservation Challenges" of this plan for more detail about energy efficiency and conversion targets).

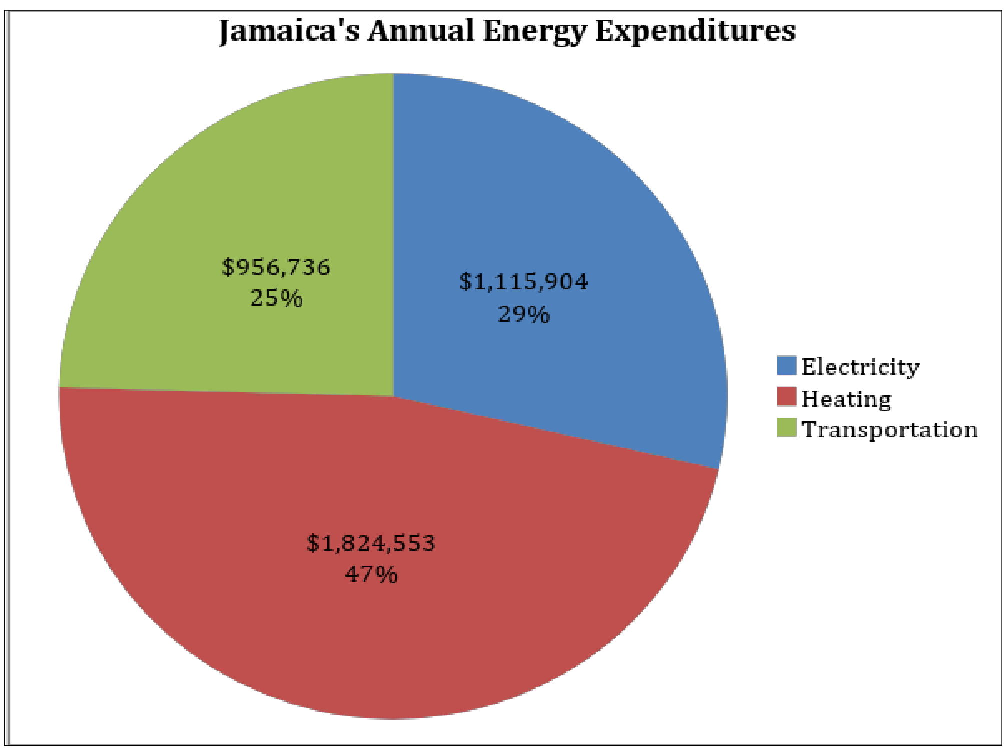

Figure E4
Jamaica's energy costs by energy category

Jamaica's Constraints & Potential for Energy Generation Resources

Jamaica is adopting all of the above except industrial wind generation in order to meet renewable energy generation targets. Energy resources within Jamaica are all renewable resources: wood, solar, micro-hydro, and residential wind. In order to reduce dependence on conventional energy sources, of which the costs and availability are outside residents' control (see the section above), the use and generation of appropriately-sited alternative energy sources is encouraged. A mix of PV solar, residential wind, and micro-hydro installations will provide a more robust renewable energy generation capability and expand the opportunity for property owners to participate in the new energy economy. Solar and Wind potential for Jamaica is shown in maps 1 and 2 of Appendix A. Additionally, Jamaica may share a unique resource with neighboring Townshend in the Ball Mountain and Townshend Dams that may someday be suitable for a hydroelectric pumped energy storage system if and when current structural deficiencies and serious sediment accumulation problems in the existing reservoirs of these federally-owned facilities are addressed and corrected.

Photovoltaic (PV) Solar Potential

PV Solar renewable energy trends support high potential for PV solar generation contributing substantially to meeting Jamaica's renewable energy generation goals. While State and regional plans are aspirational, it is considered that conversion to renewable energy sources will be driven by economic considerations. Jamaica residents most likely will act in what they perceive to be their economic self-interest, i.e. the opportunity to enjoy substantially lower energy costs for electricity, heating, and transportation needs. We anticipate that the falling price of renewable energy, including PV Solar, will align our residents' economic interests with meeting our renewable energy generation targets with substantial conversion to PV solar generation. Figure E5 below shows the declining prices of PV solar and wind renewable energy in comparison to that from coal and natural gas. Cross-over of renewable sources costs with those of fossil fuel sources is anticipated to occur in 2022 according, to this Bloomberg data.

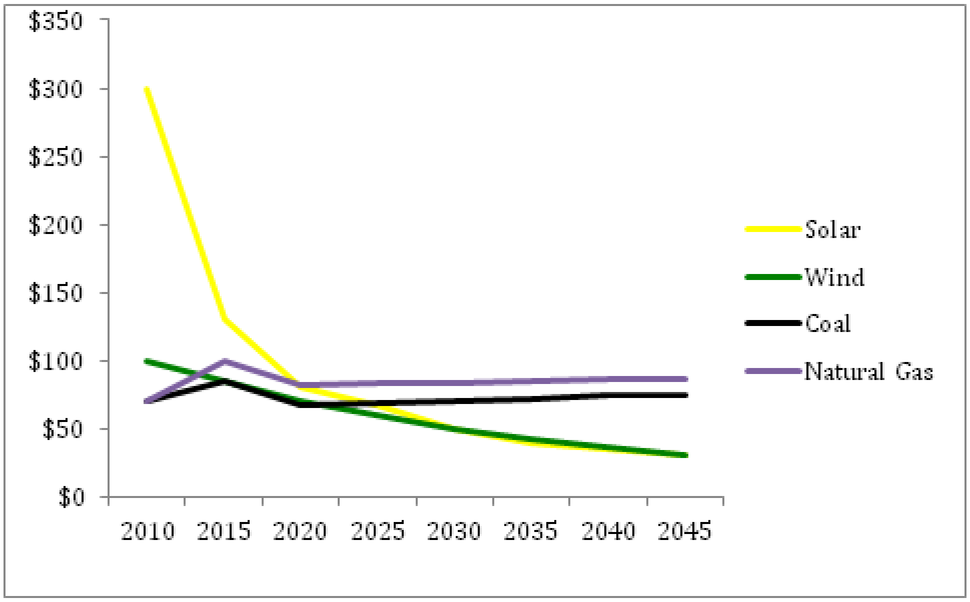

Figure E5
Cost per MWh by fuel type
Source: Bloomberg New Energy Finance as reprinted in April 2017 National Geographic

Large PV Solar generator projects scheduled for completion beyond this date are anticipating usage rates well below the $0.14 current average. The spread between current and anticipated future usage rates from renewable sources will finance innovative business models. Homeowners will be offered a variety of energy loans or lease-based financial products with little or no capital requirements for installation of PV solar systems that will include usage rates well below current averages. Venture capital most likely will be readily available for financing consortium-based community PV solar generators.

Solar Panel efficiencies currently available are in the 17% to 18% range, somewhat better than the 15% assumed in the 2016 CEP. However, there are a number of research efforts to improve solar cell efficiency. As of 2016, various solar cell efficiencies ranging from 20% to 46% have been demonstrated in laboratories.[1] The time and effort required to transition laboratory results to production solar panels cannot be predicted with certainty and expectation of near term availability is not reasonable. Nevertheless, in the 32 years until 2050, it is entirely reasonable to expect that these research efforts will result in major improvements in PV solar source efficiency. Efficiency improvements will increase power outputs, make marginal sites viable, and reduce required footprints for given output levels -- all of which will lower costs. It is likely that in retrospect, targets assigned in 2018 will seem very conservative by 2050.

[1] M. Malinowski, J. I. Leon and H. Abu-Rub, "Solar Photovoltaic and Thermal Energy Systems: Current Technology and Future Trends," in *Proceedings of the IEEE*, vol. 105, no. 11, pp. 2132-2146, Nov. 2017.

A vigorous national research and development effort is underway to enable large scale penetration of renewable energy sources into the nation's power grid. These include a revolution in the grid itself, reorganizing it into a "smart grid", a network of "micro-grids" which include local generators, users, and energy storage. Micro-grids will be the building blocks of the larger smart grid and be capable of being controlled as if they were a single net-metered user transferring energy in and out of the larger smart grid. They will also be capable of "island mode" or stand-alone operation independent of the larger network. Consuming and storing energy where it is generated will provide significant energy savings, as much as 30% relative to current grid operations.

Enabling Technologies

Large scale penetration of the power grid by renewable energy sources is dependent on commercial availability of several enabling technologies.[2] The fluctuating nature of renewable energy sources makes maintaining grid power quality while accommodating large amounts of power generated by renewable sources very difficult. Vermont's current limitations on net-metering are a reflection of this difficulty. Large scale conversion to renewable energy generation, in the absence of devices and controls that support efficient utilization of energy from renewable sources, leaves homeowners converting to renewable energy generation being forced to operate in a virtual off-the-grid mode in which power in excess of that needed onsite will be wasted, i.e. shunt to ground rather than sold.

Occasionally, when energy stored in home batteries is exhausted, the home may draw power from the grid if not physically disconnected. Larger community generators will be forced to sell power to the wholesale market on a 'catch as catch can' opportunity basis. Returns from capital investment will be reduced below the level that full utilization of the generators could produce. While ideal for some remote locations, large scale realization of off-grid operation of renewable energy sources will be inefficient and create major difficulties for those homeowners that have not converted to renewable energy sources.[3] Those remaining customers will have to bear the cost of GMP's distribution system resulting in much higher rates.

For these reasons, technologies necessary to effectively integrate renewable energy generation on a scale envisioned by this plan must be broadly available. These technologies are energy storage, solid-state power electronics, smart grid architecture, and smart grid control, including control algorithms and their distributed high performance computing based implementation. They are in various stages of research and development with uncertain maturity dates. Their commercial availability will pace the achievable rate of conversion to renewable energy. As these technologies mature, the most salient measure

[2] Molina, Marcelo G. "Energy Storage and Power Electronics Technologies: A Strong Combination to Empower the Transformation to the Smart Grid." *Proceedings of the IEEE*105, no. 11 (2017): 2191-2219.

[3] Vermont Department of Public Service, 2016 Comprehensive Energy Plan (2016 CEP), Ch. 7, p. 112

of their adoption and integration into the power grid will be the relaxation of the net-metering limitations from its current 15% to 100%, i.e., every watt of renewable energy generated will be used.

The falling cost of renewable energy (see figure E5) and the expansion of the market for renewable energy products that relaxation of current net-metering will lead to the development of business models that make conversion to renewable energy affordable for the average homeowner. The cost spread between fossil-based renewable energy will stimulate financing plans that allow incorporation of up-front capital costs into usage rates that still offer cost savings to energy consumers. Early adopters with capital to invest in future energy savings will realize excellent return on their investment in the form of low energy costs. All of this will be paced by the availability of the enabling technology required to support full utilization of renewable energy.

Energy Storage

Energy storage is considered fundamental to integrating PV solar and residential wind energy generation into the power grid. Indeed, expert opinion considers that a self-sufficient system cannot be achieved without suitable energy storage.[4] There are a number of technologies that provide energy storage; mechanical, electrical, electrochemical, chemical and thermal.[5] Energy storage technology will provide a number of essential services to future smart grid components. Those of relevance to a possible West River Valley-based micro-grid element of a regional or state smart grid are: (1) electrical storage devices for maintaining power levels and quality over short periods of time (seconds to minutes) and (2) electrochemical (battery) storage systems that provide peak shaving and longer term (hours to days) load leveling. Additionally, battery storage at the micro-grid level will allow separation of the times of energy generation and delivery to users. The ability of battery-based energy storage to absorb peaks of fluctuating power from renewable generators and deliver needed additional power during valleys of generation to maintain a constant power output is absolutely essential to lifting the stringent limits on net-metering. Renewable energy generators with adequate energy storage and the right controls may emulate conventional synchronous generators, producing grid-quality power for a predictable amount

[4] Gómez-Expósito, Antonio, Angel Arcos-Vargas, José M. Maza-Ortega, José A. Rosendo-Macías, Gabriel Alvarez-Cordero, Susana Carillo-Aparicio, Juan González-Lara, Daniel Morales-Wagner, and Tomás González-García. "City-Friendly Smart Network Technologies and Infrastructures: The Spanish Experience." *Proceedings of the IEEE* 106, no. 4 (2018): 626-660.

[5] Molina, Marcelo G. "Energy Storage and Power Electronics Technologies: A Strong Combination to Empower the Transformation to the Smart Grid." *Proceedings of the IEEE*105, no. 11 (2017): 2191-2219.

of time.[6] In its absence, PV solar generators would have to operate in a virtual off-the-grid mode as described above.

Energy storage research includes both efforts to increase the charge-carrying capacity of chemical batteries and efforts to produce low-cost batteries for applications where size and weight are not constraints. The former is important for meeting energy storage needs where constrained by size, weight or available space. Historically, large scale deployment of batteries as energy storage systems has been too expensive. However, prices are declining and expected to fall by 60% by 2020.[7] The latter research effort addresses this need.

Although not envisioned by the 2016 CEP or the targets assigned by the WRC, a batteries-only conversion to the renewable energy grid may prove beneficial to those property owners for whom none of the renewable energy generation systems are appropriate. With sufficient battery capacity, homeowners may separate time of delivery of electricity from time of its generation. This will maximize the efficiency of local distribution of renewable energy within a micro-grid. It will also minimize the need for supplemental electricity from outside local micro-grids. Arrays of batteries, either closely coupled with community solar arrays or as stand-alone arrays, will play a similar role for an entire micro-grid. Power excess from distributed generators may be saved and redistributed locally as needed. Local excess reserves may be made available more predictably to the larger grid and deficits more predictably provided for.

Pumped hydroelectric storage systems are responsible for the bulk of the world's energy storage.[8] These normally are massive systems consisting of two reservoirs separated in elevation and a pump/generator at the lower reservoir. Water is pumped up to the upper reservoir with electrical energy to be saved as kinetic energy and released to flow to the generator at the lower reservoir to be recovered as electrical energy. Costing hundreds of millions of dollars to build, they are used to store GWh of energy for large energy providers. While not feasible now because of dam limitations, serious sediment accumulation problems within the existing reservoirs, and shoreline erosion concerns, Jamaica is investigating the possibility of a more modest pumped hydro energy storage system utilizing the Ball Mountain and Townshend dams if dam and environment concerns are addressed. If these problems are mitigated, such a system could provide bulk energy storage for a potential future West River Valley-based micro grid.

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[6] Gómez-Expósito, Antonio, Angel Arcos-Vargas, José M. Maza-Ortega, José A. Rosendo-Macías, Gabriel Alvarez-Cordero, Susana Carillo-Aparicio, Juan González-Lara, Daniel Morales-Wagner, and Tomás González-García. "City-Friendly Smart Network Technologies and Infrastructures: The Spanish Experience." *Proceedings of the IEEE* 106, no. 4 (2018): 626-660.

[7] 2016 Vermont Comprehensive Energy Plan, Chapter 10, pp 641

[8] Molina, Marcelo G. "Energy Storage and Power Electronics Technologies: A Strong Combination to Empower the Transformation to the Smart Grid." *Proceedings of the IEEE*105, no. 11 (2017): 2191-2219.

Smart Grid

By 2050, the 2016 CEP envisions a radical reorganization of the power grid into what has become known as the smart grid. In concept, the smart grid is an inter-connected network of micro-grids. Micro-grids are smaller connections of power generators, energy storage, and power users. Generators may be both residential and community-based PV solar and residential wind generators and energy storage may be both “behind the meter” and at the community generator level. Micro grids will be controlled as a single entity, a single unified producer and consumer of electrical power, and capable of operating as an externally controlled element of the larger smart grid or in a stand alone, “island” mode.

