# CENTRAL VERMONT
# REGIONAL PLANNING COMMISSION

# REGIONAL ENERGY PLAN

## Approved by the
## CVRPC Board of Commissioners
## May 8, 2018

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# ACKNOWLEDGEMENTS

The development of this plan would not have been possible without the assistance of the dedicated individuals that volunteered their time to participate on the Regional Energy Committee. This committee was established by the CVRPC Board of Commissioners to provide recommendations regarding energy planning and lead to action by the full Commission. The committee represented a diverse cross section of the region and interests to provide multiple perspectives that were critical to the development of this plan. The members that served on this committee include:

Steve Fitzhugh, Chair, Town of Northfield Planning Commission
Bram Towbin, Vice-Chair, Town of Plainfield Selectboard
Alex Bravakis, Novus Energy Development
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Janet Shatney, CVRPC (Barre City)
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Jamie Stewart, Central Vermont Economic Development Corporation
Paul Zabriskie, Capstone Community Action

<u>How This  Plan Will Be Used</u>

The Central Vermont Regional Energy Plan will establish the policies that will help the Regional Planning Commission achieve its share of the state's goal of 90% of the state's energy coming from renewable sources by 2050, as outlined in the 2016 State Comprehensive Energy Plan. In order for this document to have standing, it will need to receive a Determination of Energy Compliance (DOEC) from the Vermont Public Utility Commission (PUC). This determination will give the Central Vermont Regional Plan "substantial deference" before the PUC during their review of applications for Certificates of Public Good related to renewable energy generation facilities.

Once a DOEC has been issued, the Central Vermont Regional Plan will be used to establish a position in proceedings before the PUC if warranted Additionally, where applicable, the plan will be used during Act 250 proceedings before the District 5 Environmental Commission. Finally, once a DOEC has been issued to the region, municipal plans will be reviewed against the Regional Energy Plan and against the standards of Act 174 for municipal planning. If all the requirements for municipal planning are successfully met, the Region will issue a DOEC for the municipal plan. This determination will provide the municipal plan with "substantial deference" before the PUC as applicable.

Additional Energy Generation Technology

The general premise of the Central Vermont Regional Energy Plan is based on the idea that generation of energy will be achieved using more renewable sources and less fossil fuel based resources. To this end, the focus for generation of energy is primarily based on existing technologies such as solar, wind, and hydroelectric. Additionally, the plan notes woody biomass and biogas as renewable forms of energy generation when developed in a sustainable manner. This direction is taken from the State's Comprehensive Energy Plan which focuses on electrification of the grid in order to meet their goals of 90% of the state's energy use coming from renewable sources by 2050.

The sources of renewable energy generation that are identified in this plan include current technologies that are known and supported in Vermont. Advances in the development of renewable energy technologies may result in generation measures or techniques that are not currently considered in this plan but may be more efficient or effective. As such, this plan will consider renewable generation technologies that do not have an adverse impact on the region, its municipalities, or the policies that guide the Regional Planning Commission and not be limited exclusively to the generation techniques and technologies noted herein.

## EXECUTIVE SUMMARY & INTRODUCTION

The 2017 Central Vermont Regional Energy Plan represents the efforts of the Central Vermont Regional Planning Commission, through it's Regional Energy Committee to develop a plan that will receive a Determination of Energy Compliance (DOEC) through the Vermont Public Utilities Commission (PUC). A DOEC will give the Central Vermont Regional Plan "substantial deference" before the PUC for applications that seek to receive a Certificate of Public Good.

The 2016 State Comprehensive Energy Plan identified a goal to have 90% of the state's energy needs derived from renewable sources by 2050. As part of this goal, the Vermont State Legislature passed Act 174 in 2016. Act 174 provides an avenue for regions and municipalities to have increased input in PUC determinations for Certificates of Public Good regarding renewable energy generation facilities. As such, Act 174 identified standards that need to be met in support of the state's goal of 90% renewable energy by 2050 in order to have a plan receive a DOEC and have "substantial deference". Otherwise, a plan will receive "due consideration" in the Section 248 review process. Act 174 is categorized as enhanced energy planning and goes beyond what is outlined in 24 VSA 117 Section §4348a and §4382 respectively.

Through Act 174, three primary planning areas are identified and need to be met satisfactorily in order for successful compliance. These sections include Analysis & Targets; Pathways & Implementation Actions; and Mapping. All three sections include an evaluation of energy sectors that include thermal (heating), electrical, and transportation.

Section I: Analysis & Targets

This section provides a baseline of information for where a region or municipality currently stand in terms of energy and identifies the trajectories and pace of change needed to meet targeted reductions and conservation of energy. It incudes information on current electricity use for residential and non-residential uses; existing and potential renewable resource generation; and current transportation energy use information. Additionally, targets are established to provide milestones for thermal efficiency, renewable energy use, and conversion of thermal and transportation energy from fossil fuels to renewable resources. These milestones are intended to help the region measure progress towards the overall goals and are not identified as requirements. Targets are established for the years 2025, 2035, and 2050 which coincide with the State Comprehensive Energy Plan.

Specific information in this section notes the region currently uses approximately 600,000 megawatt hours of electricity on an annual basis across the identified sectors. By comparison, the regional share of new renewable energy generation needed to meet the state's goal is approximately 420,000 megawatt hours. Based on the mapping and resource data (Section III), the region has resources available to generate approximately 90,000,000 megawatt hours of energy.

Other analysis includes 2050 targets for fuel switching of vehicles from fossil based to alternative power, and conversion or installation of high efficiency heating systems for residential and commercial structures. Specific targets for Central Vermont include approximately 75,000 alternative powered vehicles and approximately 14,500 heating systems. These targets may be ambitious for Central Vermont based on the number of existing vehicles and structures which are listed at approximately 45,500 and 30,000 respectively. Also, specific implementation actions in this plan call for increased transit use which could reduce the overall need for vehicles region-wide. The specific 2050 targets for transportation and heating renewable use in Central Vermont are 90.2% and 92.5% respectively.

<u>Section II: Pathways & Implementation Actions</u>

Section II provides the basis for how the region will meet their target year goals as noted in Section I. The implementation actions are categorized by:

1. Conservation & efficient use of energy
2. Reducing transportation demand and single occupancy vehicles trips, and encouraging the use of renewable sources for transportation
3. Patterns and densities of land use likely to result in conservation of energy
4. The siting of renewable energy generation

The implementation actions that are identified in this section focus primarily in areas where the Central Vermont Regional Planning Commission is already working to support its member municipalities through local land use, transportation, and environmental planning activities.

To this end, the 2016 Central Vermont Regional Plan was first reviewed and implementation actions that pertained to any of the above mentioned sections were noted. These implementation items were carried forward for inclusion in the Regional Energy Plan to establish consistency with the two documents. To ensure all the categories for implementation as noted above were adequately addressed, guidance from the Department of Public Service related to implementation was utilized.

The implementation actions identify who will be responsible for completing each action, the timeframe for when it should be completed, and an anticipated outcome that will help provide a measure of success. This section will serve as the basis for how energy planning will be incorporated into regional activities. The implementation actions that were included are based on the CVRPC's ability to lead the action. This will create consistency with regard to implementation and put the responsibility for action on the CVRPC. Other partners are listed when appropriate to indicate which groups will be engaged support the successful completion of the identified actions.

Section III: Mapping

The mapping section allows the region to visually identify where renewable energy generation is most suitable. This section combines resource information with specific known and possible constraints to the development of renewable energy generation. The mapping section also allows the opportunity to identify preferred locations for renewable energy development and areas that are unsuitable for development of any kind. In addition, the maps identify existing infrastructure to support renewable energy development.

In general, the mapping information looks at state-level data and breaks it down to a regional perspective. From there, an analysis was done (as noted in Section I) regarding the potential renewable energy generation that might be possible based on resource areas and constraints. This information is useful to visualize what geographies throughout Central Vermont are most ideally suited or best to avoid regarding renewable energy siting.

This section also contains specific policy information regarding the development and siting of renewable energy resources that are reflected on the maps. It was determined that no specific locations would be identified at a regional level as being preferred or prohibited areas for the development of renewable energy generation. This was done to allow the municipalities to decide if it was appropriate to identify these areas locally, rather then have this information dictated by the region. The Regional Planning Commission did, however, identify additional possible constraints to be considered. These include elevations above 2,500 feet, slopes greater than 25%, municipally owned lands, and lakeshore protection buffer areas of 250 feet. The decision was made to include these resources as possible constraints to allow for further analysis by the region or the municipalities to determine if development of renewable energy generation facilities may be appropriate based on specific conditions.

Appendices

There are three appendices included with this plan. Appendix A provides definitions for the known, possible, and regional constraints that are included on the maps and discussed in Section III. These definitions include source information and in several instances provide insight as to why the particular resource is listed as a known, possible, or regional constraint. Appendix B includes the specific regional resource and constraint maps. Included in the resource mapping is data specific to wind, solar, hydrological, and woody biomass. All of these maps also include information regarding three-phase power and transmission lines; roads; and other relevant data used to assist with siting of renewable energy development. Finally, Appendix C includes information related to Long-Range Energy Alternatives Planning (LEAP) modeling. The LEAP model is what established the baseline information for the entire state regarding current energy use and necessary reductions in energy use in order to achieve the state's goals of 90% renewable energy use by 2050. This information serves as the primary data source for the information in Section I. The methodology for how the modeling was conducted is also included in Appendix C.

## CONFLICT RESOLUTION

The following information is being provided to help guide the process and ensure conflicts that may arise through regional or local energy planning are identified and addressed as early in the process as possible. Municipalities are encouraged to work with the Regional Planning Commission and their neighbors when developing an energy plan to identify any potential conflicts. Early discussions during the planning process may help alleviate the need to engage in the conflict resolution process as noted below.

Three conflict types are identified. These include:

1. Conflicts between a municipal energy plan and the regional energy plan
2. Conflicts between two municipal energy plans
3. Conflicts between the regional energy plan and the Central Vermont Regional Plan.

Conflicts between a municipal energy plan and the regional energy plan

The regional energy plan has been purposefully written to limit the region from dictating how the municipalities need to address renewable energy development and the standards of Act 174. The regional plan focuses on impacts at the regional scale and provides general guidance to municipalities regarding siting, renewable energy generation technology, and specific implementation actions. This was done to allow municipal energy plans to include specific detail related to these aspects while limiting conflicts with the regional energy plan.

If a municipal energy plan is in conflict with the regional energy plan regarding siting, the type of renewable energy generation, or implementation actions that will only impact the host municipality, the municipal energy plan will take precedent. If, however, the municipality proposes an action that will adversely impact a regionally significant resource (such as critical habitat) that is specifically identified in the Central Vermont Regional Plan, then the regional energy plan would take precedent and provide guidance to the Public Utility Commission or the District 5 Environmental Commission. Consistency with the Central Vermont Regional Plan and regional energy plan is necessary for municipalities requesting regional approval of their municipal development plan or municipal energy plan.

Conflicts between municipal energy plans

Requirements for a municipal development plan are outlined in statute. Specifically, 24 VSA 117 §4382(a)(8) requires, "A statement indicating how the plan relates to development trends and plans for adjacent municipalities, areas and the region developed under this title." To this end, municipalities are required to consider the development trends and plans in adjacent municipalities during the drafting of their municipal development plans. As such, the following process will be considered to assist in the resolution of potential conflicts between municipalities during the development of municipal energy plans.

This process only applies to the development of municipal energy plans. Notifications for specific projects seeking a Certificate of Public Good from the Public Utility Commission will follow the process outlined in 30 VSA 5 §248 for notification of municipal planning commissions, regional planning commissions, and interested parties.

1. If the policy or action being proposed by the host municipality will adversely impact a resource within the adjacent municipality (or municipalities) that has been identified in a municipal development plan, the host municipality must provide justification in writing as to why the policy or action is necessary. This notice must be sent to all effected adjacent municipalities and the Regional Planning Commission. If the adjacent municipality is outside of the Central Vermont RPC's jurisdiction, the adjacent municipality's RPC will also be notified.

2. If the adjacent municipality or regional planning commission objects to the justification as presented, a written response will be provided to the host municipality citing any studies or empirical data to support their objection. If the host municipality is not persuaded by any objections to change its position, the statement addressing 24 VSA 117 §4382(a)(8) will include information noting the inconsistency with the adjacent municipality. This notation may impact a municipality's ability to receive regional approval of a municipal plan.

An affected municipality may request assistance in mediating the conflict from the Regional Planning Commission. The Regional Planning Commission will consider the impacts on available resources when evaluating these requests.

Conflicts between the regional energy plan and the regional development plan

The Central Vermont Regional Energy Plan is intended to be a complimentary document and to inform land use decisions of the region related to energy. While efforts have been taken to ensure consistency with the regional energy plan and the rest of the Central Vermont Regional Plan, conflicts may exist. In the instance a conflict exists between policies or actions of the Central Vermont Regional Plan and the Central Vermont Regional Energy Plan, the more restrictive interpretation will be used to evaluate a proposal of regional significance. Additionally, the inconsistency will be noted and discussed by the Regional Plan Committee who will provide a recommendation to the full Commission on how to rectify the inconsistency.

## PUBLIC PROCESS

The Regional Energy Committee held public meetings each month from December through May to develop a draft regional energy plan that could be reviewed against the specific standards outlined in Act 174. This draft was presented to the Regional Commission for consideration at their regular meeting on June 13, 2017. At that meeting, the three primary sections of the plan were presented for consideration. Several minor comments were discussed and changes were made as appropriate. On June 19, 2017, the Draft Central Vermont Regional Energy Plan was submitted to the Department of Public Service for review and comments against the standards of Act 174.

On October 30, 2017, the Department of Public Service returned comments on the Draft Central Vermont Regional Energy Plan. In the same transmittal, comments from the Agency of Natural Resources and the Agency of Agriculture, Food, & Markets were provided. Comments were also received from the public and staff at the Agency of Transportation who participated as members of the Regional Energy Committee. All of these comments were evaluated and incorporated as appropriate. On November 29, 2017 and December 7, 2017, the Central Vermont Regional Energy Committee met to discuss the updates to the draft regional energy plan and recommend additional changes based on the comments received. At the meeting on December 7th, the Regional Energy Committee made a recommendation to the Central Vermont Regional Planning Commission's Board of Commissioners regarding approval of the draft.

In addition to the regular public meetings of the Regional Energy Committee, The CVRPC engaged in a robust public outreach effort to solicit feedback on the Draft Central Vermont Regional Energy Plan. This included:

- Tabling at the Waterbury LEAP Energy Fair
- Informational handouts distributed at 2017 Town Meeting Day
- Addition of a section of the CVRPC webpage dedicated to energy
- Presentations to the Barre Area Development Corporation on 12/12/2016 & 11/13/2017
- Open public comment period on the draft plan from 09/22/2017 through 10/31/2017
- Presentation to the Barre City Energy Committee on 10/23/2017
- Memo and discussion with the Central Vermont Transportation Advisory Committee on 10/24/2017
- Presentation to Downstreet Housing & Community Development on 11/15/2017
- Presentation to the Montpelier Energy Advisory Committee on 11/21/2017
- Two training sessions on Act 174 requirements and standards throughout the region
- Development of analysis & targets and mapping data for each CVRPC municipality

Additionally, the CVRPC will continue to evaluate and update the Central Vermont Regional Energy Plan as needed to ensure actions and information remains current and consistent with statewide planning goals.

## ANALYSIS & TARGETS

In order to adequately determine if the Central Vermont Region is on the right path to meeting it's share of the state's goal of 90% of the energy used being produced by renewable sources, an identification and analysis of current energy use is necessary. To this end, the following questions have been identified to help determine current energy use and targets for moving forward.

I. *Does the plan estimate current energy use across transportation, heating, and electric sectors?*

II. *Does the plan establish 2025, 2035, and 2050 targets for thermal and electric efficiency improvements, and use of renewable energy for transportation, heating, and electricity?*

III. *Does the plan evaluate the amount of thermal-sector conservation, efficiency, and conversion to alternative heating fuels needed to achieve these targets?*

IV. *Does the plan evaluate transportation system changes and land use strategies needed to achieve these targets?*

V. *Does the plan evaluate electric-sector conservation and efficiency needed to achieve these targets?*

These five questions and their respective responses serve as the basis for identifying where the region is now, where the region needs to go, and how it will get there in terms of its energy future.

The information needed to answer the five questions listed above was procured from various sources. This includes information from the American Community Survey (as part of the U.S. Census), The Vermont Agency of Transportation, the Vermont Department of Labor, the Vermont Department of Public Service, Efficiency Vermont, the Vermont Energy Investment Corporation (VEIC), and the Central Vermont Regional Planning Commission. A significant portion of the data related to targets was provided by the VEIC through a process known as Long-Range Energy Alternatives Planning or LEAP. This modeling factors in a significant number of data points and has been used extensively throughout the world for energy planning such as this.

The majority of the data in this section was developed with a "bottom up" approach. That is to say, the data was developed at a municipal scale to complete the requirements of Standard 5 of the Energy Planning Standards for Regional Plans. The municipal data was then aggregated to establish a regional total. The one primary exception to that is the LEAP data, which was modeled at a regional scale. The LEAP data serves as the basis for the conservation and efficiency targets that are included in this plan. To that end, it is important to note that the data provided herein is only a starting point and should be used to establish a general direction, not a required outcome. This data is presented as a way to gauge the region's overall progress towards achieving 90% of its regional energy used produced from renewable sources. As new or better data is provided or developed, these tables will be updated to reflect the changes.

## I. Estimates of current energy use across transportation, heating, and electric sectors

In order to determine where we need to go with our energy future, it is important to know where we currently are. Included in this is an identification of the existing sources of energy generation. In general, energy can be divided into four basic categories where discussions can be focused. These include resource type, land use, transportation, and siting. While all four are related and interconnected, they all serve separate components that need to be addressed individually as well as collectively.

### Resource Type

The 2016 State Comprehensive Energy Plan notes four primary resource types for energy that are used throughout the state. These include non-combustion based renewables (including wind, hydroelectric, and solar), combustion based renewables (including biomass), nuclear energy, and fossil fuels. Fossil fuels account for a majority of the energy used in the state with natural gas and petroleum products accounting for 62% of Vermont's total energy use[1].

Non-Combustion Based Renewables

Non-combustion based renewables includes all the typical sources of energy generation such as wind, solar, and hydroelectric. Based on information from the Vermont Department of Public Service and the Energy Action Network's Community Energy Dashboard, there are approximately 1,300 sites in Central Vermont that are producing renewable energy across the three resource types. This accounts for approximately 130,000 megawatt hours of energy produced annually within Central Vermont. This amounts to approximately 3.5% of the annual energy consumption in Central Vermont.

Combustion Based Renewables

A second category of renewable energy generation is combustion based. Combustion based renewables include methane gas, anaerobic digesters, biodiesel, combined heat and power, compost heat, and woody biomass. Combustion based renewables are used for both electricity generation and thermal heating.

When looking at combustion based renewables for thermal heating, woody biomass is the most common form in Central Vermont. Wood products or byproducts such as wood pellets or wood chips are the most popular form of biomass heating. According to data from the U.S. Energy Information Administration, in 2015 one in six Vermont households used some form of biomass as their primary home heating source.

Currently, the primary electricity generator of combustion based renewables is methane gas. In Central Vermont, the Moretown Landfill provides the primary source of electrical generation from biomass in the form of methane gas. According to the 2014 Green Mountain Power (GMP) Integrated Resource Plan, GMP has an agreement with Moretown Landfill to purchase 100% of their energy generation capacity totaling approximately three megawatts, through 2023. Additionally, the Washington Electric Cooperative receives a majority of its energy generation from the Coventry Landfill in Coventry, Vermont. According to the Washington Electric Cooperative's data, in 2014 over 53% of their power came from the Coventry facility. Table One indicates the existing renewable electricity generation for the Central Vermont region.

1. 2016 Comprehensive Energy Plan – p.389.

| TABLE ONE<br>EXISTING REGIONAL RENEWABLE ELECTRICITY GENERATION | | |
|---|---|---|
| **RESOURCE TYPE** | **MEGAWATTS** | **MEGAWATT HOURS** |
| Solar | 24 | 29,919 |
| Wind | .14 | 486 |
| Hydroelectric | 25 | 88,467 |
| Biomass (including wood, methane, and farm biogas) | 3 | 13,091 |
| Other | 0 | 0 |
| Total Existing Regional Renewable Electricity Generation | 52.14 | 131,963 |

Notes:
1. Information provided by the Department of Public Service, 2015
2. Regional totals were aggregated from each municipal total therefore not all calculations will be consistent.
3. Municipal data can be found at http://centralvtplanning.org/programs/energy/municipal-energy-planning/

## Nuclear Energy

The Central Vermont Region's energy portfolio has been significantly impacted by the decommissioning of the Vermont Yankee Nuclear Facility in Vernon, Vermont. This facility, which was shut down at the end of 2014, provided approximately 55% of the electrical generation capacity for the State of Vermont. To make up for the loss of generation from Vermont Yankee, utility companies throughout the state have filled this gap through a variety of ways and established long-term contracts with other market power providers. Sources for this electricity generator consist of both renewable and non-renewable sources including wind, solar, hydroelectric, natural gas or other in-state utility owned renewable generation contracts.

Based on data from the Vermont Public Service Department, in 2011 the majority of energy being provided to Central Vermont from Green Mountain Power, Hardwick Electric Department, Northfield Electric Department, and Washington Electric Cooperative was from hydroelectric sources including Hydro Quebec. In fact nuclear energy as a source accounted for only about 10% of the energy generation for the service providers in Central Vermont.

## Fossil Fuels

Fossil fuels are all non-renewable sources of energy that are generally carbon based and formed over millions of years from organic matter (including plants and animals) that were gradually buried under layers of rock. These fuels include natural gas, coal, and oil. Fossil fuels are typically refined for use as gasoline or other distillate fuels such as diesel fuel; home heating oil; or transported as natural gas.

In general, the majority of fossil fuel usage is attributed to home heating (including water) in the form of natural gas or home heating oil, or for transportation to fuel vehicles. According to information from the U.S. Energy Information Administration, natural gas fired power plants are providing energy to Vermonters, however these plants are generally located outside of the state. Additional information regarding fossil fuels will be included in the discussion on transportation later in this document.

