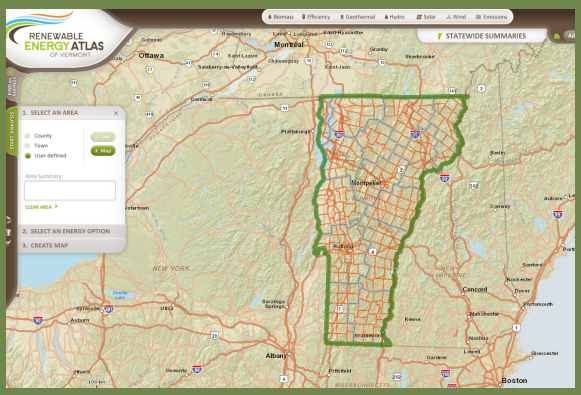
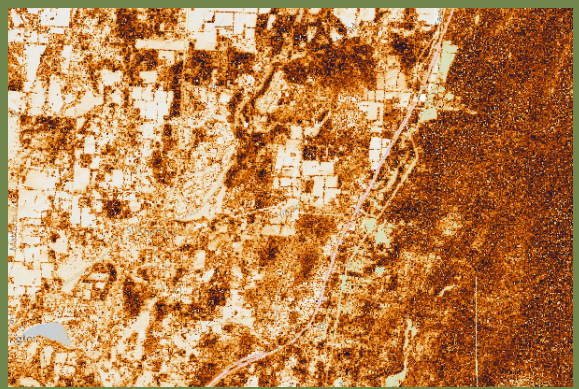
VERMONT BIOENERGY INITIATIVE

A program of the Vermont Sustainable Jobs Fund

RENEWABLE ENERGY ATLAS





U.S. DOE Award #DE-FG36-08GO88182

ABOUT THE VERMONT BIOENERGY INITIATIVE

The purpose of the **Vermont Bioenergy Initiative** (VBI) was to foster the development of sustainable, distributed, small-scale biodiesel from oilseeds and algae and grass/mixed fiber industries in Vermont that would enable the production and use of bioenergy for local transportation, agricultural, and thermal applications. Our investments in feasibility analyses, research and development, and demonstration projects for various bioenergy feedstocks were intended to lead to their commercialization over 7 year time horizon. This initiative was a statewide market building approach to sustainable development that may be replicated in other rural states around the country.

As a grant-making entity, project manager, and technical assistance provider, the Vermont Sustainable Jobs Fund (VSJF) solicited and selected the best sub-recipient proposals for bioenergy related projects through a competitive Request for Proposal process and conducted a number of staff directed investigations, all designed to support the four key priorities of the U.S. Department of Energy's EERE Strategic Plan:

1.) Dramatically reduce dependence on foreign oil;
2.) Promote the use of diverse, domestic and sustainable energy resources;
3.) Reduce carbon emissions from energy production and consumption;
4.) Establish a domestic bio-industry.

Thank you to the office of U.S. Senator Patrick Leahy for securing three U.S. Department of Energy congressionally directed awards (FY08, FY09, FY10) to financially support the Vermont Bioenergy Initiative.

Learn more at

VERMONT BIOENERGY INITIATIVE

http://vermontbioenergy.com

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Vermont Sustainable Jobs Fund

WWW.VSJF.ORG

The Vermont Sustainable Jobs Fund (VSJF) is a 501 (c) (3) nonprofit based in Montpelier, Vermont. VSJF was created by the Vermont Legislature in 1995 to nurture the sustainable development of Vermont's economy.

VSJF provides business assistance, network development, research, and financing in food system, forest product, waste management, renewable energy, and environmental technology sectors.

ATLAS SUMMARY

The Renewable Energy Atlas of Vermont was developed as a GIS-based website for identifying, analyzing, and visualizing existing and promising locations for renewable energy projects. The Atlas was devised to fulfill basic research and education needs for bioenergy market development for the Vermont Bioenergy Initiative, but was expanded to include a wider range of renewable energy products.

The Atlas was created to assist town energy committees, Vermont's Clean Energy Development Fund and other funders, farmers, educators, planners, policy-makers, and businesses in making informed decisions about the planning and implementation of renewable energy in their communities—decisions that ultimately lead to successful projects, greater energy security, a cleaner and healthier environment.

The state-of-the-art Atlas was the first tool of its kind in the United States that enabled end users to *click* on their town (or several towns or county/counties) and select from a suite of renewable energy options: biomass, efficiency, geothermal, hydroelectric, solar, and wind. In 2016, the Atlas was merged into the Energy Action Network's **Community Energy Dashboard** a powerful suite of interactive tools to set goals, track progress, map actions, share stories, and hear from trusted neighbors. The Dashboard helps translate Vermont's goal of 90% by 2050 into achievable action.

The results of this body of work include:

- First of its kind resource assisted Regional Planning Commissions, Vermont Department of Public Service, **Vermont Energy and Climate Action Network**, and other stakeholders in analyzing renewable energy potential and reporting results.
- Creation of renewable energy GIS data layers available for download at the **Vermont Center for Geographic Information** website.
- Creation of database of all renewable energy installations in Vermont.

THE OPPORTUNITY

Throughout America, concerns about economic security, dependence on foreign oil supplies, and the realities of oil depletion and climate change are leading public officials, research laboratories, educational institutions, investors, and entrepreneurs to accelerate the rate of research and capital deployment for renewable energy sources and increased energy efficiency. When the VBI began in 2008, for example, the State of Indiana initiated a comprehensive project called **BioTown USA**, and discovered that it was thermodynamically possible to convert a small, 'test' town from reliance on fossil fuels to biomass-derived fuels and electricity (Jenner, 2006). At the national-scale, the Department of Energy and the Department of Agriculture (2005) sponsored a **study** that determined that America could replace 30% of imported petroleum with one billion tons of biomass. At a global-scale, in 2007 **REN21** calculated that over $100 billion was invested in new renewable energy capacity, manufacturing plants, and research and development, which they called "a true global milestone" (2008: 6).

Growing interest in energy issues and climate change set the stage for Vermont to accelerate its transition toward a renewable energy and energy efficiency based economy. A series of studies and collaborative processes completed just as development of the Renewable Energy Atlas was underway identified pathways for developing diversified, community-scale renewable energy and energy efficiency projects that can increasingly replace our dependence on non-renewable electric and liquid fuel supplies.

For example, a public engagement process and deliberative polling exercise conducted by the Vermont Department of Public Service demonstrated a strongly voiced desire for locally produced, renewable energy and energy efficiency (Wark, 2008). In 2007, the **Vermont Council on Rural Development** convened a Rural Energy Council to answer the question: "What combination of conservation, efficiency, in-state electric generation and alternative fuel development will effectively provide the leverage to support the prosperity and sustainability of Vermont communities?" The Rural Energy Council issued two reports, **The Vermont Energy Digest** and **Strengthening Vermont's Energy Economy**, that identified a number

of recommendations for policy-makers, as well as a series of energy development scenarios that would create jobs, reduce emissions, and provide for between 3.95 to 9.26 percent of Vermont's energy consumption.

In 2008, Vermont's (now defunct) **25 by '25** Initiative Steering Committee published preliminary findings and conclusions for consideration by policy-makers (Spring Hill Solutions, 2008). The Steering Committee calculated that Vermont could generate 25.71% of its energy needs from renewable sources by 2025, with about 79% of that total coming from agricultural and forest resources.

In 2007, the **Biomass Energy Resource Center** (BERC) completed **The Vermont Wood Fuel Supply Study** for the Vermont Department of Forests, Parks & Recreation and the Vermont Department of Buildings & General Services. This study attempted to answer the question: "How much wood is out there?" It analyzed the potential supply of low-grade wood from the net annual growth on accessible timberland in all of Vermont's counties and 10 adjacent counties in New York, Massachusetts, and New Hampshire. Depending on the scenario, BERC estimated that there are between 387,491 and 2,342,053 green tons of wood available from Vermont counties, with Windham County having the highest concentration of net available low-grade wood.

In 2003, **Vermont Environmental Research Associates** (VERA) completed a study for the Vermont Department of Public Service that estimated the wind power potential on public lands in Vermont. The study determined that nearly 3,830 square miles, or 41%, of Vermont's land area falls under a wind class of 1 to 3. The U.S. Department of Energy (DOE) estimates that Vermont has useful solar resources—3,500 to 4,000 Whr per square mile per day—for flat plate collectors; vast low-temperature resources suitable for geothermal heat pumps; and good hydro resources.

In 2015, the Vermont legislature passed the second strongest renewable portfolio standard in the country—**H.40 (Act 56) - RESET**, which requires utilities to purchase 55% of electricity from renewable sources (or renewable energy credits) by 2017 and 75% by 2032. **Vermont's Comprehensive Energy Plan** calls for 90% of the state's energy consumption to be derived from renewable sources by 2050 (up from 20% today—mostly renewable electricity from hydropower, biomass, and wind, followed by wood for heating and ethanol).