The smart grid will network micro grids, providing exchange of power among them and providing power to them on those occasions when local sources are inadequate, e.g. during prolonged periods of overcast skies and calm winds when renewable energy generation is inadequate. A certain amount of conventional power generation will be at the smart grid’s disposal for this purpose, but its use will be limited and — more importantly — predictable, well in advance of need. Consuming power locally where generated and better controlled transfer of power directly from centralized generators to micro-grids will avoid transmission losses the grid currently experiences, saving 5% of current electrical energy generated.[9]

Power Electronics

Power electronics are those solid-state devices found in inverters and transformers needed to transform the output of renewable energy generators to 60 cycle AC power that homeowners and business users consume. Other power electronics are used in the grid to transform power between AC and DC currents and between different voltage levels for long haul transmission. An emerging form of power electronics is the Flexible AC Transmission System (FACTS). The components in FACTS are to be used in the smart grid to support active control of power transfer, both within and among the smart grid’s micro-grids. Local consumption of power flowing in and out of micro-grids will require external control of these devices by the larger smart grid control system.

Smart Grid Control

The fundamental building block of the smart grid will be smart meters that report in real time the state of all connected micro-grid elements to the micro-grid controller. Intra micro-grid control is exercised based on the aggregate of smart meter reports. Micro-grid states, computed from smart meter reports, are reported to the smart grid controller to exercise control of the overall grid. Control of the smart grid is envisioned to be implemented on a distributed computing network of high performance computers, e.g., distributed cloud computing. Control algorithms for implementing the above hierarchical control of the smart

[9] "How Much Electricity Is Lost in Transmission and Distribution in the United States January 29, 2018. Accessed June 06, 2018. https://www.eia.gov/.

grid, the supporting hardware, and software computing architecture are currently in the conceptual stage of research and development efforts.[10]

Solar Constraints

The above discussion of enabling PV Solar technology is to make the point that the pace at which the technology necessary to integrate renewable energy generation into the power grid will constrain the rate at which Jamaica, and the rest of the state, can adopt it. Jamaica fully accepts the WRC targets for PV solar energy generation and their scheduled implementation as the best estimate of what can be achieved based on the 2016 CEP. However, we expect that near-term targets will be subject to change as the pace of enabling technology reaching market availability becomes clearer. We expect that as the enabling technology is realized as products, business models that make it attractive to consumers will quickly follow. As Jamaica residents and vacation home owners become aware of PV solar systems available to them at energy cost savings, we expect them to act to take advantage of energy costs savings and expeditious conversion to renewable generation including PV solar energy will follow. Accordingly, it follows that a major part of Jamaica's path forward will be to maintain awareness of the state of PV solar enabling technologies and supporting business models so that our residents and vacation homeowners may be made aware of their availability at the earliest opportunity.

Wind Potential

As mentioned above, Jamaica will encourage a mix of renewable energy generation sources, including residential wind as defined by the Windham Regional Energy Plan in areas specified by the Wind Potential Maps (map 4 of Appendix A) of the Mapping Appendix of this plan. The WRC targets identify 1060 acres available for residential wind energy generation. Therefore, there is substantial potential for effective utilization of residential wind for renewable energy generation. It is considered that residential wind installations would be beneficial supplements to PV solar generation, and particularly useful in areas where PV solar may be impractical. The cost of wind-based renewable energy closely tracks that of PV solar and will offer the same cost savings opportunities as PV solar. Since wind velocities fluctuate independently from sunlight, the overlap of wind and PV solar energy offers a more robust renewable energy generation capability than either can provide alone. The above discussion of enabling technologies applies equally to residential wind renewable energy utilization as well.

Wind Constraints

Jamaica does not consider industrial-scale wind to be an acceptable source of renewable energy as its introduction in potential wind energy regions of the Town is inconsistent with other elements of our Town Plan and detrimental to the town's economic interests, which depend on maintaining its rural and scenic qualities, as described below under

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[10] Gómez-Expósito, Antonio, Angel Arcos-Vargas, José M. Maza-Ortega, José A. Rosendo-Macías, Gabriel Alvarez-Cordero, Susana Carillo-Aparicio, Juan González-Lara, Daniel Morales-Wagner, and Tomás González-García. "City-Friendly Smart Network Technologies and Infrastructures: The Spanish Experience." *Proceedings of the IEEE* 106, no. 4 (2018): 636.

“Environmental Concerns” and “Economic Concerns”. While the regional plan does not assign any large or small industrial wind target to Jamaica, this plan explicitly prohibits industrial wind development. This prohibition does not interfere with the town’s ability to meet its renewable energy targets

Ridge Line Protection

It is a long-standing policy of Jamaica to protect the ridge lines of surrounding mountains from commercial and residential development.[11] The Town’s natural beauty, particularly its forested ridge lines, is the main attraction for our full-time residents, vacation home owners, and the many visitors we enjoy. Jamaica is home to the State’s most popular State Park. The views of surrounding ridge lines are one of the major attractions enjoyed by visitors to this park.

Specific ridge lines that are to be protected from development include the Pinnacle, Sage Hill, and Mundal Hill. Ridge lines associated with these mountains are viewsheds shared both by Jamaica and the neighboring Stratton resort area. Ridge lines of Cottage Hill, Ball Mountain, South Hill, and Attridge Mountain surrounding Jamaica State Park are viewsheds included in Jamaica’s protected ridge lines as viewsheds enjoyed by visitors to Jamaica State Park. The Vermont Land Trust holds a conservation easement on most of the privately owned Shatterack Mountain ridge line which would be negatively impacted by ridgeline industrial wind development. The Nature Conservancy owns most of the Turkey Mountain ridge line with industrial wind potential. Any industrial wind development on the portion of the Turkey Mountain ridge line would negatively affect this conserved land. Turkey Mountain and South Hill ridge lines are important viewsheds for travelers along Route 30 during fall foliage season. Ridge line development in these view sheds is prohibited by the Land Use section of Jamaica’s Town Plan. Map 5 of Appendix A shows the juxtaposition of public lands and large forest blocks with ridgeline areas suitable for large commercial wind development.

Environmental Concerns

Areas identified as secondary wind energy resources either lie within or adjacent to conservation areas.[12] Per the State’s Town of Jamaica Wind Resource Map, all the named peaks and associated ridge lines, except South Hill, lie in Vermont Conservation Design[13] Highest Priority Forest Blocks. Deer wintering areas are located on the sides of Turkey Mountain and South Hill ridgelines. Location of industrial wind towers in these areas has a high potential to cause severe environmental damage to these areas, interrupt wildlife habits, and in some cases, cause runoff damage to local brooks and streams and the West River. Map 6 of Appendix A shows the juxtaposition of conserved and proposed

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[11] Town Plan, Town of Jamaica, Vermont, November 13, 2017, Appendix

[12] Town Plan, Town of Jamaica, Vermont, November 13, 2017, Town Plan Maps, Proposed Land Use Map

[13] "Vermont Highest Priority Interior Forest Blocks," Geodata.vermont.gov., accessed June 05, 2018, http://geodata.vermont.gov/datasets/b05737376a3f4553a025967aba4cac6a_183

conservation and scenic hills or ridgelines with areas suitable for large and small commercial wind development.

The entire town of Jamaica lies within the West River Watershed and is included in the Vermont Department of Environmental Conservation (VDEC) Basin 11 Strategic Plan. Due to the challenges of balancing recreational, commercial and industrial uses of the West River and its tributaries, the Basin 11 Strategic Plan was developed to identify priority actions to improve water quality, and protect natural communities and the rare, threatened and endangered species concentrated along the surface water areas. The plan specifically identifies the need to work with the Town of Jamaica to address sediment and temperature impairments to the local waterways.

The focus of the Plan included an attention to building with flood resiliency in mind. For the Town of Jamaica, actions include the implementation of sediment and storm water restoration and storm water control actions to reduce flow, sedimentation, and promote the regrowth of riparian vegetation.

The ridge lines listed above are a direct source of runoff to tributaries or smaller brooks that empty into the West River and are governed by the VDEC Basin 11 Strategic Plan. Many of these areas include steeply graded and severe terrain that increases the amount and velocity of storm water runoff to lower elevations. The earthwork process of tree clearing and grading to construct access roads and the wind turbine sites are actions that would add to the amount of storm water runoff, increase soil exposure areas, erosion, and direct sunlight, and directly contradict the actions and goals identified in the Basin 11 Plan. Runoff from industrial wind turbine sites, if located on protected ridge lines, has a high potential to cause unacceptable levels of contamination in the West River, ponds, and wetlands included in the Jamaica Watershed.

Economic Concerns

A large part of Jamaica's economy is centered on tourism or providing goods and services to vacation homeowners. The natural beauty of the Town's forests and mountains are a major draw for both. Vacation homeowners are both summer residents and winter residents who take advantage of the nearby ski resorts. Vacation homes constitute the major portion of the town's grand list. Any industrial wind installations degrading the natural beauty of the area has a high potential to adversely affect property values, increase the tax burden of full time residents, and reduce the considerable contribution of Jamaica tax revenue to the State's Education Fund. The entire town of Jamaica constitutes the easterly viewshed form the Stratton Resort. The western ridge lines of the Pinnacles, Sage Hill, or Mundal Hill are in the primary foreground of Stratton's easterly view. If the damaging effects of industrial wind development on any of Jamaica's ridgelines described in the above text were actually to happen, damage to the town of Stratton would occur. Jamaica is undertaking economic development efforts, infrastructure improvements, and outreach efforts to attract new businesses and residents. The area's natural beauty is the primary advantage we offer to potential new residents.

Necessity
Industrial wind energy generation is not necessary to meet the Jamaica targets for renewable energy generation. The mix of PV solar, residential wind, and micro-hydro will be sufficient. If, as expected, the next 32 years see substantial improvement in PV solar efficiency and battery storage capacity, the goals established by the WRC plan will prove to be conservative and easily exceeded with PV solar energy alone.

Hydro Potential
The presence of two perennial fast-flowing waterways, the West River and Ball Mountain Brook, presents a significant opportunity for harnessing renewable energy. Based on Efficiency Vermont 2014 figures for residential electricity use in the Town of Jamaica, 1,164 residences utilize 6,102.37 kWh per residence/year. Assuming 85% efficiency, a single 100kW micro-hydro turbine could generate electricity for 120 homes a month. The State of Vermont has certified large-scale hydroelectric plants on the West River just upstream of Jamaica at the Ball Mountain and downstream at Townsend Dam. Micro-hydro (<100kW and >10kW) is an option for hydro power on the West River, Ball Mountain Brook, and potentially in perennial waterways on individual parcels. Hydropower technology is the most aesthetically and environmentally-conforming of the renewable energy types to the Town Plan's "low impact development strategy." While water-flow dependent, it can provide continuous power output, independent of time of day or wind conditions, and can be connected to the power grid for net metering. Adequate flow for new low impact river-run turbines will be determined during development of small and micro hydroelectric projects." In 2015, the State of Vermont established the Vermont Small Hydropower Assistance Program (VSHAP) in order to facilitate permitting of hydroelectric power and incentivize hydropower installations. Upfront costs for micro-hydropower are considerably lower than for solar or wind, given the smaller scale, and levelized costs are the lowest of the three renewable technologies. Current technological advances meet the demand for low impact 'run-of-the-river' turbines that are 'fish friendly' and report up to 90% efficiency. Companies such as Voith Hydro and General Electric have innovative technology that has proven to meet stringent environmental regulations. Another consideration which would help alleviate or avoid otherwise applicable environmental concerns would be the placement of hydro technology in existing infrastructure such as a storm sewer outlet or in connection to existing bridge footings.

Hydro Constraints
Permitting for micro-hydropower presents the greatest challenge to installation. As of January 2018, there have been no permits issued through the VSHAP program. The State of Vermont has tried to facilitate permitting; however, there is no financial incentive offered at the present time as of spring 2018. While technology allows for hydropower to be installed in the "river run", greater energy returns are achieved where hydropower is installed at a dam or weir with, "head height," or waterfall. However, dams or weirs that obstruct or alter river or stream flow regimes are prohibited under existing state and federal water quality laws. Run-of-the-river hydro generators can potentially be permitted. The West River and Ball Mountain Brook do not have dams or weirs below the Ball Mountain

Dam. While levelized costs, i.e., lifetime costs including initial start up costs, of the infrastructure and maintenance of hydropower technology are the lowest, energy returns would also be significantly less than solar or wind due to technological limitations related to water flow. Water flow also fluctuates seasonally. In order to connect to the grid, a buried pipeline enclosing electrical cables may need to be installed which may be considered unacceptable from an environmental and aesthetic standpoint. The parameters required for participation in the VSHAP program would need to be determined and met before the State would even consider initiating the permitting process. The Town of Jamaica would need to enlist the help of the Army Corps of Engineers to obtain data relating to water flow. A consultation with a hydropower specialist would also be needed to determine project feasibility. The cost of a micro hydropower installation could range from $1,000 - $20,000. Expert consultation, in conjunction with the Army Corps of Engineers, is required to determine feasibility and the real cost of a micro or small hydropower installation.

Potential Heating Energy Conservation and Constraints

Wood Heating

The fact that Jamaica's forests are able to supply significant quantities of cordwood for local cordwood businesses plus the ready availability of wood pellets heightens the potential for increasing the number of homeowners who heat with wood. The lower cost of heating BTUs from wood relative to fuel oil is an added incentive for wood heating. To the extent that Jamaica residents cut their own firewood, the cost of wood heating is further reduced. Further, Jamaica's extensive forest lands act as an important CO_2 sink.

However, there is an important caveat to encouraging a further increase in the use of wood for home heating. Burning wood is half of a CO_2 cycle. To be a recyclable source of energy, growing new trees must reabsorb the CO_2 released from burning wood. Burning wood releases nearly as much CO_2 per BTU as heating oil. Growing a tree to replace a tree consumed will reabsorb the CO_2 released, but it will take the tree's lifetime. The CO_2 load in the atmosphere will build up until a sufficient number of replacement trees establish equilibrium. Figure E6 illustrates the effect for three scenarios.