In order to further refine the existing energy picture within Central Vermont, the CVRPC calculated its current energy consumption for transportation, heating, and electric use. This included both commercial and residential heating information. This information is listed in Tables Two through Six.

| TABLE TWO<br>CURRENT REGIONAL TRANSPORTATION ENERGY USE | |
|---|---|
| **DATA CATEGORY** | **INFORMATION** |
| Total number of vehicles | 45,584 vehicles |
| Average miles traveled per vehicle | 12,500 miles |
| Total regional miles traveled | 567,650,000 miles |
| Average gallons of fuel used per vehicle per year | 576 gallons |
| Total regional gallons of fuel used per year | 30,518,817 |
| Transportation energy used per year (in Billions) | 3,396 BTUs |
| Average regional cost per gallon of fuel | $2.31 |
| Regional fuel costs per year | $70,488,465.00 |

Notes:
1. Regional totals were aggregated from each municipal total therefore not all calculations will be consistent.
2. Total vehicles provided by the American Community Survey.
3. Average miles traveled & Average gallons of fuel used per vehicle provided by VTrans.
4. Average cost per gallon of fuel provided by the CVRPC.
5. Information related to public transit is not included in this table.

| TABLE THREE<br>CURRENT REGIONAL RESIDENTIAL HEATING ENERGY USE BY FUEL SOURCE | | | | |
|---|---|---|---|---|
| **FUEL SOURCE** | **NUMBER OF HOUSEHOLDS** | **PERCENT OF HOUSEHOLDS** | **REGIONAL HEATED SQUARE FOOTAGE** | **REGIONAL BTUs (in Billions)** |
| Natural Gas & Propane | 5,983 | 22.2% | 9,632,438 | 578 |
| Electricity | 1,206 | 4.5% | 1,494,263 | 90 |
| Fuel Oil | 14,238 | 52.9% | 24,431,228 | 1,466 |
| Coal | 66 | .2% | 132,664 | 8 |
| Wood | 5,031 | 18.7% | 9,493,439 | 570 |
| Other (includes solar) | 392 | 1.5% | 696,536 | 42 |
| No Fuel | 22 | .1% | 42,680 | 3 |
| **TOTAL** | **26,938** | **100%** | **45,923,248** | **2,755** |

Notes:
1. Regional totals were aggregated from each municipal total therefore not all calculations will be consistent.
2. Data provided by the American Community Survey.

| TABLE FOUR<br>CURRENT REGIONAL COMMERCIAL THERMAL (HEATING) ENERGY USE | | |
|---|---|---|
| **COMMERCIAL ESTABLISHMENTS** | **AVERAGE THERMAL ENERGY USED PER ESTABLISHMENT** | **COMMERCIAL THERMAL ENERGY USED REGIONALLY** |
| 2,647 | 699 | 1,847,355 |

Notes:
1. Regional totals were aggregated from each municipal total therefore not all calculations will be consistent.
2. Thermal energy use is expressed in Millions of BTUs.
3. Information provided by the Vermont Department of Labor and the Department of Public Service.

While Table Four identifies the amount of energy used regionally for commercial thermal (heating) purposes, Table Five provides a list of the sources of fuel being used by the commercial establishments in the region for thermal purposes. Even though a large percent of commercial establishments currently use electricity for their heating needs, non-renewable fuels such as propane and fuel oils are almost as common.

| TABLE FIVE<br>CURRENT REGIONAL COMMERCIAL HEATING USE BY FUEL SOURCE | | |
|---|---|---|
| **FUEL SOURCE** | **NUMBER OF ESTABLISHMENTS** | **PERCENT OF ESTABLISHMENTS** |
| Biofuel | 0 | 0.0% |
| Distillate Fuel Oil | 505 | 19.1% |
| Electric Use | 922 | 34.8% |
| LPG | 381 | 14.4% |
| Natural Gas | 0 | 0.0% |
| Residual Fuel Oil | 51 | 2.0% |
| Wood & Wood Waste | 165 | 6.2% |
| Other | 623 | 23.5% |
| **Total Commercial Establishments** | **2,647** | **100%** |

Notes:
1. Information derived from VEIC LEAP Modeling.
2. Data based on 2015 information

| TABLE SIX<br>CURRENT REGIONAL ELECTRICITY USE | |
|---|---|
| **USE SECTOR** | **CURRENT ELECTRICITY USE** |
| Residential | 241,268 megawatt hours |
| Commercial & Industrial | 353,117 megawatt hours |
| **TOTAL** | **594,385 megawatt hours** |

Notes:
1. Regional totals were aggregated from each municipal total therefore not all calculations will be consistent.
2. Information provided by Efficiency Vermont.

## II. 2025, 2035, and 2050 targets for thermal and electric efficiency improvements, and use of renewable energy for transportation, heating, and electricity

With the baseline information established for the region, the next step is to identify what targets need to be met in order for the region to achieve its share of the state's renewable energy goals. The 2016 State Comprehensive Energy Plan identifies target years of 2025, 2035, and 2050 as specific points to help measure progress. Using these same target years, the Central Vermont RPC has identified percentage targets for efficiency improvements regarding transportation, heating, and electricity.

The targets indicated in Tables Seven, Eight, and Nine are cumulative totals and account for the previous target year's percentages. For example, the residential thermal efficiency target for 2035 in Table Seven indicates that 42% of the residential units should be weatherized and efficient. This could be done through a combination of new construction or weatherization of existing structures. These are targets for the region to try and achieve and not a mandate on what they must accommodate.

The information in Tables Seven, Eight, and Nine were developed using the Long-Range Energy Alternatives Planning (LEAP) Model as provided by the Vermont Energy Investment Corporation (VEIC). VEIC was contracted to provide modeling support for this project and developed the LEAP model for each Regional Planning Commission to reflect their share of the state totals. The percentages are weighted heavier in the later years which assumes increases in efficiencies and technological improvements that will establish these targets.

| TABLE SEVEN<br>REGIONAL TARGETS FOR THERMAL EFFICIENCY IMPROVEMENTS OF EXISTING STRUCTURES | | | |
|---|---|---|---|
| **SECTOR TYPE** | **2025** | **2035** | **2050** |
| Residential Thermal Efficiency | 20% | 42% | 92% |
| Commercial Thermal Efficiency | 22% | 33% | 61% |

Notes:
1. Information derived from VEIC LEAP Modeling.
2. Assumes a base year of 2015.
3. Percentages are cumulative for each target year.

Table Seven identifies the percentage of existing residential and commercial structures in Central Vermont that would need to be weatherized in each of the target years to meet the State's energy goals. These targets also assume that new structures will be built based on existing state energy codes and therefore meet or exceed the needed efficiency standards.

In addition to the thermal efficiency improvements of existing buildings outlined in Table Seven, Table Eight identifies the electric efficiency improvements needed for each target year to meet the renewable energy goals in the State's Comprehensive Energy Plan. The electric efficiency is an indication of how much efficiency is needed across all sectors. It is a comparison between anticipated electricity use for each target year versus the electricity use in the base year, which in this case, is 2010.

| TABLE EIGHT<br>REGIONAL TARGETS FOR ELECTRIC EFFICIENCY IMPROVEMENTS ACROSS ALL SECTORS | | | |
|---|---|---|---|
| **SECTOR TYPE** | **2025** | **2035** | **2050** |
| Electric Efficiency | 1.5% | 7.3% | 15.2% |

Notes:
1. Information derived from VEIC LEAP Modeling.
2. Assumes a base year of 2015.
3. Percentages are cumulative for each target year.

Table Eight outlines the electric efficiency improvements needed for each of the three target years. These targets would cover all sectors including electric, thermal (heating), and transportation. Many of these efficiencies will be met through technological changes and improvements that will occur over time, however conversions to more efficient technologies will need to be supported. Specific policies and actions to encourage conversions for efficiencies are outlined in the Pathways & Implementation Actions section.

Similar to Tables Seven and Eight, Table Nine identifies the percent of energy use to be derived from renewable sources for energy related to transportation and thermal needs. While energy needs for transportation and thermal uses are different, Table Nine is intended to identify percentage of renewable energy use for these two sectors and not intended to provide a parallel association between these two sectors.

| TABLE NINE<br>REGIONAL TARGETS FOR RENEWABLE ENERGY USE BY SECTOR | | | |
|---|---|---|---|
| **SECTOR TYPE** | **2025** | **2035** | **2050** |
| Transportation Use | 9.6% | 31.3% | 90.2% |
| Thermal Use | 52.3% | 66.6% | 92.5% |

Notes:
1. Information derived from VEIC LEAP Modeling.
2. Assumes a base year of 2015.
3. Percentages are cumulative for each target year.

A major factor that will impact these targets are market forces which are beyond the control of an individual municipality or region. With that in mind, the region (and therefore the municipalities) should work to ensure barriers don't exist that would adversely impact the ability to reach these targets. The Pathways & Implementation Actions identified in this plan will discuss this in more detail.

| TABLE TEN<br>REGIONAL TARGETS FOR NEW RENEWABLE ELECTRIC ENERGY GENERATION | | | |
|---|---|---|---|
| **SECTOR TYPE** | **2025** | **2035** | **2050** |
| New Renewable Electric Energy Generation | 104,620 | 167,404 | 418,531 |

Notes:
1. Information provided by The Department of Public Service.
2. Values are in megawatt hours.
3. Assumes a base year of 2015.

Table Ten notes the renewable electricity generation for each of the target years and is expressed in megawatt hours. The identification of these targets by megawatt hour is a significant factor because it represents energy (megawatt hours) as opposed to power (megawatt). In this case, the megawatt hours identified denote the amount of renewable energy that should be consumed as part of the total energy being consumed by the target years. This information was generated base on data provided by the Department of Public Service and information developed by the Regional Planning Commission.

## III. Evaluation of the amount of thermal-sector conservation, efficiency, and conversion to alternative heating fuels needed to achieve these targets

One important way for each region to support and work collectively to achieve the state's goal of 90% renewable energy generation by 2050 is through conversion and development of alternative fuels. Conversions to more efficient technologies such as cold climate heat pumps for residential heating or switching to electric vehicles will mean that less energy needs to be generated as efficiencies in technologies increase. If less energy needs to be generated, the energy being generated from renewable sources will provide more of the demand over time.

Table Eleven outlines the thermal sector conversions to wood heat and heat pumps. For these tables residential and commercial uses are combined to indicate the total fuel switching needed.

**TABLE ELEVEN**
**REGIONAL THERMAL SECTOR CONVERSIONS**
***(RESIDENTIAL & COMMERCIAL)***

| SYSTEM TYPE | 2025 | 2035 | 2050 |
|---|---|---|---|
| New Efficient Wood Heat Systems | 117 | 108 | 966 |
| New Heat Pumps | 2,792 | 7,198 | 13,630 |

Notes:
1. Regional totals were aggregated from each municipal total therefore not all calculations will be consistent.
2. Information derived from VEIC LEAP Modeling.
3. Heat pumps includes both space heating and hot water heating.

The information in Table Eleven is derived from calculations based on information provided in the LEAP modeling data. As with other targets, the numbers identified for each target year represent the number of new systems needed to achieve the overall efficiency goals. It should be noted that Table Eleven only highlights efficient wood burning systems and heat pumps. This is an indication that using these two technologies could account for all the changes needed in Central Vermont regarding conversions from fossil fuel based heating systems such as fuel oil or natural gas.

Other options for conversion of residential and commercial heating systems may be available that would satisfy the goals of the state's comprehensive energy plan. Wood systems are being highlighted due to their renewable fuel. Heat pumps are being highlighted because the 2016 State Comprehensive Energy Plan focuses on electrification. Therefore a high efficiency electric heat pump would address the efficiency goals while the electricity to power the system being generated from renewable sources.

Another system type that should be encouraged is geothermal heating and cooling. Geothermal systems use the consistent temperature of the earth to either provide heat or cooling to homes and businesses. Geothermal systems generally require an electric fan to force air through the system, however like with other systems, the increase in efficiency through technology and the electrification of the grid make systems like this a viable option to address conservation and conversion of systems.

One challenge that will need to be addressed regarding conversions and conservation efforts will be the tracking and monitoring of system upgrades or improvements that address efficiency to increase weatherization of residential and commercial properties. While specific programs are set up to help track and score these changes, many homeowners and business owners make changes and upgrades as part of the normal lifecycle of a property. These systems are often upgraded without any formal acknowledgement of the possible efficiency improvements being made. In order to measure how the targets in Table Eleven are being met (or not being met), a methodology should be developed to ensure the necessary information is gathered when changes occur. This will be addressed in the Pathways and Implementation Actions section.

## IV. Evaluation of transportation system changes and land use strategies needed to achieve these targets

### Transportation

As noted in Table Two, the average vehicle miles traveled for residents in Central Vermont is approximately 12,500 miles per year. At an average cost of approximately $2.31 per gallon of fuel and an efficiency factor of approximately 22 miles per gallon of fuel, the average person living in Central Vermont is spending approximately $1,300 dollars on fuel each year. According to information from the American Automobile Association, the average cost of owning a vehicle can range from approximately $6,500 for a small sedan to $10,400 for an SUV[2]. By creating development patterns whereby uses are in closer proximity to where people live, work, or recreate, trips can be combined or alternative modes of transportation can be employed. This will reduce the vehicle miles traveled and therefore reduce the transportation costs to individuals.

Another option to consider when evaluating system changes is the conversion to electric or alternative fuel vehicles. Vehicles that are powered by renewable energy sources increase efficiency, reduce greenhouse gas emissions, and can reduce the need for fossil fuels. While switching to alternative fuel vehicles does not reduce the vehicle miles traveled, it does reduce the dependence on fossil fuels. These changes also require improvements to infrastructure such as grid capacity to transmit the electricity as well as an increase in the volume of charging stations to provide additional opportunities and locations for vehicle charging thus increasing the range of electric vehicles.

An evaluation of LEAP data and information from the American Community Survey identifies the number of vehicles needed to be switched from fossil fuels to renewable fuels. Specifically, conversion to electric vehicles and biodiesel vehicles was noted in the LEAP analysis in order to meet the needed reductions in energy related to transportation. Table Twelve identifies the number of electric and biodiesel vehicles needed for each of the three target years in order to meet the energy reduction goals related to transportation as identified in the LEAP analysis.

2. 2016 article from the American Automobile Association (AAA) http://newsroom.aaa.com/auto/your-driving-costs/. Costs include fuel, insurance, maintenance, registration, depreciation, and similar expenses associated with owning a vehicle and is based on driving 15,000 miles per year.

| TABLE TWELVE<br>REGIONAL TRANSPORTATION FUEL SWITCHING TARGETS | | | |
|---|---|---|---|
| **FUEL TYPE** | **2025** | **2035** | **2050** |
| Electric Vehicles | 3,902 | 26,954 | 53,809 |
| Biodiesel Vehicles | 6,801 | 12,603 | 20,438 |

Notes:
1. Information derived from VEIC LEAP Modeling.
2. Assumes the replacement of existing vehicles with new alternative fuel vehicles.

It is important to note that Table Twelve indicates the number of fossil fuel based vehicles that would need to be replaced with alternative fuel vehicles to meet the reduction goals for transportation energy by each target year. That is to say that of all the new vehicles on the road in 2025, approximately 10,700 of those vehicles would need to use alternative fuels as the primary fuel type. For reference, electric vehicles would be similar to a standard passenger vehicle currently using gasoline and biodiesel vehicles would be consistent with light or heavy duty trucks that currently run on standard diesel fuels.

In addition to the information regarding transportation that is noted in this plan, the Central Vermont Regional Planning Commission maintains a regional transportation plan. Under the direction of a Transportation Advisory Committee (TAC), the CVRPC identifies annual transportation priorities to be considered by the Agency of Transportation. These priorities will help determine not only the direction of future transportation projects within the region, but may also impact land use decisions a the regional or local level. This underscores the importance to coordinate transportation objectives with land use priorities to ensure a coordinated approach to land development is pursued. The confluence of land use and transportation will impact future needs and impacts to energy use including conservation, conversions, infrastructure needs, and siting. The Regional Transportation Plan provides more significant detail on specific projects that may impact the Region's energy planning future and should be considered part of the Region's energy planning priorities.

**Land Use**

One key factor that impacts the amount of energy being used is land use. Land use directly impacts and influences our choices, especially as they relate to transportation. When land use patterns focus on density, compact development, or mixing of uses, the result can be an area that is walkable, bicycle friendly, or promote public transit use.

Land use planning and management can have a direct impact on how much energy is used and consumed in regard to transportation. As development density decreases (creating fewer lots or uses per acre), the impacts associated with that decrease in density will rise. This includes both costs and consumption of resources including energy to move people from place to place. As land uses are spread further from one another, more resources are required to link those uses together. This includes infrastructure such as roads or utilities; needs for emergency services such as police, fire, and ambulance, and increases in municipal service needs such as road maintenance.

In order to reduce the costs and needs for energy related to transportation and land uses, changes in land development will need to occur. One significant way that this can be addressed is through amendments to land development regulations such as zoning or subdivision. Changes to land development regulations that require pedestrian facilities such as sidewalks or multi-use paths to connect uses or activity centers is one technique that can be used to help create alternative transportation options in a community. Additionally, smaller changes could be implemented that can have larger impacts. Examples of this include reducing lot sizes, reducing parking requirements, adjusting setbacks, implementing traffic calming measures, or increasing building heights are all ways to maximize development potential within the framework of existing land development regulations.

If a municipality does not have land development regulations, there are still avenues that can be explored from the non-regulatory side that would impact land development practices. For example, developing a capital plan for public utilities and services that is consistent with a municipal plan can identify and prioritize where public funds should be spent. This could include sidewalk connections, park & ride facilities, or water and wastewater services. Expansions to emergency services or road maintenance equipment can also be a way to signal intended growth. Receiving a state designation for a Downtown, Village Center, Growth Center, New Town Center, or New Neighborhood Development Area can provide the basis for non-regulatory growth management and the tools necessary to regulate development without a formally adopted set of regulations. Finally, having clear goals, policies, and action items identified in municipal plans will impact how a community grows and therefore how the connection between land use and transportation is addressed on a municipal basis.

Currently, 19 of the 23 municipalities in the Central Vermont Region have some form of development regulation. Six of the 19 only have zoning regulations in place while the other 13 have zoning and subdivision regulations. Additionally, 12 of the municipalities have an active state designation and several municipalities have multiple designations. For example, the City of Montpelier has both a Downtown and a Growth Center designation, while the Town of Calais has three village centers that are designated including Adamant, East Calais, and Maple Corners.

While the techniques noted herein can help provide avenues for changes to support development density and create compact development patterns, a primary factor that will influence development density is adequate infrastructure to accommodate water and wastewater. Water and wastewater infrastructure is critical to provide a development pattern that includes density, mixed uses, and alternative transportation options. This is done by moving the supply and treatment of water and wastewater off-site therefore, reducing the need for land to accommodate these facilities on-site. Doing so creates opportunities for smaller lots, denser development, increased building heights, and mixed uses. All of these are positive steps to reducing the need for infrastructure to accommodate single-occupancy vehicles such as parking areas, but also begin to support the critical mass that is necessary to support public transit.

As noted previously, regulatory and non-regulatory approaches can have an impact on energy use due to the future development patterns in a community. While there isn't a single approach that will address all of the Region's energy needs, municipalities are encouraged to identify what programs or actions will work best to implement their community's future transportation and land use planning. Specific actions from the Region that can assist with municipal transportation and land use priorities can be found in the next section of this plan regarding Pathways & Implementation Actions. Ultimately, positioning the municipalities to take control of their energy futures while working collectively as a region could be a successful outcome for all.

## V. <u>Evaluate electric-sector conservation and efficiency needed to achieve these targets</u>

Conservation and efficiency of electricity is a key component to achieving the state's comprehensive energy planning goals. Over time, advancements in technology will provide a degree of the needed efficiency and conservation measures to achieve these goals, but also, efforts can be taken now to ensure that Central Vermont is on track to meet their conservation and efficiency targets. Targets for electric efficiency improvements for Central Vermont were previously noted in Table Eight. Information related to renewable energy generation, which is a necessary component in achieving these targets, is noted below.

### Siting

A discussion of electric sector conversions and efficiencies should include information related to the ability to generate electricity through renewable means, but also to have a grid that can support the distribution of that electricity. An analysis of existing land and renewable resource potential will help determine what the capacity of the region is to generate and distribute local renewable energy. As noted previously, Table One identifies the current renewable generation for the region, while Table Thirteen identifies the potential generation for the region.

**TABLE THIRTEEN**
**EXISTING POTENTIAL NEW REGIONAL RENEWABLE ELECTRIC ENERGY GENERATION**

| RESOURCE TYPE | MEGAWATTS | MEGAWATT HOURS |
|---|---|---|
| Rooftop Solar | 40 | 49,268 |
| Ground-mounted Solar | 15,622 | 19,160,098 |
| Wind | 23,050 | 70,671,678 |
| Hydroelectric | .01 | 28 |
| Biomass & Methane[3] | Unknown | Unknown |
| Other | 0 | 0 |
| Total Potential Regional Renewable Energy Generation | 38,713 | 89,881,072 |

<u>Notes</u>:
1. Regional totals were aggregated from each municipal total therefore not all calculations will be consistent.
2. Information calculated by the CVRPC based on data provided by the Vermont Center for Geographic Information and efficiency factors provided by the Department of Public Service.
3. Municipal data can be found at http://centralvtplanning.org/programs/energy/municipal-energy-planning/

Based on the information included in Table Thirteen, the municipalities in Central Vermont have enough potential resource area (both prime and secondary) that is not impacted by known or possible constraints (as defined in Appendix A) to sufficiently accommodate the megawatt hour allocation and meet their share of the state's renewable energy goal as noted previously in Table Ten. This means that the municipalities can reasonably identify additional constraints or preferred locations to align with their own land use planning goals if they so choose.

3. Biomass and methane are not restricted by resource locations and should be sited accordingly to provide maximum benefit to the greatest number of end users or to meet municipal needs. Siting will be more dependent on local regulatory controls and should be planned for accordingly.

To better understand the relationship between megawatts and megawatt hours, the following conversions are used. It should be noted that some renewable generation types are more efficient at producing energy when they are actively in production. For example, the wind does not always blow and the sun is not always shining, therefore a constant production of these resources may not be possible. On the other hand, methane generated from a landfill will be producing consistently for a finite number of years therefore, its efficiency factor will be greater for the useful life of the facility. Table Fourteen outlines the various renewable technologies including their capacity factor and annual megawatt hour output per installed megawatt of capacity.

Table Fourteen reinforces the fact that multiple options of renewable energy generation exist and can be utilized at a regional and municipal level. For all of these generation types, understanding where the resources that support these sources are the best or preferred is critical. This information will be further discussed in the mapping section, however planning for the siting of renewable energy generation will ensure that, like any other land use, a municipality has made a concerted effort to ensure compatibility with other uses while accounting for possible future needs.

**TABLE FOURTEEN**
**RENEWABLE ENERGY GENERATION OUTPUTS & CAPACITY FACTORS**

| RESOURCE TYPE | CAPACITY FACTOR | ANNUAL MEGAWATT HOUR OUTPUT PER INSTALLED MEGAWATT |
|---|---|---|
| Solar | 14% - 16% | 1,300 |
| Small Wind | 20% - 25% | 2,000 |
| Utility Scale Wind | 25% - 35% | 2,600 |
| Methane | 60% - 90% | 6,600 |
| Biomass | 60% - 80% | 6,100 |
| Small Hydroelectric | 40% - 60% | 4,400 |

Notes:
1. Information provided by the Vermont Department of Public Service.
2. "Capacity Factor" indicates the percent of time an identified resource is actively producing electricity.

As Table Fourteen indicates, solar installations have the lowest capacity factor, however the costs associated with installation of solar generation facilities are also low compared to other resource types. The economics of using a given resource may prove to be more of a consideration than the actual energy output. As such, measures may need to be considered to off-set the costs associated with higher capacity resource generators if they are to be viable throughout the region.

It should be noted that while biomass has a high level of annual output per installed megawatt, the source of the biomass should be taken into consideration. When possible, locally sourced biomass will have the greatest benefit to the community. In order to limit the secondary impacts associated with biomass, the origin of the fuel source should be considered. Transporting biomass from out of region or out of state will have increased costs and the impacts from transportation will off-set a portion of the efficiencies. Also, invasive species that impact woody biomass need to be considered.

Currently, there are two Federal quarantine regulations that are relevant to the movement of woody biomass (including chips, cordwood, and logs) from New York and Massachusetts. These include the emerald ash borer and the Asian longhorned beetle. Additionally, the State of Vermont has quarantines for external firewood and the hemlock woody adelgid. All of these factors need to be considered to ensure a sustainable supply of woody biomass can be sourced as locally as possible to limit the spread of these invasive species that could adversely impact the forest cover.