As these studies suggest, the cumulative impact of a combination of demand-side and supply-side projects can make a substantial impact on Vermont's energy future by reducing energy demand and increasing the supply of renewable energy.

With so many valuable pieces of information gathered, Vermont has effectively answered the "why" and "what" questions. Why focus on renewable energy and energy efficiency? Because they provide plausible avenues for Vermont to 1) create jobs, 2) prepare for, mitigate against, and adapt to peak oil and climate change, 3) and Vermont has the human, technological, and natural resources to accomplish the goal of replacing 25% of its energy demand with renewable, locally produced energy by 2025. What types of renewable energy sources and technologies, as well as energy efficiency opportunities, are available and feasible in Vermont? Except for ocean tidal power, Vermont has access to the full suite of renewable energy and energy efficiency options.

The Atlas tried to answer "where" and "how" questions. Where will Vermont's bioenergy, wind, solar, geothermal, small-scale hydro, and efficiency technologies be located? Vermont is an ideal location to explore the creation of distributed renewable liquid fuel production and electricity generation in strategically identified locations around the state. The precedent for the Renewable Energy Atlas of Vermont was set by the Renewable Energy Atlas of the West and the Renewable Energy Atlas of Alaska. Both efforts used Geographic Information System (GIS) technology to develop renewable resource maps for policy-makers and others. However, the Atlas of the West and the Atlas of Alaska were state-level printed snapshots, while the Renewable Energy Atlas of Vermont provided Town and County level data via a dynamic website.

STATEMENT OF PROJECT OBJECTIVES

The purpose of this project was to create the Renewable Energy Atlas of Vermont, a GIS-based mapping website that analyzed potential biomass resources that could be sustainably used for bioenergy production. The scope of the project was expanded to include all renewable energy resources in Vermont. VSJF worked with Mike Brouillette, Senior Project Manager at the Vermont Center for Geographic Information, to develop data "layers" to depict renewable energy potential. We worked with Fountains Spatial (now VHB) and Overit Media to program and develop the website, and we later worked with Vermont Design Works to design, program, and merge the Atlas into the Energy Action Network's Community Energy Dashboard.

RENEWABLE ENERGY ATLAS AND COMMUNITY ENERGY DASHBOARD

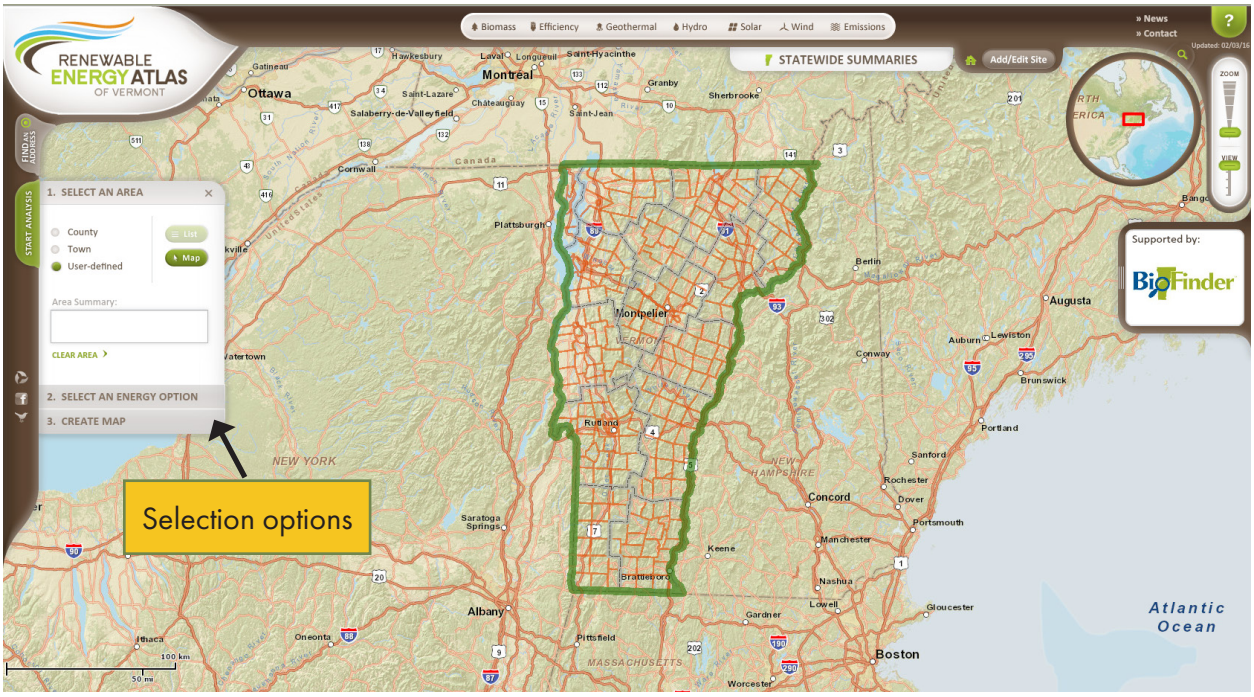
Fiscal Year(s)	Sub-Recipient	DOE Funds	Total Project Cost
FY08-10	**VSJF:** project management	$82,214	$82,214
FY08-10	**Vermont Center for Geographic Information:** Energy data layer creation	$116,667	$116,667
FY08-10	**Fountains Spatial:** website development and hosting	$114,067	$114,067
FY08-10	**Vermont Design Works:** Community Energy Dashboard data conversion	$32, 129	$32, 129
	TASK TOTAL	**$345,077**	**$345,077**

RENEWABLE ENERGY ATLAS OF VERMONT

To develop the Atlas, VSJF interviewed the organizations responsible for the creating the BioTown, USA report, the Renewable Energy Atlas of the West, and the Renewable Energy Atlas of Alaska. In March 2008, we began working with the Vermont Center for Geographic Information (VCGI) to discuss data sources, technical assistance, scope of work, budget, and recommendations for a technical working group. We sought guidance from the now defunct Vermont 25 by '25 steering committee, developed a technical work group, prepared a request for proposals for website development firms, and successfully hired Fountains Spatial (now VHB) to build the website. Along the way VSJF identified and engaged partner organizations to increase buy-in and to utilize all available expertise.

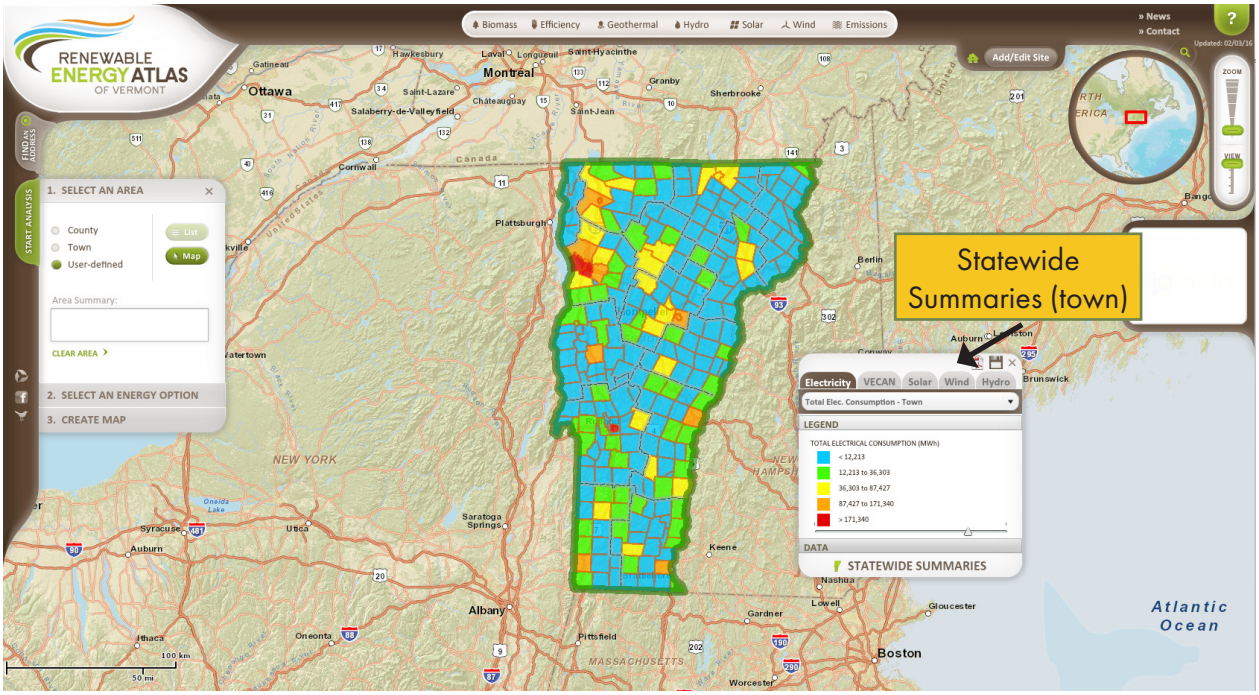
The Renewable Energy Atlas of Vermont went live on April 22, 2010— Earth Day.