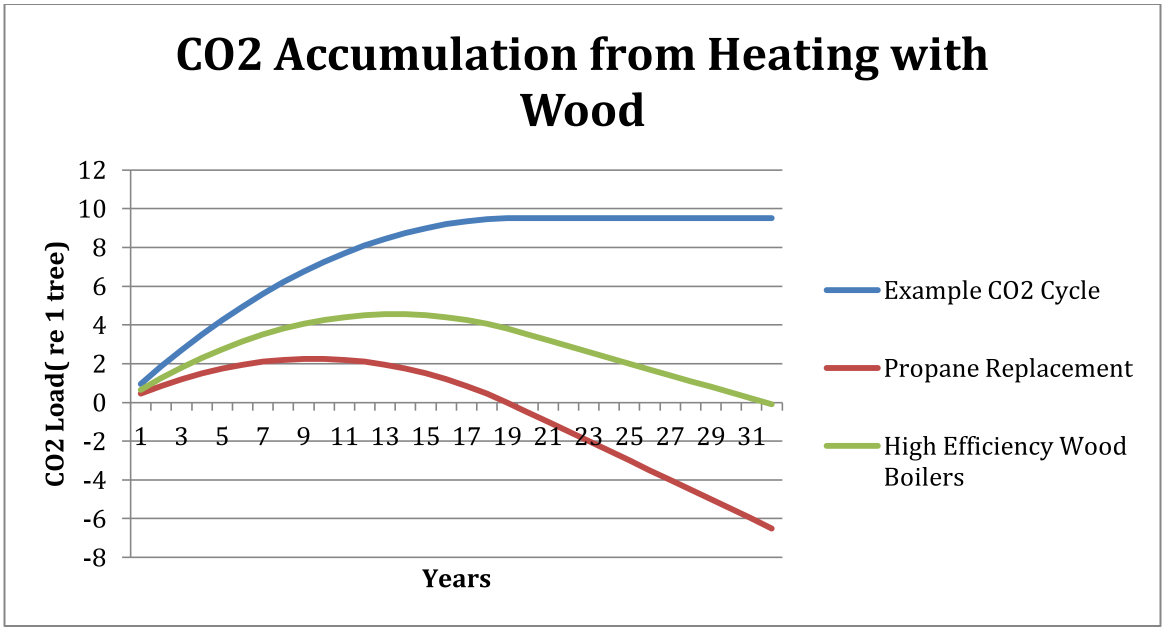


Figure E6
CO_2 atmospheric load buildup and dissipation
for three wood heating conversion scenarios

The blue curve illustrates a representative CO_2 cycle for a wood burning stove. Heating with a conventional wood stove (blue curve) and tree-for-tree replacement of trees burned will cause a buildup of CO_2 until sufficient replacement trees have been planted to absorb the CO_2 released by each tree consumed. In this example, a 20-year life cycle is assumed; i.e., each replacement tree absorbs 5% of the CO_2 released per year. Accumulated replacement trees therefore absorb the CO_2 released by burning a single tree. Equilibrium, i.e., the condition in which the CO_2 released by each tree burned is absorbed by 20 growing trees, is reached after 20 years. Twenty trees, each absorbing 5% of the CO_2 released by burning a single tree have been accumulated and thereafter harvested at the rate consumed.

The CO_2 cycle in Jamaica's mature forest is more complex. CO_2 release varies by tree species and absorption rates vary by species and tree age. Further, a tree must reach a certain size before significant absorption can occur. Therefore, the CO_2 cycle in Jamaica's mature forest does not occur in isolation as illustrated above but rather in the context of a forest that is already absorbing CO_2 at its maximum capacity. Adding a new fossil fuel (including wood) heating system will only generate CO_2 beyond its capacity to absorb unless new trees are introduced to the forest to absorb the new CO_2 generated. If the fuel is wood harvested from the Jamaica forest, then two trees must replace each tree burned; one to maintain the existing equilibrium and one to offset the CO_2 released by the new system. If the fuel is oil, new trees must be introduced at the rate of the blue curve example to offset the new source of CO_2. In both cases, CO_2 will increase to a new equilibrium point as shown in the blue curve.

The red curve illustrates the effect on contribution to the CO_2 level of replacing propane or natural gas heating with conventional wood heating accompanied with tree replacement. Replacing each tree harvested plus a second tree for the number of BTUs burning a tree releases, i.e., the replacement rate for a conventional wool heating system, will cause an initial buildup of CO2 followed by a decrease in CO_2 as illustrated by the red curve. In Jamaica forest's saturated CO_2 sink, any reduction in local CO_2 load from a conversion in Jamaica will quickly be filled from excess CO_2 in the atmosphere. But Jamaica's contribution will be reduced.

Replacing conventional wood heating systems with high-efficiency wood boilers or pellet stoves has the effect of reducing the CO_2 load by approximately one third, 60% / 90% efficiency ratio in heat use. If tree-for-tree replacement were already in effect for the replaced conventional system, the replacement will cause more CO_2 to be absorbed than generated as shown by the green curve. As with the propane example, any unused capacity of Jamaica's forest to absorb CO_2 will quickly be used by excess in the atmosphere, but Jamaica's contribution will be reduced. If the pellet or high-efficiency wood boiler system is new, then trees harvested from Jamaica's forest must be replaced at the rate consumed and new trees must be added, but at a rate that is two thirds of that required by a conventional wood heating system.

The foregoing discussion is to illustrate that to be effective in addressing the fundamental objective of the State's 2016 CEP, i.e., reducing the greenhouse gas loads from energy generation, use of wood for heating energy must be accompanied by responsible forest management.[14] Firewood must be harvested at a sustainable rate and in a manner that assures replacement trees grow at a rate not less than one-for-one replacement for existing systems and greater for new systems. Jamaica is largely covered in forest and Jamaica has a long-standing policy of encouraging responsible forest management practices.[15] While this policy has been motivated by esthetic and economic reasons in the past, promoting increases in the use of wood for heating energy must be accompanied by re-emphasis of good forest management to ensure Jamaica remains a CO_2 sink for itself and perhaps other less-wooded towns.

A major constraint to conversion of current residential heating systems to high-efficiency wood heating is cost. High-efficiency wood stoves and wood gasification wood boilers are expensive. Initial costs may be offset through the Department of Public Services Micro Renewable Energy Incentive program (SSREI) rebate offers for advanced wood pellet, chip boilers, and solar heating systems. The department also offers low-interest loans through the Heat Saver Loan program to offset up-front costs for energy upgrades that may be used to finance conversion to wood heating. Cost savings of wood pellets and cordwood relative to fuel oil, propane, and electricity heat will allow homeowners to recover conversion costs. Jamaica will ensure that citizens are informed of available financial assistance for conversion to high efficiency wood heating.

[14] 2016 Comprehensive Energy Plan, Chapter 9, pp 194
[15] Town Plan, Town of Jamaica, Vermont, November 13, 2017, Natural Resources, p14

Heat Pumps
Heat pumps offer an efficient alternative to electric, propane and oil heating. This is because heat pumps move heat (calories) rather than create them through burning or passing electric current through electrical resistance. In a manner analogous to electrical transformers, heat pumps extract calories from a large volume of outdoor air at low temperatures and release them to a lower volume of air at a higher temperature indoors. Given their efficiency relative to fossil fuel heating, they offer homeowners significant cost savings. They lose their effectiveness at sub-zero temperatures, so on Vermont's coldest days they must be supplemented with a second heating source. Ground-based heat pumps that extract calories from the ground to heat indoor air can deliver 100% of a building heat even on the coldest days. Because of excavation costs, they are costlier than air source heat pumps.

Depending on the source of electricity to operate them, the CO_2 load on the atmosphere varies. Because of their improved efficiency, CO_2 loads are reduced even if powered by electricity distributed from fossil-fueled generators. With the conversion to renewable power, their use will create no CO_2 impact.

Financing conversion to heat pumps may be eased through rebates and income-based low-interest loans available through Efficiency Vermont. Businesses may finance conversion to heat pumps through business energy loans also available through Efficiency Vermont.

Other Alternative Heating
Geothermal heating and solar hot water heating systems are alternative heating sources to replace or augment non-renewable heating. They may require augmentation from a second source. While the energy element of the Windham Regional Plan does not assign a target for savings from these alternative heating systems, they may offer an attractive alternative renewable heating option. The SSREI and Heat Saver Loan programs may help finance conversion to these alternative heating options.

Potential Transportation Energy Saving and Constraints
Based on 2016 five-year estimates of commuting times from 2010 census data, the average daily round trip commute for Jamaica residents is 43 miles. Energy use for all transportation from regional data is 3075 MBTUs. Meeting these needs with electric vehicles, provided they are charged with electricity from renewable sources, or with reusable fuel, has the potential of significantly reducing greenhouse gas loads of the atmosphere. While Jamaica adopts the WRC targets as Jamaica's goals for transportation energy saving, the pace at which these goals can be met is dependent on factors beyond the Town's control. These include the pace at which enabling technology is brought to market, the availability of suitable vehicles at affordable prices, and the development of infrastructure needed to support vehicles using alternative fuel or power.

Because of the multi-use automotive needs of Jamaica residents, winter driving conditions, and the preponderance of Class 2 and Class 3 dirt roads with difficult driving conditions in mud season, residents require all-wheel drive or four-wheel drive vehicles or light trucks. Additionally, many local businesses require vans and trucks. It is not known when electric or alternative fuel versions of these vehicles will be available for purchase. An additional lag will occur until they are available as more affordable used vehicles.

Battery Technology

The current state of battery technology limits the range of electric vehicles to approximately 200 miles, the mean weekly commuting distance of Jamaica workers. This range is for a relatively light car. A much lower range would be possible for the larger all-wheel or four-wheel drive cars and light duty trucks appropriate for Jamaica's roads. A number of research and development efforts are underway to increase the charge-carrying capacity of batteries that will increase electric car range and make their use in heavier car models practical.

Current battery charging times are lengthy and battery charging infrastructure is limited for the most part to home recharging. Limited public electric vehicle recharging is available in regionally, but for the most part, electric vehicles will have to be recharged at home. This is satisfactory for commuting purposes, but not for longer trips. A "chicken and egg" relationship between infrastructure development and electric car use is anticipated. More electric cars will stimulate more infrastructure development which will support more electric car buying.

Renewable Energy

Electric vehicles, because of their energy recovery systems, are slightly more efficient than internal combustion vehicles. Their real impact on reducing CO_2 will come when they are recharged from renewable energy sources. Drawing transportation energy from significantly cheaper renewable energy will offer a major reduction in operating costs and provide an incentive to buy electric vehicles. The rate at which the grid converts to renewable sources will therefore pace transition to electric vehicles.

Alternative Automotive Technologies

Although electric vehicles are the most advanced of renewable or recyclable energy automotive technologies now, other approaches are in various stages of research and development. The automotive technologies of 2050 are far from settled. These include alternative fuels such as biodiesel, hydrogen, and even ammonia, hydrogen fuel cells, and hybrid electric / alternative fuel cell vehicles. The latter would address the long haul problem of all electric vehicles. These technologies are not mature and their commercial availability is uncertain.

Resource Mapping Process and Policy Tool

Jamaica will utilize the Town of Jamaica Solar Energy Potential and Town of Jamaica Wind

Energy maps generated by the Windham Regional Commission as baseline maps supporting the town's energy policies (maps 1 and 2 of Appendix A). We have augmented these maps by superimposing the Jamaica parcel maps on them so that solar and wind energy potentials may be identified by parcel and owner. Both the Town and individual parcel owners will then be better able to use these maps in future renewable energy conversion determinations.

Solar Resource Maps
Jamaica's solar map includes raw resource potential, known and possible constraints, grid infrastructure, transmission and distribution resources and constraints. There are 818 acres of prime solar generation land available without constraints and 4503 acres available with some constraints. There are a few solar projects in existence and one larger net-metered project in the permitting process. 54.7 KW are currently generated from ground and rooftop PV solar generators. Parcel boundaries have been superimposed over the solar energy map. Comparison of the parcel boundaries with the indexed parcel map in the Town Office will allow identification of parcel owners and facilitate promoting solar energy conversion to and by individual parcel owners. It will also support forming consortiums or other business partnerships for community solar generation.

Wind Resource Maps
Jamaica's wind map includes raw resource potential, known and possible constraints, grid infrastructure, transmission and distribution resources and constraints. There are no existing wind installations. There are 1687 acres suitable for large scale commercial wind generation, 1683 with possible, potential constraints and only 4 without constraints. There are a total of 6175 acres in Jamaica with potential for small-scale commercial wind generation, 136 without constraints and 6038 available with possible, potential constraints. This estimate does not include the recent purchase of land on Turkey Mountain by the Nature Conservancy which will significantly reduce land available for development of any wind resource. Development of either large or small commercial wind generation on Jamaica's mountain ridge lines is deemed unacceptable for reasons enumerated elsewhere. There are 12572 acres with potential residential wind development in Jamaica, 1060 without possible, potential constraints and 11513 acres available with possible, potential constraints. Jamaica will encourage residential wind generation development where feasible. As with the solar map, parcel boundaries have been superimposed to facilitate location of possible residential wind installations. Comparison with the Town's indexed parcel map will facilitate both planners and parcel owners to determine the residential wind energy potential of their property.

Jamaica's Preferred Locations
Jamaica will determine specific areas suitable for community solar generators by comparison of solar potential maps with our Existing Land Use and Proposed Land Use District maps, included in this Energy Plan. In this determination, ridge lines, conservation areas, and special interest areas will be excluded from consideration (see maps 4,5 and 6 of Appendix A). State-defined preferred locations, such as previously developed sites,

brownfields, and gravel pits will be identified, as well as existing open fields where solar fields may be unobtrusively located. Community generators, co-ops, or other ventures will be encouraged to develop these sites. Residential sites for rooftop solar panels or small stand-alone solar arrays must be handled individually in that house orientation and available direct sunlight vary from property to property. Similarly, Jamaica will encourage homeowners to determine the suitability of their property for residential solar or wind generation by using the solar and wind potential maps with parcel overlays. Our energy committee will request suitability information from our residents. A planned town survey may be used for this purpose. This data will be used to keep homeowners informed as anticipated technology and business developments enable economic conversion to renewable energy generation.

Areas Unsuitable for Energy Siting

Jamaica has overlaid the conservation and special siting areas from our 2017 Town Plan Proposed Land Use District map and the public land and conservation easement areas from our Existing Land Use map with the wind and solar potential maps from the WRC (see map 5, 6, and 7 of Appendix A). The high degree of correlation between ridge lines with industrial wind potential and the existing and proposed and current conservation areas and special sites leaves no areas with commercial wind potential that would not have unacceptable environmental consequences and would not be in conflict with the Town's land-use policies. Existing and proposed conservation areas generally correspond with ridge lines identified in our 2017 Town Plan. Jamaica seeks to protect these areas for economic as well as environmental reasons. This is further reason to exclude industrial wind from our approach to meeting regional targets. Excluding commercial wind development does not interfere with the town's ability to meet renewable energy targets.

Jamaica's Energy Targets and Conservation Challenges

The Windham region was given an overall renewable energy generation target, as determined by the Department of Public Service, based on its percentage of the State's population (which directly affects its share of statewide consumption). The Windham Regional Commission (WRC) then determined energy generation targets for each of their member-towns, based on both the resource availability in town and its population. The resulting Jamaica generation targets are an average between those two characteristics.

Energy Generation Targets

In Jamaica, it is estimated that 1,231 MWh of renewable energy should be generated each year by 2050. This figure is an average of 1,167 MWh (based on the town's share of the regional population), and 1,294 MWh (based on the percent of regional resource availability). This estimated generation target serves as a starting point from which the town can develop policy to address its energy needs. We have applied the 25% and 40% ratios to determine interim targets for the benchmark years.

To translate this figure into what kinds of installations would be required, 1231 megawatt hours of renewable energy each year would require a total of 946.57 kilowatts of solar photovoltaic installations (using the assumption that only solar energy would contribute to the overall energy generation target, not any other generation source). On the landscape, this could mean that the town identifies 57 acres of solar-capable land. This is a very conservative figure; assuming that each megawatt of energy requires 60 acres (on average, solar installations produce a single megawatt over 8 acres). Using the 60 acres/megawatt energy production rate is for contingency; it reserves space for landowner, grid, or spatial constraints that may limit development. This ensures enough space would be delineated. Acres needed for the actual footprint of the development to accommodate for the target is 8 based on 8 acres/megawatt.

While not included in the target, residential wind and micro-hydro generation that may be installed will supplement renewable energy generation contributing to meeting or exceeding Jamaica's target. It should be noted that a 2.2 megawatt hydro generator recently commenced operation at the Ball Mountain Dam, and is accounted for in determining existing power generation.