Central Vermont enjoys rich natural and scenic resources. This is represented by the peaks of the Worcester and Green Mountain ranges (including Camel's Hump State Park), which are characteristic of many Vermont communities. These areas are important to Central Vermont not only for their natural, scenic, and recreational value, but also for the predominance of critical plant and animal habitat that exists in the undisturbed forest blocks. In support of the protection of these areas, the 2016 Central Vermont Regional Plan identifies critical resources areas including wildlife habitat, steep slopes, and lands above 2,500 feet in elevation. These areas are specifically identified for their value as a regional resource.

With this in mind, the Central Vermont Regional Planning Commission has determined that industrial-scale wind development is not compatible with the future land use patterns of Central Vermont. For the purposes of this plan, industrial-scale wind development will include any wind turbine with a hub height greater than 125 feet (excluding the blades). Additionally, wind energy development will be restricted above 2,500 feet in elevation consistent with the 2016 Central Vermont Regional Plan's future land use plan.

For the purposes of this energy plan, a 125 foot hub height is expected to accommodate both residential and commercial wind generation. Hub heights above 125 feet will be considered industrial in scale and not fitting for Central Vermont. This height restriction is intended to reduce the visual impact of wind generation facilities while still permitting commercial and residential land uses to incorporate wind generation as appropriate. Additionally, the height restriction will limit the amount of land needed to accommodate wind generation and help maintain the sensitive natural resources throughout the region where industrial-scale wind resources have been identified.

To further support this limitation on industrial-scale wind generation, the 2016 Central Vermont Regional Plan identifies two distinct planning areas that encompass a significant portion of the region and includes almost all of the resource areas identified for wind generation. These planning areas are Rural and Resource and are delineated on the Future Land Use Map in Appendix A of the 2016 Central Vermont Regional Plan. These planning areas are described as:

Rural – These areas encompass much of the Region's large forest blocks, sand/gravel/mineral deposits, and prime agricultural soils that, when in productive use, contribute to the working landscape and have significant economic value. Rural areas also include residential, small-scale commercial and industrial, and recreational uses.

Resource – These areas are dominated by lands requiring special protection or consideration due to their uniqueness, irreplaceable or fragile nature, or important ecological function. These include, protected lands; elevations above 2,500 feet (elevations above 1,700 feet in Waitsfield, as regulated); slopes of 25% or more; rare, threatened or endangered species and significant natural communities; wetlands; special flood hazard areas; and shoreline protection areas. As a subcategory of Resource lands, this plan recognizes critical resource areas as key sites that are particularly sensitive and should be given maximum protection.

Based on the mapping analysis completed by the CVRPC, there are approximately 250,000 acres of wind resource area within Central Vermont that has no known constraints (but does include possible constraints). Of that land, approximately 27,000 acres of wind resource area is specifically classified for industrial-scale wind generation. Of those 27,000 acres, all but approximately 15 acres of wind resource area is located within land that is designated as Rural or Resource on the Future Land Use map included in Appendix A of the 2016 Central Vermont Regional Plan.

These 15 acres of land are located in the Industrial future land use designation. The regional plan identifies industrial areas to support economic development in the region including expansion, development, or redevelopment of existing industrial uses. These 15 acres of land are located on property that is an active quarrying operation which has been in existence for over 100 years. This use is expected to continue for the life of this plan and well into the future as an on-going economic force in the region that is supported by the regional plan therefore a change of use is not expected. With this in mind, there is currently no suitable land available where industrial/utility-scale wind generation could be developed.

The restriction on industrial-scale wind generation is also consistent with other policies outlined in the Regional Plan's Land Use element. Policies in the Rural designation support clustered development in order to protect important resources such as agricultural soils or forest blocks. The policies also support the development of small-scale business opportunities that do not adversely impact the forestry or agricultural uses or diminish the rural character of these areas. The plan notes that these uses should be established in conjunction with existing rural developments where appropriate, and not be a dominant feature.

Land use policies associated with the Resource designation propose the avoidance of development on steep slopes; fragmentation of habitat connectors and forest blocks; wetlands; and ridgelines. The Resource district also discourages the extension of permanent roads, energy transmission facilities, and utilities. The policies further state that development should be subject to extensive planning, review, and conditions to protect these areas, but does not outright prohibit development. Additional policies that support smaller scale development in the Rural or Resource areas of the region are included in the land use element and consistent with the limitation on industrial-scale wind development.

The following is an excerpt of policies related to the Rural and Resource Land Uses. A complete list of the Future Land Use Policies identified herein can be found beginning on page 2-18 of the Regional Plan.

**Rural Land Use Policies:**

6. Wildlife connectivity areas should be protected from fragmentation and uses that reduce their viability for movement of wildlife, particularly where they connect forest blocks.

7. Non-residential uses, including small service businesses, small professional offices and inns are acceptable land uses for Rural Areas provided that such uses are planned as relatively small in size or scale, are not primary or dominant uses in an area, do not unduly conflict with existing or planned residential, forestry or agricultural uses, and do not unduly affect rural character. Towns should limit the number and size of such establishments to prevent a proliferation of scattered commercial development that does not serve the needs of the community.

8. Occupations that are customarily practiced in residential areas, and which do not affect the character of those areas, are another form of small-scale commercial use common in and appropriate for rural areas. Small professional offices, antique shops, and craft studios are examples of such "customary home occupations."

9. Cross country ski centers, mountain biking facilities and other outdoor recreational areas represent an economically viable means of maintaining rural open spaces with little secondary development; both expansion and development of new facilities are consistent with this Plan.

**Resource Land Use Policies:**

1. Conservation of the natural landscape and careful management of lands is sought for these areas. Development in these areas should be subject to extensive planning, review and conditions that ensure its protection.

2. Any development proposed within critical resource areas shall provide evidence as to why the development cannot be avoided, and shall provide mitigation for natural resources impacted by the development.

3. The extension of permanent roads, energy transmission facilities, and utilities into Resource areas is discouraged.

4. Development on wetlands, steep slopes of 25% or more, and ridge lines should be avoided.

5. Avoid or limit development and investment in identified flood hazard areas, where feasible.

6. Avoid development that fragments forest blocks and habitat connectors.

Finally, the land use element notes that smaller scale or clustered development is appropriate in certain locations. Policies 1 and 2 under Resort Centers discusses support for expansion of the existing commercial ski areas including Sugarbush and Mad River Glen (in Warren and Fayston) instead of resort development at new locations. Both of these ski areas include limited development that extends above 2,500 feet in elevation. Aside from these uses, few structures exist above 2,500 feet in elevation throughout the Region further supporting the restriction on development in the area designated as Resource on the Future Land Use map.

If, through the development of a local energy plan consistent with Act 174, a municipality identifies industrial-scale wind generation as a community supported resource, the CVRPC may revise or amend this plan to consider the location(s) that has been identified. Prior to any amendments, the CVRPC will consider regional planning goals, mitigation of any identified constraints, and compatibility with the plans of adjacent municipalities.

**Energy Storage**

Finally, a discussion of electrical conservation and conversions would not be complete without acknowledging the potential limitations. Electricity as the primary power source for future needs will have to also consider the infrastructure and demand. If homes and vehicles are converted to electric power, there will be an increased demand for these resources in locations that may not currently be suited to provide that demand. Additionally, limitations on renewable resource technology will impact peak needs which may create a demand for storage of electrical power.

These factors will need to be considered in all our future decisions if a 90% renewable energy system is to become a reality. This may require potential changes to land use regulations that will accommodate battery or other storage options. Incentives to establish or upgrade infrastructure may be necessary and new construction may be required to include enhanced mechanical systems to handle increased electrical loads or design contingencies for fuel storage. While these challenges are not insurmountable, they will require an additional level of planning and consideration to ensure unforeseen issues are limited. More specific details regarding possible implementation actions to address these needs are included in the Pathways & Implementation Actions section of this plan.

**Conclusion**

As noted throughout this section, the Central Vermont Region faces challenges similar to the rest of the state regarding its energy future including the need for conservation, renewable energy development, and changing habits and attitudes towards renewable technology and land use choices. All of these components need to work together in order to ensure a collective and comprehensive approach to energy planning is initiated.

The information provided in this section has shown that Central Vermont has the ability to shape its energy future within the spectrum of the avenues that it can control. The unknown component is whether or not the changes and development will occur and when. The State Comprehensive Energy Plan has set a goal of 90% renewable energy by the year 2050. This goal is achievable if all stakeholders including the state, the region, municipalities, energy developers, private land owners, special interest groups, and interested citizens come together to discuss the issues and work collectively to identify the outcomes that satisfy the needs of the whole to the best of their ability.

This plan primarily explores renewable energy related to the production of electricity and electrification of the grid. In addition to the resources noted herein, it's important to consider other forms or technologies that could contribute to our renewable energy future. With advancements in safety, efficiency, and technology, the Region's energy future could look vastly different in the next five or ten years. This will not only impact the generation of energy, but the delivery and infrastructure to support distribution of energy.

## PATHWAYS & IMPLEMENTATION ACTIONS

The following policies, pathways, and implementation actions outline the specific strategies for the region to consider in order to effectively support the State of Vermont's goals that are outlined in the 2016 Comprehensive Energy Plan. These actions are intended to cover a variety of pathways that address land use and siting of developments (including renewable energy generation); efficiency of building construction and weatherization; and fuel switching from fossil based fuels to more sustainable and renewable options.

The specific actions identified herein include a list of the responsible parties, the timeframe for the action, and a measure to determine success or to gauge progress towards a specific action. A key factor that will influence the success or progress on these actions will be available resources. This includes funding, personnel, and other work plan priorities. The specific resources available may impact which actions are prioritized for completion. When possible, actions outlined below may be combined with other work plan tasks to limit the duplication of resources and to expedite their completion.

This implementation program reflects actions that will be the primary responsibility of the Central Vermont Regional Planning Commission. When appropriate, other organizations are listed under the heading of "Responsibility" with the expectation that their guidance, insights, or expertise will be sought to support the Regional Planning Commission's efforts. In some cases, the term "regional partners" is used. This general term is intended to be a catch-all to limit the need for an exhaustive list of possible organizations that could assist in completing the identified action as all the partners may not initially be known.

Additionally, groups could be added or removed as an action progresses based on the specific needs identified to complete each task. The groups listed in this column are intended to provide a general sense of who may be involved in a specific action and not intended to be a list of required organizations. The list of responsible parties will provide guidance to the CVRPC to help establish project priorities and how actions may relate to one another.

Finally, the pathways and implementation actions included below outline actions that the Central Vermont Regional Planning Commission will engage in to support the 2016 State Comprehensive Energy Plan's goal of 90 percent renewable energy generation by 2050. As the comprehensive energy plan is updated, priorities may change which could impact the specific actions that will be necessary to meet the state's overall goals. As such, actions may change, be amended, or removed as appropriate to reflect changing trends or priorities.

## A. Conservation and Efficiency

**Policy A-1**: Increase conservation of energy by individuals and organizations.

Conservation of energy is a key component to achieving the State's goals of 90% energy derived from renewable sources by 2050. Conservation of energy in-turn will reduce the amount of energy needed to support the existing and future systems thus allowing small increases in generation to support more uses overall.

| | IMPLEMENTATION ACTION | RESPONSIBILITY | PRIORITY/ TIMELINE | MEASURE OF SUCCESS |
|---|---|---|---|---|
| 1 | Identify and maintain a directory of regional organizations that offer assistance in weatherization and make this information available to the Region's municipalities, including residents, businesses, and other interested parties on a quarterly basis. | CVRPC, Regional Partners, other RPCs | High<br><br>On-going | Directory is established and available |
| 2 | Identify existing information regarding energy efficiency, conservation, weatherization, and their benefits related to cost savings that can be distributed through multiple media formats.<br><br>a. Work with regional partners to develop this information and update as appropriate.<br><br>b. Distribute this information to municipalities for display or dissemination at a municipal level. | CVRPC, Regional Partners, Utility Providers, other RPCs | High<br><br>On-going | Information is identified and available |
| 3 | Identify underserved populations such as low-income households and work with regional partners to encourage participation in programs such as the state Weatherization Assistance Program or similar initiatives. | CVRPC, Regional Partners | High<br><br>1 to 3 years | Population segments identified and contacts established |
| 4 | Work with interested municipalities to form municipally supported Energy or Climate Action Committees to address local energy concerns and provide support as appropriate. | CVRPC, Regional Partners | Medium<br><br>On-going | Committees formed |
| 5 | Continue to provide technical assistance to municipalities and encourage municipal bylaws that promote energy conservation and the development of renewable energy resources. | CVRPC, Regional Partners | High<br><br>On-going | Regulations updated to reflect energy specific requirements |

**Policy A-2**: Promote energy efficiency in the design, construction, renovation, operation, and retrofitting of systems for buildings and structures.

Energy efficient building designs provide benefits to the owners and occupants by reducing the amount of energy needed to heat, cool, and maintain the mechanical systems within the building. Establishing and promoting energy efficiency in design, construction, retrofits, and renovations will ensure new buildings and building practices will be more efficient into the future. These efficiencies can also lead to conservation of energy which can promote cost savings and affordability for owners and renters.

| IMPLEMENTATION ACTION | | RESPONSIBILITY | PRIORITY/ TIMELINE | MEASURE OF SUCCESS |
|---|---|---|---|---|
| 1 | Partner with existing organizations to provide education and support to interested municipalities to establish "stretch codes"[4] for residential and commercial building standards. | CVRPC, State Agencies, Regional Partners | High<br><br>1 to 3 years | Codes established and adopted |
| 2 | Work with municipalities to develop local energy codes requiring or promoting energy efficient site design and renewable fuel use in new construction projects that require an Act 250 permit. | CVRPC | High<br><br>1 to 3 years | New regulations established as appropriate |
| 3 | Identify existing educational materials related to net-zero ready buildings[5] to be utilized by municipalities to inform their citizens about the efficiency of this design technique. | CVRPC, Regional Partners | Medium<br><br>3 to 5 years | Materials developed and available |
| 4 | Work with community organizations or existing businesses to identify available information regarding the use of landscaping for energy efficiency including the importance of tree canopies, pervious surfaces, and similar design practices. | CVRPC, Regional Partners | Low<br><br>5 to 10 years | Information identified and available |
| 5 | Identify existing information that promotes the use of Vermont's residential building energy label/score to inform the community of the importance of energy efficiency in building design and construction including cost savings and affordability. | CVRPC, Regional Partners | Low<br><br>5 to 10 years | Materials identified and available |

4. Vermont has Residential Building Energy Standards (RBES) and Commercial Building Energy Standards (CBES). Stretch energy codes are those that achieve greater energy savings than the base RBES and CBES by including more stringent requirements for design and evaluation of energy efficiency.

5. A net-zero ready building is generally defined as a building whereby an equal or greater amount of energy used by a building is produced on site.

**Policy A-3**: Identify ways to decrease the use of fossil fuels for heating.

Reliance on fossil fuels such as oil, kerosene, or propane for heating is an unsustainable practice. Fossil fuels are non-renewable therefore they will eventually be depleted to a point where they are too expensive or too rare to be viable. Establishing alternative sources of renewable fuels for heating or conversions to heating from electric sources (which can be generated through renewable methods) will promote a more sustainable thermal energy future.

| | IMPLEMENTATION ACTION | RESPONSIBILITY | PRIORITY/ TIMELINE | MEASURE OF SUCCESS |
|---|---|---|---|---|
| 1 | Identify existing funding programs or partners that can assist with conversion of heating sources from fossil fuels to renewable based systems for homes and businesses. | CVRPC, Regional Partners, State Agencies | High<br><br>1 to 3 years | List of existing funding sources identified |
| 2 | Identify innovative products such as solar shingles, solar panels, cold climate heat pumps, ground source heat pumps, district heating[6], or high efficiency combustion wood stoves that would be suitable for home and business conversions and educate users on their advantages. | CVRPC, Industry Experts, Regional Partners | High<br><br>1 to 3 years | Information sessions conducted bi-annually |
| 3 | Identify potential locations throughout the region that could benefit from district heating projects based on building density, proximity to resources such as biomass, or status as a use by right where applicable. | CVRPC, Municipalities | Low<br><br>5 to 10 years | Locations identified and mapped |
| 4 | Work with interested municipalities to evaluate and amend as necessary local regulations to ensure district heating or similar centralized renewable generation facilities such as biogas or bio-digesters are permitted in appropriate locations. | CVRPC, Municipalities | High<br><br>1 to 3 years | Local regulations updated as needed |
| 5 | Identify sources of renewable materials such as biomass, farm waste, or food waste (such as schools, restaurants, or food processors) to determine supply of alternative fuels that may be available for district heating or other heating alternatives for homes or businesses. | CVRPC, Municipalities, Business Community | Medium<br><br>3 to 5 years | Locations identified and mapped |

6. District heating is a system for distributing heat generated in a centralized location for two or more homes and/or buildings' heating requirements.

| | IMPLEMENTATION ACTION | RESPONSIBILITY | PRIORITY/ TIMELINE | MEASURE OF SUCCESS |
|---|---|---|---|---|
| 6 | Work with state agencies to identify and inventory known sources and supplies of woody biomass that do not contribute to the spread of Federal or state identified invasive species and make this information available to the public as appropriate. | CVRPC, State Agencies | Medium<br><br>3 to 5 years | Sources are identified, mapped, and publicized |
| 7 | Identify energy storage technologies such as batteries to support off-grid systems or emergency pack-up power and educate the community on the costs, benefits, or challenges associated with these technologies. | CVRPC, Industry Experts, Utility Providers | High<br><br>1 to 3 years | Information is collected and disseminated as appropriate |
| 8 | Due to the rural nature of Central Vermont, identify and map large farm operations that may provide a sustained source of materials that could be used for bio-digesters. | CVRPC, Agency of Agriculture, Food, & Markets, Municipalities | Medium<br><br>3 to 5 years | Locations are identified and mapped |

## B. Reducing Transportation Energy Demand, Single-Occupancy Vehicle Use, and Encouraging Renewable or Lower-Emission Energy Sources for Transportation

**Policy B-1**: Encourage increased use of transit as a primary method to complete daily trips and reduce demands on existing infrastructure such as roads and parking.

Public transit offers communities the ability to move multiple persons utilizing existing roadway or railway infrastructure. Convenient, reliable and efficient public transit provides an alternative mode for individuals that might otherwise choose to drive alone. Public transit has the ability to reduce the need for parking in certain locations, provide more walkability in communities, and reduce congestion on local roads.

| | IMPLEMENTATION ACTION | RESPONSIBILITY | PRIORITY/ TIMELINE | MEASURE OF SUCCESS |
|---|---|---|---|---|
| 1 | Assist municipalities and regional partners including state agencies and the development community to identify incentives that encourage the inclusion of public transit in land development plans such as reductions in parking requirements, reduced local permit fees, or similar incentives. | CVRPC, Development Community, Regional Partners, State Agencies | High<br><br>1 to 3 years | Incentives identified and regulations updated as necessary |
| 2 | Work with regional partners including state agencies and the business community to identify incentives that encourage employers to support the use of public transit by their employees such as discounted transit fares, flexibility in work hours, or similar incentives. | CVRPC, Business Community, Regional Partners, State Agencies | High<br><br>1 to 3 years | Incentives identified and presented as necessary |
| 3 | Work with VTrans and Green Mountain Transit to identify future growth areas or development centers to ensure public transit will be accommodated in these locations including access to park & ride locations when appropriate. | CVRPC, Vtrans, Municipalities, GMT | High<br><br>1 to 3 years | Areas identified and prioritized as appropriate |
| 4 | Work with public transit providers and other partners to identify underserved communities such as rural areas or low-income neighborhoods to identify transit opportunities in these locations. | CVRPC, VTrans, Regional Partners, GMT | High<br><br>1 to 3 years | Service options identified for designated locations |
| 5 | Ensure the Central Vermont Regional Plan includes clear policy language that requires large scale developments to consult with transit providers regarding the need to include transit or multi-modal infrastructure with development proposals. | CVRPC | High<br><br>1 to 3 years | The Central Vermont Regional Plan is updated as appropriate |

| | IMPLEMENTATION ACTION | RESPONSIBILITY | PRIORITY/ TIMELINE | MEASURE OF SUCCESS |
|---|---|---|---|---|
| 6 | Work with regional partners and municipalities to establish a comprehensive transportation plan that incorporates policies and implementation regarding the expansion of public transit that considers locations of park & ride facilities; public facilities such as schools and government buildings; or other activity centers and uses throughout the Region and identifies possible funding sources to support implementation and the Region's future land use planning efforts. | CVRPC, VTrans, GMT, Regional Partners | High<br><br>1 to 3 years | Plan developed, areas prioritized, and funding options identified |
| 7 | Ensure the continued support of inter-municipal or inter-regional public transit options are maintained, such as bus or rail service. | CVRPC, VTrans, GMT | On-going | Services are maintained |
| 8 | Work with municipalities to evaluate and determine the feasibility of intermodal transit facilities in appropriate regional locations that can be supported by infrastructure, population, and resources. | CVRPC, Municipalities, VTrans, GMT | High<br><br>1 to 3 years | Locations are identified and mapped |
| 9 | Provide technical assistance to transit providers as appropriate regarding land use, infrastructure, and future planning considerations to help plan for service needs. | CVRPC, VTrans, GMT | On-going | Technical assistance is provided as requested |

**Policy B-2**: Promote the shift away from single-occupancy vehicle trips to reduce congestion, impacts to local facilities, and support alternative options for transportation needs.

Due to the rural nature of Central Vermont, single-occupancy vehicle trips are a common occurrence. While many people rely on their vehicle to perform general day-to-day tasks, reducing the rate of these trips can reduce congestion on local roads; reduce conflicts with vehicles and pedestrians; and provide more support for ride shares, public transit, or similar multi-occupancy trips.

| | IMPLEMENTATION ACTION | RESPONSIBILITY | PRIORITY/ TIMELINE | MEASURE OF SUCCESS |
|---|---|---|---|---|
| 1 | Promote the use of ride share programs within the region such as GoVermont, and maintain an active list of available services that can be distributed to the municipalities. | CVRPC, VTrans | Medium<br>On-going | List of providers developed and maintained |
| 2 | Work with regional partners such as VTrans to ensure inventories of park & ride locations and conditions are up-to-date and are consistent with the State Park & Ride Plan. This may include occupancy studies or user surveys to assess specific needs. | CVRPC, VTrans | Medium<br>On-going | Inventories completed and prioritized |
| 3 | Identify park & ride facilities that are near or over capacity to ensure future planning will accommodate expansions, upgrades, modifications, or alternative locations are identified as appropriate. | CVRPC, VTrans | High<br>On-going | Facility upgrades/ improvements are identified for priority locations |
| 4 | Work with utility companies and municipalities to inventory and map infrastructure such as fiber optic cable to identify gaps that may prohibit information accessibility or telecommuting options. | CVRPC, Utility Providers | High<br>On-going | Identify gaps and prioritize needs |

**Policy B-3**: Promote the shift away from gas/diesel vehicles to electric or non-fossil fuel transportation options to reduce dependency on non-renewable fuel sources for transportation.