RENEWABLE ENERGY ATLAS — HOMEPAGE

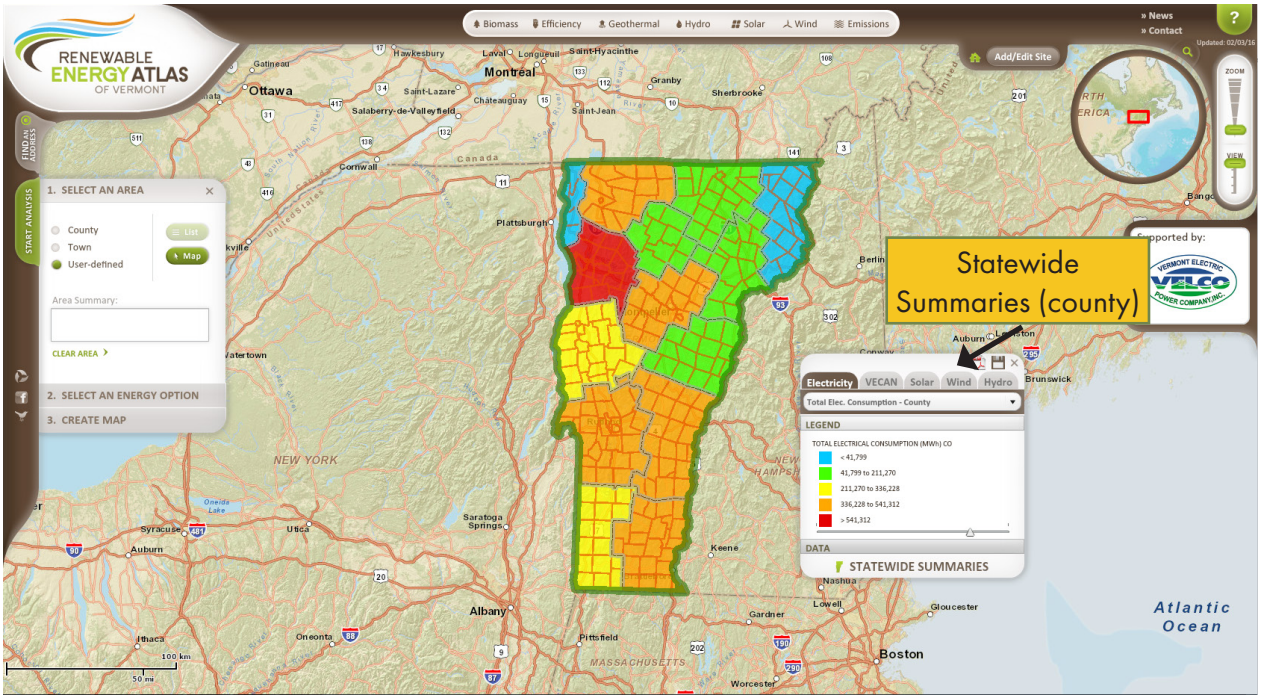


The Renewable Energy Atlas of Vermont homepage featured selection options for Areas (e.g., Town, County, Draw Your Own), Energy (e.g., Biomass, Geothermal, Hydro, Solar, Wind), and Creating a Map on the left side of the screen. Users could find their own address on the map, zoom in and out, and change their View from street maps and satellite maps. A button at the top of the screen ("Add/Edit Site) allowed users to enter their own energy sites or make edits to existing sites.

RENEWABLE ENERGY ATLAS — STATEWIDE SUMMARIES

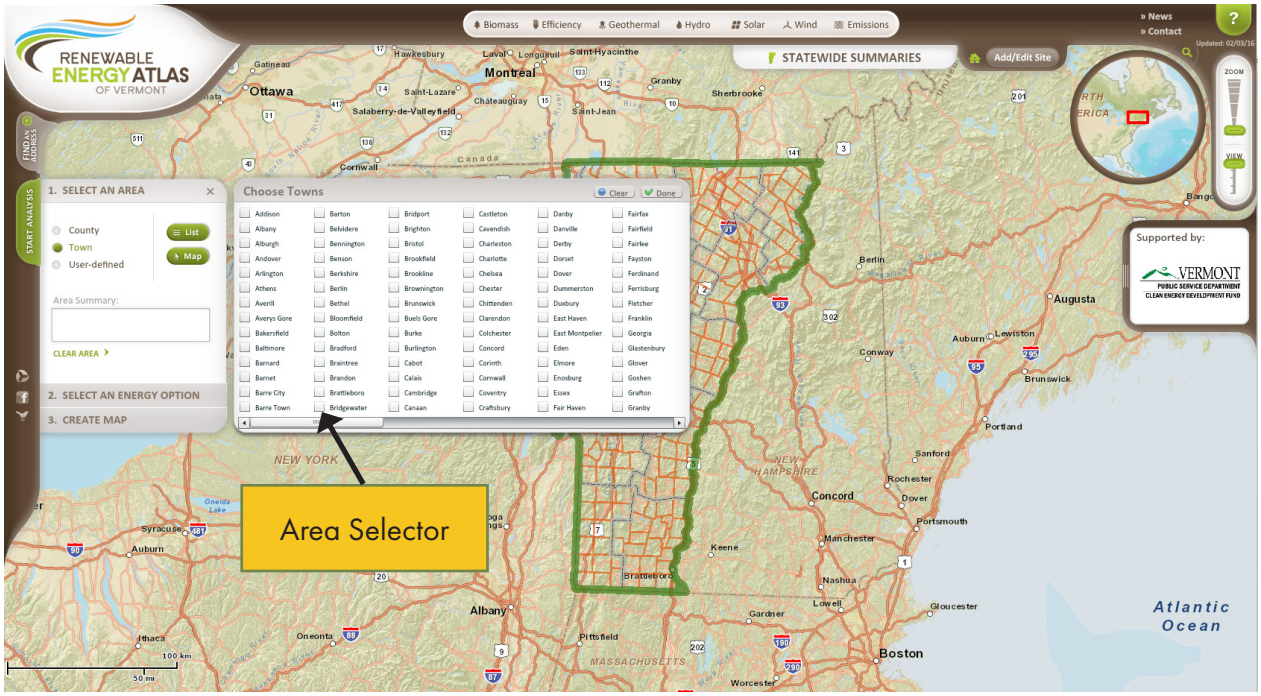


Atlas users could click on a button at the top of the screen called "Statewide Summaries" to view Town level summaries of solar, wind, and hydro installations and installed capacities, as well as electricity consumption and savings data.



Atlas users could click on a button at the top of the screen called "Statewide Summaries" to view County level summaries of solar, wind, and hydro installations and installed capacities, as well as electricity consumption and savings data. Statewide Summaries allowed for at-a-glance comparisons of communities in Vermont.

RENEWABLE ENERGY ATLAS — AREA SELECTOR

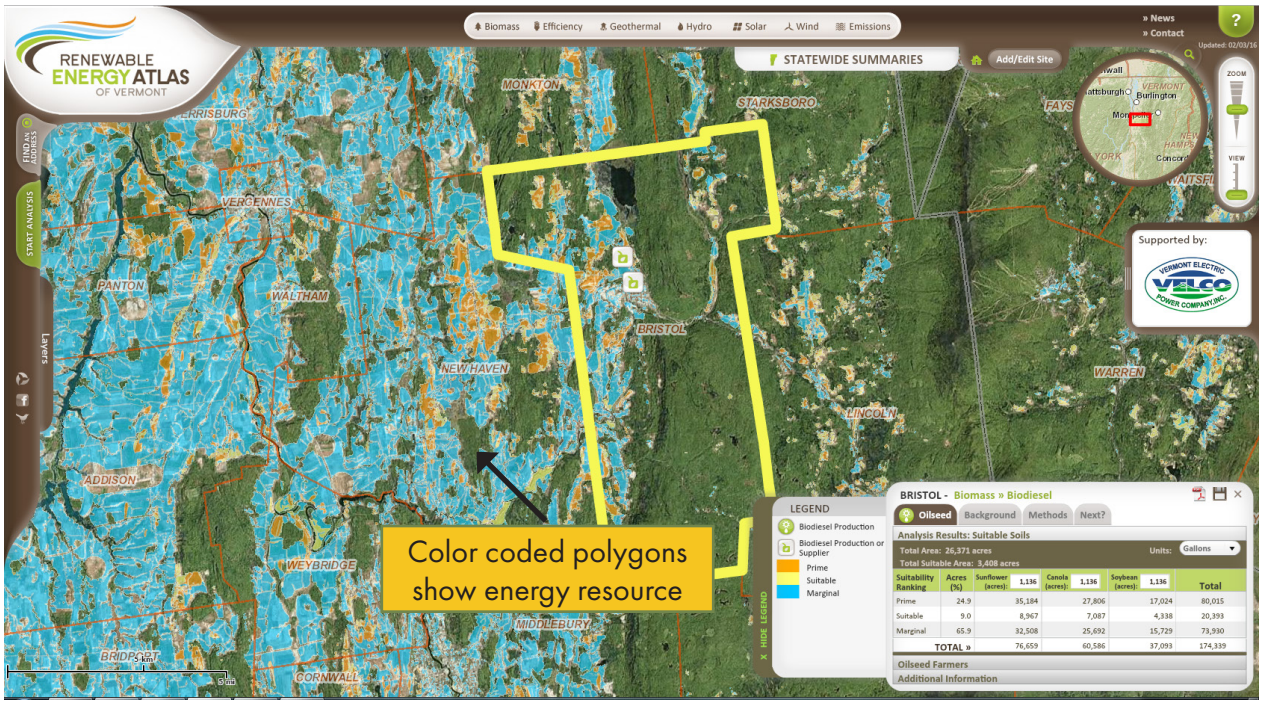


Atlas users could select their town or county from a list of towns and counties, or by clicking directly on the map.