Although renewable energy generation can occur in the Town and supply its residents with reliable, affordable, and clean power, the Town is challenged by the current amount of energy being consumed. In order to minimize the amount of energy generation required, the town must first develop strategies to reduce the amount of energy consumed.

Projected Energy Use: LEAP Model Results

To help inform Jamaica's policies on energy conservation measures, Jamaica used guidance from the LEAP (Long-Range Energy Alternatives Planning system) model, conducted by the Vermont Energy Investment Corporation as part of the state's comprehensive energy planning initiative.

The LEAP model is used to guide Vermont's regions towards reducing the amount of greenhouse gas emissions and consuming 90% renewable energy by 2050 (referred to as the "90x50" goal). To accomplish the state's energy goals, there are several interim benchmarks built into the LEAP model which ensure a progressive pace in attaining that "90 x 50" goal. Vermont's energy goals are:

- Greenhouse gas reduction goals of 50% from 1990 levels by 2028 and 75% by 2050.
- 25% of energy supplied by renewable resources by 2025 (25 x 25).
- Building efficiency of 25% of homes (80,000 units) by 2020.

Incorporating those goals into the model produced energy generation, conservation, and fuel conversion targets at benchmark dates for all regions in the state, and is informed by the region's current energy profile. The WRC received the results from this model and was tasked with making those results relevant to its member towns. The WRC therefore divided its region-wide benchmark targets among its towns based on their population (which is assumed to most directly impact the amount of energy the towns consume).

The following paragraphs and figures show Jamaica's LEAP model results, and how much energy could be conserved in order to reduce the burden of energy generation facilities in the region.

Residential Heating Conservation & Fuel Conversion

In order to determine how much energy would have to be conserved or how much fuel conversion to renewable energy achieved, the LEAP model produced both "Reference" and "90x50" scenarios. The Reference scenario is meant to depict energy use over decades if no major changes were made in our energy profile. It is the "business as usual" scenario. The "90x50" scenario shows one pathway that communities can adopt in order to reduce greenhouse gas emissions, conserve energy, and generate renewable energy so as to meet the state's goals. This pathway is translated to Jamaica's use, and is shown below. It is another data estimate that serves to help inform the Town to develop its own policies for energy conservation and fuel conversion.

Figure E7 below show the LEAP results for Jamaica's residential heating sector. In both the Reference and 90x50 scenarios, energy consumption is modeled to decrease (on account of technological improvements, building innovation, and home efficiency improvements).

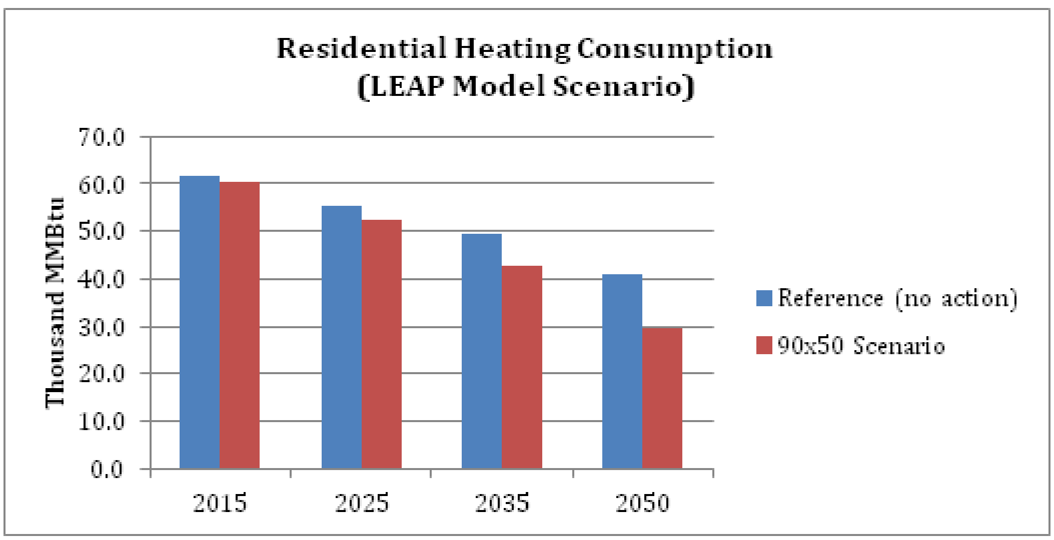


Figure E7

Jamaica Residential Heating Sector LEAP Results

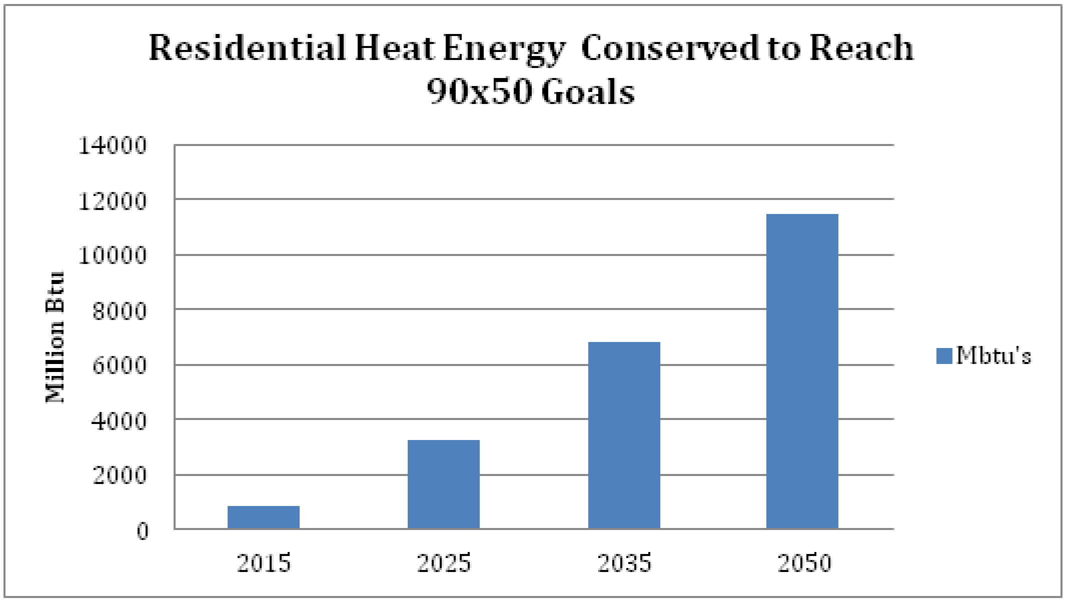


Figure E8
Jamaica Residential Heat Energy Conserved to Reach 90x50 Goals

However, the 90x50 scenario shows a sharper increase in the amount of energy conserved in residential heating. Figure E8 shows how much energy should be conserved through 2025, 2035, and 2050, to help the Town arrive at these energy goals. Not only would energy need to be conserved solely by building efficiency measures, but fuel conversion to more efficient energy sources would be promoted.

In order to attain the renewable energy goals, the following cumulative targets have been established for Jamaica for years 2025, 2035, and 2050.

Thermal (Heat) Efficiency Targets at Benchmark Years

Use/Sector	2025	2035	2050
Residential thermal (increased efficiency and conservation): Percent of municipal households to be weatherized over benchmark years to meet efficiency targets.	9%	17%	36%

Residential thermal (increased efficiency and conservation): Estimated number of municipal households to be weatherized.	94	184	377
Commercial thermal (increased efficiency and conservation): Percent of commercial establishments to be weatherized over benchmark years to meet efficiency targets.	9%	16%	30%
Commercial thermal (increased efficiency and conservation): Estimated number of commercial establishments to be weatherized.	3	6	10

Table E3
Jamaica Thermal (Heat) Efficiency Targets at Benchmark Years

Additionally, the following fuel conversion targets are set for heating fuel types used, with an emphasis towards shifting to more renewable heat sources and using more efficient sources (such as heat pumps).

Heating Fuel Switching Targets			
Use/Sector	**2025**	**2035**	**2050**
Residential and Commercial Thermal Fuel: Estimated **new efficient wood heat systems overall** (in units) in the LEAP 90x50 scenario (this includes both wood stoves and wood pellet burners for homes and businesses). This number may decline over the target years, which indicates an overall trend toward energy conservation and building weatherizing, which reduces the demand on heating systems.	280	266	266
Residential and Commercial Thermal Fuel: Estimated **new wood pellet systems only** (in units) in the LEAP 90x50 scenario.	49	54	67
Residential and Thermal Fuel: Estimated **new heat pumps** (in units).	87	172	243

Table E4
Jamaica Heating Fuel Switching Targets

Transportation System Changes

The LEAP model created benchmark targets for both light and heavy duty vehicles, assuming a difference in residential and industrial energy needs and changes over time. Below are the two interpretations of these sector's efficiencies over time.

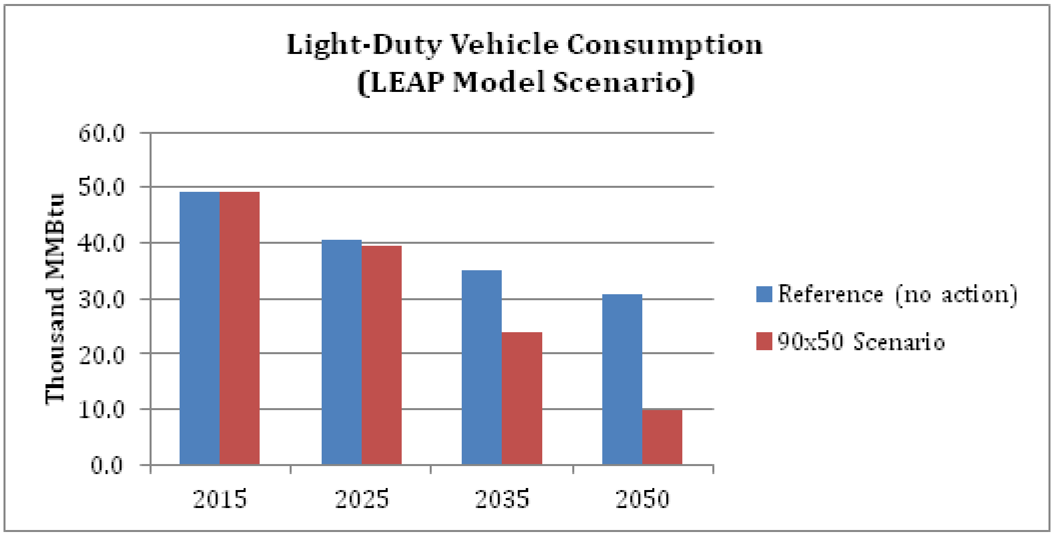


Figure E9

Jamaica Light-Duty Vehicle Consumption (LEAP Model Scenario)

Light-duty vehicle consumption represents a larger portion of the total amount of energy consumed by the transportation sector, and there is a large amount of energy conservation required. The LEAP model projects much of this conservation of energy comes from the electrification of the vehicle fleet, especially as market demand changes and technology improves. This reduction in gasoline consumption and electrification of the car motor comes in addition to increased cluster developments and other land use changes that improve the efficiency of our community's transportation network. Jamaica's economic development policies encourage business development in Jamaica Village and Rawsonville. Improved local availability of goods and services will decrease vehicle use. The following targets for the years 2025, 2035, 2050 are set for the town's transportation fuel conversion:

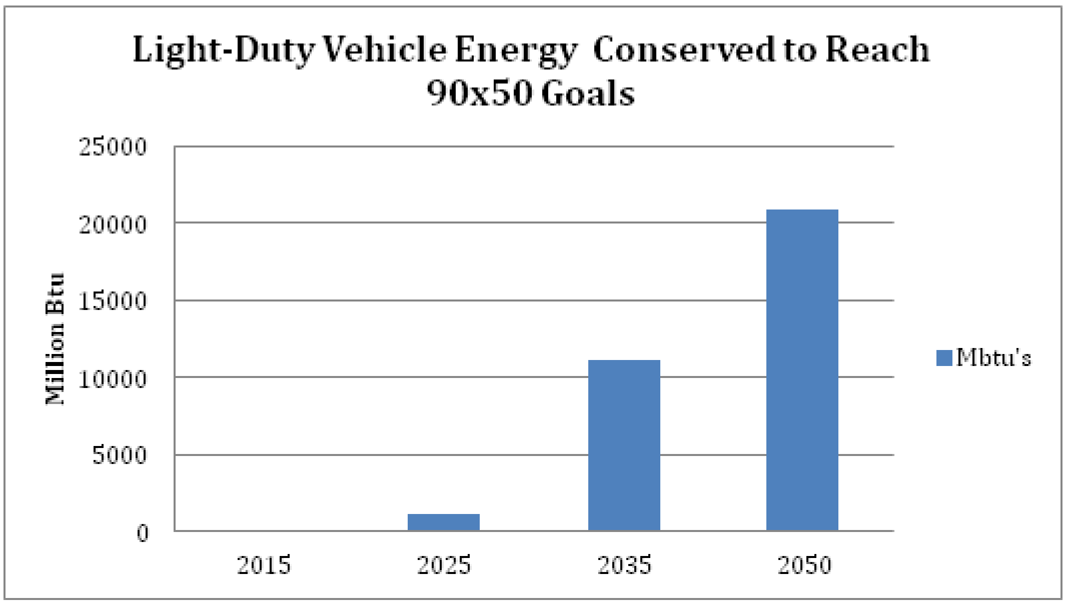


Figure E10

Jamaica Light-Duty Vehicle Energy Conserved to Reach 90x50 Goals

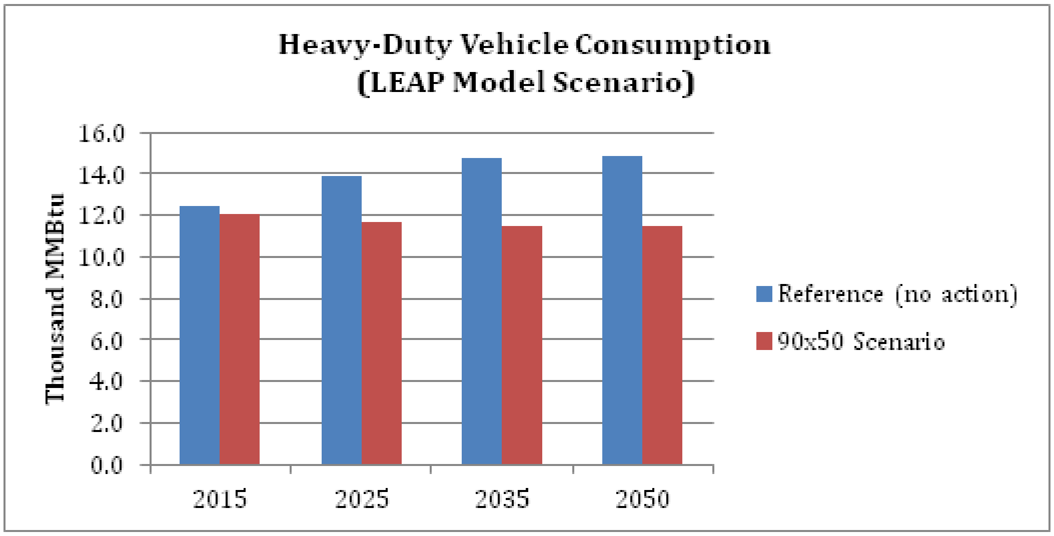


Figure E11
Jamaica Heavy-Duty Vehicle Consumption (LEAP Model Scenario)