Reducing the dependency on fossil fuels and other non-renewable fuels is a key pathway to achieving the state's energy planning goals. Switching to electric or non-fossil fuel based vehicles will help reduce greenhouse gas emissions and promote cleaner fuel alternatives.

| | IMPLEMENTATION ACTION | RESPONSIBILITY | PRIORITY/ TIMELINE | MEASURE OF SUCCESS |
|---|---|---|---|---|
| 1 | Work with municipalities to ensure land use regulations do not prohibit the installation of electric vehicle charging stations or similar alternative fuel technologies (such as bio-diesel) and identify model language that can be considered by municipalities to support these uses. | CVRPC, Municipalities | Medium<br><br>3 to 5 years | Model regulations developed and approved by municipalities |
| 2 | Identify businesses and municipalities in the region that operate large fleets of vehicles to provide assistance evaluating the possibility of integrating electric or non-fossil fuel based vehicles into their fleets. | CVRPC | Medium<br><br>3 to 5 years | Businesses inventoried and contacts established |
| 3 | Inventory existing locations of electric vehicle charging stations to identify where infrastructure gaps may exist or where needs could be met to provide greater access for electric vehicle owners. | CVRPC, Drive Electric Vermont | Medium<br><br>On-going | Inventory of locations mapped to identify potential gaps |
| 4 | Work with industry advocates and municipalities to ensure open communications exist to disseminate information about alternative fuel vehicles (including financial, environmental, and sustainability benefits) on a routine basis. This may be done through regular meetings, special events, or other avenues as deemed appropriate. | CVRPC, Industry Representatives, Lending Institutions, State Agencies | Low<br><br>On-going | Contacts established and regularly engaged |
| 5 | Consult with the Vermont Energy Investment Corporation's Drive Electric Vermont program to ensure the CVRPC staff is up-to date on current technology trends related to electric vehicles in order to provide guidance to municipalities. | CVRPC, VEIC | On-going | Regular updates are provided as necessary |
| 6 | Consider regulations that would require electric vehicle charging stations or infrastructure to be included in large scale developments as appropriate. | CVRPC, municipalities | Low<br><br>5 to 10 years | Regulations developed and implemented where appropriate |

**Policy B-4**: Facilitate the development of walking and biking infrastructure to provide alternative transportation options for the community.

Walking and biking provide valuable alternatives to motorized vehicle travel. Ensuring a safe, efficient, and convenient infrastructure exists to promote walking and biking is essential to the future growth and sustainability of the Region's municipalities.

| | IMPLEMENTATION ACTION | RESPONSIBILITY | PRIORITY/ TIMELINE | MEASURE OF SUCCESS |
|---|---|---|---|---|
| 1 | Evaluate local regulations and recommend changes as necessary to support state complete streets legislation as noted in 19 V.S.A §309d, which would include walking, biking, or transit infrastructure to be considered in the land development process. | CVRPC, municipalities | Medium<br><br>On-going | Regulations evaluated and recommendations made |
| 2 | Develop model regulations to be evaluated by municipalities that require walking and biking infrastructure in downtowns, village centers, growth areas, or locations that propose high density development patterns. | CVRPC, municipalities | Medium<br><br>3 to 5 years | Model regulations developed |
| 3 | Provide regular updates and training to municipalities that discuss complete streets concepts and to effectively implement these facilities including sample language to be evaluated for inclusion in local regulations. | CVRPC, VTrans | Medium<br><br>On-going | Regular reports to VTrans regarding trainings held |
| 4 | Work with its municipalities and regional partners to develop a walking and biking master plan that identifies priority projects, gaps in the infrastructure, and implementation strategies for incorporating facilities where appropriate. | CVRPC, municipalities, regional partners, state agencies, business community | Low<br><br>5 to 10 years | Plan developed and priority projects identified |
| 5 | Evaluate land use patterns to ensure walking and biking connections exist or are possible between key land uses such as schools, parks/greenways, commercial areas, or neighborhoods to help create walkable communities. | CVRPC | Low<br><br>5 to 10 years | Connections evaluated or established |

## C. Patterns and Densities of Land Use Likely to Result in Conservation of Energy

**Policy C-1**: Central Vermont is committed to reducing sprawl and minimizing low-density development by encouraging density in areas where infrastructure exists or is planned to support growth.

Land use policies that work to limit the proliferation of large lot development in favor of small lots in a compact area help communities address conditions that create sprawl, or the outward pattern of development that is characterized by auto-centric uses in an expanded geography. By limiting conditions that lead to sprawling development patterns, the Region can more effectively support energy independence.

| | IMPLEMENTATION ACTION | RESPONSIBILITY | PRIORITY/ TIMELINE | MEASURE OF SUCCESS |
|---|---|---|---|---|
| 1 | Evaluate municipal regulations to ensure higher density development patterns are located in regional and town centers to maintain existing settlement patterns and do not inadvertently promote sprawling development. | CVRPC, Municipalities | Medium<br><br>On-going | Regulations are evaluated as needed and recommendations are included |
| 2 | Assist municipalities to identify future growth areas that can accommodate development needs while meeting smart growth principles and respecting historic settlement patterns of compact villages, neighborhoods, and urban centers as appropriate. | CVRPC, Municipalities | Medium<br><br>On-going | Assistance provided and areas identified |
| 3 | Assist municipalities in preparing information necessary to acquire or maintain state designations including statutory requirements. | CVRPC, Municipalities, ACCD | Low<br><br>On-going | State designations are maintained or acquired |
| 4 | Work with municipalities and regional partners to inventory and map existing infrastructure such as water and wastewater to evaluate capacity and development potential. | CVRPC, Municipalities | Medium<br><br>3 to 5 years | Infrastructure mapped and updated as needed |
| 5 | Work with communities to evaluate their land development regulations to ensure these regulations (including scale, massing, building height, and minimum lot size) are suitable to support density in appropriate locations and in proximity to needed infrastructure that is consistent with community character. | CVRPC | Low<br><br>5 to 10 years | Regulations evaluated and updated as appropriate |
| 6 | Develop or make available model ordinances related to Planned Unit Developments, for review and consideration by municipalities as a way to establish compact development patterns outside of existing growth areas. | CVRPC | Low<br><br>5 to 10 years | Model regulations developed |

| | IMPLEMENTATION ACTION | RESPONSIBILITY | PRIORITY/ TIMELINE | MEASURE OF SUCCESS |
|---|---|---|---|---|
| 7 | Provide information related to available funding opportunities (including sources and programs) for municipal infrastructure projects or improvements that will promote or support development density or compact development patterns. | CVRPC, State Agencies | High<br><br>1 to 3 years | Information on funding collected and available |
| 8 | Work with interested municipalities to create policies that incentivize development in designated growth areas with opportunities that could expedite land development reviews, permitting, or other regulatory processes as appropriate. | CVRPC, Municipalities, State Agencies | High<br><br>1 to 3 years | Regulations & processes updated as appropriate |
| 9 | Assist interested municipalities to review regulations and develop updates as appropriate that would support the development of community scale infrastructure for renewable energy generation and conservation. | CVRPC, Municipalities | Medium<br><br>3 to 5 years | Regulations updated as appropriate |
| 10 | Work with interested municipalities to ensure adequate land exists for agricultural uses as a way to encourage local food production. | CVRPC, Municipalities | Medium<br><br>3 to 5 years | Regulations updated as appropriate |
| 11 | Work with municipalities and the Agency of Agriculture, Food & Markets to ensure prime farmland inventories are up-to-date and mapped. | CVRPC, Agency of Agriculture, Food, & Markets, municipalities | On-going | Prime agricultural land inventories are updated and mapped |
| 12 | Support amendments to local regulations that encourage local food production through regulatory and non-regulatory approaches that focus development and preserve agricultural opportunities. | CVRPC, Municipalities, Agency of Agriculture, Food, & Markets | Medium<br><br>3 to 5 years | Regulations are updated as appropriate |

**Policy C-2**: Strongly prioritize development in compact, mixed-use centers when feasible and appropriate; and identify ways to make compact development more feasible throughout Central Vermont.

Compact development patterns create opportunities whereby land uses that support where people live, work, and recreate, are all within close proximity. This not only creates a greater sense of place but it provides opportunities to walk, bike, or utilize public transit as the primary mode of transportation. Additionally, compact development patterns can promote conservation of energy through the redevelopment of underutilized spaces therefore including more energy efficient building designs.

| | IMPLEMENTATION ACTION | RESPONSIBILITY | PRIORITY/ TIMELINE | MEASURE OF SUCCESS |
|---|---|---|---|---|
| 1 | Provide information to municipalities regarding alternative land use regulations such as form-based codes and identify communities where similar regulations have been successfully implemented including rural or non-urban scale regulations. | CVRPC | Low<br><br>5 to 10 years | Workshops or other informational sessions conducted |
| 2 | Evaluate municipal regulations and recommend amendments that will support and encourage infill development, redevelopment, adaptive reuse of existing buildings such as historic structures, and reuse of "brownfield" sites | CVRPC, Municipalities, Regional Partners | High<br><br>1 to 3 years | Regulations evaluated and recommendations made as appropriate |
| 3 | Provide information to municipalities on capital planning, public investment strategies, or state and federal programs that support infill development within core community areas. | CVRPC, State Partners | High<br><br>1 to 3 years | Workshops or other informational sessions conducted |
| 4 | Evaluate roadways in existing villages, downtowns, or municipal activity centers to identify conflict points between motorized and non-motorized modes of travel and recommend options to promote walkable and bike friendly centers that encourage alternative transportation choices | CVRPC, VTrans, Municipalities | Medium<br><br>3 to 5 years | Evaluations completed as needed and recommendations provided |
| 5 | Work with municipalities to identify priority development zones, growth areas, or locations where high demand for electric loads exist or are planned (such as industrial parks) to ensure current planning acknowledges future needs. | CVRPC, Municipalities, State Partners | High<br><br>1 to 3 years | Locations are identified and incentives established as appropriate |

## D. Development and Siting of Renewable Energy Resources

**Policy D-1**: Evaluate generation from existing renewable energy generation by municipality including the identification of constraints, resource areas, and existing infrastructure by energy type.

Identifying and mapping existing renewable energy generation facilities throughout the region will provide a baseline to determine the generation that currently exists. This information can provide a better understanding for where developments are currently being established and can help prioritize assistance that may be needed at the municipal level. Additionally, mapping existing constraints will provide municipalities with a better understanding of resources that are available within their community.

| | IMPLEMENTATION ACTION | RESPONSIBILITY | PRIORITY/ TIMELINE | MEASURE OF SUCCESS |
|---|---|---|---|---|
| 1 | Provide regular mapping updates to municipalities regarding existing generation facilities to maintain an up-to-date inventory of locations. | CVRPC, Department of Public Service | On-going | Updated maps provided as requested |
| 2 | Provide regular mapping updates to municipalities regarding known and possible constraints to ensure consistency with state guidelines on renewable energy siting. | CVRPC, State Agencies | On-going | Updated maps provided as necessary |
| 3 | Update regional maps to reflect changes at the municipal level regarding preferred or unsuitable locations for renewable energy generation. | CVRPC, Municipalities | On-going | Maps and information updated as necessary |
| 4 | Work with state agencies to map locations of woody biomass or methane generation for possible fuel sources. | CVRPC, State Agencies | On-going | Specific locations are identified and mapped |

**Policy D-2**: Evaluate generation from potential renewable energy generation by municipality including the identification of constraints, resource areas, and existing infrastructure by energy type.

Identifying and mapping potential renewable energy generation throughout the region will provide municipalities with information regarding available land area where renewable energy generation could be located. This information can be used to help municipalities prioritize and evaluate where future renewable generation could or should occur based on municipal land use policies and constraints. Additionally, information on potential renewable energy generation will ensure municipalities are working to support the state's renewable energy generation goals of 90% of the state's energy needs coming from renewable sources by 2050.

| IMPLEMENTATION ACTION | | RESPONSIBILITY | PRIORITY/ TIMELINE | MEASURE OF SUCCESS |
|---|---|---|---|---|
| 1 | Evaluate known, possible, and regionally identified constraints to ensure up-to-date information is available for future planning purposes. | CVRPC, State Agencies | On-going | Constraints will be evaluated and mapped as necessary |
| 2 | Update information on utility infrastructure including existing and proposed transmission facilities to ensure accurate data exists. | CVRPC, Utility Providers | On-going | Utility information is updated and mapped as necessary |
| 3 | Evaluate and update preferred and unsuitable locations for future renewable energy generation siting as needed based on state, regional, and municipal policies and plans. | CVRPC, Municipalities, State Agencies | On-going | Preferred and prohibited locations are evaluated and mapped as necessary |
| 4 | Update generation potential based on future land developments, changes to land uses, or updates to priority areas as identified by state, regional, or municipal actions. | CVRPC, Municipalities, State Agencies | On-going | Generation potential is updated as necessary |
| 5 | Work with municipalities, as requested, to evaluate and prioritize future renewable energy generation technologies and locations to best suit municipal needs and policies. | CVRPC, Municipalities | On-going | Locations and technologies will be evaluated and prioritized |

## MAPPING

As noted in the Pathways & Implementation Actions section, specific policies have been identified related to mapping. These policies include evaluation of existing renewable energy generation and future renewable energy generation potential. The following information provides additional detail related to mapping including infrastructure, constraints, and specific locational preferences. In addition to the information in this section, Appendix B includes regional maps to support the discussion in this section.

The siting and generation of renewable resources is a critical part to identifying whether or not the region can meet its share of the state's renewable energy goals by 2050. Furthermore, this analysis is important to determine where resources are available throughout the region to ensure no one municipality is unduly burdened with supporting more than should be reasonably anticipated. Finally, this information will better position the region and its municipalities to evaluate the renewable energy generation options that are available to meet these goals.

To this end, maps were created for Central Vermont at a regional and municipal level that identify resources related to solar, wind, hydroelectric, and woody biomass. Maps were also created to identify constraints that may limit the overall area of possible resource development within Central Vermont. The following information will address the evaluation of current and future generation potential within the region.

### Existing Renewable Energy Generation

As noted in the Analysis & Targets section, Table One identifies the existing renewable generation for Central Vermont. Information on existing generation is a representation of all projects that were issued a Certificate of Public Good by the Public Service Board through the end of 2014. Projects that are currently under review are not included in these numbers therefore additional renewable energy generation may be developed that will not be included in the total generation represented in Table One.

One resource that provides data on existing generation is the Vermont Energy Action Network's Energy Dashboard. This resource incorporates data from the Department of Public Service relative to projects that have received a Certificate of Public Good, but also includes information from the community on self-reported actions. These include activities such as weatherization of buildings, switching of lightbulbs to high efficiency LED technologies, conversions to high efficiency appliances, or replacement of fossil fueled vehicles with alternative fuel technologies. The Energy Dashboard can be accessed by visiting http://www.vtenergydashboard.org/energy-atlas.

Appendix B includes maps with existing solar generation greater than 15 kW and all wind and woody biomass generation sites. Solar projects are the predominant form of generation in Central Vermont. In addition to the mapped locations for solar generation, the Energy Dashboard identifies approximately 1,000 additional solar sites in the region that are less than 15 kW. These are primarily individual homes with solar installations to supplement conventional electrical service. Also, approximately 250 solar hot water installations existing within the region bringing the total number of solar generation facilities in the region to just over 1,300 installations.

Potential Renewable Energy Generation

Table Thirteen in the Analysis & Targets section identifies potential generation of renewable energy for Central Vermont. This information is based on mapping data provided by the Vermont Center for Geographic Information (VCGI) and the Department of Public Service. This information includes specific data related to prime resource areas for solar and wind development which is an indication of where the conditions are most ideal for generation of the specific resource. Also included with this data is information regarding constraints to be considered when evaluating areas for renewable energy development. Additional detail regarding known and possible constraints is discussed below.

Constraints[7]

As part of this effort, the CVRPC has identified information related to renewable energy generation that includes an analysis and evaluation of resource areas within the region and how those resource areas are impacted by statewide and regionally identified constraints. In order to determine the impacts, an understanding of the constraints needs to be discussed.

For the purpose of this plan, constraints are separated into two main categories; known and possible. Known constraints are those areas where development of a renewable resources are very limited and therefore not likely to occur. Known constraints that have been identified include:

- Vernal Pools (confirmed or unconfirmed)
- River Corridors as identified by the Vermont Department of Environmental Conservation
- Federal Emergency Management Agency Identified Floodways
- State-significant Natural Communities and Rare, Threatened, and Endangered Species
- National Wilderness Areas
- Class 1 and Class 2 Wetlands (as noted in the Vermont State Wetlands Inventory or Advisory Layers
- Regionally or Locally Identified Critical Resources

Similarly, the state has identified a list of possible constraints to be considered. Possible constraints identify areas where additional analysis will need to occur in order to determine if development of renewable energy resources is appropriate. In some cases, conditions may be prohibitive, but in others the conditions may be suitable for renewable energy development. The possible constraints include:

- Agricultural Soils
- Federal Emergency Management Agency Special Flood Hazard Areas
- Protected Lands (State fee lands and private conservation lands)
- Act 250 Agricultural Soil Mitigation Areas
- Deer Wintering Areas
- Vermont Agency of Natural Resources Conservation Design Highest Priority Forest Blocks
- Hydric Soils
- Regionally or Locally Identified Resources

7. Appendix A provides specific definitions for the known and possible constraints.

In addition to the items listed above, the Regional Planning Commission, through its Regional Energy Committee, has identified additional constraints to be included. For the purposes of this mapping exercise, all of the regional constraints are considered possible constraints. This is due to the fact that the Regional Energy Committee determined that, like the statewide possible constraints, conditions could be such that developing renewable energy resources in these locations could occur but should be studied further to determine if the specific conditions regarding these locations are suitable. The possible regional constraints that were identified include:

- Elevations above 2,500 feet
- Slopes greater than 25%
- Municipally Owned Lands
- Lakeshore Protection Buffer Areas of 250 feet

It should be noted that the regionally identified constraints are intended to be a starting point. Future updates to the Regional Energy Plan may include additional analysis of regional constraints. Changes to regional priorities may impact specific constraints that should be considered. This could include factors such as contiguous blocks of farmland, parcel sizes, or other factors that are identified as regional priorities.

Methodology

With all the known and possible constraints identified, this information was overlaid on the resources maps for solar and wind resources. Where known constraints existed, the resource areas were deleted. Where possible constraints existed, the resource areas were shaded. The resulting areas included those lands where prime resources exist without any constraints and prime resources with possible constraints. The total area within these two categories served as the basis to determine the amount of resource that is available for potential development within Central Vermont.

As noted in Table Thirteen of the Analysis & Targets section, based on the solar, wind, and hydroelectric potential within Central Vermont, approximately 90,000,000 megawatt hours of energy could be produced, well above the region's allocation of 418,531 megawatt hours by 2050. The potential energy generation for Central Vermont increases when other sources of renewable energy generation such as biomass, biogas, and methane are included. No specific generation numbers are listed in Table Thirteen for these types of energy generation as their siting is not specifically tied to the availability of a resource, therefore calculating a potential for generation would be difficult.

Finally, the constraints outlined above have been evaluated to ensure sufficient resource area will exist to meet the region's share of the state's renewable energy targets. As noted, the regional constraints are included as "possible" therefore development of renewable resources could occur in these locations after an analysis of the specific site has been concluded. Additionally, multiple technologies could be used to meet the region's target. This means that some technologies, such as wind or hydroelectric, could be replaced by biomass or biogas to meet the region's target.

Transmission Infrastructure

In addition to identifying and calculating possible generation of renewable energy based on resources and constraints, the mapping included in this plan also incorporates the existing three phase power infrastructure throughout the region. This is important to include because large-scale renewable energy generation typically needs three phase power to provide energy generation back to the grid. Smaller generation facilities (such as residential scale) can typically be accommodated by single phase transmission even when not located close to the load, therefore three phase power may not be a limiting factor in renewable energy development.

Similar to limits on three phase power are potential limitations on existing transmission infrastructure and the ability to transmit energy from its point of generation to the possible users. As noted previously, the mapping includes three phase power, but it also includes information on current transmission infrastructure. This is another component to consider when identifying where specific generation types should be located to ensure the transmission capacity exists within the grid or to identify areas where upgrades may be needed before development of renewable energy generation can occur.

Based on the factors noted above, it may be appropriate for mapping to identify areas where significant energy loads are currently occurring or anticipated based on future land use and zoning. Locations of high energy use were not included on the current mapping and this information should first be considered at a municipal level before being identified regionally. This process would be consistent with others herein that support municipal identification of energy planning needs to ensure consistency with local regulations and planning efforts.

In the future, it may be appropriate to evaluate the entire transmission and distribution network to determine not only where there may be limitations to grid capacity, but also to identify where there may be surplus capacity. Identifying where limits and excesses exist throughout the electrical grid will be valuable information to inform future planning decisions related to both the siting of future renewable energy generation, but also when considering future land uses or development patterns. These evaluations could also identify locations that may be suitable for microgrids to address critical facilities or similar needs to ensure continuous power supplies are available.

Preferred & Unsuitable Siting Locations

Similar to the discussion regarding the identification of constraints at a regional scale, the Regional Energy Committee recommended that preferred and unsuitable areas would not be included on the mapping with the exception of statewide preferred locations that may exist within the region. The statewide preferred locations include:

- Parking lots
- Gravel pits
- Brownfield sites as defined in 10 V.S.A. §6642[8]
- Sanitary Landfills as defined in 10 V.S.A. §6602
- Rooftop installations

8. The State of Vermont is developing specific guidance to ensure brownfield sites have been properly evaluated to include the identification and the extent of the possible contamination. Based on this guidance, a Phase I and/or Phase II analysis may be required prior to the site being formally designated as a brownfield. This may impact the eligibility of a specific site to meet this designation and be considered a preferred site for renewable energy development.

The Regional Energy Committee further concluded that the final determination and identification of suitable sites would be left to the individual municipalities as they develop and evaluate their needs, development patterns, and future land use goals. Similarly, unsuitable areas for development of renewable energy generation were not included on the regional maps and no specific examples beyond the constraint layers are noted. This will allow the municipalities to use local insight and knowledge to evaluate and establish the criteria for identifying locally preferred or unsuitable locations. Regional maps may be updated to include locally identified preferred or unsuitable sites as municipalities work to identify these locations through local energy planning processes. This could include siting for all resource technologies including biogas, biosolids, wind, solar, and woody biomass.

The CVRPC will also evaluate and consider preferred locations as identified by the Public Utility Commission's net metering rules. This will ensure consistency between state, regional, and locally preferred locations for renewable energy siting. In addition to the actions outlined in the Pathways & Implementation Actions section, a map identifying existing locations of statewide preferred locations as noted previously can be found in Appendix B.

Finally, the Central Vermont Regional Energy Plan supports the development of renewable energy generation technology that will not result in an undue adverse impact on the built or natural environment or conflict with identified regional policies. Similar to constraint mapping, it was decided that the region should not limit the extent to which municipalities can plan for their energy future. Due to the diverse nature of Central Vermont, including urban and rural areas, there was no way to develop a consistent regional policy that would be equitable to all the municipalities, therefore all renewable energy generation types (both current and developed through future advances in technology or innovations in the industry) may be considered for application in Central Vermont.

Municipal Information

As part of this effort, the Central Vermont Regional Planning Commission developed information for all 23 municipalities within the region related to Analysis & Targets and Mapping, using best available information. This information was completed and distributed on April 28, 2017. The CVRPC website was the mechanism for this information to be disseminated and including guidance and other resources for how to best use the information. This information is available at [http://centralvtplanning.org/programs/energy/municipal-energy-planning/](http://centralvtplanning.org/programs/energy/municipal-energy-planning/)

Regional Mapping

To provide a more specific visual representation of resources and constraints, mapping was developed that includes:

- Solar Resource Areas
- Wind Resource Areas
- Hydroelectric Resource Areas
- Known Constraints
- Possible Constraints
- Woody Biomass Resource Area

These maps should be used as a starting point to determine what areas may exhibit characteristics consistent with conditions that would support renewable energy development. More detailed review and analysis should be conducted to determine specific boundaries for resource areas or constraints. These maps can be found in Appendix B.