RENEWABLE ENERGY ATLAS WITH TOWN SELECTED

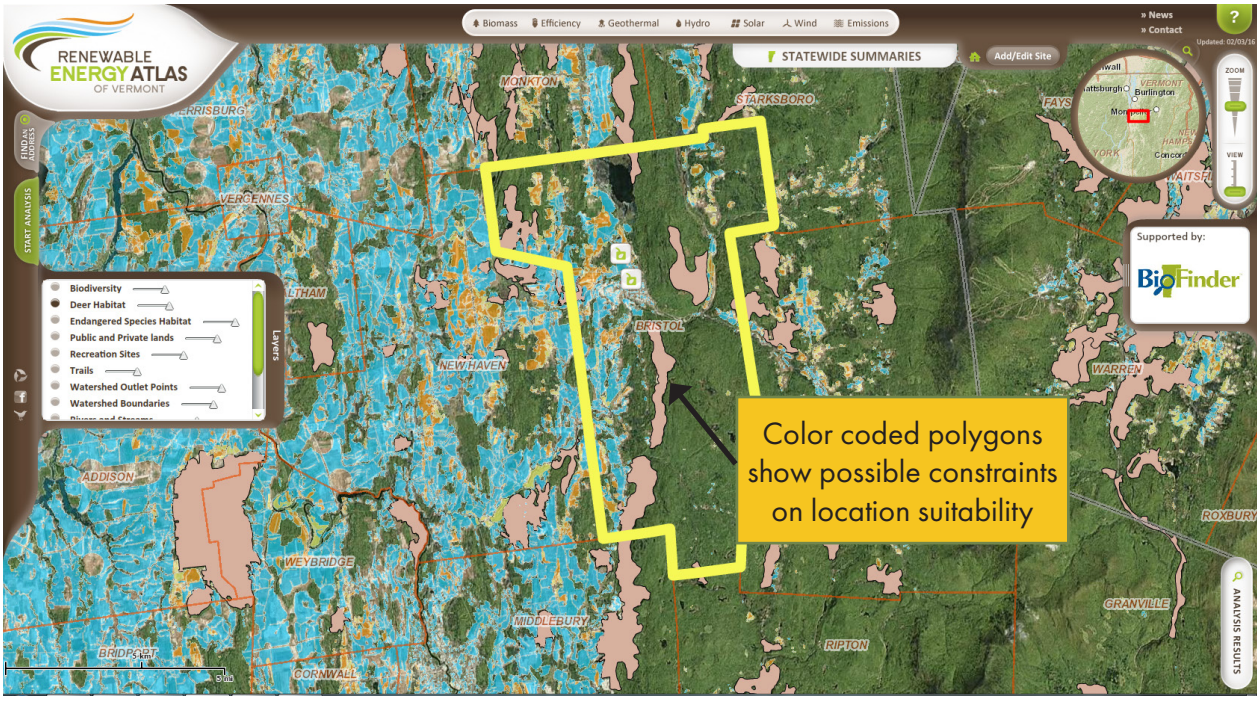
Once an Area was selected, the map would zoom into that location. Atlas users could then select an Energy option.

RENEWABLE ENERGY ATLAS WITH ENERGY LAYER SELECTED

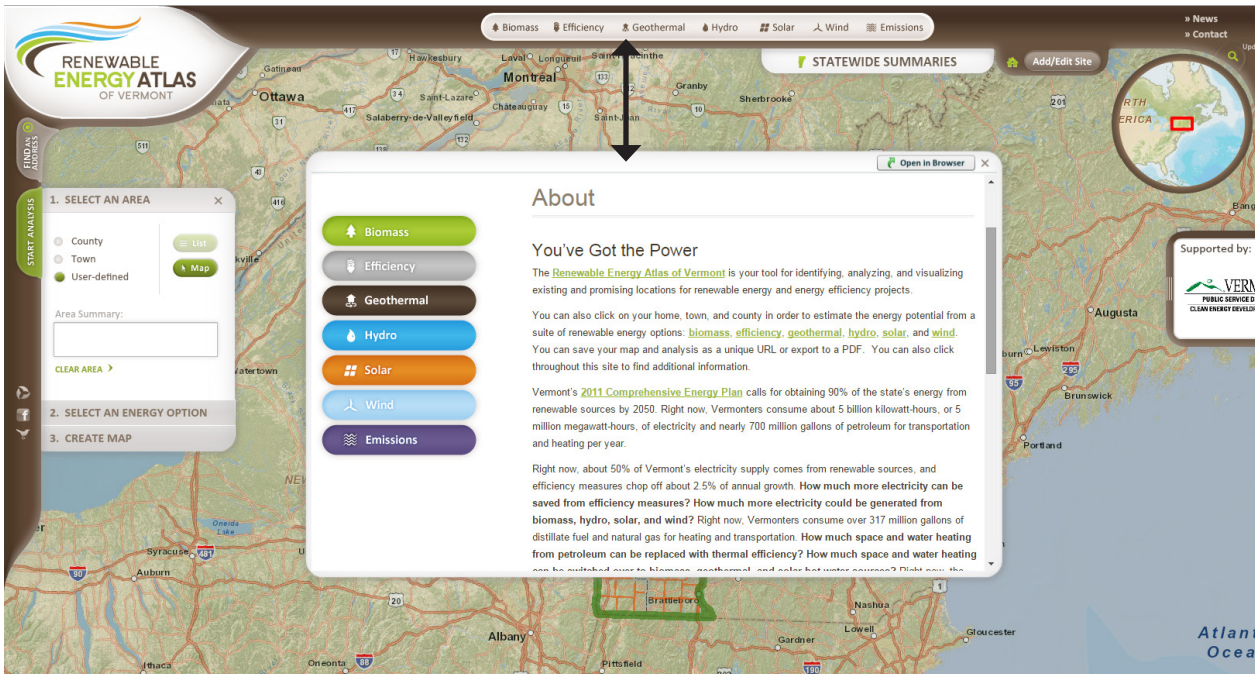


After an Area was selected, Atlas users could choose a variety of energy options. In this example, Oilseed Crop Biodiesel was selected. The map shows soil polygons deemed suitable for growing sunflowers, canola, and soybeans. An Analysis Results panel appeared in the lower right corner of the screen, containing a Legend, and calculation tools for crop and biodiesel production.

RENEWABLE ENERGY ATLAS WITH DEER HABITAT LAYER SELECTED



Atlas users could turn on additional "suitability" layers. In this case, the Deer Habitat layer is turned on.



A set of resources across the top of the screen provided additional information about Biomass, Effiency, Geothermal, Hydro, Solar, and Wind energy, as well as data about Vermont's greenhouse gas emissions. These resources opened into a separate WordPress website that contained funding sources, data sources, and resources by energy category.

Data Layers and Analysis

VCGI used the ESRI Spatial Analysis Model Builder tool to develop and process renewable energy data layers. Model Builder is a series of process wizards and diagramming tools that aid in the construction of spatial models represented as process flow diagrams. These flow diagrams aid in the visualization of the process being modeled, their quality control review, and they can be saved, documented, shared and easily rerun when variables are modified for model calibration. Individual metrics are treated as building blocks that can be combined in a variety of ways in the ESRI Model Builder environment. This approach is flexible and allows for customization of individual metrics as needed.

VSJF built the "sites" database that includes renewable energy installations, installed capacity, and additional relevant information about these sites (e.g., residential, farm, business). Data for all of the sites that appear as pins on the map are collected from "certificates of public good" issued by the Vermont Public Service Board, the Vermont Dam Inventory, AgSTAR, and crowdsourcing. The sites database later became a major engine for the functionality and data displays on the Community Energy Dashboard.