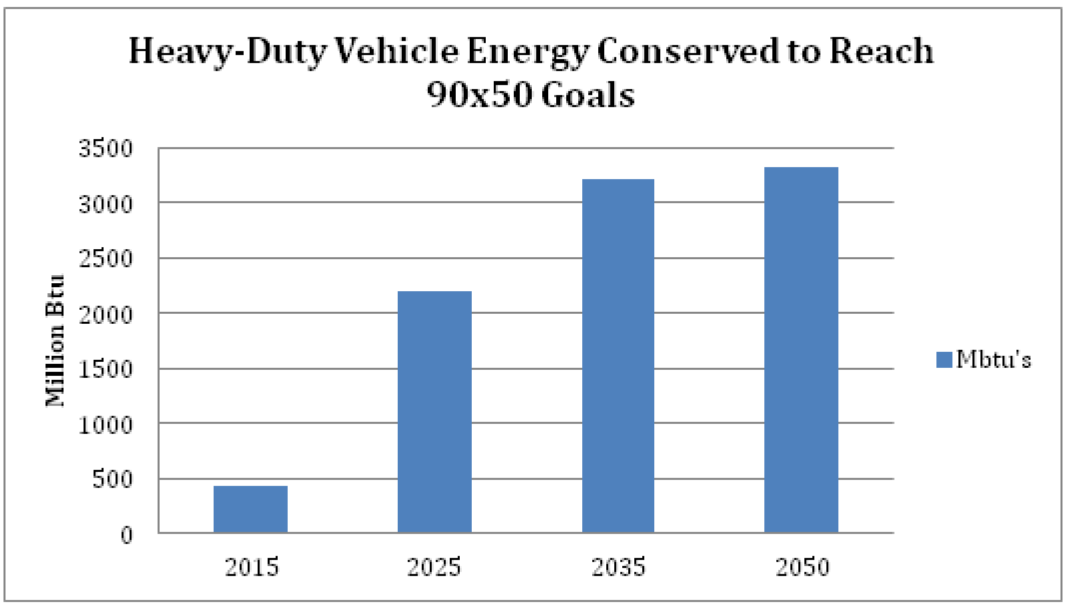


Figure E12
Jamaica Heavy-Duty Vehicle Energy Conserved to Reach 90x50 Goals

Transportation Fuel Switching Targets			
Use/Sector	**2025**	**2035**	**2050**
Transportation Fuel: Estimated number of **new electric vehicles, in town.**	60	424	896
Transportation Fuel: Estimated number of **biodiesel-powered vehicles, in town.**	92	176	304

Table E5:
Fuel switching targets for the transportation sector, across the benchmark years.

Heavy-duty vehicle consumption doesn't show the same curves as per light-duty vehicles, since commercial and industrial applications for this vehicle fleet isn't anticipated to change as much. However, efficiency in this sector is achieved by changing the fuel type for these vehicles from diesel to bio-diesel.

Electricity Conservation

Over the benchmark years, electricity rates are anticipated to increase in the Reference scenario, due to a combination of more amenities, appliances, and motors being supplied by electric power, and an increase in the number of people using those products. The 90x50 scenario promotes electricity conservation in the form of energy-efficient appliances, lighting, and heating/cooling.

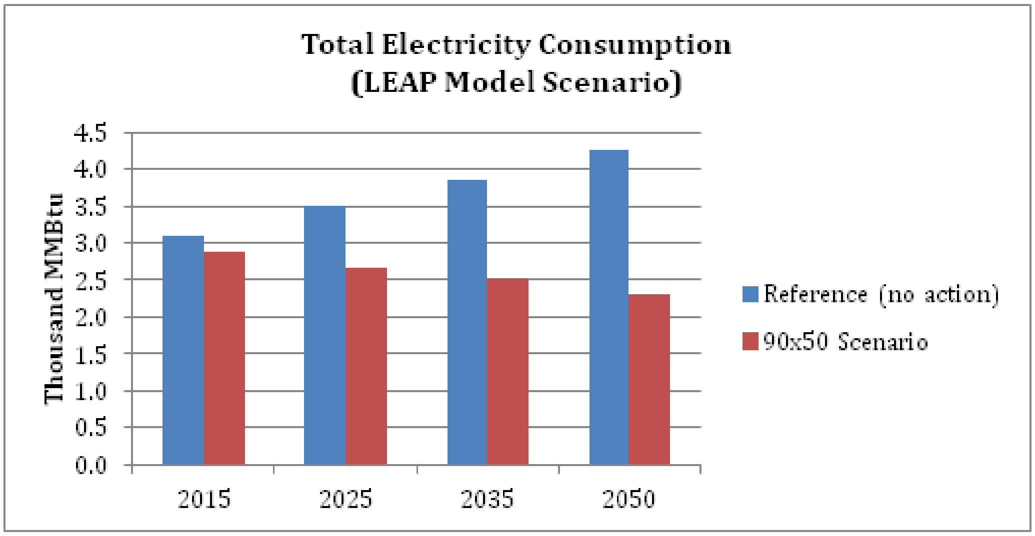


Figure E13

Jamaica Total Energy Consumption (LEAP Model Scenario)

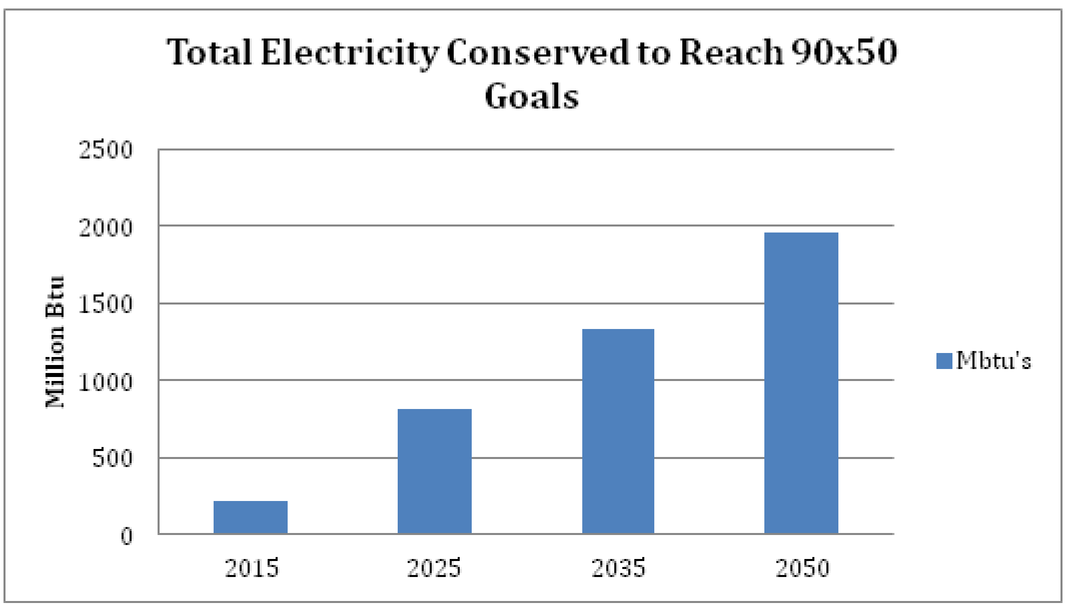


Figure E14

Jamaica Total Electricity Conserved to Reach 90x50 Goals

Pursuing these upgrades, the town is targeted to save the following in electrical conservation measures for target years 2025, 2035, 2050:

Efficiency Targets at Benchmark Years			
Use/Sector	**2025**	**2035**	**2050**
Electricity: Number of kilowatt hours to be conserved, annually, over the target years.	561,700	917,900	1,342,600
Electricity: Percentage of number of homes and buildings that will have been upgraded with electric efficiency improvements.	42%	68%	100%

Table E6:
Electric-sector efficiency targets across the benchmark years.

Conservation and Efficiency Strategies
With total energy expenditures in the Town in excess of 164,862 MBTUs, there is considerable opportunity for savings from various energy conservation and improved efficiency measures. Because most of the energy use in Jamaica is for private uses (home heating, commuting, etc), savings would accrue primarily to residents. Public education is one of the most effective strategies to bring about savings through energy conservation and improved efficiency, though there are some specific policies that can also move the community in that direction.

Most new construction in Jamaica is required by the State to meet or exceed the Vermont Building Energy Standards (for both residential and commercial buildings) through the use of insulation, heating systems, and weatherproof windows and doors. Current state building codes provide basic energy efficiency requirements for buildings; however, technology advancements have generated higher standards such as net-zero energy construction standards in which buildings generate as much energy as they consume. Green construction and LEED Construction (Leadership in Energy and Environmental Design) standards promote the use of natural, recycled and durable building materials, as well as energy efficiency. These efficiency standards are also applied to landscaping, advocating for native plantings that are low-maintenance.

The siting, design, and construction of buildings strongly influences the amount of energy needed for heating as well as the amount of electricity needed for lighting. Proper subdivision design, building orientation, construction, and landscaping provide opportunities for energy conservation such as less vehicular travel, and by designs incorporating passive solar space, domestic hot water heating, natural lighting and photovoltaic electricity production.

Energy savings can be realized by retrofitting existing buildings with insulation, installing high-performance windows and doors to reduce heat loss, weather-stripping, replacing incandescent lights with LED bulbs, and using energy efficient appliances. The following programs are available to residents of Jamaica:

- Southeastern Vermont Community Action (SEVCA): SEVCA is the service provider in Windham County that runs the Weatherization Assistance Program. Weatherization services, which include an energy audit, diagnostic tests, analysis and installation measures, are available at no cost to income-eligible homeowners and renters. SEVCA is also available to help in the event of a heating emergency. They can help purchase oil, kerosene, propane or wood. In addition, they also work with electric companies in order to prevent disconnection and help negotiate payment plans.
- Efficiency Vermont: Efficiency Vermont is the State's provider of energy efficiency services. They provide technical and financial assistance to electrical consumers for the purpose of improving the efficiency of existing and new facilities.
- ENERGY STAR Home Rebates: Energy Star Homes meet strict energy efficiency guidelines set by the U.S. Environmental Protection Agency and U.S. Department of Energy. Efficiency Vermont provides free financial, design, and technical to help build an ENERGY STAR qualified home. Benefits of being an ENERGY STAR home include financial incentives such as product rebates; utility savings; higher resale value; increased comfort and air quality; and other environmental benefits.
- Vermont Housing Finance Authority's Energy Saver Loan Program: Administered by Windham & Windsor Housing Trust, this program offers low interest loan funding for homeowners for an energy audit and improvements specified in the audit.

Transportation-related efficiency strategies are a very significant part of Jamaica's efforts, since it represents a significant portion of the energy demand. Simple changes, such as ride-sharing, combining trips and using alternative transportation, will conserve fuel and reduce wear and tear and maintenance costs on individual vehicles. Fuel-efficient and electric cars will use less gasoline and emit less pollution.

Effective land use planning can promote energy conservation. Targeting new development toward areas located close to the community's major roads and existing settlements will minimize the energy consumed by residents commuting, and will reduce the energy required to deliver essential services to residents and businesses.

Energy Goals, Policies, and Action Steps

Goal 1: Jamaica will reduce the total energy use by our Town through education and promotion of economic opportunities to implement energy conservation and efficiency measures and convert to renewable and recyclable energy sources.

Jamaica is starting from a minimal base of renewable energy sources. Current rooftop capacity is 57 KW. A 500 KW commercial array exists, but it provides power to a different community. There are no residential wind towers. A 2.2 MW hydro source does exist at Ball Mountain Dam, but its operation is not well publicized. Because of this, informing Jamaica's citizenry is the essential first step of implementing this plan.

Jamaica will use the communications tools available to inform our citizenry and promote energy savings and conversion opportunities. We will enable residents to exploit the nexus of advances in energy savings technology and the innovative financing methods that will follow with economic self-interest. We will combine the interests of good citizenship in reducing the CO_2 burden on the atmosphere with energy cost savings products and practices. Most importantly, we will bring low up-front cost financing programs to our citizens' attention to make it financially feasible for everyone to participate in energy saving efforts.

Heating costs are a major element of all Jamaica residents' budgets and a significant municipal operating cost. Conversion to advanced heating technology can save sufficient energy costs to more than pay for conversion. Financing programs that reduce initial capital outlay can make energy savings possible for everyone. Jamaica will encourage conversion to efficient heating systems. We will identify local businesses selling wood heating products including cord, pellet and wood chip fuel and high efficiency wood heating systems.

Responsible forest management is required to make wood heating effective in reducing CO_2 from wood heating systems. With its preponderance of forest lands, Jamaica is in an excellent position to do this and will continue to emphasize responsible forestry for CO_2 reduction as well as environmental and economic concerns. Harvesting wood for heating purposes as well as timber sales in a manner that promotes forest re-growth will be encouraged.

Jamaica will lead by example by identifying and promoting opportunities for cost savings through energy conservation. Opportunities may include improvements in conservation such as improved insulation and weatherization as well as heating source conversion. For demonstration projects involving town owned buildings, initial costs and lifecycle cost reduction will be assessed to determine cost effectiveness of improvements considered. The number of years required for heating cost reduction to offset capital outlay will be determined and used as the major decision criteria. Energy certifications will be sought. Capital costs of projects to be undertaken will be included in proposed Town budgets.

As recognized in the 2016 CEP, compliance with all the energy savings goals is dependent on voluntary actions of an informed citizenry. Informing Jamaica's residents of available opportunities is therefore key to meeting all policy objectives. The Planning Commission's approach to meeting all goals will be by facilitating the alignment of our residents' economic interests with available energy-saving programs, products and — most importantly — low-cost, low up-front capital financing opportunities. A number of opportunities currently exist while others will emerge as the enabling energy savings and conversion technologies mature. For example, the lifecycle cost of cold weather heating systems will decrease as conversion to PV solar electricity generation proceeds. The spread in operating costs will, in turn, enable attractive financing options for conversion. A primary responsibility of the Planning Commission's Energy Committee will be to maintain awareness of the state of energy conservation technology and financing opportunities in order to inform our citizens and encourage adoption of the various conservation measures.

Policy 1.1: Jamaica will promote individual energy conservation through use of the town website and informational town energy presentations and workshops.

Action Steps:

1. Maintain an energy committee responsible for overseeing implementation of this plan (see policy 1.5).

2. Promote state Energy Efficiency Utility (EEU) and the Weatherization programs by using the town website to inform our citizens. We will provide links to available electric, natural gas, and deliverable fuel EEU program resources and Efficiency Excellence Network (EEN) contractors.

3. Co-sponsor weatherization information presentation to town meetings, recording them for later viewing on our website for those unable to attend the original presentation.

4. Promote energy-efficiency opportunities in new construction and remodeling to businesses we hope to attract to Jamaica (see economic development). Jamaica will focus energy conservation measures on the buildings that are municipally owned with particular emphasis on measures to reduce operating costs.

5. Encourage energy audits in any affordable housing units Jamaica develops.

Policy 1.2: Jamaica will promote the efficient use of heating energy in commercial and residential buildings by encouraging citizens to follow energy saving standards and building codes emphasizing lifecycle costs savings of heating energy conservation.

Action Steps:

1. Promote the use of Vermont's residential building energy score/label through use of the

town's website. We will encourage local realtors to feature energy labels in real estate offers.

2. Make commercial building energy standards available to all commercial and residential land use registration applicants.