# APPENDIX A

# KNOWN & POSSIBLE CONSTRAINT DEFINITIONS & DESCRIPTIONS

The following is a list of the known, possible, and regional constraints that were used and referenced in the mapping section of this document. A definition of the constraint including source of the data is provided.

## Known Constraints

Vernal Pools (confirmed and unconfirmed layers) –
*Source: Vermont Fish and Wildlife, 2009 - present*

Vernal pools are temporary pools of water that provide habitat for distinctive plants and animals. Data was collected remotely using color infrared aerial photo interpretation. "Potential" vernal pools were mapped and available for the purpose of confirming whether vernal pool habitat was present through site visits. This layer represents both those site which have not yet been field-visited or verified as vernal pools, and those that have.

Department of Environmental Conservation (DEC) River Corridors –
*Source: DEC Watershed Management District Rivers Program, January 2015*

River corridors are delineated to provide for the least erosive meandering and floodplain geometry toward which a river will evolve over time. River corridor maps guide State actions to protect, restore and maintain naturally stable meanders and riparian areas to minimize erosion hazards. Land within and immediately abutting a river corridor may be at higher risk to fluvial erosion during floods.

River corridors encompass an area around and adjacent to the present channel where fluvial erosion, channel evolution and down-valley meander migration are most likely to occur. River corridor widths are calculated to represent the narrowest band of valley bottom and riparian land necessary to accommodate the least erosive channel and floodplain geometry that would be created and maintained naturally within a given valley setting.

Federal Emergency Management Agency (FEMA) Floodways –
*Source: FEMA Floodway included in Zones AE – FEMA Map Service Center*

These are areas subject to inundation by the 1-percent-annual-chance flood event determined by detailed methods. A "Regulatory Floodway" means the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height.

State-significant Natural Communities and Rare, Threatened, and Endangered Species –
*Source: Vermont Fish and Wildlife, National Heritage Inventory*

The Vermont Fish and Wildlife Department's Natural Heritage Inventory (NHI) maintains a database of rare, threatened and endangered species and natural (plant) communities in Vermont. The Element Occurrence (EO) records that form the core of the Natural Heritage Inventory database include information on the location, status, characteristics, numbers, condition, and distribution of elements of biological diversity using established Natural Heritage Methodology developed by NatureServe and The Nature Conservancy.

An Element Occurrence (EO) is an area of land and/or water in which a species or natural community is, or was, present. An EO should have practical conservation value for the Element as evidenced by potential continued (or historical) presence and/or regular recurrence at a given location. For species Elements, the EO often corresponds with the local population, but when appropriate may be a portion of a population or a group of nearby populations (e.g., metapopulation).

National Wilderness Areas –
*Source: United States Department of Agriculture Forest Service*

A parcel of Forest Service land congressionally designated as wilderness.

Class 1 and Class 2 Wetlands –
*Source: Vermont Significant Wetland Inventory (VSWI) and advisory layers*

The State of Vermont protects wetlands which provide significant functions and values and also protects a buffer zone directly adjacent to significant wetlands. Wetlands in Vermont are classified as Class I, II, or III based on the significance of the functions and values they provide. Class I and Class II wetlands provide significant functions and values and are protected by the Vermont Wetland Rules. Any activity within a Class I or II wetland or buffer zone which is not exempt or considered an "allowed use" under the Vermont Wetland Rules requires a permit.

Class I wetlands have been determined to be, based on their functions and values, exceptional or irreplaceable in its contribution to Vermont's natural heritage and, therefore, merits the highest level of protection. All wetlands contiguous to wetlands shown on the VSWI maps are presumed to be Class II wetlands, unless identified as Class I or III wetlands, or unless determined otherwise by the Secretary or Panel pursuant to Section 8 of the Vermont Wetland Rules.

## Possible Constraints

Agricultural Soils –
*Source: Natural Resources Conservation Service (NRCS)*

Primary agricultural soils" are defined as "soil map units with the best combination of physical and chemical characteristics that have a potential for growing food, feed, and forage crops, have sufficient moisture and drainage, plant nutrients or responsiveness to fertilizers, few limitations for cultivation or limitations which may be easily overcome, and an average slope that does not exceed 15 percent. Present uses may be cropland, pasture, regenerating forests, forestland, or other agricultural or silvicultural uses.

The soils must be of a size and location, relative to adjoining land uses, so that those soils will be capable, following removal of any identified limitations, of supporting or contributing to an economic or commercial agricultural operation. Unless contradicted by the qualifications stated above, primary agricultural soils include important farmland soils map units with a rating of prime, statewide, or local importance as defined by the Natural Resources Conservation Service of the United States Department of Agriculture.

FEMA Special Flood Hazard Areas -

The land area covered by the floodwaters of the base flood is the Special Flood Hazard Area (SFHA) on NFIP maps. The SFHA is the area where the National Flood Insurance Program's (NFIP's) floodplain management regulations must be enforced and the area where the mandatory purchase of flood insurance applies.

Protected Lands –

State fee land and private conservation lands are considered protected lands. Other state level, non-profit and regional entities also contribute to this dataset. The Vermont Protected Lands Database is based on an updated version of the original Protected Lands Coding Scheme reflecting decisions made by the Protected Lands Database Work Group to plan for a sustainable update process for this important geospatial data layer.

Act 250 Ag Mitigation Parcels –
*Source: Vermont Department of Agriculture*

All projects reducing the potential of primary agricultural soils on a project tract are required to provide "suitable mitigation," either "onsite or offsite," which is dependent on the location of the project. This constraint layer includes all parcels in the Act 250 Ag Mitigation Program as of 2006.

Deer Wintering Areas (DWA) –
*Source: Vermont Department of Fish and Wildlife*

Deer winter habitat is critical to the long term survival of white-tailed deer (Odocoileus virginianus) in Vermont. Being near the northern extreme of the white-tailed deer's range, functional winter habitats are essential to maintain stable populations of deer in many years when and where yarding conditions occur. Consequently, deer wintering areas are considered under Act 250 and other local, state, and federal regulations that require the protection of important wildlife habitats. DWAs are generally characterized by rather dense softwood (conifer) cover, such as hemlock, balsam fir, red spruce, or white pine. Occasionally DWAs are found in mixed forest with a strong softwood component or even on found west facing hardwood slopes in conjunction with softwood cover. The DWA were mapped on mylar overlays on topographic maps and based on small scale aerial photos.

Vermont Conservation Design include the following Highest Priority Forest Blocks: Connectivity, Interior, and Physical Landscape Diversity –
*Source: Vermont Department of Fish and Wildlife*

The lands and waters identified in this constraint are the areas of the state that are of highest priority for maintaining ecological integrity. Together, these lands comprise a connected landscape of large and intact forested habitat, healthy aquatic and riparian systems, and a full range of physical features (bedrock, soils, elevation, slope, and aspect) on which plant and animal natural communities depend.

Hydric Soils –
*Source: Natural Resources Conservation Service*

A hydric soil is a soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part. This constraint layer includes soils that have hydric named components in the map unit.

## Regional Constraints

Elevations above 2500 feet –

This constraint uses USGS contours over 2500 feet.

250 Foot Lake Shore Protection Buffers –

For this constraint, CVRPC selected Vermont Hydrologic Dataset lakes and ponds greater than 10 acres and then buffered those by 250 feet.

Slopes Greater Than 25% –

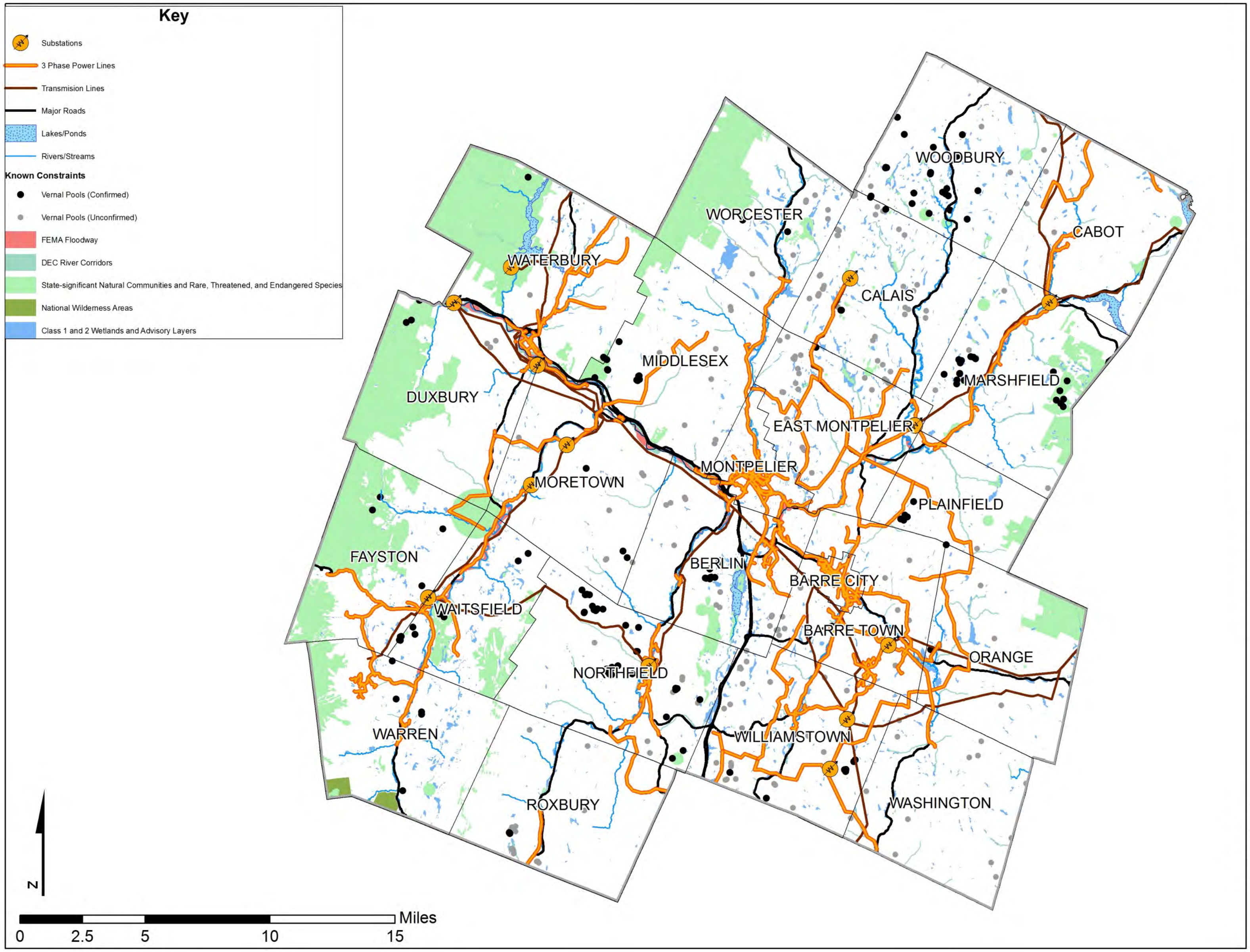
For this constraint, CVRPC performed a slope analysis using a 10 meter Digital Elevation Model.

Municipal Lands –

For this constraint, CVRPC used the Vermont Center for Geographic Information's Protected Lands Database.

# APPENDIX B

# REGIONAL RESOURCE MAPS




# Known Constraints Map

**Known Constraints**

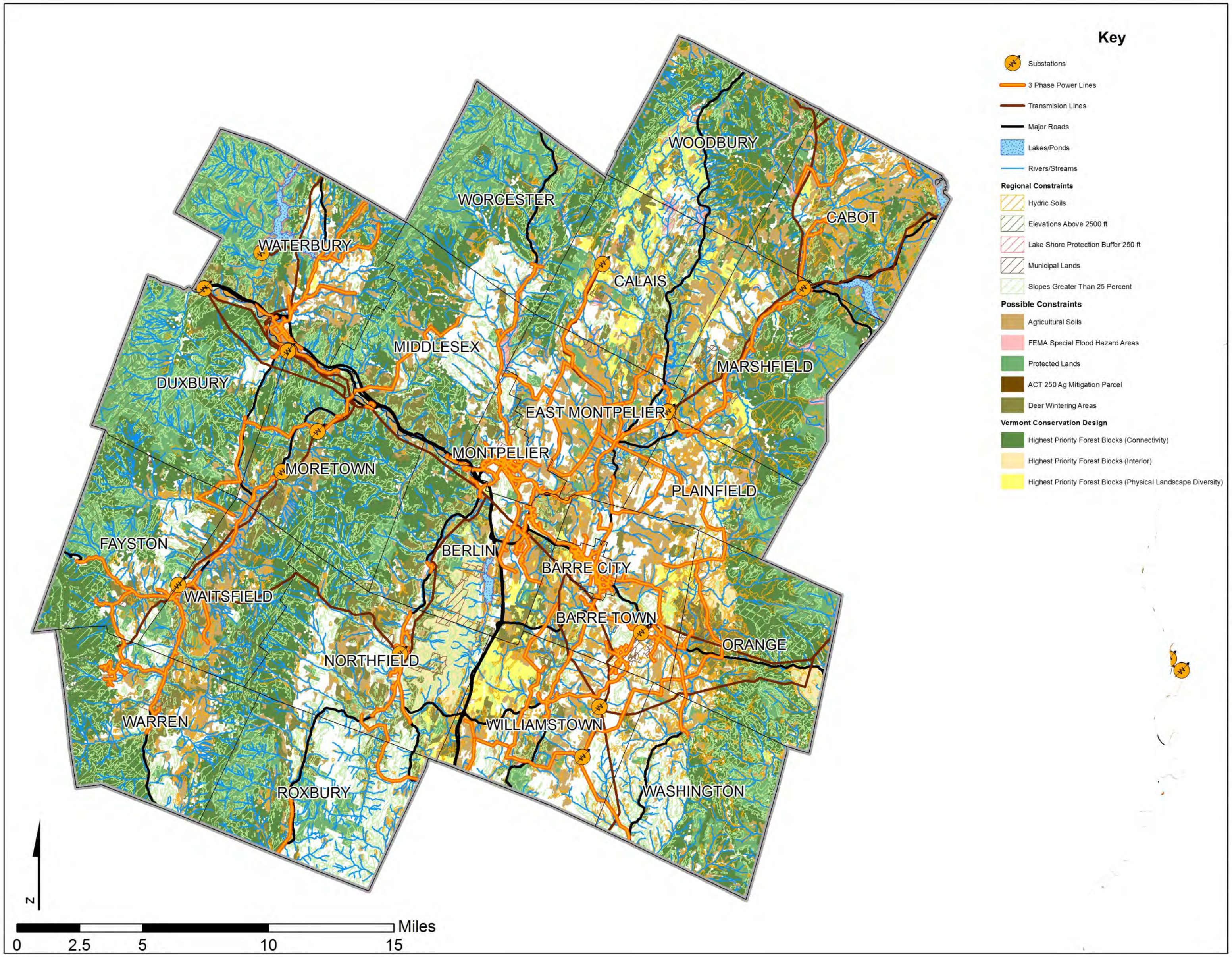
These constraints signal likely, though not absolute, unsuitability for development based on statewide or local regulation or designated critical resources.

Link to Data - http://vcgi.vermont.gov/opendata/act174

Known Constraints
Vernal Pools incuding confirmed and unconfirmed -
Vermont Fish and Wildlife
DEC River Corridors -
DEC WSMD Rivers Program 1/2/15
FEMA Floodway included in Zones AE -
FEMA Map Service Center
State-significant Natural Communities and Rare, Threatened, and Endangered Species -
Vermont Fish and Wildlife, Natural Heritage Inventory
National Wilderness Areas -
USDA Forest Service
Class 1 and Class 2 Wetlands (VSWI) and Advisory Layers - VT Watershed Management Division

This map was created as part of a Regional Energy Planning Initiative being conducted by the Bennington County Regional Commission, and the Vermont Public Service Department.

**Created:** December 2016 by CVRPC GIS.




# Possible Constraints Map

**Possible Constraints**

These constraints signals conditions that would likely require mitigation, and which may prove a site unsuitable after site-specific study, based on statewide or regional/ local policies that are currently adopted or in effect.

Link to Data - http://vcgi.vermont.gov /opendata/act174

Possible Constraints Data Sources
Agricultural Soils include local, prime and statewide classifications - NRCS
FEMA Special Flood Hazard Areas include Zones A and AE - FEMA Map Service Center
Protected Lands - Include State fee lands and private conservation lands - VCGI
Act 250 Ag Mitigation Parcels include parcel as of 2006 - VT Dept. of Ag
Deer Wintering Areas - VT Fish and Wildlife
Vermont Conservation Design include the following Highest Priority Forest Blocks: Connectivity, Interior, and Physical Landscape Diversity) - VT Fish and Wildlife
Hydric Soils include soils that have hydric named components in the map unit - NRCS

This map was created as part of a Regional Energy Planning Initiative being conducted by the Bennington County Regional Commission, and the Vermont Public Service Department.

**Created:** December 2016 by CVRPC GIS.

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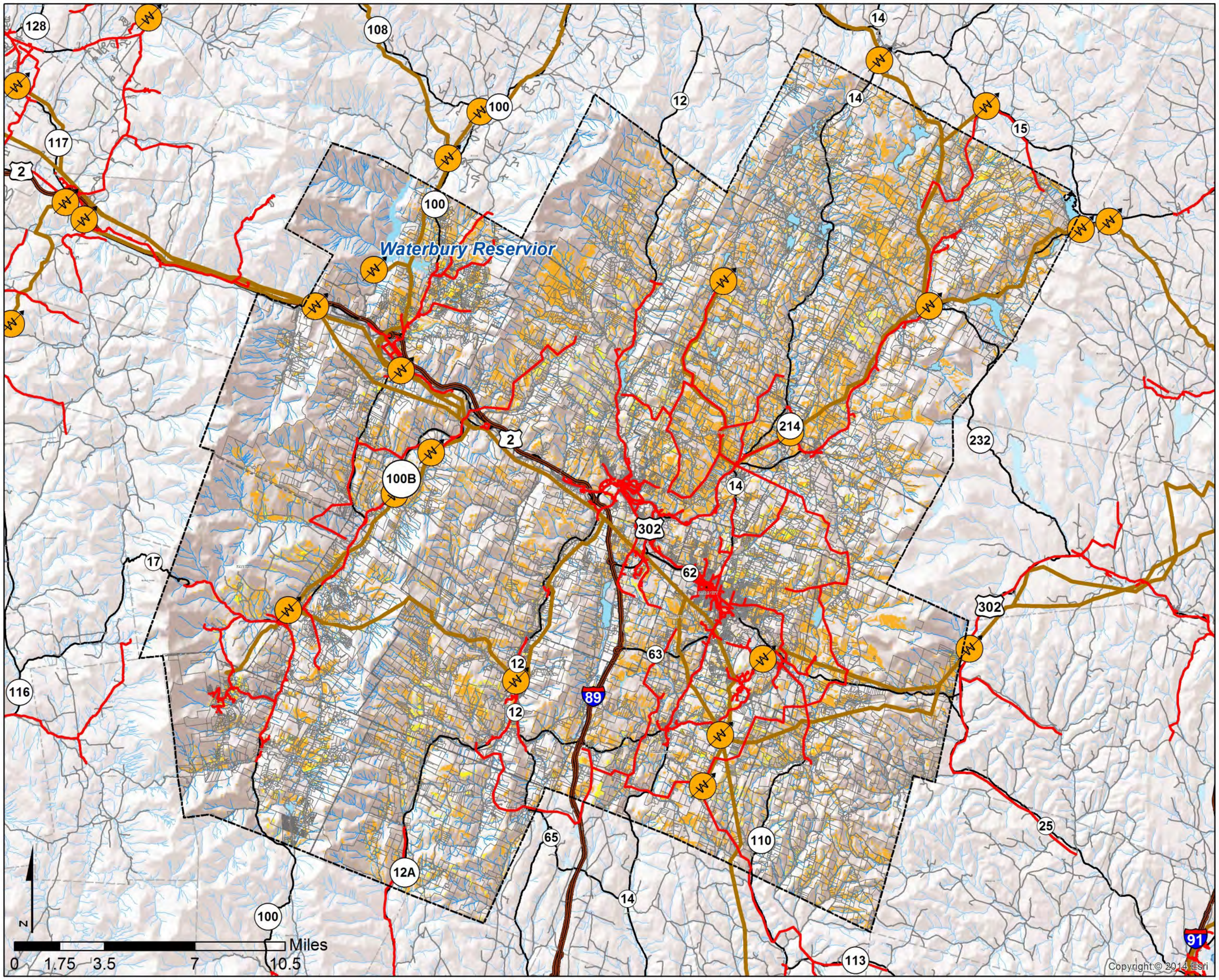


## Solar Resources Map

**Legend**

- Substations
- 3 Phase Power Lines
- Distribution Lines

**Solar Potential**

- Prime (No Constraint)
- Secondary (Possible Constraint)
- Parcels

**Roads**

- Interstate
- US Highway
- Vermont State Highway
- Town Class 1-3

**Known Constraints**

Areas not shown on map

Vernal Pools
River Corridors
FEMA Floodways
Natural Communities & Rare, Threatened and Endangered Species
National Wilderness Areas
Wetlands Class 1 and 2

**Possible Constraints**

VT Agriculturally Important Soils
FEMA Special Flood Hazard Areas
Protected Lands
Act 250 Agricultural Soil Mitigation Areas
Deer Wintering Areas
Highest Priority Forest Blocks
Hydric Soils
Elevations Above 2500Ft
Lake Shore Protection Buffer 250 Ft
Municipal Lands
Slopes Greater Than 25 Percent

Created by: CVRPC GIS 4/4/2017
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Act174_Energy\Solar Resources 11X17

Data is only as accurate as the original source materials.
This map is for planning purposes.
This map may contain errors and omissions