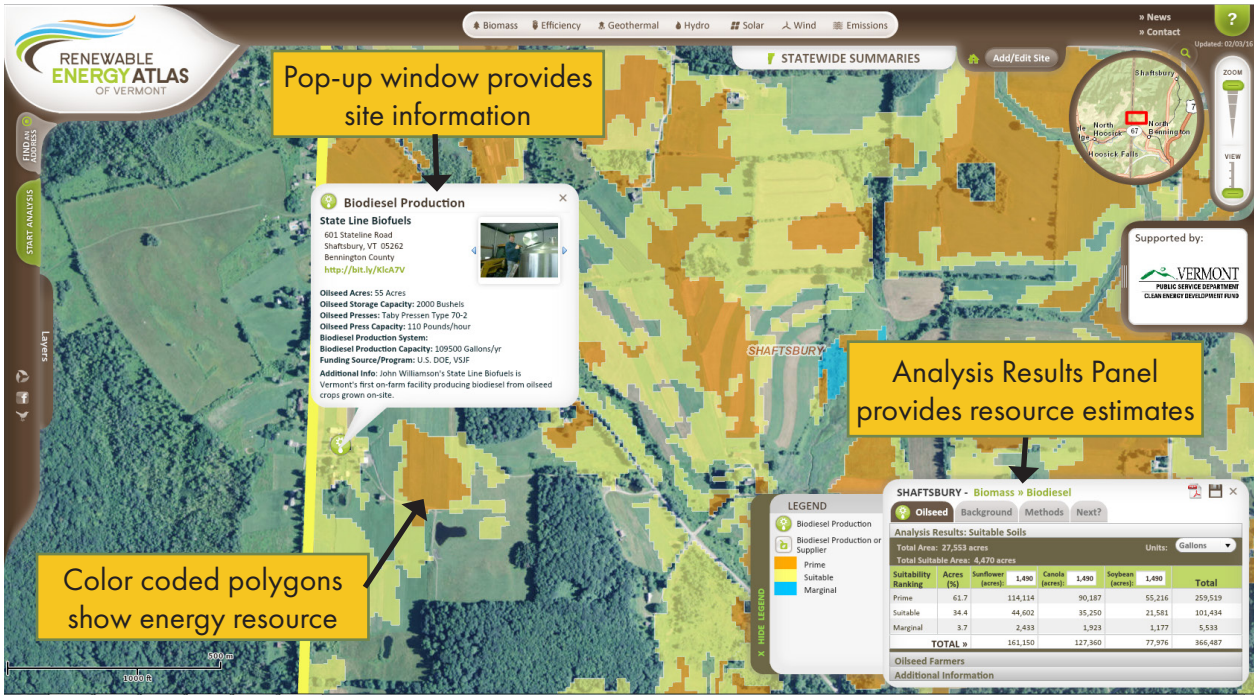
BIOMASS: The biomass layer refers to biologically-based feedstocks such as algae, food waste, grasses, methane, oilseed crops, and wood that can be converted into energy sources such as biodiesel, ethanol, and wood chips / pellets, which can run vehicles, heat buildings, or generate electricity. Atlas users had several options to choose from under the Biomass category: Oilseed Crop-based Biodiesel; Algae-based Biodiesel; Waste Vegetable Oil-based Biodiesel; Grass Energy; Anaerobic Digesters; "Waste"-to-Energy; and Woody Biomass.

- **Oilseed Crop-based Biodiesel:** Three crops that have been successfully grown in Vermont and converted into biodiesel were spatially depicted and analyzed: Canola, Sunflowers, and Soybeans.

At the time, no existing spatial data existed for the distribution of these biodiesel crops in Vermont. VCGI created the oilseed crop data layer using information from the USDA Natural Resources Conservation Service (NRCS) plants database growth requirements, input from Dr. Heather Darby (University of Vermont Extension), in-house data, and structured queries provided by the local USDA NRCS office while adhering to applicable Sustainable Biodiesel Alliance Baseline Practices within a number of their Sustainable Feedstock Categories. In cooperation with NRCS, VCGI queried the plant requirements for each crop from the Soil Survey Geographic Database (SSURGO) to produce a gross distribution extent of soil types. The SSURGO dataset exists for all counties in Vermont (except Essex County), but the data quality varies from county to county. To control and minimize soil erosion, those soils that are "highly erodible" were removed from consideration (i.e., not visible as a map polygon). Units for this data were provided in acres. Dr. Darby provided conversion values for those acres that appeared in the Analysis Results Panel (i.e., converting each crop type into bushels per acre for prime, suitable, and marginal soils; and then converting bushels in gallons; and acres into gallons of biodiesel).

When an Atlas user clicked on Biodiesel and selected "Oilseed Crop," they would see a map of agricultural soils (e.g., Prime, Suitable, Marginal) as color coded polygons that met oilseed crop growing conditions. Existing biodiesel production facilities were depicted as clickable map points. The Analysis Results Panel calculated conversion values on the fly (e.g., bushels per acre; oil (gallon) per bushel; and biodiesel (gallon) per acre).

RENEWABLE ENERGY ATLAS — OILSEED BIODIESEL LAYER SELECTED



In this example, the Town of Shaftsbury—home of State Line Biofuels—has been selected. Orange, yellow, and blue polygons indicate soil types. The pin for State Line Biofuels has been clicked on and a pop-up window describing the facility is visible. The Analysis Results Panel provides conversion values.

- **Algae-based Biodiesel:** Second generation biofuels such as algae are expected to produce substantially more fuel, using far less land, than first generation biofuels. National research and development was co-locating prototype algal photobioreactors with CO_2 and other greenhouse gas emitting facilities to aid in algal growth.

When an Atlas user clicked on Biodiesel and selected "Algae" the process was that they would see a map of existing methane digester locations (i.e., map pins) and wastewater treatment facility locations. This layer was speculative in the sense that it did not indicate how much algae could be produced, but rather where it might be produced.

- **Waste Vegetable Oil-based Biodiesel:** Waste vegetable oil produced at food establishments can be converted through the transesterification process into biodiesel.

When an Atlas user clicked on Biodiesel and selected "Waste Vegetable Oil" the map would populate with pins at the location of Food Establishments. This layer was speculative in the sense that we could identify the locations of most restaurants/food establishments but had no means of estimating the volume of waste vegetable oil being generated.

- **Grass Energy:** This layer considered two fast growing perennial grasses, switchgrass and big bluestem. National and international experts overwhelmingly emphasized switchgrass and big bluestem at the November 12, 2008 Vermont Grass Energy Symposium.

VCGI applied the same process used to develop the Oilseed Crop-Based Biodiesel layer, but, in this case, Dr. Sid Bosworth (University of Vermont) was consulted. When an Atlas user clicked on Grass Energy, they would see a map of agricultural soils (e.g., Prime, Suitable, Marginal) as color coded polygons that met perennial grass growing conditions. Existing pellet making facilities were depicted as clickable map points. The Analysis Results Panel calculated conversion values on the fly (e.g., tons per acre and million BTUs per acre).

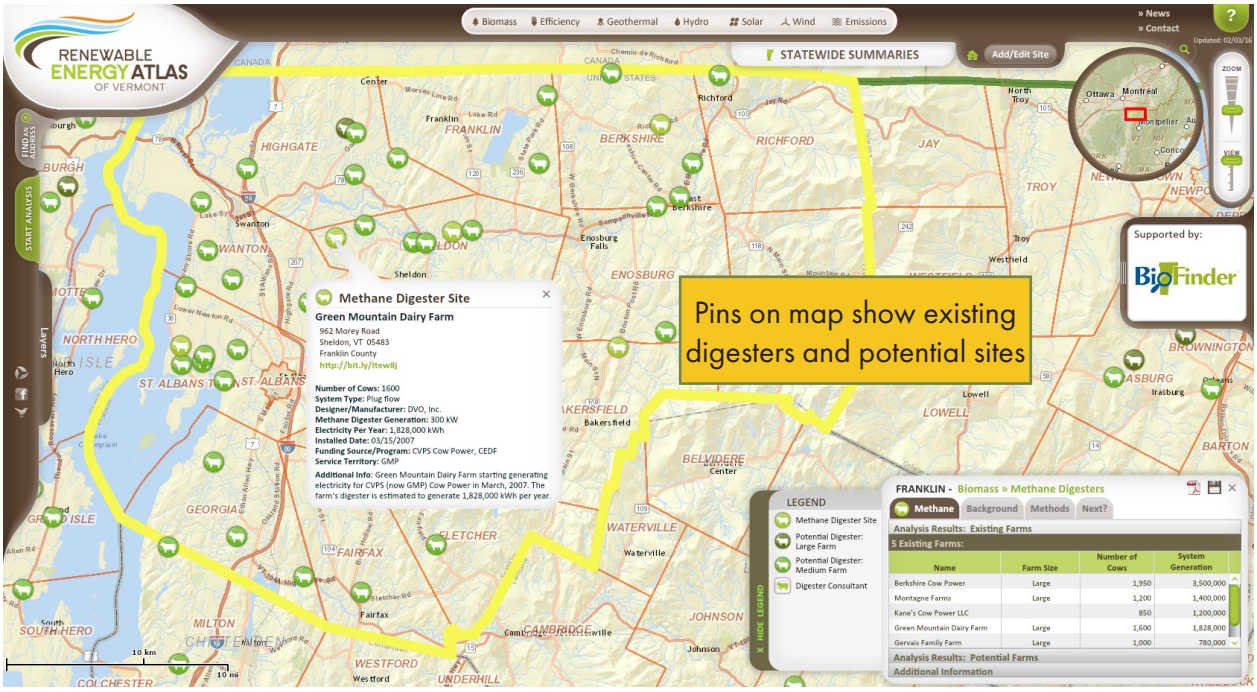
- **Manure / Methane:** Anaerobic digesters, or biodigesters, transform cow manure, corn silage, haylage, and other biological material into "biogas" or methane. Anaerobic digesters are basically covered tanks that heat up as the biological material decomposes in the absence of oxygen. Bacteria in the digester turn the biological material into biogas that can then be piped to a generator to create electricity and heat for the farm and/or be sold to the grid.