3. Encourage the use of the EPA's Portfolio Manager tool with EEU assistance for commercial building construction and renovation. The residential stretch energy codes will be promoted for all residential Act 250 projects and required for all commercial Act 250 projects.

4. Review and evaluate making the stretch energy code the standard recommended for all building additions, alterations, and repairs.

5. Join the Vermont Climate Action Coalition and its popular tool, the Vermont Energy Dashboard, to encourage citizens to take energy-actions, no matter how small. The Planning Commission will take the lead on publicizing and implementing. See https://www.vtenergydashboard.org/stories/vermont-climate-action-communities

Policy 1.3: Jamaica will promote the decreased use of fossil fuel for heating by encouraging the use of efficient heat technology to reduce heating costs.

Action Steps:
1. Encourage conversion to cold climate heat pumps and use of ground-source heat pumps as primary heat sources for new construction and major remodeling projects.

2. Assess the cost-effectiveness of converting municipal building heating systems to cold weather heat pumps. Promote conversion based on potential costs savings.

3. Encourage the use of efficient wood heating systems in both commercial and residential buildings including the upgrade of the significant number of wood heating units already in use to EPA approved cord and pellet stoves by making heating cost reduction information available through the town website and town energy information meetings.

4. Encourage the installation of district heating systems in Jamaica Village and Rawsonville.

5. Identify local businesses selling wood heating products including cord, pellet and wood chip fuel and high efficiency wood heating systems.

Policy 1.4: Jamaica will lead by example by assessing and, where cost effective, upgrading the heating of municipally owned buildings.

Action Steps:
1. Jamaica will conduct a baseline energy study including energy audits to determine energy use and identify opportunities for energy cost savings.

2. Identify energy conservation cost saving opportunities. Evaluate capital investment requirements to implement identified actions and return on investment through operating costs reductions.

3. Prepare Town Budget proposal for implementation for Town budgets to be approved in annual Town meetings.

Policy 1.5: The Jamaica Planning Commission's Energy Committee will educate itself on the current state of energy conservation technology and energy conservation financial assistance programs. This policy is considered key to meeting all of our Energy Plan goals.

Action Steps:
1. The Energy Committee will maintain awareness of the current state of renewable energy technology and related financing options.

2. Review available material on energy conservation technology and financial assistance programs from both State and commercial sources on an ongoing basis to maintain a current awareness of available conservation measures suitable for Jamaica's residents.

3. Participation in the Vermont Energy Dashboard and related future programs will facilitate this.

Goal 2: Jamaica will address reduction of transportation energy with steps to immediately facilitate ride sharing. We will encourage use of electric vehicles and or alternative fuel vehicles as alternative automotive technology and renewable or recyclable fuel becomes available and economically feasible.

As noted above, the dispersed commuting and shopping needs of our rural community are unmet by public transportation or alternative vehicles and fuels. In the near term, Jamaica will implement measures to facilitate ride-sharing to common destinations. Anticipated advancement in automotive technology that will increase the range of electric vehicles and the variety of models appropriate to rural community needs will make it practical to promote their purchase for family and municipal use. As conversion to renewable electricity proceeds, savings in fuel costs will provide economic incentives for their use. As they become available, Jamaica will implement measures to promote the use of alternative vehicles and fuels and the economic benefits they offer.

Policy 2.1: Jamaica will encourage the increased use of public transit.

Action Steps:
1. Identify public transit options available to Jamaica residents, including those offered by local service organizations, such as Neighborhood Connections, Senior Solutions, Southeast Vermont Transit (operates The Current, the Moover, and Dial-A-Ride).

2. Develop an information-dissemination strategy, including print, online, and in-person methods in order to keep Jamaica residents aware of options and choices.

3. Examine strategies to increase effective communications and exchange of knowledge.

Policy 2.2: Jamaica will promote a shift away from single-occupancy vehicle trips through strategies appropriate to Jamaica.

Action Steps:
1. Identify established local ride-sharing and public transit options (as outlined above).

2. Develop a local database or clearinghouse to identify Jamaica residents who make regular trips to popular destinations (Brattleboro, Grace Cottage, etc).

3. Investigate liability and insurance impacts for those taking part in ride-sharing opportunities, either as drivers or riders.

4. Examine strategies for publicizing the above -- utilizing varied online and offline messaging formats.

5. Investigate the possibility of locating CSA share drops in local establishments to save driving transport time.

Policy 2.3: Jamaica will promote a shift away from gas/diesel vehicles to electric or other non-fossil fuel transportation options through strategies appropriate to Jamaica.

Action Steps:
1. Identify costs and funding opportunities for installing EV charging stations in the Village Center.

2. Develop marketing and publicity for the above (if installed) to alert visitors to Jamaica State Park of the availability of EV charging opportunities. In the meantime, alert potential visitors to Jamaica of other charging stations in the area.

3. Examine strategies for funding and maintenance for EV charging stations. Investigate technology for solar charging of EV stations.

Policy 2.4: Jamaica will facilitate the development of walking and biking infrastructure through strategies appropriate to Jamaica.

Action Steps:
1. Identify locations in Jamaica Village and elsewhere in town where bicycle racks would be most used.

2. Develop marketing and publicity to inform residents and visitors of safe places to keep their bikes in town.

3. Examine strategies to secure funding for the above.

Goal 3: Jamaica will continue its standing policy of encouraging development in Jamaica Village and Rawsonville. We will continue our policies that encourage low density development in areas distant from Route 30 and the village centers. Recent and planned infrastructure improvements in Jamaica village and along route 30 will be promoted to encourage development in our villages and in designated areas along this corridor. Policies promoting low-density land use and preservation of forests that are central to the Town's economic development goals will be followed.

Responsible forest management practices that are essential to absorb the increase in CO_2 that increased use of wood heating will produce will continue to be emphasized.

Policy 3.1: Jamaica's land use policies and descriptions of current and future land use per our 2017 Town Plan will encourage low-density development outside Jamaica Village and Rawsonville except for certain subdivided areas.

Land Use Policies:
1. Jamaica Village shall continue as the center of the Town. Future expansion of publicly owned community facilities buildings shall be in the Village.

2. Further development within and adjacent to the village districts will be carefully planned to minimize adverse impacts on the character of the village, existing water supply and wastewater disposal, and traffic within the villages.

3. The character of Jamaica Village is an important asset to the community. The character of the Village shall be maintained by limiting uses within the Village to those that are compatible with the existing commercial and residential uses.

4. Encourage the restoration and preservation of buildings that contribute to the architectural and historical character of the Town. When such buildings become obsolete, new uses shall be found for them that will preserve the architectural and historic character of the buildings.

5. Lands adjacent to or including areas of historical, educational, cultural, scientific or architectural value shall be used in a manner that will not reduce or destroy the value of the site or area.

6. Lands adjacent to existing public land and existing or planned public facilities shall be used in a manner that will not diminish the value of such investments or interfere with their intended uses.

7. Require appropriate site planning and landscape design by siting structures to fit into the natural characteristics of the land and maintaining vegetative buffers along roads and parcel boundaries.

8. Require the use of low impact development strategies (e.g., cluster development, conservation easements) that minimize the fragmentation and loss of agricultural land, forest land, unique or ecologically sensitive areas and special sites and areas.

9. Encourage the Town to purchase or accept donations of rights to properties that have high public value.

10. Scenic hills and ridge lines shall be left in their natural condition, free from all development, including roads, building structures, utilities, and wireless broadcast and telecommunications facilities.

11. Require developers to incorporate the following in the site planning of commercial facilities: shared access, landscaping, and provisions for pedestrians.

12. Reduce light pollution by using fixtures that direct light below the horizontal plane, utilizing energy efficient lamps, and using light levels appropriate for the use of the property.

13. Light shall not trespass onto adjacent properties or create dangerous conditions due to glare on adjacent roadways.

14. Lighting design shall include the installation of timers, photo sensors, and other energy saving devices to reduce the overall energy required and to eliminate unnecessary lighting.

15. Require that housing developments not have undue adverse impact on natural resources, open space, and important agricultural and forest lands.

Action Steps:
1. Identify practical ways to identify potential threats to the policies outlined in the 2017 Town Plan.

2. Develop bylaws to strengthen the Land Use policies in the 2017 Town Plan.

3. Examine strategies to achieve broad support for the goals outlined in the 2017 Town Plan.

Policy 3.2: Jamaica will prioritize development in compact, mixed-use centers when physically feasible and appropriate to the use of the development, or identify steps to make such compact development more feasible.

Action Steps:
1. Identify barriers to development in compact, mixed-use centers (septic, water issues etc.)

2. Develop consensus of citizens to address the above.

3. Examine and promote strategies to remove barriers, including exploring funding opportunities.

Goal 4: Jamaica will locate areas suitable for renewable energy generator siting, PV solar, residential wind and micro-hydro.

Because of Jamaica's rural nature and the emphasis we place on conservation, the types of preferred sites for PV solar arrays, as specified by the Public Utility Commission rule 5.100 are limited to rooftops, possible future municipally-designated preferred sites, and potentially, part of an active gravel pit. Jamaica will identify those land parcels that are suitable for either rooftop or residential ground mounted PV solar installations. Jamaica will identify areas comprised of one or more contiguous parcels that are suitable for a commercial PV solar array. Jamaica will identify parcels suitable for residential wind towers. Jamaica will investigate the suitability of siting small hydroelectric generators in the West River to include the potential to meet the stringent licensing requirements. Initial identification of appropriate sites will occur when this plan is adopted and will be repeated as advances in renewable energy technology increase the potential of currently marginal sites. Additionally, Jamaica will investigate the feasibility of developing a hydroelectric pumped energy storage system at the Ball Mountain and Townshend dams.

Jamaica will utilize the April 2017 WRC Solar Resource and Wind Resource maps with Town Parcel Map and Conservation Area overlays (maps 3 and 4 of Appendix A) to identify individual parcels with either PV solar or residential wind potential and areas comprised of contiguous parcels for community PV solar arrays to contribute to meeting 2050 targets. See appendix A. The following decision criteria will be utilized:

- PV solar or residential wind potential of parcel
- Consistency with 2017 Jamaica Town Plan land use policies
- Minimal viewshed impact
- Minimal impact on agricultural use of high quality soils
- No impact on conservation areas, wildlife travel corridors, or living habitat
- Location on agricultural soils only with facility design compatible with continued agricultural use
- No interference with enhanced flood plains
- South facing slopes or out of agricultural production river bottomlands which allow higher density PV solar arrays.
- For commercial PV solar arrays, proximity to 3-phase power lines to minimize Infrastructure expansion
- Existing road structure suitable for installation and maintenance

Jamaica's 2050 target for commercial PV solar generation is 230 MWh. This equates to 176 KW of generation capacity, which in turn will require 1.4 acres of actual footprint. Using the criteria that 60 candidate acres are necessary to locate an 8-acre footprint for each MW generator, Jamaica's target is to locate 10.6 candidate acres containing sufficient contiguous acreage for one or more large solar arrays (150KW – 1MW) or two or more medium size arrays (15KW – 150KW) sufficient to meet our 2050 target.

Jamaica's total 2050 target of 1231 MWh of renewable energy generation can be met with: (1) 130 residential building rooftops, 6.25 small commercial building rooftops and 1.25 large commercial buildings rooftop using PV solar arrays and (2) 10.6 acres of PV solar capable land. Residential wind installations and micro-hydro, if proven feasible, will augment solar contribution to meeting 2050 targets. Given the solar (818 acres of solar potential land without constraints), residential wind (1060 acres of land with potential for residential wind generation without constraints), and micro-hydro potential identified in maps 3 and 4 of appendix A, 2050 targets seem conservative and readily attainable.

Other than ridge line protection and flood plain restrictions, Jamaica has no outright prohibitions on individual property owners' land use, but rather policies encouraging land use consistent with the Town's goals for natural resource protection, cultural heritage, and economic development objectives. The Town's policies will encourage individual landowners of parcels identified as high potential solar or residential wind sites to develop renewable energy projects in a manner consistent with these goals.

Commercial solar development will be encouraged in areas determined suitable from map 3 in Appendix A. Jamaica will not impose any constraints nor discourage renewable energy generation systems, other than prohibition of development in designated ridge line areas that are subject to Act 250 or section 248 jurisdictions, which could limit the town's ability to meet 2050 targets. Jamaica will review the parcels with PV solar or residential wind generation potential to determine those unsuitable for development because of conflict with designated conservation areas, special interest areas, and protected ridgelines. Maps 5, 6, and 7 of Appendix A identify these areas.

A major theme to this Energy Plan is that innovative financing plans that will accompany renewable energy technology development will motivate conversion to renewable energy on the basis of cost reduction. Jamaica will take the lead in demonstrating that conversion to renewable energy for town-owned buildings and surrounding property will reduce annual town operating costs. Budget savings will be translated to tax savings and publicized in town meetings or other energy information presentations.

Jamaica will monitor commercial offerings of renewable energy conversion projects to determine the availability of renewable energy technology that offers either low or no capital investment and reduced energy costs. Falling renewable energy costs, coupled with renewable energy technology advancements, should support this by mid-2020. As it becomes economically advantageous, Jamaica will initiate projects to save taxpayer money and demonstrate financial advantages to town residents.

Policy 4.1 Jamaica will identify sufficient parcels and or areas to meet 2050 targets for renewable energy generation.

Action Steps:
1. Upon approval of this Energy Plan, conduct an initial assessment of parcels with suitable potential for meeting 2050 renewable energy targets utilizing renewable energy potential maps with parcel overlays, Maps 3 and 4 from appendix A.

2**.** Identify Jamaica municipal parcels or multi-parcel zones with adequate PV solar generation potential.

3. Identify Jamaica municipal parcels with adequate wind potential for residential wind generation.

4. Apply above criteria to identified PV Solar and residential wind parcels to eliminate unsatisfactory sites.

5. Make identified parcel PV solar and residential wind potential available to parcel owners.

6. Male identified parcel PV solar potential map available to PV solar contractors.

7. Review site potential assessment as enabling renewable energy technology advances increase the potential of previously marginal areas.

Policy 4.2: Jamaica will ensure that a sufficient amount of land, with sufficient PV solar, residential wind potential, or micro-hydro to meet 2050 renewable energy generation goals is identified.

Action Steps:
1. Jamaica will review the suitable parcels identified in goal 4.1 as having potential for PV solar or residential wind generation potential to identify those that are homesteads.

2. Jamaica will use the energy section of the planned town survey update to assess the suitability of homesteads' suitability for rooftop or ground-mounted PV solar and residential wind with questions of building orientation, available space for ground mounted arrays, space for a residential wind tower and interest in reducing energy costs with renewable energy technology to identify the number of buildings likely to contribute to meeting 2050 targets.

3. Jamaica will review the parcels identified in Goal 4.1 as having solar potential to determine the total acreage suitable for community PV solar arrays.

4. Jamaica will use the energy section of the planned town survey update to determine suitable acreage owner's interest in leasing acreage for community solar array development to identify the acreage likely to contribute to meeting 2050 targets.

Policy 4.3: In the absence of zoning laws, Jamaica has no constraints on or prohibitions of individual landowner's development of residential solar or wind installations beyond prohibition of development in designated ridge line areas that are subject to Act 250 or section 248 jurisdictions. While Town Plan land use prohibition of ridge line development limits industrial wind development, Jamaica will impose no constraints on meeting 2050 targets with residential PV solar, micro-hydro, and wind and community solar arrays.