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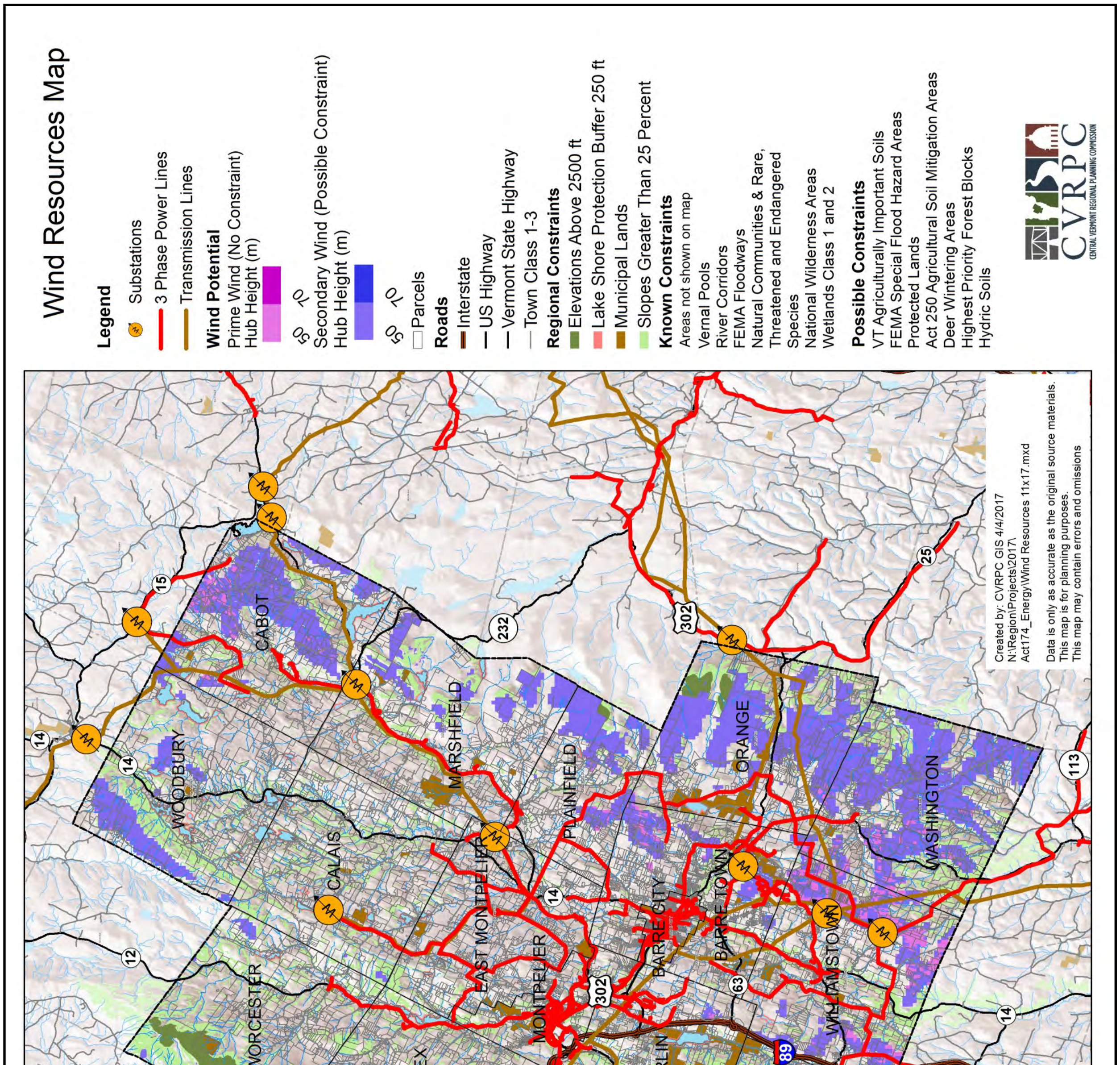

Wind Resources Map
Legend
Substations
3 Phase Power Lines
Transmission Lines
Wind Potential
Prime Wind (No Constraint)
Hub Height (m)
50
70
Secondary Wind (Possible Constraint)
Hub Height (m)
50
70
Parcels
Roads
Interstate
US Highway
Vermont State Highway
Town Class 1-3
Regional Constraints
Elevations Above 2500 ft
Lake Shore Protection Buffer 250 ft
Municipal Lands
Slopes Greater Than 25 Percent
Known Constraints
Areas not shown on map
Vernal Pools
River Corridors
FEMA Floodways
Natural Communities & Rare, Threatened and Endangered Species
National Wilderness Areas
Wetlands Class 1 and 2
Possible Constraints
VT Agriculturally Important Soils
FEMA Special Flood Hazard Areas
Protected Lands
Act 250 Agricultural Soil Mitigation Areas
Deer Wintering Areas
Highest Priority Forest Blocks
Hydric Soils
CVRPC
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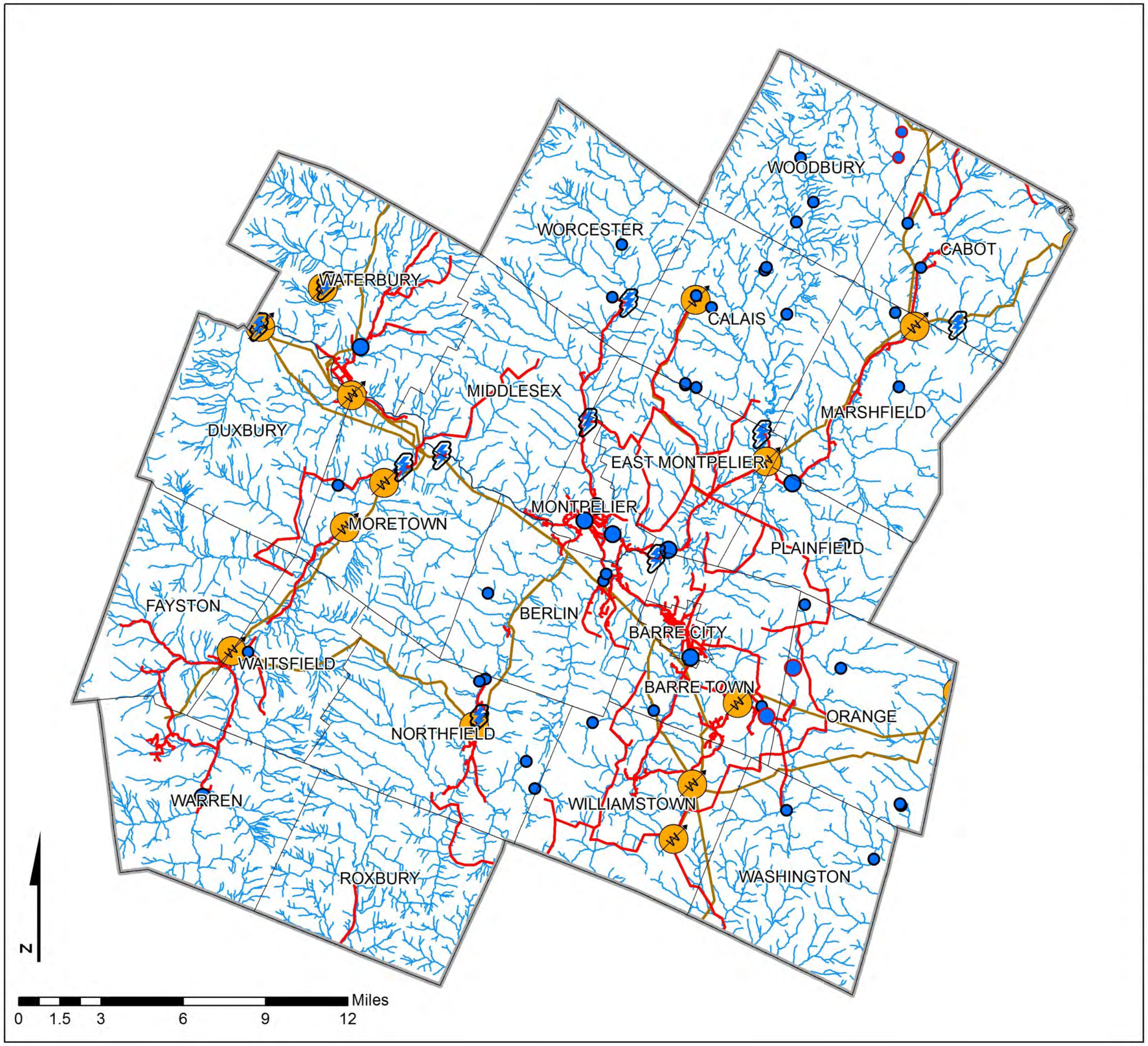
Created by: CVRPC GIS 4/4/2017
N:\Region\Projects\2017\
Act174_Energy\Wind Resources 11x17.mxd
Data is only as accurate as the original source materials.
This map is for planning purposes.
This map may contain errors and omissions
CABOT
WOODBURY
MARSHFIELD
PLAINFIELD
CALAIS
EAST MONTPELIER
ORANGE
WASHINGTON
BARRE TOWN
BARRE CITY
WILLIAMSTOWN
MONTPELIER
WORCESTER
MIDDLESEX
BERLIN
NORTHFIELD
MORETOWN
WATERBURY
DUXBURY
WAITSFIELD
FAYSTON
WARREN
ROXBURY
0
3.25
6.5
13
Miles
N

# Hydroelectric Resources Map




**Key**

- Substations
- 3 Phase Power Lines
- Transmission Lines
- Major Roads
- Lakes/Ponds
- Rivers/Streams
- Dams not on National Wild and Scenic Rivers
- Dams on National Wild and Scenic Rivers

**Potential Hydroelectric Facilities**

Potential Hydroelectric Facilities

- < 50 kW Capacity
- > 50 kW Capacity
- High Hazard with < 50 kW Capacity
- High Hazard with > 50 kW Capacity

**Methodology**

This map shows areas of resource potential for renewable energy generation from hydroelectric , i.e., dams that could be converted in to hydroelectric facilities as well as active hydroelectric sites. Existing hydroelectric dam information was extracted from the Vermont Dam Inventory, while potential hydroelectric sites were derived from a study conducted by Community Hydro in 2007.1 Based on estimates conducted within the report, this map categorizes dams based on their potential hydroelectric generation capacity, and the downstream hazard risk that would be involved in hydroelectric production at each site.

High hazard potential dams are those where failure or mis-operation will probably cause loss of human life. The other rankings were grouped together and their failure or mis-operation results in no probable loss of human life, but could cause economic loss, environmental damage, disruption of lifeline facilities, or impact other concerns. These dams are often located in predominately rural or agricultural areas, but could be located in areas withpopulation and significant infrastructure.

This map was created as part of a Regional Energy Planning Initiative being conducted by the Bennington County Regional Commission, and the Vermont Public Service Department.

**Created:** December 2016 by CVRPC GIS.
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Hydroelectric Resources 11x17.mxd

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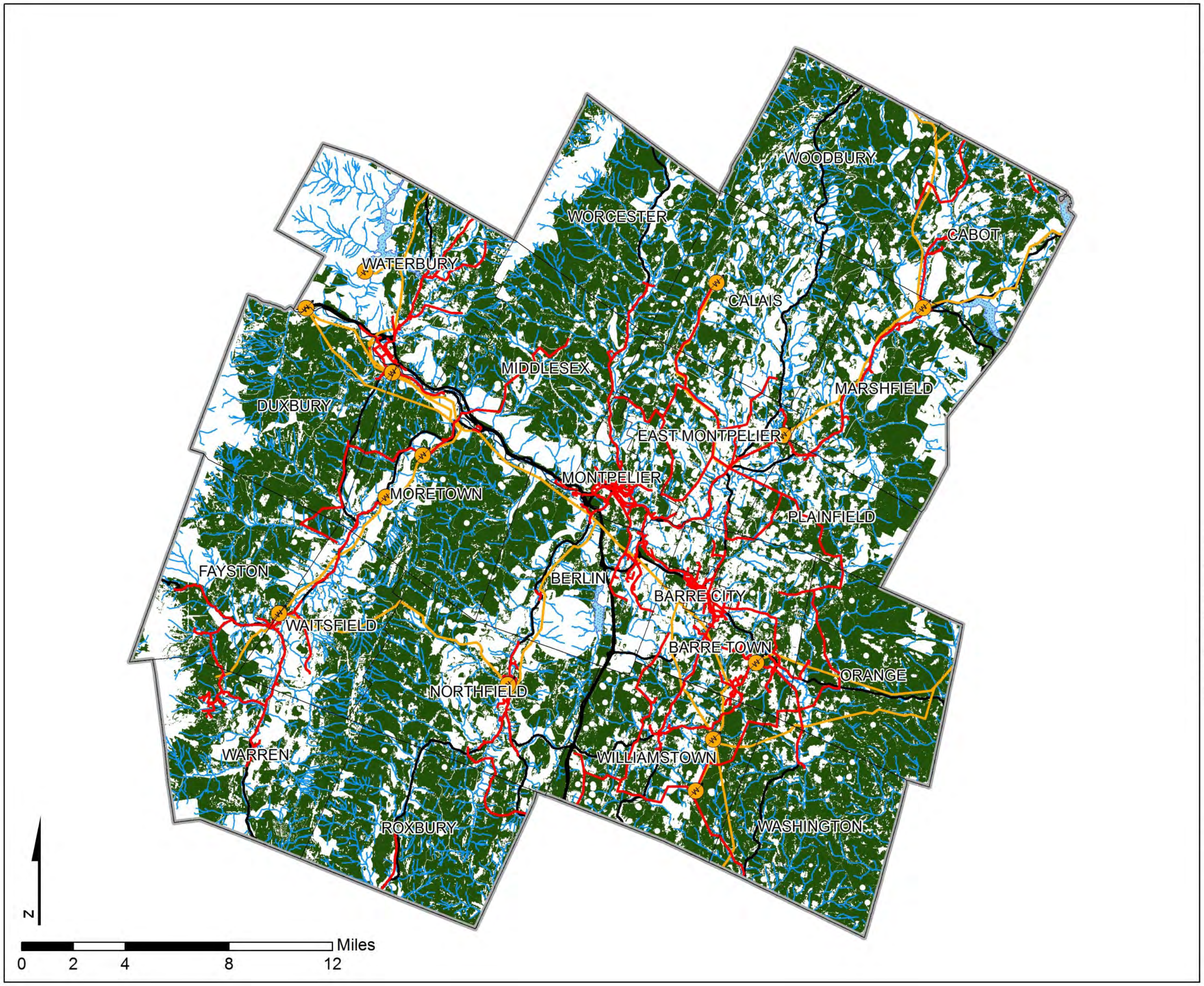
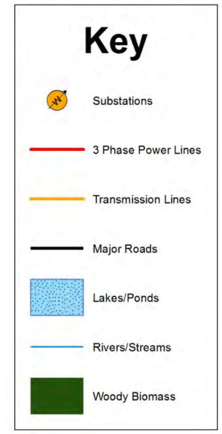
# Woody Biomass Resources Map




**Methodology**

This map shows areas of resource potential for woody biomass, i.e., locations where forested areas are. This map also considers various other conditions, such as ecological zones, that may impact the feasibility of renewable energy/alternative heating source. These conditions are referred to as constraints. This map does not include areas where other types of biomass, such as biomass from agricultural residue, could be grown/harvested.

This map was created as part of a Regional Energy Planning Initiative being conducted by the Bennington County Regional Commission, and the Vermont Public Service Department.

**Created:** December 2016 by CVRPC GIS.

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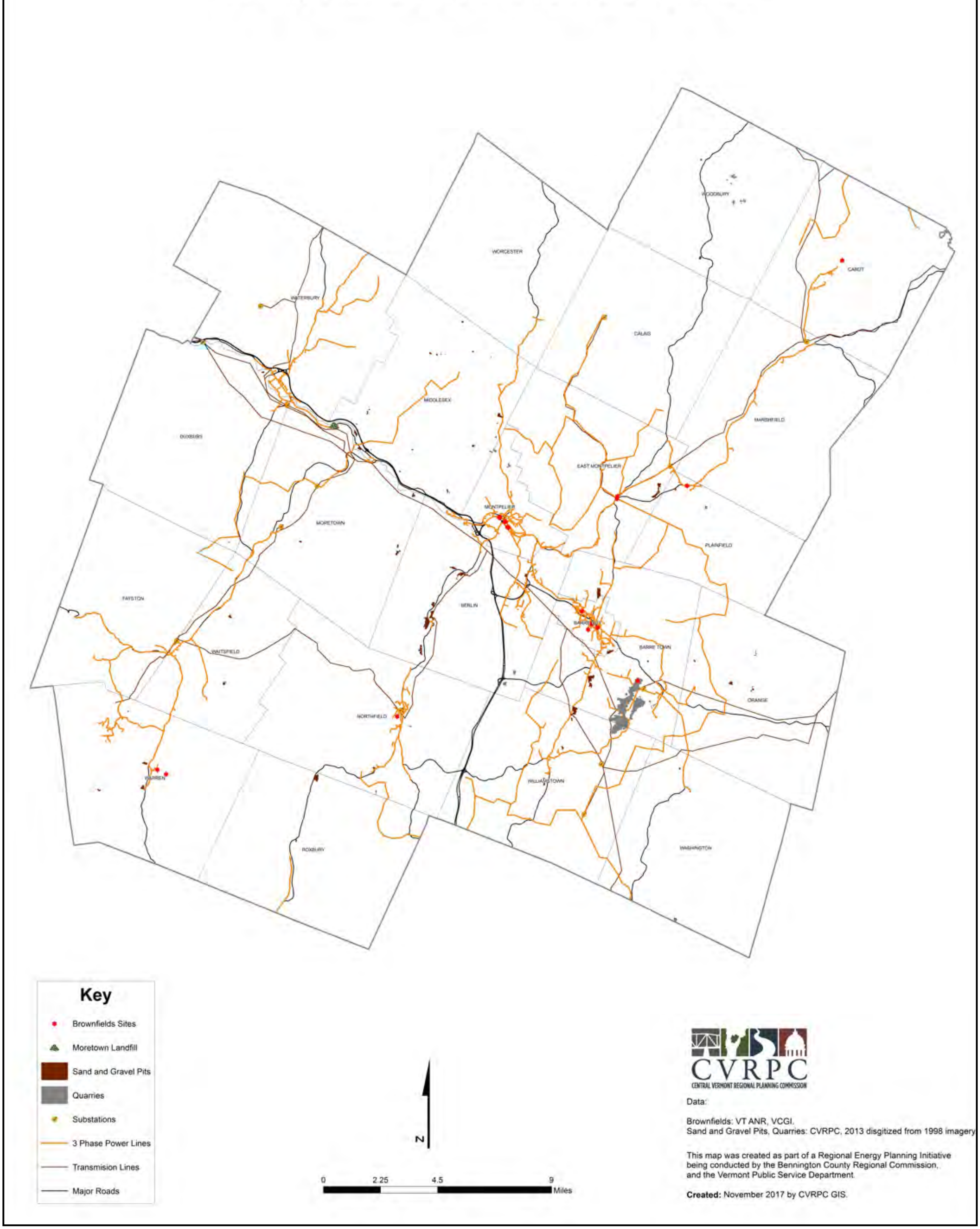
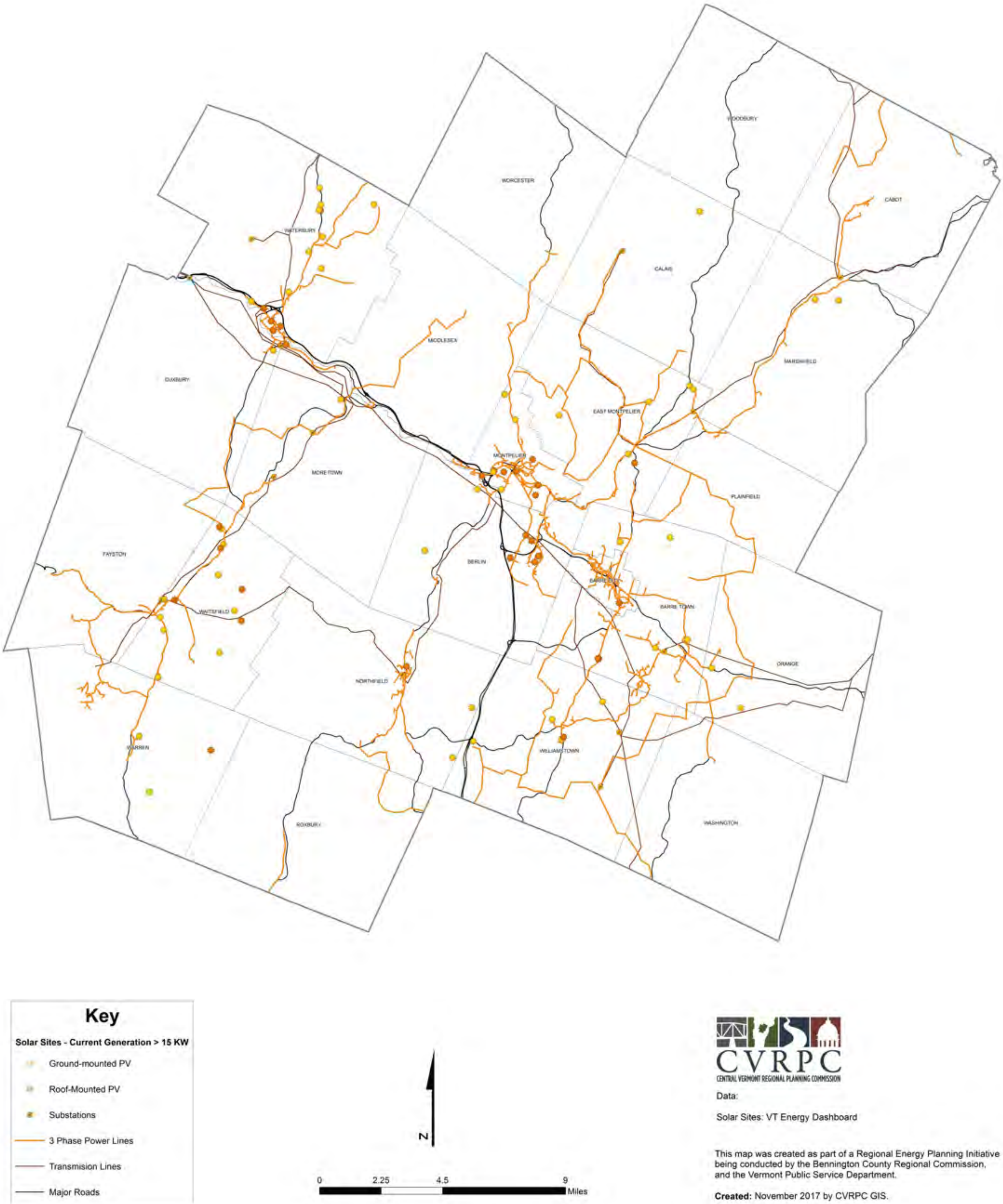
# Central Vermont Regional Planning Commission
# Energy Planning Statewide Preferred Sites



# Central Vermont Regional Planning Commission
# Current Solar Energy Generation Sites > 15 KW



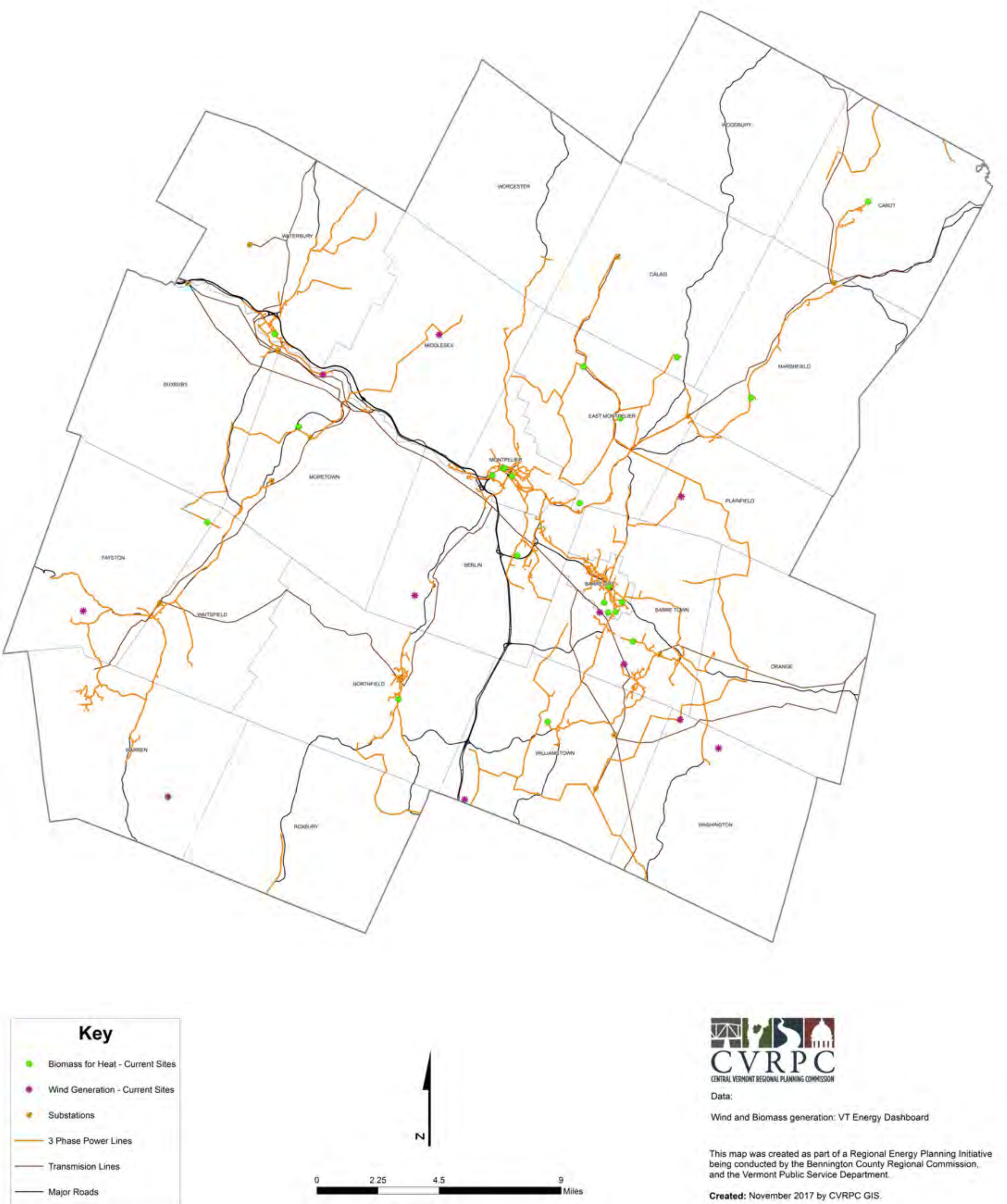

Data:

Solar Sites: VT Energy Dashboard

This map was created as part of a Regional Energy Planning Initiative being conducted by the Bennington County Regional Commission, and the Vermont Public Service Department.