Methane digester sites were collected and verified from multiple sources, including "certificates of public good" issued by the Vermont Public Service Board, and AgSTAR, a program of the U.S. Environmental Protection Agency. When an Atlas user clicked on Manure/Methane, the process was that they would see a map of existing methane digester sites as well as large and medium dairy farms.

- **Waste to Energy:** Waste, in this case, referred animal waste, food waste, and electricity generation at landfills.

When an Atlas user clicked on "Waste" to Energy a map of dairy farms, restaurants, and landfill methane sites would appear. As with other layers, this layer was speculative in the sense that, except for landfill methane, it only indicated possible locations that waste was being generated.

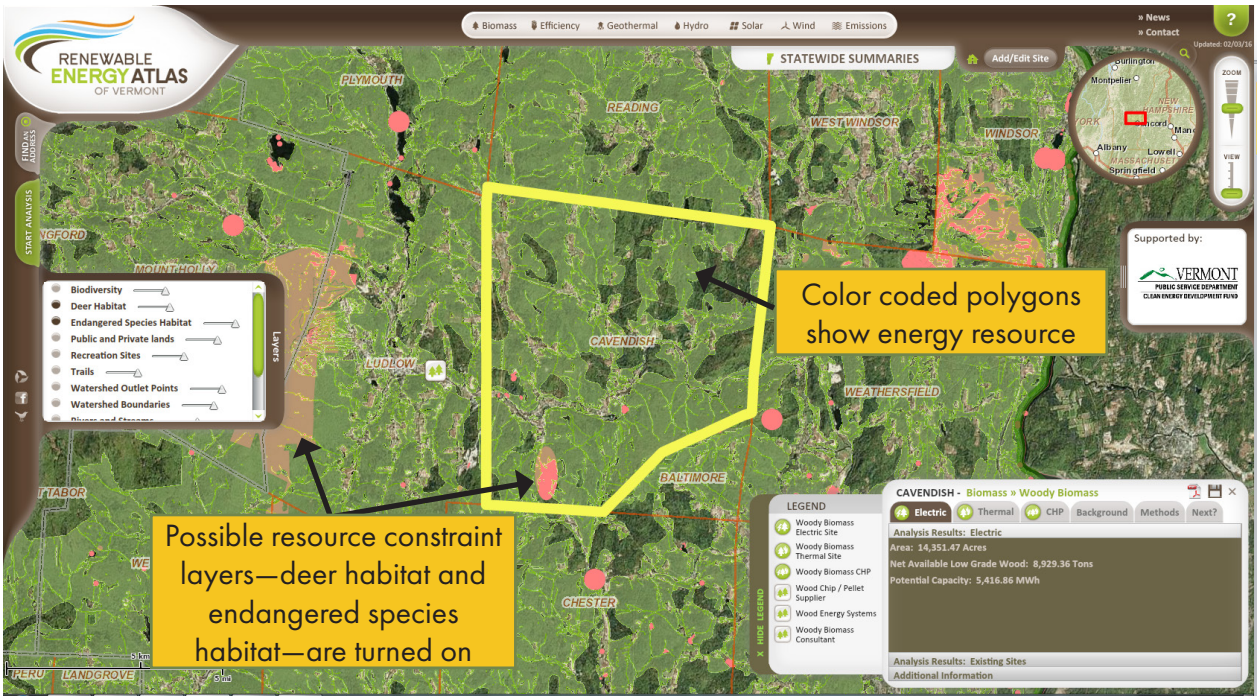
RENEWABLE ENERGY ATLAS — DIGESTER LAYER SELECTED



- **Wood (Chips / Pellets):** Wood chips / pellets can be burned in a boiler for heat, or to produce steam which then causes a turbine to rotate and generate electricity, or for combined heat and power possibilities.

VCGI worked with the Biomass Energy Resource Center (BERC) to develop this data layer. BERC has national and Vermont-specific expertise on a wide range of forest health and wood energy issues. BERC had developed a method of estimating the amount of Net Available Low-grade Growth (NALG) wood. This estimation is useful because it reports only the appropriate capacity of Vermont forests beyond existing demand for wood fiber (e.g., saw logs and firewood), however the estimations were limited to the county level. As part of a pilot project in Addison County, BERC developed an approach that allocated county level data to the town level. All forest land cover is extracted from the 2006 National Land Cover Dataset and further filtered using GIS to remove "mask" portions of the land base that should not be included for various reasons (e.g., ecological constraints). The product of available forest acreage data was input to a spreadsheet model using county specific USDA Forest Service data for forest ownership, inventory, composition, and growth on a per acre basis in order to calculate the estimated net annual growth of low-grade wood at the town level.

RENEWABLE ENERGY ATLAS — WOODY BIOMASS LAYER SELECTED



When an Atlas user clicked on Woody Biomass a map with color coded polygons indicating the forest resource as well as pins indicating woody biomass users appeared. The Analysis Results Panel calculated NALG wood in the selected boundaries on the fly and reported available tons. ►

- **Geothermal:** We focused on ground source heat pumps. There are four basic kinds of geothermal heat pump systems: Closed Loop Systems (vertical, horizontal, and pond) and Open Loop Systems (wells or water bodies).

No readily available data layer existed for the geothermal systems, but a composite layer for Closed and Open Loop Systems was constructed by VCGI. As with several other layers, the Geothermal layer was speculative in the sense that it does not indicate how much heat / energy can be produced, but rather where geothermal systems might be located.

Closed Loop Horizontal Systems: According to the U.S. Department of Energy, Closed Loop Horizontal Systems are generally most cost-effective for residential installations, particularly for new construction where sufficient land is available. It requires trenches at least four feet deep. The most common layouts either use two pipes, one buried at six feet, and the other at four feet, or two pipes placed side-by-side at five feet in the ground in a two-foot wide trench. In this case, VCGI queried the SSURGO database for areas where the depth to bedrock was greater

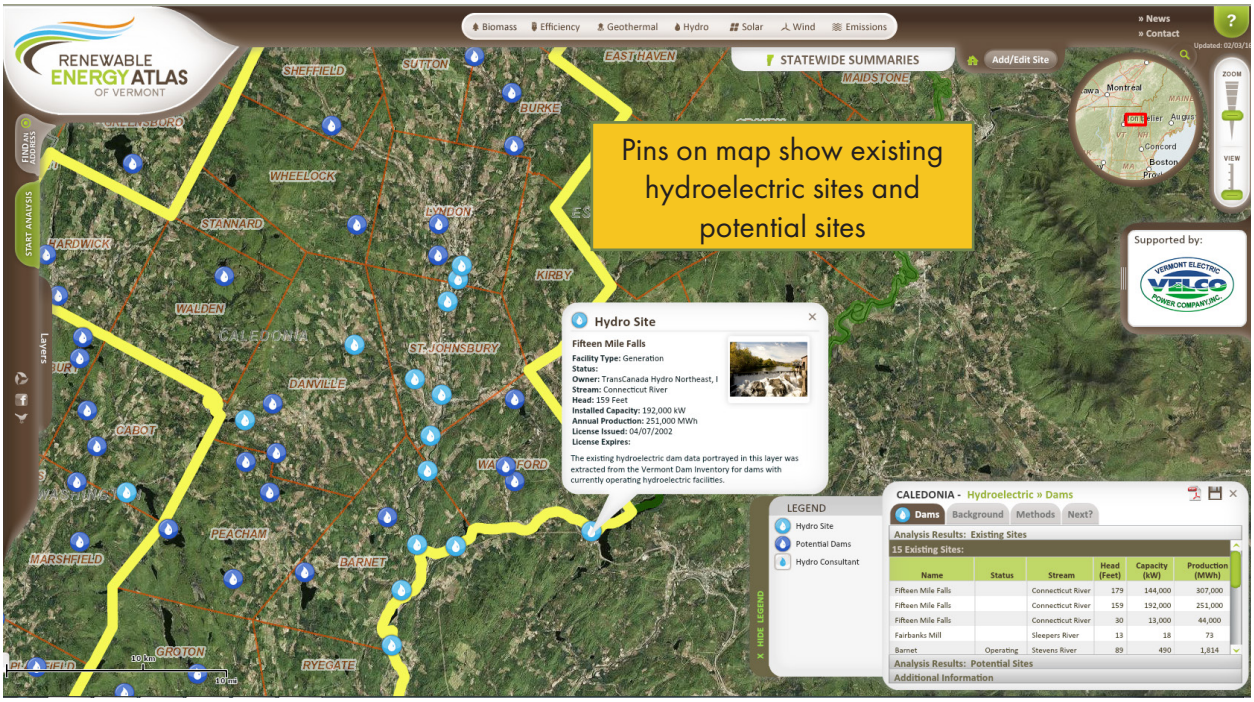
than 5 feet — under the presumption that it would be easier to dig these sites.