Action Steps:
1. Jamaica will ensure that any changes to the Town Plan Land Use section will be assessed for their impact on changing the number of parcels likely to install either rooftop PV solar or residential wind renewable energy generators. If any impact is identified, Jamaica will ensure that the benefit of the change, e.g. enhancing environmental preservation, outweigh the impact on meeting renewable energy development.

2. If action step 1 identifies any reduction in available parcels for renewable energy generation, Jamaica will ensure that the remaining land resources are adequate to meet 2050 targets.

Policy 4.4 Jamaica will identify preferred, potential, and unsuitable areas for renewable energy generation.

Action Steps:
1. Jamaica will review the parcels with PV solar or residential wind potential developed with the action steps of policy 4.1 and 4.2 to identify any meeting the criteria of Public Utility Commission Rule 5.100.

2. Utilizing the Solar and Wind Generation Potential Maps with parcel conservation and special interest areas from Jamaica's Town Plan Planned Land Use Maps overlaid, identify those parcels in which commercial wind development is prohibited or in which solar or residential wind development is unsuitable because of low potential. Identification of areas deemed unsuitable for PV solar or residential wind generation will not interfere with the town's ability to reach its target.

Policy 4.5: Jamaica will review parcels identified in the action steps of policy 4.1 to identify areas comprised of one or more contiguous parcels as preferred areas for commercial PV solar generator siting.

Action Steps:
1. From the set of parcels identified in the action steps of policy 4.1 with potential for PV solar generation, Jamaica will identify areas, comprised of one or more parcels with sufficient area for either a large or medium sized PV solar generator. Jamaica will identify at least 10.6 acres meeting these criteria.

2. Jamaica will prioritize areas identified according to the distance to 3 phase power lines, and access from existing roads criteria of policy 4.1.

3. Jamaica will advise owners of parcels that include areas suitable for commercial generator siting of their identification as such.

4. With parcel owner's consent, Jamaica will advise commercial PV solar generator developers of site availability.

Policy 4.6: Jamaica will demonstrate leadership by example with respect to the deployment of renewable energy

Action Steps:
1. Jamaica will maintain awareness of the state of renewable energy technology and financing option available from solar enterprises.

2. As anticipated advances occur, Jamaica will conduct a feasibility study of conversion of town-owned buildings, town office, town garage, and firehouse, to renewable energy utilizing rooftops and surrounding land for solar arrays.

3. When feasibility studies show a combination of both electrical rate reductions and financing costs are less that existing energy costs, Town approval will be sought for executing a conversion project as both a demonstration and budget reduction effort.

4. Jamaica will conduct and economic feasibility assessment of converting town building heating systems to heat pumps. A conversion project will be initiated when capital and operational costs are lower than current heating costs.

Jamaica Energy Plan
Appendix – Energy Maps

List of Maps

1. Town of Jamaica Solar Energy Potential. Windham Regional Commission map overlays areas of Prime and Secondary Solar Potential on Town Map of Jamaica.

2. Town of Jamaica Wind Energy Potential. Windham Regional Commission map overlays areas of Prime and Secondary Wind Resources on Town Map of Jamaica.

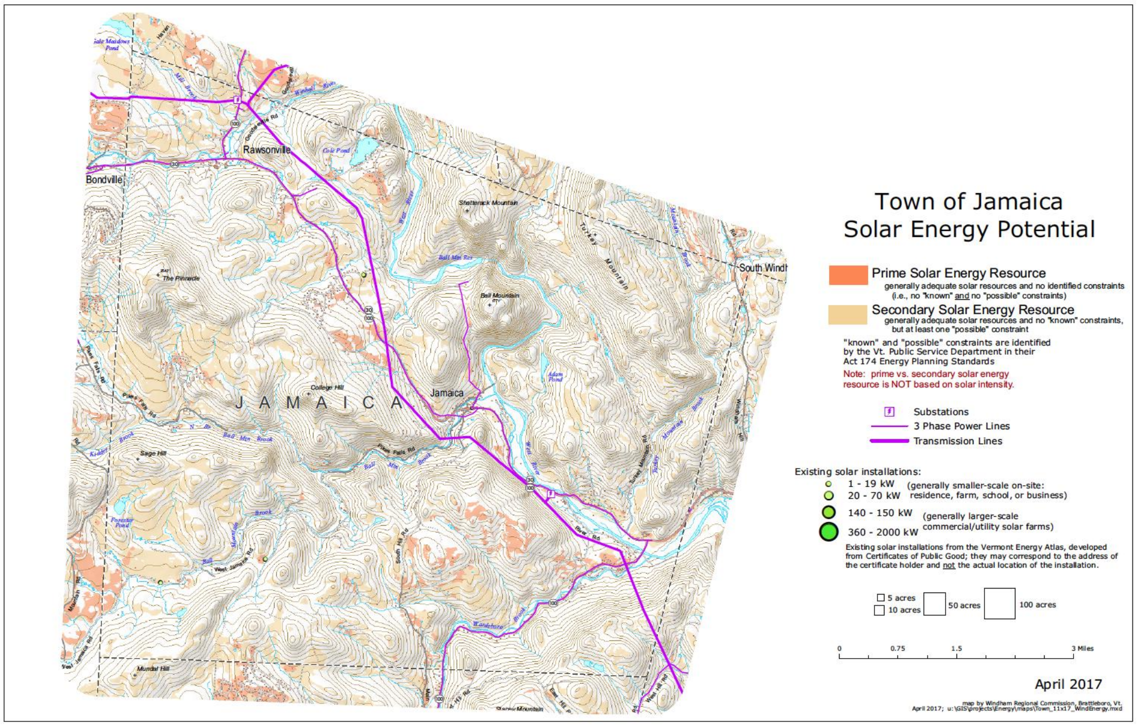
3. Solar Energy Potential in Town of Jamaica Land Parcels. Town Map of Jamaica Land Parcels is overlaid on Windham Regional Commission Town of Jamaica Solar Energy Potential maps to identify solar potential in individual Jamaica land parcels.

4. Wind Energy Potential in Town of Jamaica Land Parcels. Town Map of Jamaica Land Parcels is overlaid on Windham Regional Commission Town of Jamaica Wind Energy Potential map to identify wind potential in individual Jamaica land parcels.

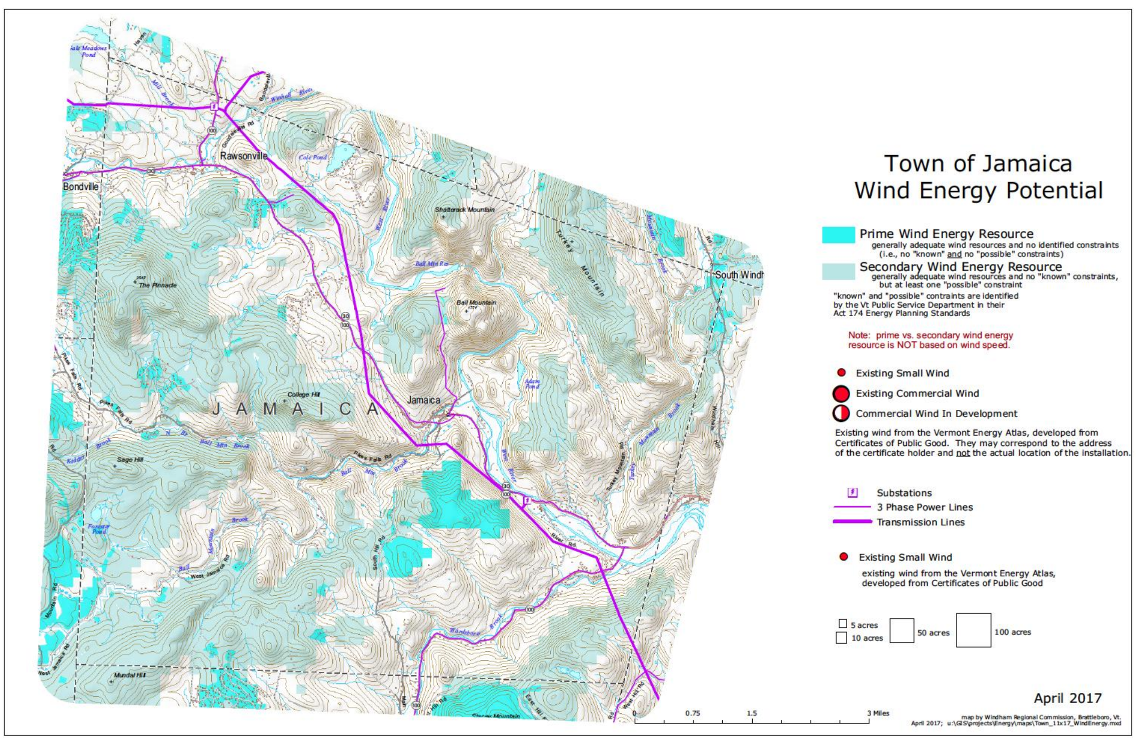
5. Jamaica Wind Resources with Existing Land Use. The Jamaica Wind Resources with Existing Land Use map overlays public land parcel and large continuous forest block layers from the Town of Jamaica Existing Land Use map on the Windham Regional Commission Wind Resource map. This map shows the juxtaposition of areas identified as suitable for large and small commercial and residential wind generator development with public lands and large forest blocks.

6. Jamaica Wind Resource with Proposed Land Use. The Jamaica Wind Resource with Proposed Land Use map overlays the Scenic Hill or Ridge Line, proposed conservation area, proposed rural resource area, and conserved land area layers from the Jamaica Existing Land Use map on the Windham Regional Wind Resource Map. This map shows the juxtaposition of scenic areas and ridgelines, proposed conservation areas, rural resource areas, and conserved areas with areas identified as suitable for large and small commercial and residential wind development.

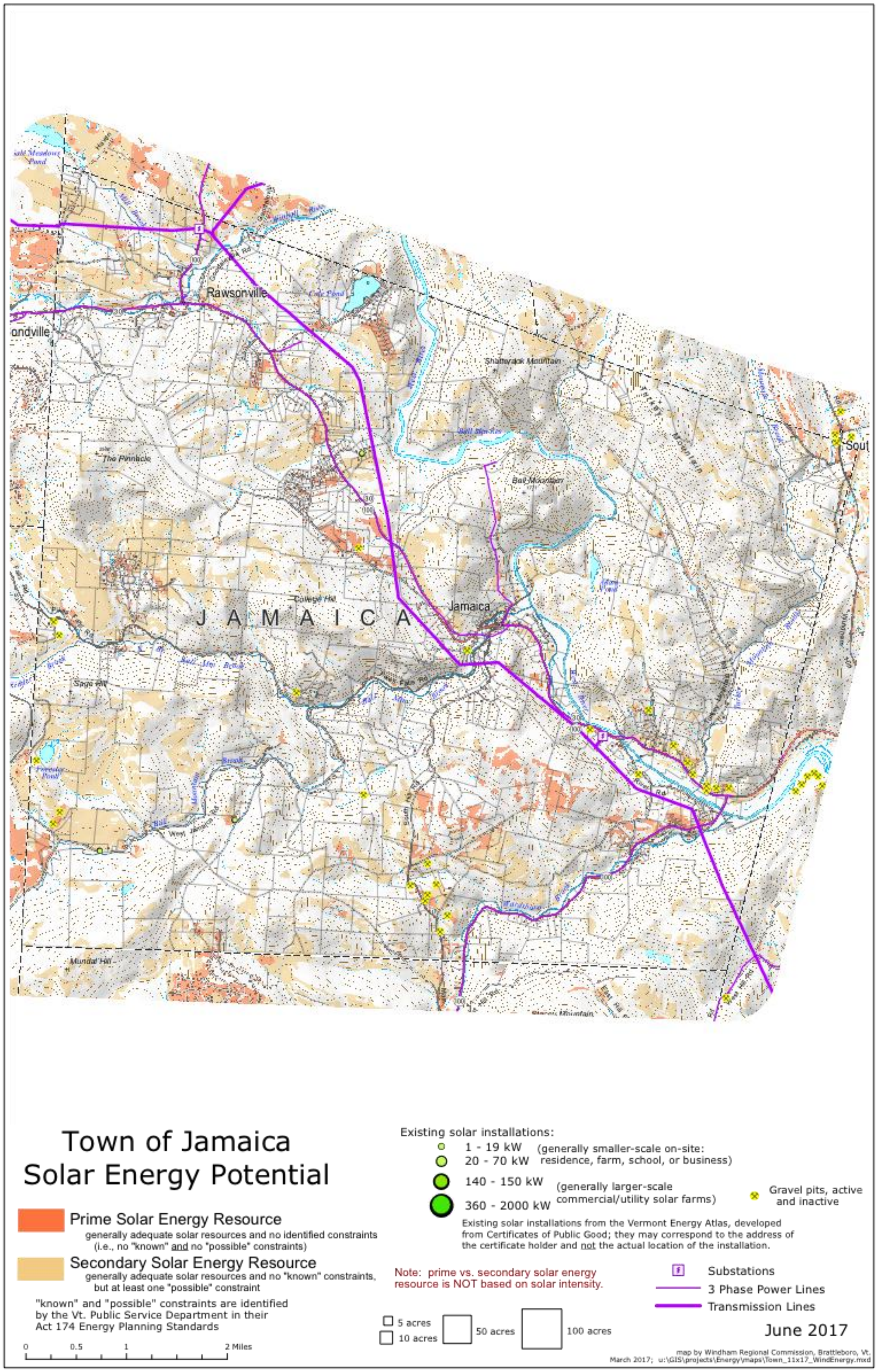
7. Jamaica Wind Resource with Special Sites. The Jamaica Wind Resource with Special Sites map overlays the scenic waterfall or gorge, federal, state, and town land, and undeveloped stream segment layers from the Jamaica Special Sites town map on the Windham Regional Commission Wind Resource Map. This map shows the juxtaposition of the scenic water fall or gorge, federal, state, and town land, and undeveloped stream segments with areas identified as suitable for large and small commercial and residential wind development.