**Created:** November 2017 by CVRPC GIS.

# Central Vermont Regional Planning Commission
# Current Wind and Biomass for Heat Sites



# APPENDIX C

# LONG-RANGE ENERGY ALTERNATIVES PLANNING DATA & INFORMATION

Introduction

This document supplements the regional energy plans created by each Regional Planning Commission (RPC). It was developed by Vermont Energy Investment Corporation (VEIC) as documentation to modeling work performed for the RPCs. An award from the Department of Energy's SunShot Solar Market Pathways program funded the creation of a detailed statewide total energy supply and demand model. The VEIC team used the statewide energy model as a foundation for the region-specific modeling efforts. More detailed methodology is included at the end of this report.

Statewide Approach

Historic information was primarily drawn from the Public Service Department's Utility Facts 2013[1] and EIA data. Projections came from the Total Energy Study (TES)[2], the utilities' Committed Supply[3], and stakeholder input.

Demand Drivers

Each sector has a unit that is used to measure activity in the sector. That unit is the "demand driver" because in the model it is multiplied by the energy intensity of the activity to calculate energy demand. The population change for each region is calculated from town data in *Vermont Population Projections 2010-2030*[4]. Growth rates are assumed constant through 2050.

| RPC | ANNUAL GROWTH |
|---|---|
| Addison | 0.00% |
| Bennington | 0.02% |
| Central VT | 0.12% |
| Chittenden | 0.48% |
| Lamoille | 1.46% |
| Northwest | 0.87% |
| NVDA | 0.21% |
| Rutland | -0.27% |
| Southern Windsor | 0.24% |
| Two Rivers | 0.29% |
| Windham | 0.34% |

1. Vermont Public Service Department, Utility Facts 2013, http://publicservice.vermont.gov/sites/dps/files/documents/Pubs_Plans_Reports/Utility_Facts/Utility%20Facts%202013.pdf

2. Vermont Public Service Department, Total Energy Study: Final Report on a Total Energy Approach to Meeting the State's Greenhouse Gas and Renewable Energy Goals. December 8, 2014. http://publicservice.vermont.gov/sites/psd/files/Pubs_Plans_Reports/TES/TES%20FINAL%20Report%2020141208.pdf.

3. Vermont Public Service Department provided the data behind the graph on the bottom half of page E.7 in Utility Facts 2013. It is compiled from utility Integrated Resource Plans

4. Jones, Ken, and Lilly Schwarz, *Vermont Population Projections-2010-2030*, August, 2013. http://dail.vermont.gov/dail-publications/publications-general-reports/vt-population-projections-2010-2030.

People per house are assumed to decrease from 2.4 in 2010 to 2.17 in 2050. This gives the number of households, the basic unit and demand driver in the model for **residential energy** consumption.

Projected change in the **energy demand from the commercial sector** was based on commercial sector data in the TES. The demand driver for the commercial sector is commercial building square feet which grow almost 17% from 2010 to 2050.

The team entered total **industrial consumption** by fuel from the TES directly into the model. It grows from 1.1 TBtu in 2010 to 1.4 TBtu in 2050.

**Transportation energy** use is based on projections of vehicle miles traveled (VMT). VMT peaked in 2006 and has since declined slightly[5]. Given this, and Vermont's efforts to concentrate development and to support alternatives to single occupant vehicles, VMT per capita is assumed to remain flat at 12,000.

The regional models use two scenarios. The **reference scenario** assumes a continuation of today's energy use patterns, but does not reflect the Vermont's renewable portfolio standard or renewable energy or greenhouse gas emissions goals. The main changes over time in the reference scenario are more fuel efficient cars because of CAFE standards and the expansion of natural gas infrastructure. The **90% x 2050** $_{\text{VEIC}}$ **scenario** is designed to achieve the goal of meeting 90% of Vermont's total energy demand with renewable sources. It is adapted from the TES TREES Local scenarios. It is a hybrid of the high and low biofuel cost scenarios, with biodiesel or renewable diesel replacing petroleum diesel in heavy duty vehicles and electricity replacing gasoline in light duty vehicles. Despite a growing population and economy, energy use declines because of efficiency and electrification. Electrification of heating and transportation has a large effect on the total demand because the electric end uses are three to four times more efficient than the combustion versions they replace.

Regionalization Approach

The demand in the statewide model was broken into the state's planning regions. Residential demand was distributed according to housing units using data from the American Community Survey. Commercial and industrial demand was allocated to the regions by service-providing and goods-producing NAICS codes respectively. Fuel use in these sectors was allocated based on existing natural gas infrastructure. In the commercial sector, it was assumed that commercial fuel use per employee has the same average energy intensity across the state. All commercial natural gas use was allocated to the regions currently served by natural gas infrastructure, and the rest of the fuel was allocated to create equal consumption by employee.

The industrial sector was assumed to be more diverse in its energy consumption. In the industrial sector, natural gas was allocated among the regions currently served by natural gas based on the number of industrial employees in each region. Other non-electric fuels were distributed among regions without access to natural gas, as it was assumed that other non-electric fuels were primarily used for combustion purposes, and that purpose could likely be served more cheaply with gas. Transportation demand was primarily regionalized through population. The passenger rail sector of transportation demand was regionalized using Amtrak

5. Jonathan Dowds et al., "Vermont Transportation Energy Profile," October 2015, http://vtrans.vermont.gov/sites/aot/files/planning/documents/planning/Vermont%20Transportation%20Energy%20Profile%202015.pdf.

boarding and alighting data to create percentages of rail miles activity by region[6]. The freight rail sector of transportation was regionalized using the following approach: in regions with freight rail infrastructure, activity level was regionalized by share of employees in goods-producing NAICS code sectors. Regions without freight rail infrastructure were determined using a Vermont Rail System map and then assigned an activity level of zero[7]. A weighting factor was applied to regions with freight rail infrastructure to bring the total activity level back up to the calculated statewide total of freight rail short-ton miles in Vermont. Each region's share of state activity and energy use is held constant throughout the analysis period as a simplifying assumption.

## Results

The numbers below show the results of the scenarios in "final units," sometimes referred to as "site" energy. This is the energy households and businesses see on their bills and pay for. Energy analysis is sometimes done at the "source" level, which accounts for inefficiency in power plants and losses from transmission and distribution power lines. The model accounts for those losses when calculating supply, but all results provided here are on the demand side, so do not show them.

The graphs below show the more efficient 90% x 2050 $_{\text{VEIC}}$ scenario, which is one path to reduce demand enough to make 90% renewable supply possible. This scenario makes use of wood energy, but there is more growth in electric heating and transportation to lower total energy demand. Where the graphs show "Avoided vs. Reference," that is the portion of energy that we do not need to provide because of the efficiency in this scenario compared to the less efficient Reference scenario

6. National Association of Railroad Passengers, "Fact Sheet: Amtrak in Vermont," 2016, https://www.narprail.org/site/assets/files/1038/states_2015.pdf.

7. Streamlined Design, "Green Mountain Railroad Map" (Vermont Rail System, 2014), http://www.vermontrailway.com/maps/regional_map.html.

Statewide Total Energy Consumption

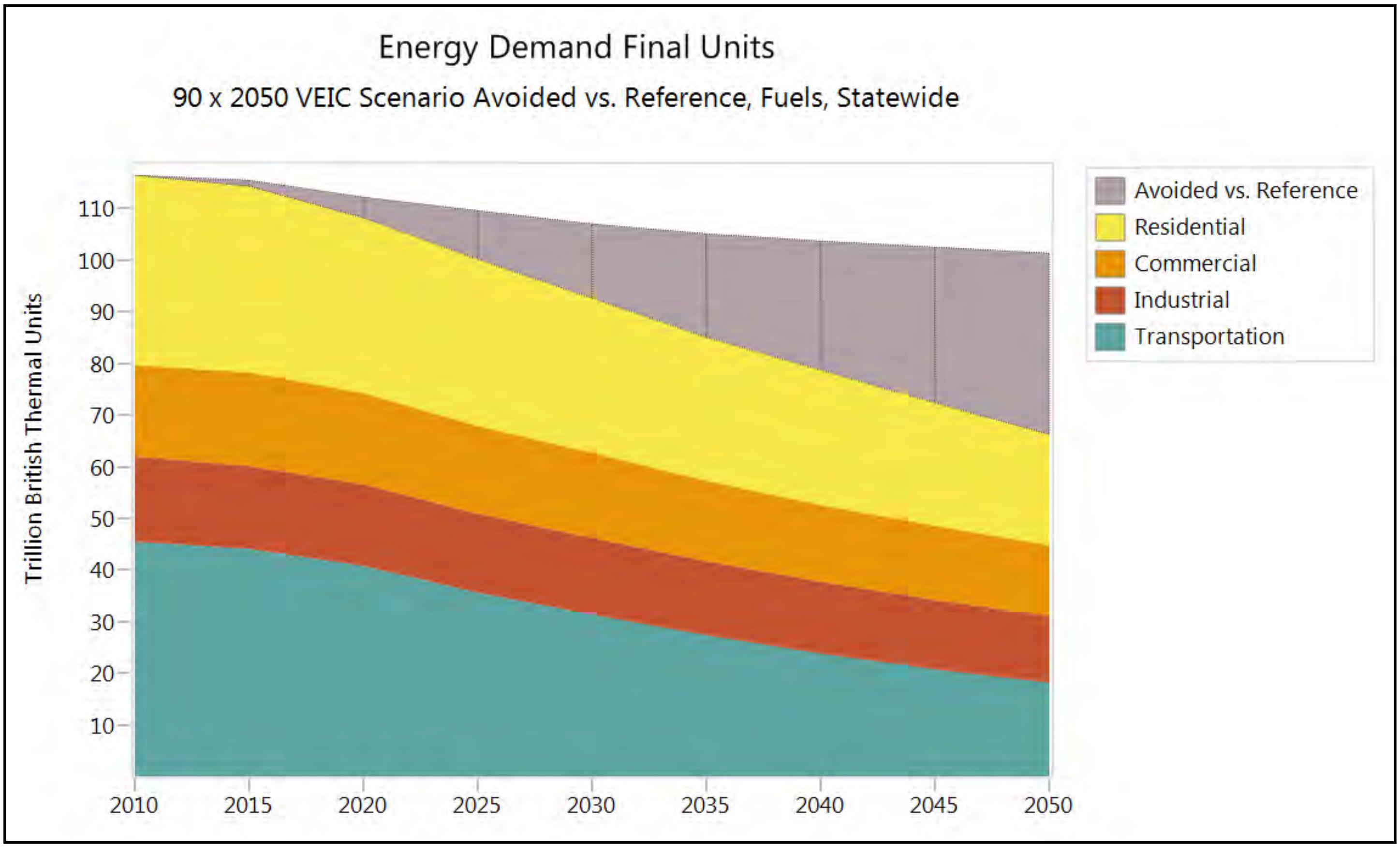



Figure 1 - Statewide energy consumption by sector, 90% x 2050 VEIC scenario compared to the reference scenario