Closed Loop Pond System: According to the U.S. Department of Energy, a supply line pipe is run underground from the building to the water and coiled into circles at least eight feet under the surface to prevent freezing. The coils should only be placed in a water source that meets minimum volume, depth, and quality criteria. In this case, VCGI generated a data layer of all water bodies at least 1/2 acre in size, again, under the presumption that it would be easier to find possible locations for closed loop pond systems.

Open Loop Systems: this type of system uses well or surface body water as the heat exchange fluid that circulates directly through the GHP system. Once it has circulated through the system, the water returns to the ground through the well, a recharge well, or surface discharge. This option is obviously practical only where there is an adequate supply of relatively clean water, and all local codes and regulations regarding groundwater discharge are met. In this case, VCGI generated a data layer of existing water wells.

- **Hydro:** Refers to all hydroelectric generating sites. We also included potential hydro sites based on an analysis conducted by Community Hydro.

RENEWABLE ENERGY ATLAS — HYDRO LAYER SELECTED



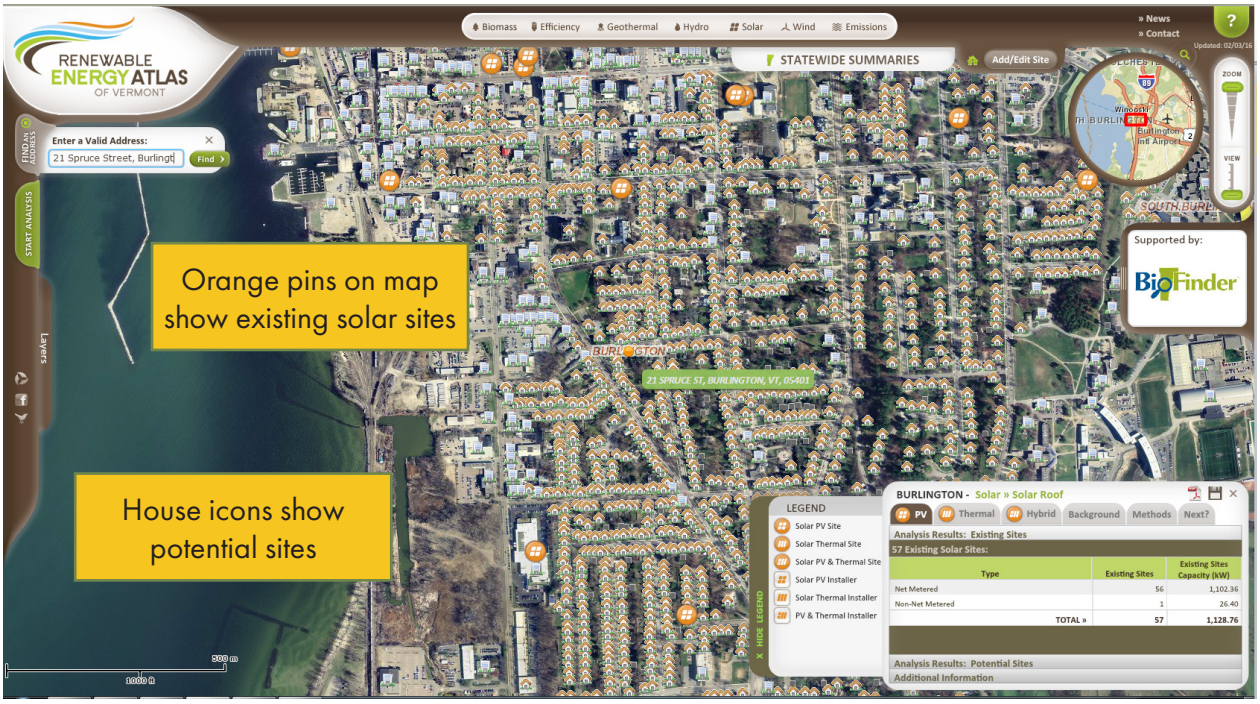
VCGI and the Vermont Agency of Natural Resources had previously developed the Vermont Dam Inventory that could be queried for electricity generating sites. In 2007, Community Hydro (Lori Barg) produced a report, *The Undeveloped Hydroelectric Potential of Vermont*, that provided energy estimates for small dams throughout Vermont.

When an Atlas user clicked on Hydro a map appeared that showed pins for existing and potential hydro sites.

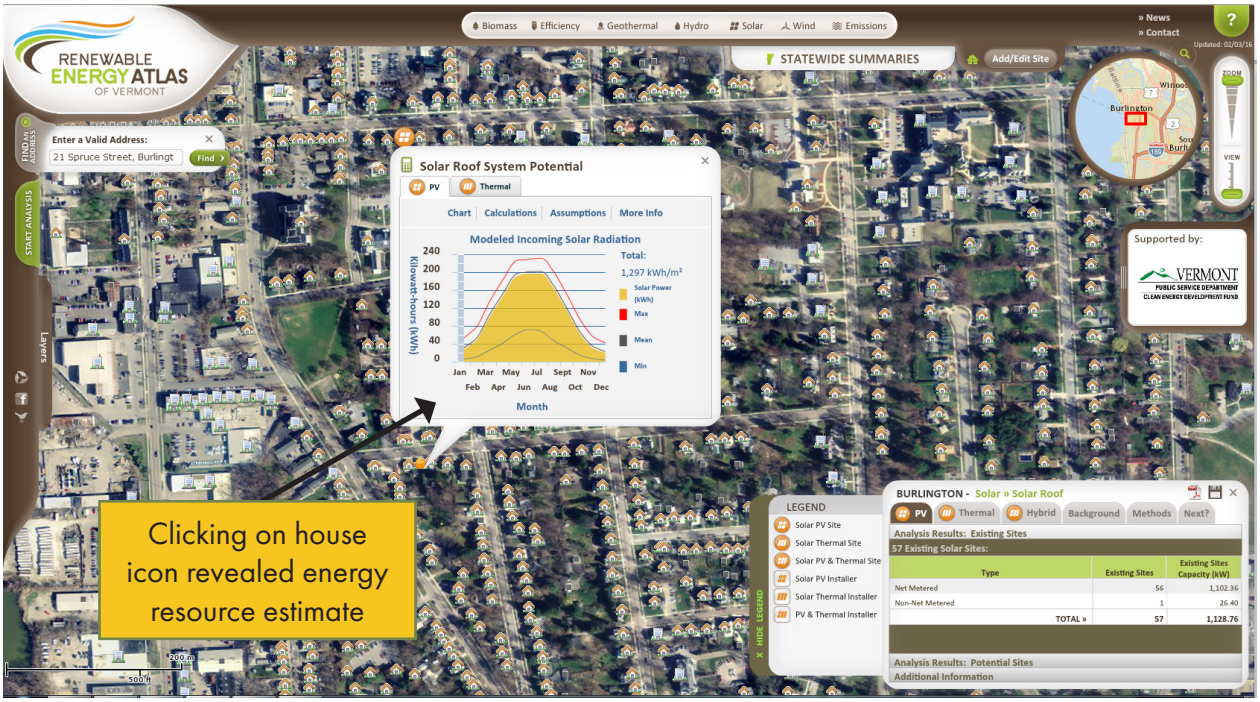
- **Solar:** Photovoltaic systems use the power of the sun to create electricity, while hot water systems convert sunshine into heat.

VCGI used the ESRI Solar Radiation tool for computing solar insolation for rooftops and on the ground. This tool accounted for topography and provided a large degree of control over the process. One critical control is a "height offset" that was used to model the solar insolation at an average height above ground (e.g., 20 feet) where solar panels are likely to be placed on a southerly facing roof at an optimal pitch. Known derate factors were applied to the optimal estimated solar values to account for site-specific variables deviating from the ideal, such as roof aspect and tilt. The ground analysis showed solar radiation organized by slope in color coded polygons.