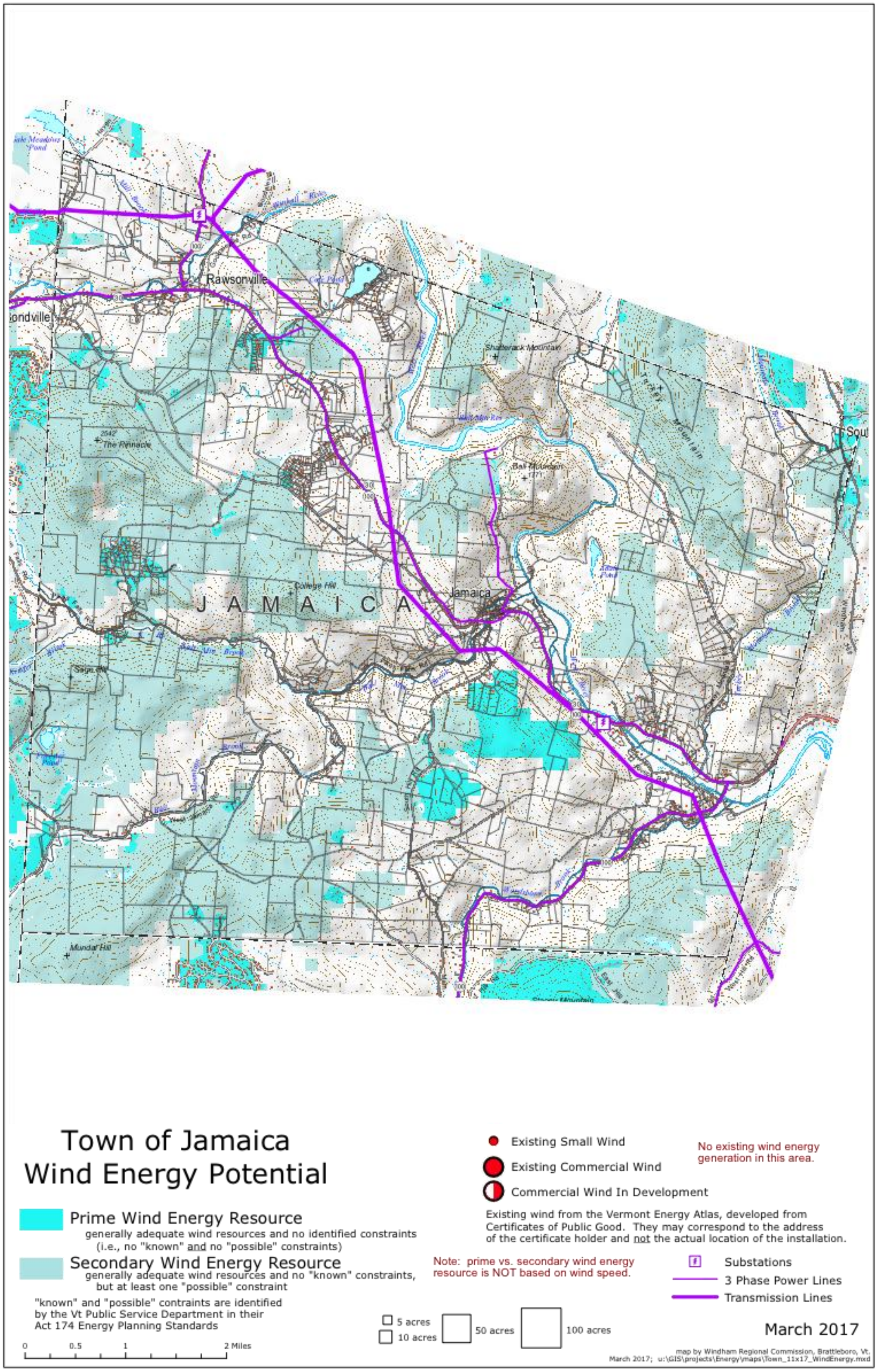
Map 1 – Town of Jamaica Solar Energy Potential



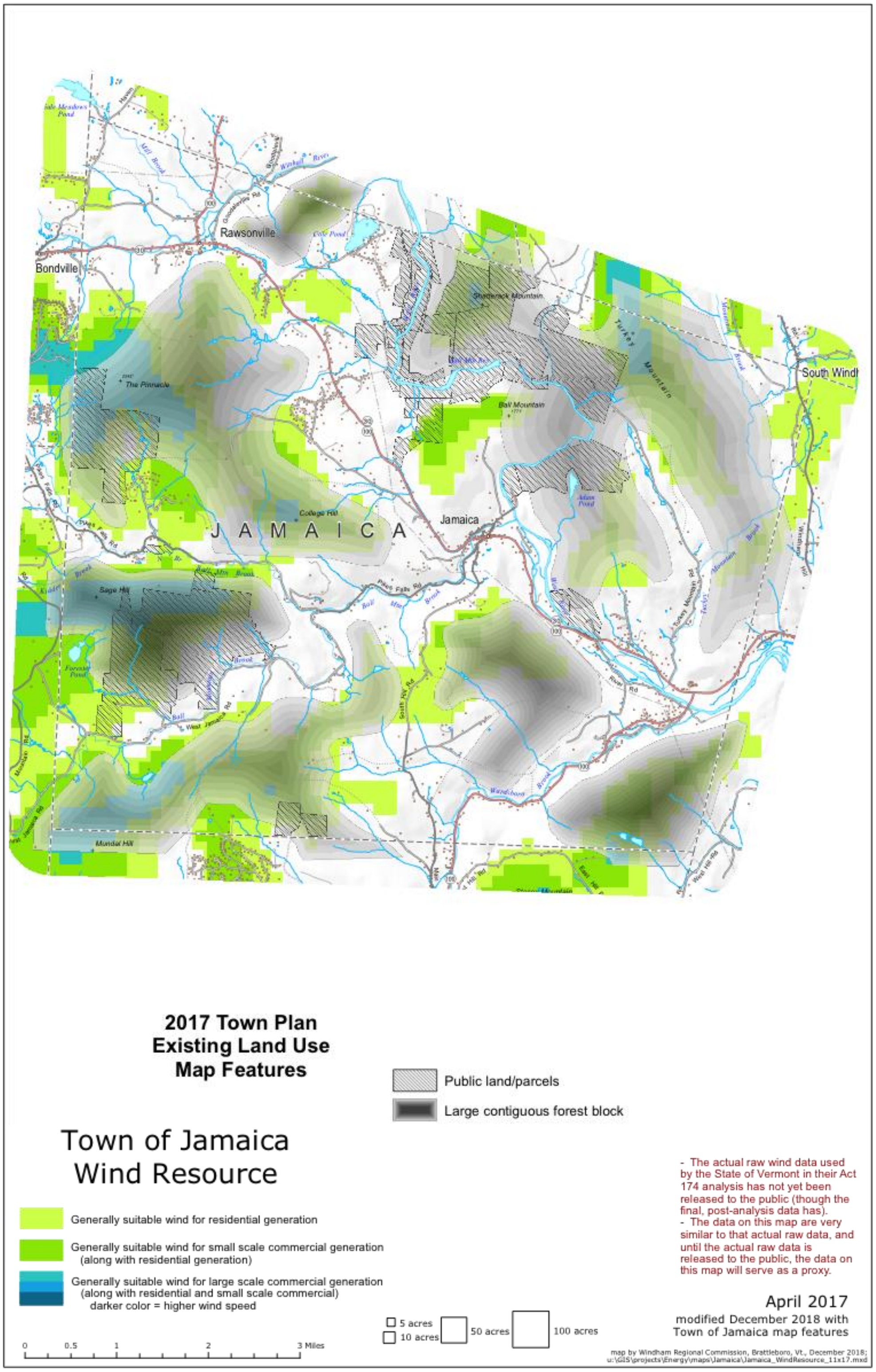
Map 2 – Town of Jamaica Wind Energy Potential



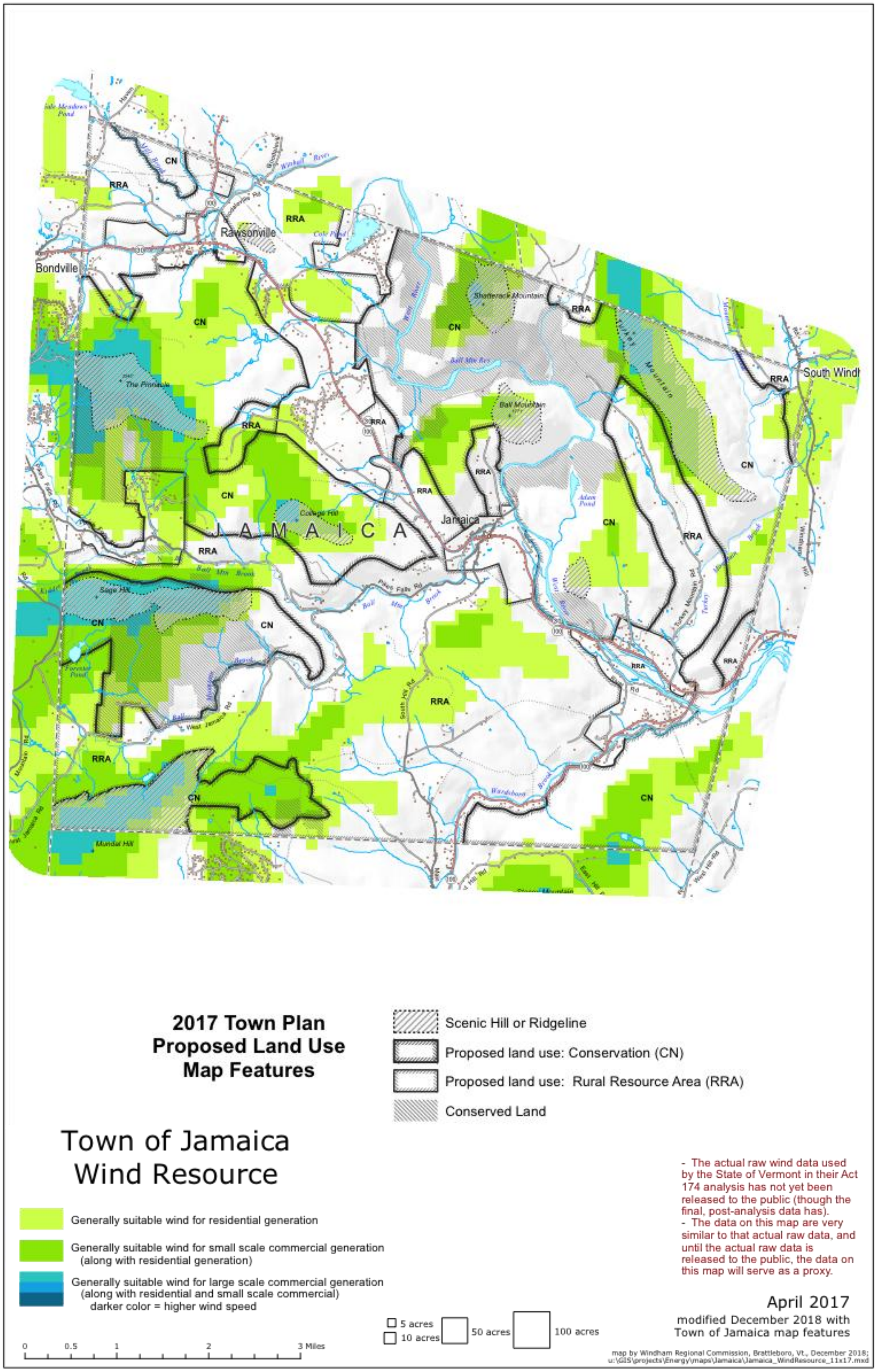
Map 3 - Solar Energy Potential in Town of Jamaica Land Parcels



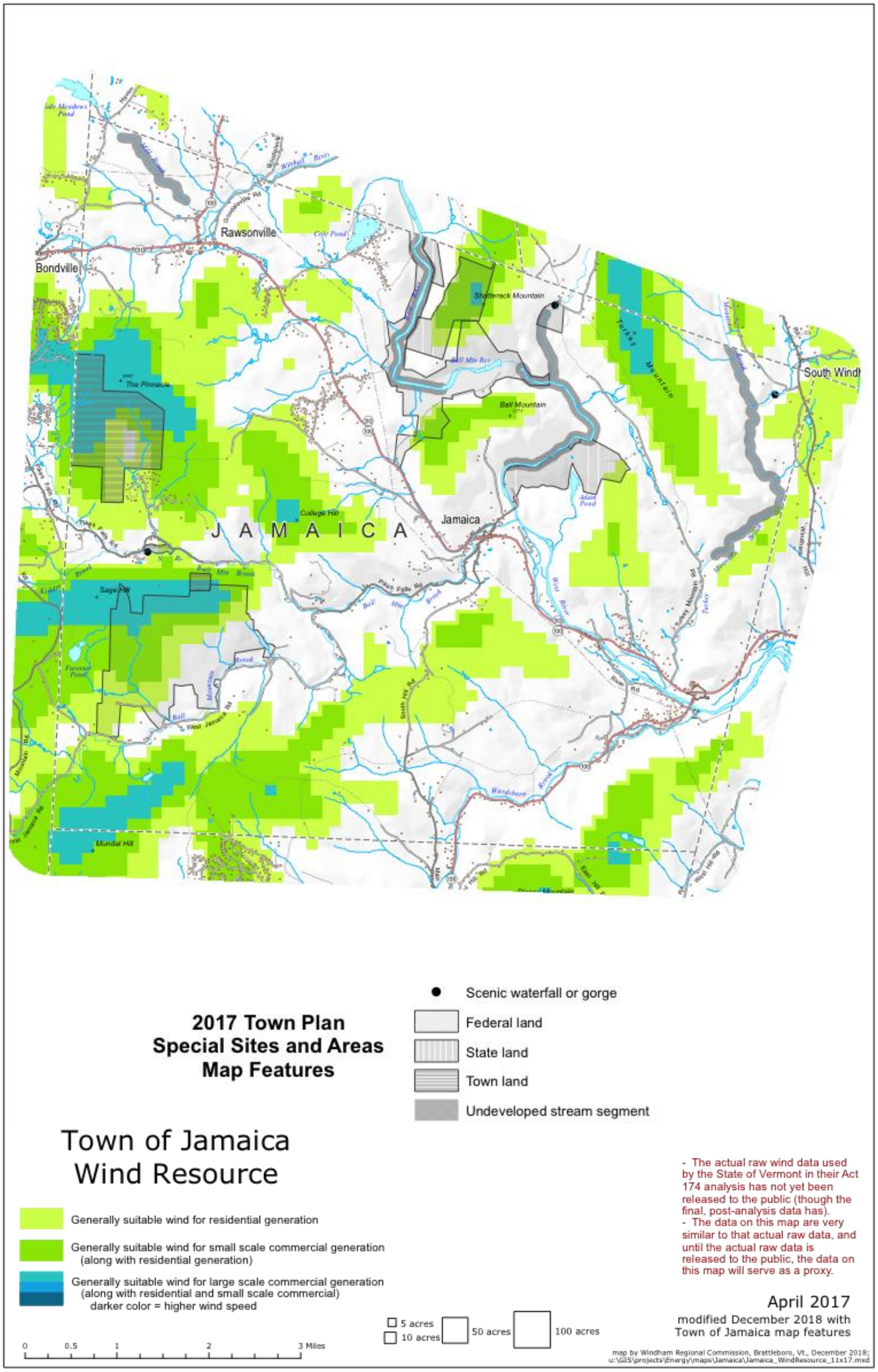
Map 4 - Wind Energy Potential in Town of Jamaica Land Parcels


Rawsonville
Bondville
The Pinnacle
Ball Mountain
College Hill
J A M A I C A
Jamaica
South Windh
Sage Hill
2017 Town Plan
Existing Land Use
Map Features
Public land/parcels
Large contiguous forest block
Town of Jamaica
Wind Resource
Generally suitable wind for residential generation
Generally suitable wind for small scale commercial generation
(along with residential generation)
Generally suitable wind for large scale commercial generation
(along with residential and small scale commercial)
darker color = higher wind speed
- The actual raw wind data used by the State of Vermont in their Act 174 analysis has not yet been released to the public (though the final, post-analysis data has).
- The data on this map are very similar to that actual raw data, and until the actual raw data is released to the public, the data on this map will serve as a proxy.
April 2017
modified December 2018 with
Town of Jamaica map features
5 acres
10 acres
50 acres
100 acres
0
0.5
1
2
3 Miles
map by Windham Regional Commission, Brattleboro, Vt., December 2018;
u:\GIS\projects\Energy\maps\Jamaica\Jamaica_WindResource_11x17.mxd

Map 5 - Jamaica Wind Resources with Existing Land Use



Map 6 - Jamaica Wind Resource with Proposed Land Use



Map 7 - Jamaica Wind Resource with Special Sites