Regional Total Energy Consumption

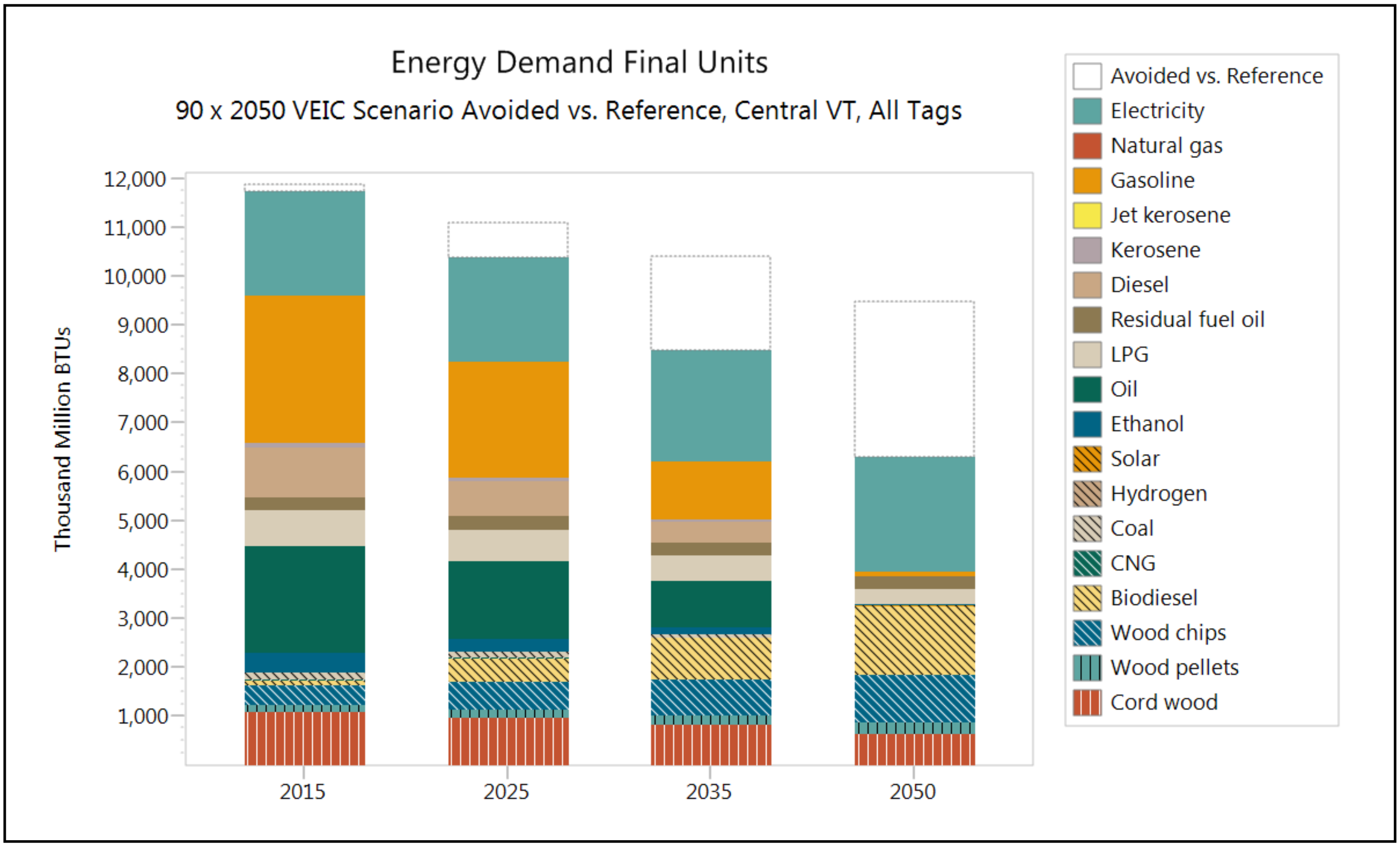



Figure 2: Regional energy consumption by fuel

Regional Energy Consumption by Sector

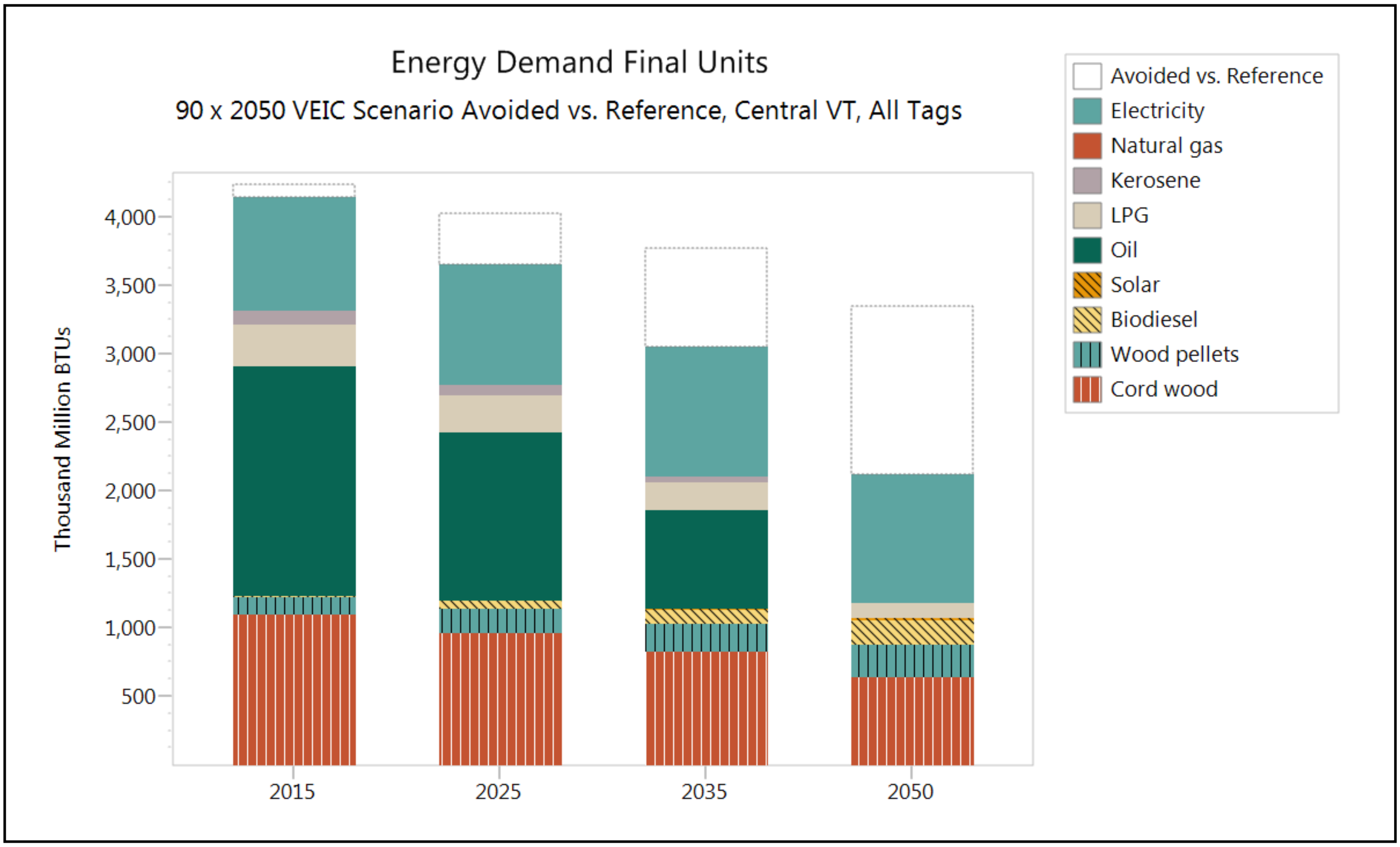



Figure 3: Regional residential energy consumption by fuel

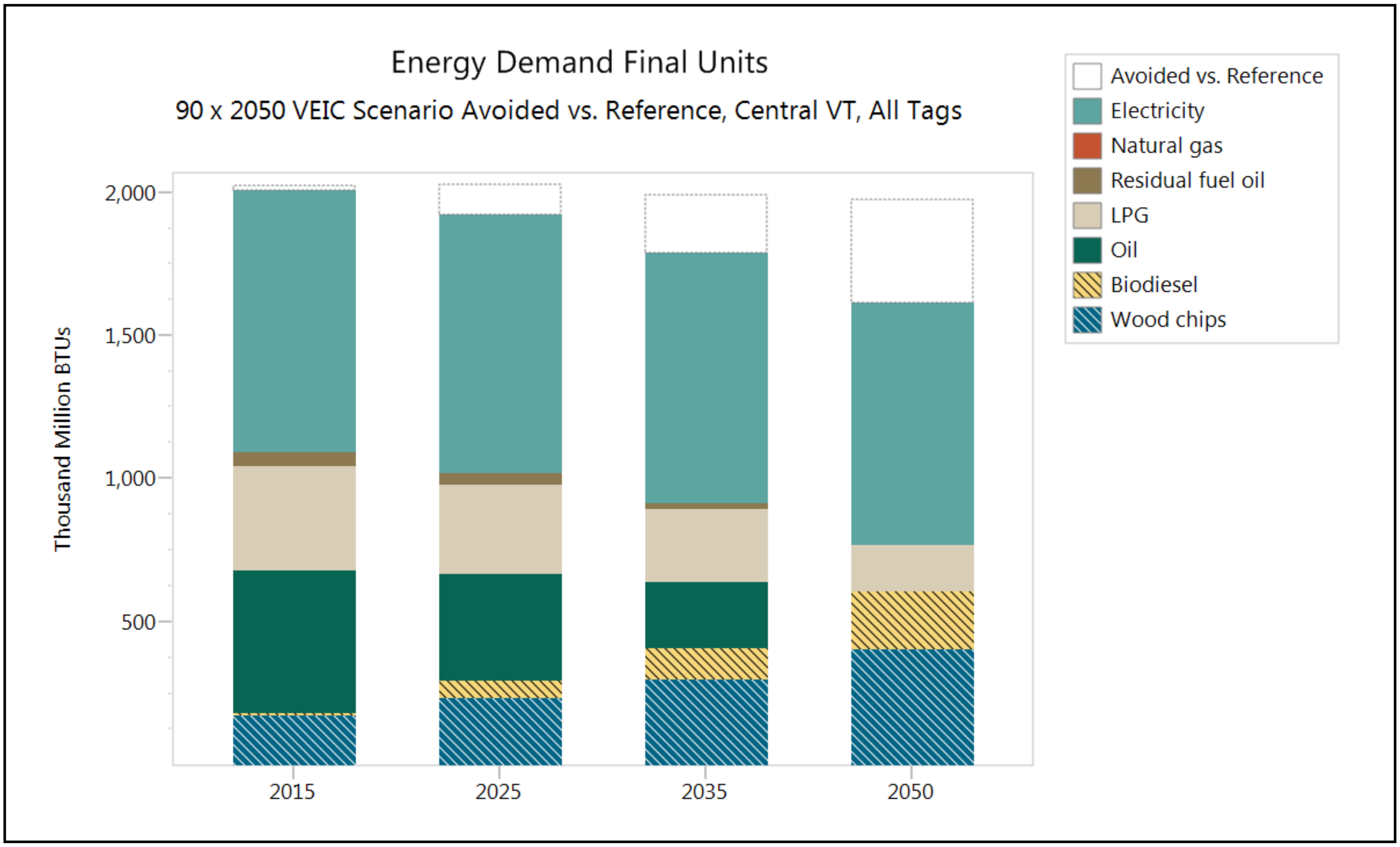



Figure 4: Regional commercial energy consumption by fuel

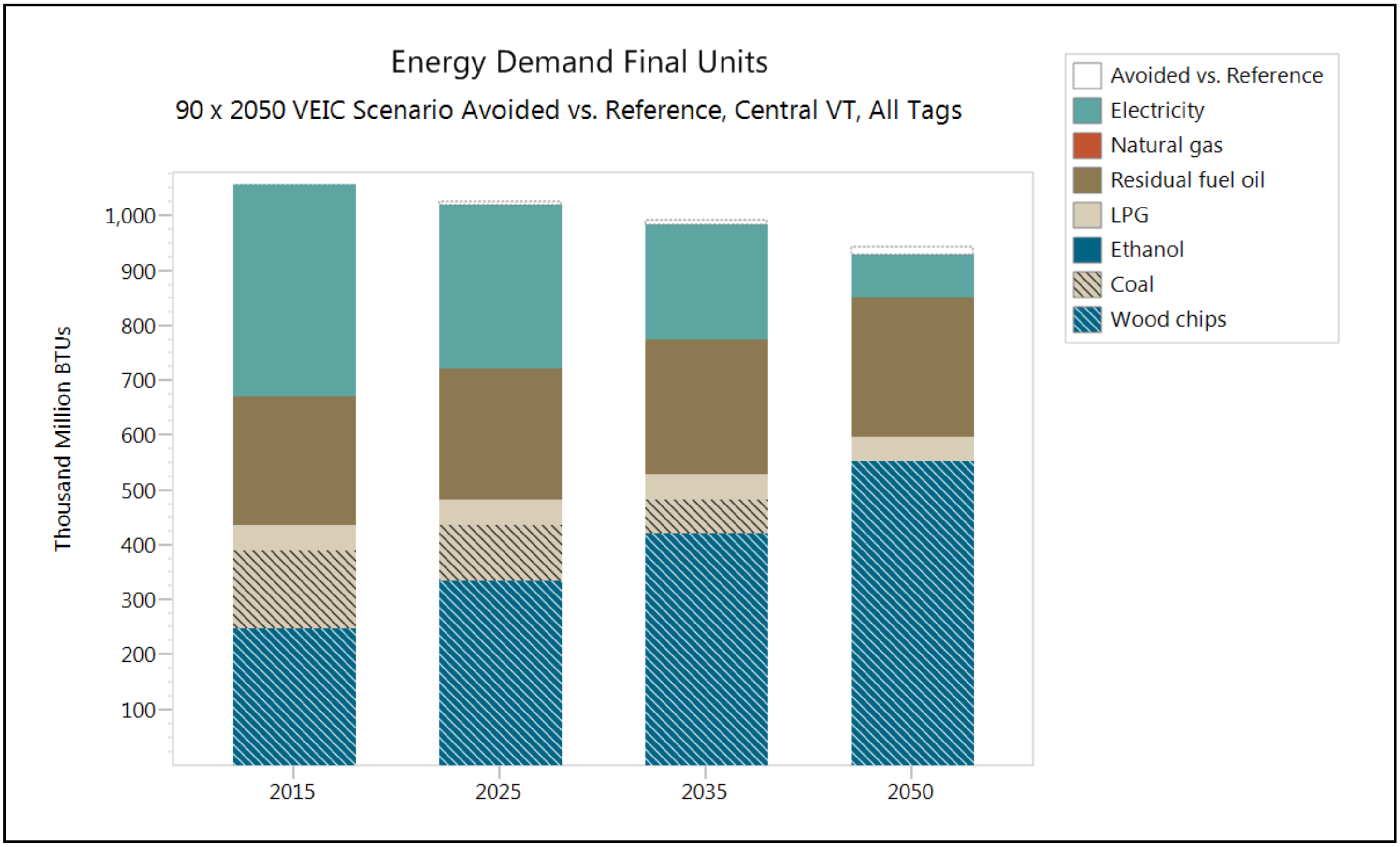



Figure 5: Regional industrial energy consumption by fuel

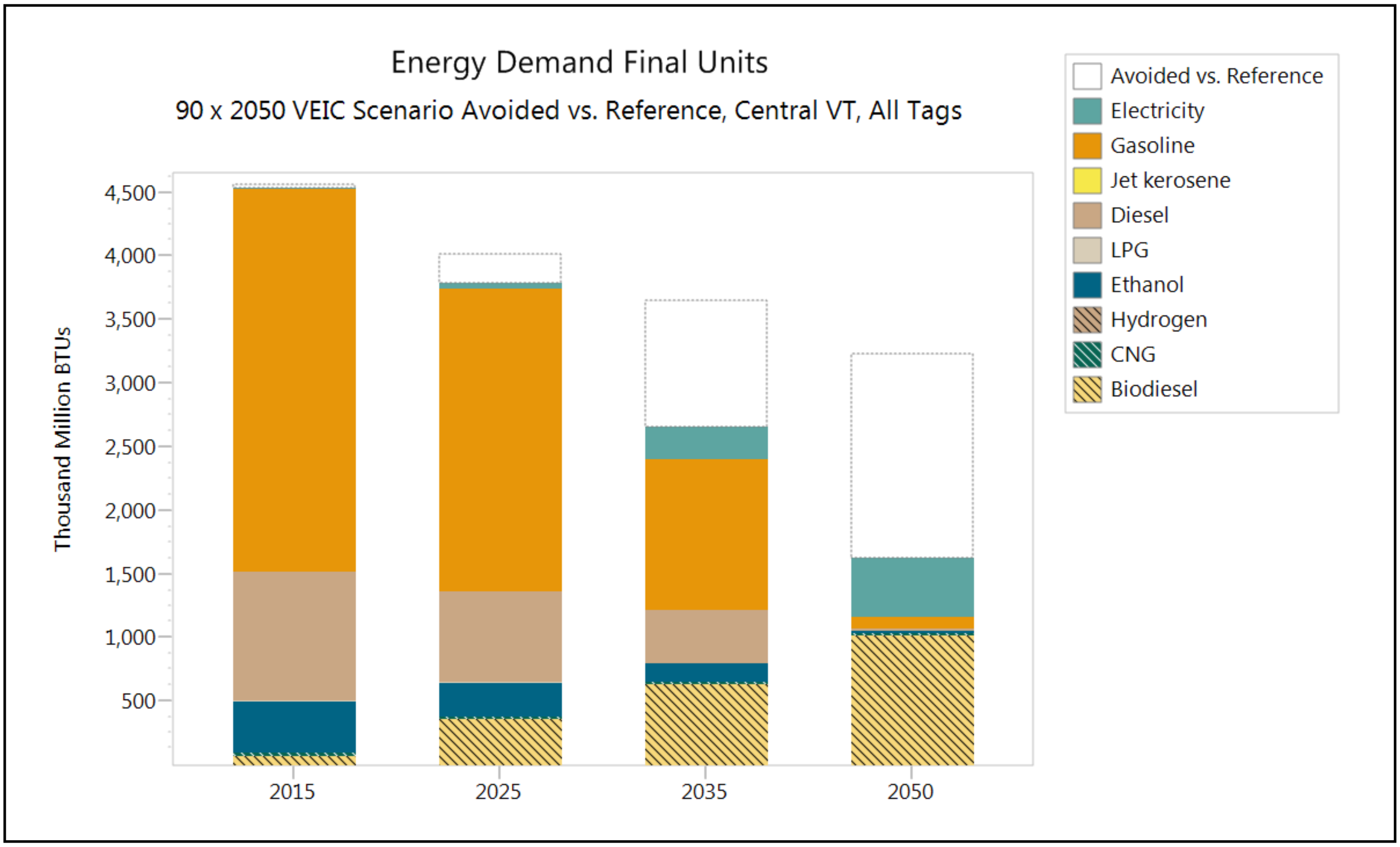



Figure 6: Regional transportation energy consumption by fuel

## Detailed Sources and Assumptions

### Residential

The TES provides total fuels used by sector. We used a combination of industry data and professional judgement to determine demand inputs at a sufficiently fine level of detail to allow for analysis at many levels, including end use (heating, water heating, appliances, etc.), device (boiler, furnace, heat pump) or home-type (single family, multi-family, seasonal, mobile). Assumptions for each are detailed below. All assumptions for residential demand are at a per-home level.

### Space Heating

The team determined per home consumption by fuel type and home type. EIA data on Vermont home heating provides the percent share of homes using each type of fuel. 2009 Residential energy consumption survey (RECS) data provided information on heating fuels used by mobile homes. Current heat pumps consumption estimates were found in a 2013 report prepared for Green Mountain Power by Steve LeTendre entitled *Hyper Efficient Devices: Assessing the Fuel Displacement Potential in Vermont of Plug-In Vehicles and Heat Pump Technology*. Future projections of heat pump efficiency were provided by Efficiency Vermont Efficient Products and Heat Pump program experts.

Additional information came from the following data sources:

- 2010 Housing Needs Assessment[8]
- EIA Vermont State Energy Profile[9]
- 2007-2008 VT Residential Fuel Assessment[10]
- EIA Adjusted Distillate Fuel Oil and Kerosene Sales by End Use[11]

The analyst team made the following assumptions for each home type:

- Multi-family units use 60% of the heating fuel used by single family homes, on average, due to assumed reduced size of multi-family units compared to single-family units. Additionally, where natural gas is available, the team assumed a slightly higher percentage of multi-family homes use natural gas as compared to single family homes, given the high number of multi-family units located in the Burlington area, which is served by the natural gas pipeline. The team also assumed that few multi-family homes rely on cordwood as a primary heating source.

- Unoccupied/Seasonal Units: On average, seasonal or unoccupied homes were expected to use 10% of the heating fuel used by single family homes. For cord wood, we expected unoccupied

8. Vermont Housing and Finance Agency, "2010 Vermont Housing Needs Assessment," December 2009 http://www.vtaffordablehousing.org/documents/resources/623_1.8_Appendix_6_2010_Vermont_Housing_Needs_Assessment.pdf.

9. U.S. Energy Information Administration, "Vermont Energy Consumption Estimates, 2004," https://www.eia.gov/state/print.cfm?sid=VT

10. Frederick P. Vermont Residential Fuel Assessment: for the 2007-2008 heating season. Vermont Department of Forest, Parks and Recreation. 2011.

11. U.S. Energy Information Administration, "Adjusted Distillate Fuel Oil and Kerosene Sales by End Use," December 2015, https://www.eia.gov/dnav/pet/pet_cons_821usea_dcu_nus_a.htm.

or seasonal homes to use 5% of heating fuel, assuming any seasonal or unoccupied home dependent on cord wood are small in number and may typically be homes unoccupied for most of the winter months (deer camps, summer camps, etc.)

- Mobile homes—we had great mobile home data from 2009 RECS. As heat pumps were not widely deployed in mobile homes in 2009 and did not appear in the RECs data, we applied the ratio of oil consumed between single family homes and mobile homes to estimated single family heat pump use to estimate mobile home heat pump use.

- The reference scenario heating demand projections were developed in line with the TES reference scenario. This included the following: assumed an increase in the number of homes using natural gas, increase in the number of homes using heat pumps as a primary heating source (up to 37% in some home types), an increase in home heated with wood pellets, and drastic decline in homes heating with heating oil. Heating system efficiency and shell efficiency were modeled together and, together, were estimated to increase 5-10% depending on the fuel type. However, heat pumps are expected to continue to rapidly increase in efficiency (becoming 45% more efficient, when combined with shell upgrades, by 2050). We also reflect some trends increasing home sizes.

- In the 90% x 2050 $_{\text{VEIC}}$ scenario, scenario heating demand projections were developed in line with the TES TREES Local scenarios, a hybrid of the high and low biofuel cost scenarios. This included the following: assumed increase in the number of homes using heat pumps as a primary heating source (up to 70% in some home types), an increase in home heated with wood pellets, a drastic decline in homes heating with heating oil and propane, and moderate decline in home heating with natural gas. Heating system efficiency and shell efficiency were modeled together and were estimated to increase 10%-20% depending on the fuel type. However, heat pumps are expected to continue to rapidly increase in efficiency (becoming 50% more efficient, when combined with shell upgrades by 2050). We also reflect some trends increasing home sizes.

Lighting

Lighting efficiency predictions were estimated by Efficiency Vermont products experts.

Water Heating

Water heating estimates were derived from the Efficiency Vermont Technical Reference Manual[12].

Appliances and Other Household Energy Use:

EnergyStar appliance estimates and the Efficiency Vermont Electric Usage Chart[13] provided estimates for appliance and other extraneous household energy uses.

12. Efficiency Vermont, "Technical Reference User Manual (TRM): Measure Savings Algorithms and Cost Assumptions, No. 2014-87," March 2015, http://psb.vermont.gov/sites/psb/files/docketsandprojects/electric/majorpendingproceedings/TRM%20User%20Manual%20No.%202015-87C.pdf

13. Efficiency Vermont, "Electric Usage Chart Tool," https://www.efficiencyvermont.com/tips-tools/tools/electric-usage-chart-tool. www.eia.gov/dnav/pet/pet_cons_821usea_dcu_nus_a.htm.

Using the sources and assumptions listed above, the team created a model that aligned with the residential fuel consumption values in the TES.

Commercial

Commercial energy use estimates are entered in to the model as energy consumed per square foot of commercial space, on average. This was calculated using data from the TES.

Industrial

Industrial use was entered directly from the results of the TES data.

Transportation

The transportation branch focused on aligning with values from the Total Energy Study (TES) Framework for Analysis of Climate-Energy-Technology Systems (FACETS) data in the transportation sector in the Business as Usual (BAU) scenario. The VEIC 90% x 2050 scenario was predominantly aligned with a blend of the Total Renewable Energy and Efficiency Standard (TREES) Local High and Low Bio scenarios in the transportation sector of FACETS data. There were slight deviations from the FACETS data, which are discussed in further detail below.

Light Duty Vehicles

Light Duty Vehicle (LDV) efficiency is based on a number of assumptions: gasoline and ethanol efficiency were derived from the Vermont Transportation Energy Profile[14]. Diesel LDV efficiency was obtained from underlying transportation data used in the Business as Usual scenario for the Total Energy Study, which is referred to as TES Transportation Data below. Biodiesel LDV efficiency was assumed to be 10% less efficient than LDV diesel efficiency[15]. Electric vehicle (EV) efficiency was derived from an Excel worksheet from Drive Electric Vermont. The worksheet calculated EV efficiency using the number of registered EVs in Vermont, EV efficiency associated with each model type, percentage driven in electric mode by model type (if a plugin hybrid vehicle), and the Vermont average annual vehicle miles traveled. LDV electric vehicle efficiency was assumed to increase at a rate of .6%. This was a calculated weighted average of 100-mile electric vehicles, 200-mile electric vehicles, plug-in 10 gasoline hybrid and plug-in 40 gasoline hybrid vehicles from the Energy Information Administration Annual Energy Outlook[16].

Miles per LDV was calculated using the following assumptions: data from the Vermont Agency of Transportation provided values for statewide vehicles per capita and annual miles traveled[17]. The total number of LDVs in Vermont was sourced TES Transportation Data. The calculated LDV miles per capita was multiplied by the population of Vermont and divided by the number of LDVs to calculate miles per LDV.

14 Jonathan Dowds et al., "Vermont Transportation Energy Profile," October 2015, http://vtrans.vermont.gov/sites/aot/files/planning/documents/planning/Vermont%20Transportation%20Energy%20Profile%202015.pdf.

15. U.S. Environmental Protection Agency: Office of Transportation & Air Quality, "Biodiesel," Www.fueleconomy.gov, accessed August 19, 2016, https://www.fueleconomy.gov/feg/biodiesel.shtml.

16. U.S. Energy Information Administration, "Light-Duty Vehicle Miles per Gallon by Technology Type," Annual Energy Outlook 2015, 2015, https://www.eia.gov/forecasts/aeo/data/browser/#/?id=50-AEO2016&cases=ref2016~ref_no_cpp&sourcekey=0.

17. Jonathan Dowds et al., "Vermont Transportation Energy Profile."

The number of EVs were sourced directly from Drive Electric Vermont, which provided a worksheet of actual EV registrations by make and model. This worksheet was used to calculate an estimate of the number of electric vehicles using the percentage driven in electric mode by vehicle type to devalue the count of plug-in hybrid vehicles. Drive Electric Vermont also provided the number of EVs in the 90% x 2050 $_{\text{VEIC}}$ scenario.

Heavy Duty Vehicles

Similar to the LDV vehicle efficiency methods above, HDV efficiency values contained a variety of assumptions from different sources. A weighted average of HDV diesel efficiency was calculated using registration and fuel economy values from the Transportation Energy Data Book[18]. The vehicle efficiency values for diesel and compressed natural gas (CNG) were all assumed to be equal[19]. Diesel efficiency was reduced by 10% to represent biodiesel efficiency[20]. Propane efficiency was calculated using a weighted average from the Energy Information Administration Annual Energy Outlook table for Freight Transportation Energy Use[21].

In the 90% x 2050 $_{\text{VEIC}}$ scenario, it was assumed HDVs will switch entirely from diesel to biodiesel or renewable diesel by 2050. This assumption is backed by recent advances with biofuel. Cities such as Oakland and San Francisco are integrating a relatively new product called renewable diesel into their municipal fleets that does not gel in colder temperatures and has a much lower overall emissions factor[22]. Historically, gelling in cold temperatures has prevented higher percentages of plant-based diesel replacement products.

Although there has been some progress toward electrifying HDVs, the VEIC 90% x 2050 scenario does not include electric HDVs. An electric transit bus toured the area and gave employees of BED, GMTA, and VEIC a nearly silent ride around Burlington. The bus is able to fast charge using an immense amount of power that few places on the grid can currently support. The California Air Resources Board indicated a very limited number of electric HDVs are in use within the state[23]. Anecdotally, Tesla communicated it is working on developing an electric semi-tractor that will reduce the costs of freight transport[24].

The total number of HDVs was calculated using the difference between the total number of HDVs and LDVs in 2010 in the Vermont Transportation Energy Profile and the total number of LDVs from TES Transportation Data[25]. HDV miles per capita was calculated using the ratio of total HDV miles traveled from the 2012

18 Ibid.

19. "Natural Gas Fuel Basics," Alternative Fuels Data Center, accessed August 19, 2016, http://www.afdc.energy.gov/fuels/natural_gas_basics.html.

20. U.S. Environmental Protection Agency: Office of Transportation & Air Quality, "Biodiesel."

21. US Energy Information Administration (EIA), "Freight Transportation Energy Use, Reference Case," Annual Energy Outlook 2015, 2015, http://www.eia.gov/forecasts/aeo/data/browser/#/?id=58-AEO2015&region=0-0&cases=ref2015&start=2012&end=2040&f=A&linechart=ref2015-d021915a.6-58-AEO2015&sourcekey=0.

22. Oregon Department of Transportation and U.S. Department of Transportation Federal Highway Administration, "Primer on Renewable Diesel," accessed August 29, 2016, http://altfueltoolkit.org/wp-content/uploads/2004/05/Renewable-Diesel-Fact-Sheet.pdf.

23. California Environmental Protection Agency Air Resources Board, "Draft Technology Assessment: Medium- and Heavy-Duty Battery Electric Trucks and Buses," October 2015, https://www.arb.ca.gov/msprog/tech/techreport/bev_tech_report.pdf.

24. Elon Musk, "Master Plan, Part Deux," Tesla, July 20, 2016, https://www.tesla.com/blog/master-plan-part-deux.

25. Jonathan Dowds et al., "Vermont Transportation Energy Profile."

Transportation Energy Data Book and the 2012 American Community Survey U.S. population estimate[26, 27]. The total number of HDVs and HDV miles per capita were combined with the population assumptions outlined above to calculate miles per HDV.

Rail

The rail sector of the transportation branch consists of two types: freight and passenger. Currently in Vermont, freight and passenger rail use diesel fuel[28, 29]. The energy intensity (Btu/short ton-mile) of freight rail was obtained from the U.S Department of Transportation Bureau of Transportation Statistics[30]. A 10-year average energy intensity of passenger rail (Btu/passenger mile) was also obtained from the U.S Department of Transportation Bureau of Transportation Statistics[31]. Passenger miles were calculated using two sets of information. First, distance between Vermont Amtrak stations and the appropriate Vermont border location were estimated using Google Maps data. Second, 2013 passenger data was obtained from the National Association of Railroad Passengers[32]. Combined, these two components created total Vermont passenger miles. We used a compound growth rate of 3% for forecast future passenger rail demand in the 90% x $2050_{VEIC}$ scenario, consistent with the historical growth rates of rail passenger miles in Vermont[33]. Passenger rail is assumed to completely transform to electric locomotion. Freight rail is assumed to transform to biodiesel or renewable diesel.

Air

The total energy of air sector used appropriate FACETS data values directly. The air sector is expected to continue using Jet Fuel in both scenarios.

26 “Transportation Energy Data Book: Edition 33” (Oak Ridge National Laboratory, n.d.), accessed August 18, 2016.

27 U. S. Census Bureau, “Total Population, Universe: Total Population, 2012 American Community Survey 1-Year Estimates,” American Fact Finder, 2012, http://factfinder.census.gov/bkmk/table/1.0/en/ACS/12_1YR/B01003/0100000US.

28. US Energy Information Administration (EIA), “Freight Transportation Energy Use, Reference Case.”

29. Vermont Agency of Transportation Operations Division - Rail Section, “Passenger Rail Equipment Options for the Amtrak Vermonter and Ethan Allen Express: A Report to the Vermont Legislature,” January 2010, http://www.leg.state.vt.us/reports/2010ExternalReports/253921.pdf.

30. U.S. Department of Transportation: Office of the Assistant Secretary for Research and Technology Bureau of Transportation Statistics, “Table 4-25: Energy Intensity of Class I Railroad Freight Service,” accessed August 26, 2016, http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_04_25.html.

31. U.S. Department of Transportation: Office of the Assistant Secretary for Research and Technology Bureau of Transportation Statistics, “Table 4-26: Energy Intensity of Amtrak Services,” accessed August 26, 2016, http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_04_26.html.

32. National Association of Railroad Passengers, “Fact Sheet: Amtrak in Vermont,” 2016, https://www.narprail.org/site/assets/files/1038/states_2015.pdf

33. Joseph Barr, AICP et al., “Vermont State Rail Plan: Regional Passenger Rail Forecasts.”