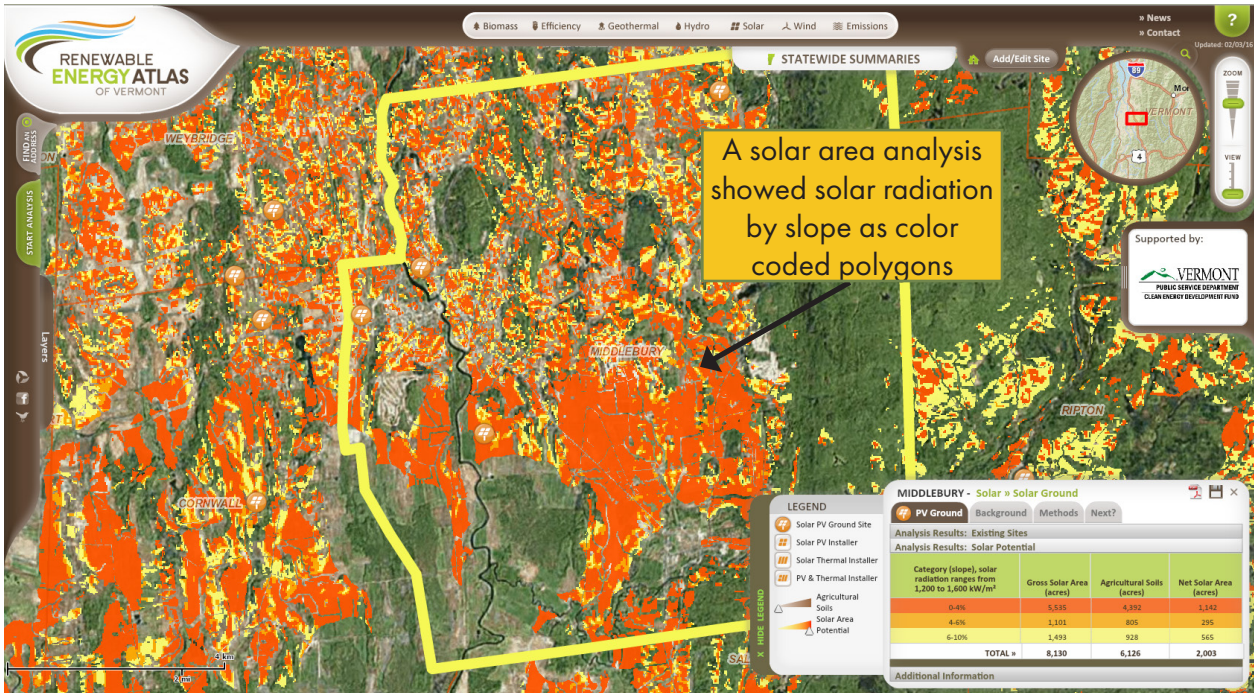
RENEWABLE ENERGY ATLAS — ROOFTOP SOLAR LAYER SELECTED



RENEWABLE ENERGY ATLAS — ROOFTOP SOLAR DETAIL



RENEWABLE ENERGY ATLAS — GROUND-MOUNTED SOLAR



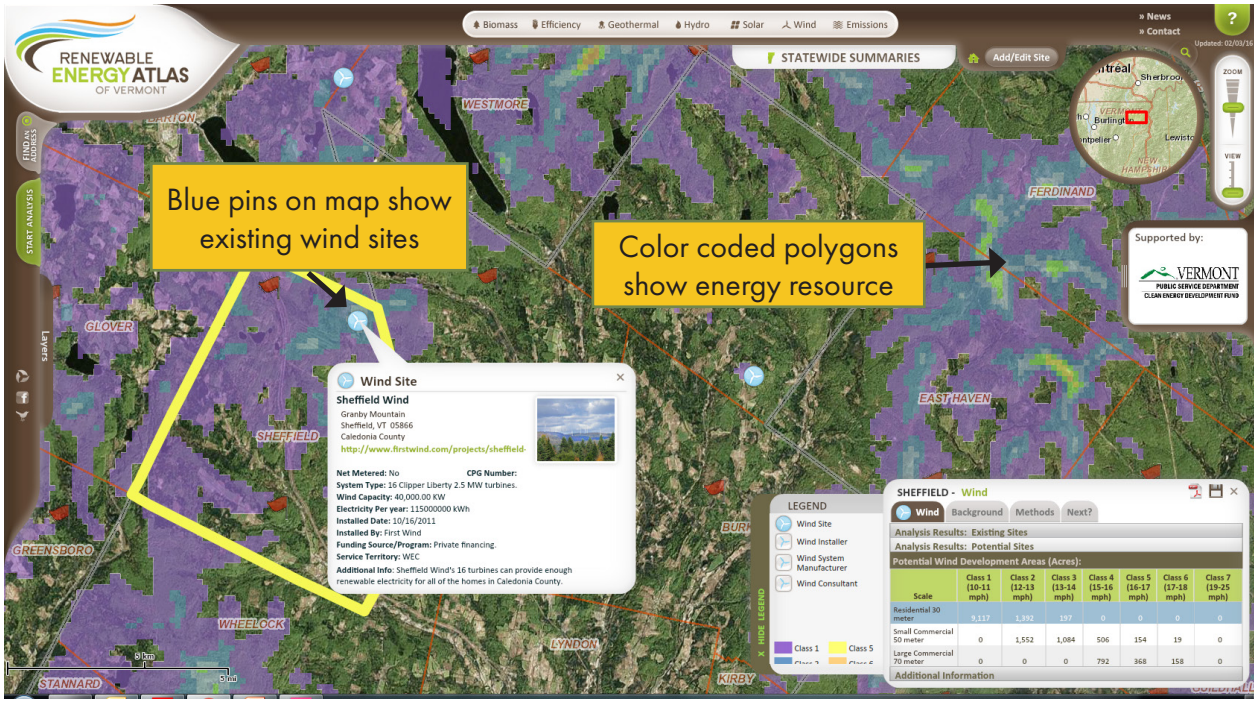
When an Atlas user clicked on Solar they had the option to choose Roof or Ground systems. For Roof Systems, a map appeared that showed orange pins for existing solar PV sites and house or building icons for potential sites. Clicking on potential sites generated a pop-up up window for solar radiation at that location, as well as derate tools for orientation, angle, and shading. For Ground Systems, orange pins appeared depicting existing ground mounted solar PV sites, while color coded polygons appeared for solar radiation.

- **Wind:** Wind power converts the kinetic energy of wind into electricity.

A collaborative effort between the Massachusetts Technology Collaborative, the Connecticut Clean Energy Fund, and the Renewable Energy Trust contracted AWS Truepower to produce the "Wind Resource Maps of Northern New England," a digital 200 meter (m) resolution dataset of predicted mean wind speed across northern New England at wind turbine hub heights of 30m, 50m, 70m, and 100m above effective ground level. This was the best "off the shelf," readily available data *and* it was publicly available.

When an Atlas user clicked on Wind they would be able to select 30m, 50m, or 70m hub heights which would appear as color coded polygons of mean wind speed. Points would appear for existing wind sites. The Analysis Results Panel would count the number of acres of land within the selected boundary by wind speed and hub height.

RENEWABLE ENERGY ATLAS — WIND LAYER SELECTED



Lessons Learned

- Use of proprietary programming software (i.e., ESRI's ArcGIS) increasingly constrained our ability to make updates to the Atlas (e.g., bulk upload of renewable energy sites was desired but not possible). Staff changes at Fountains Spatial also reduced our ability to make Atlas changes. Consequently, when we transitioned from the Renewable Energy Atlas to the Energy Action Network's **Community Energy Dashboard** we used open source software.
- The user interface of the Atlas proved to be overly complicated for some users. When we transitioned to the Dashboard we tested all features more extensively and made the user interface more intuitive.
- Bioenergy site development using the Atlas was of low interest to users compared to solar energy and wind siting and the overall statistical information that could be generated at town and county levels.
- VSJF did not have the staff capacity to provide deep technical assistance and education and outreach efforts to the many community energy groups in Vermont. This necessarily constrained the overall impact of the Atlas.

COMMUNITY ENERGY DASHBOARD

In 2014, an opportunity to work with the Energy Action Network (EAN)—a network of nonprofit, business, government, and community energy leaders—emerged that allowed VSJF to evolve the Energy Atlas into a more robust tool—the Community Energy Dashboard. VSJF led the conceptualization and development of the Dashboard, which was released in May 2016. The Dashboard has many more features than the Energy Atlas in order to serve public engagement and technology innovation leverage points, including:

BrighterVermont
CommunityEnergyDashboard
BUILDING A BETTER ENERGY FUTURE. TODAY.

- **Energy Atlas:** The Energy Atlas remains a tool for mapping town, county, and Regional Planning Commission boundaries for existing and potential renewable energy sites. With the tool, users can turn on additional "constraints" (e.g., endangered species habitat) in order to identify new potential sites that take environmental resources into account. Users can also crowdsource their own information.

- **Statistics:** Energy installations included in the Atlas database aggregate into real-time renewable energy installations, installed capacity, and electrical generation statistics for every town, county, and Regional Planning Commission in Vermont (e.g., Burlington, Franklin County, and Northeastern Vermont Development Association). Statistics allow users to see how their community ranks compared to other communities.

- **Analysis:** Statistics compiled by the Atlas and other official sources can then be turned into data visualizations (e.g., Renewable Electricity Sites) using software called Tableau that showcase long-term trends.

- **Stories:** The Dashboard is also a central repository for a growing list of Vermont energy stories, including Vermont Bioenergy Initiative created Bioenergy Now! videos and bioenergy stories.

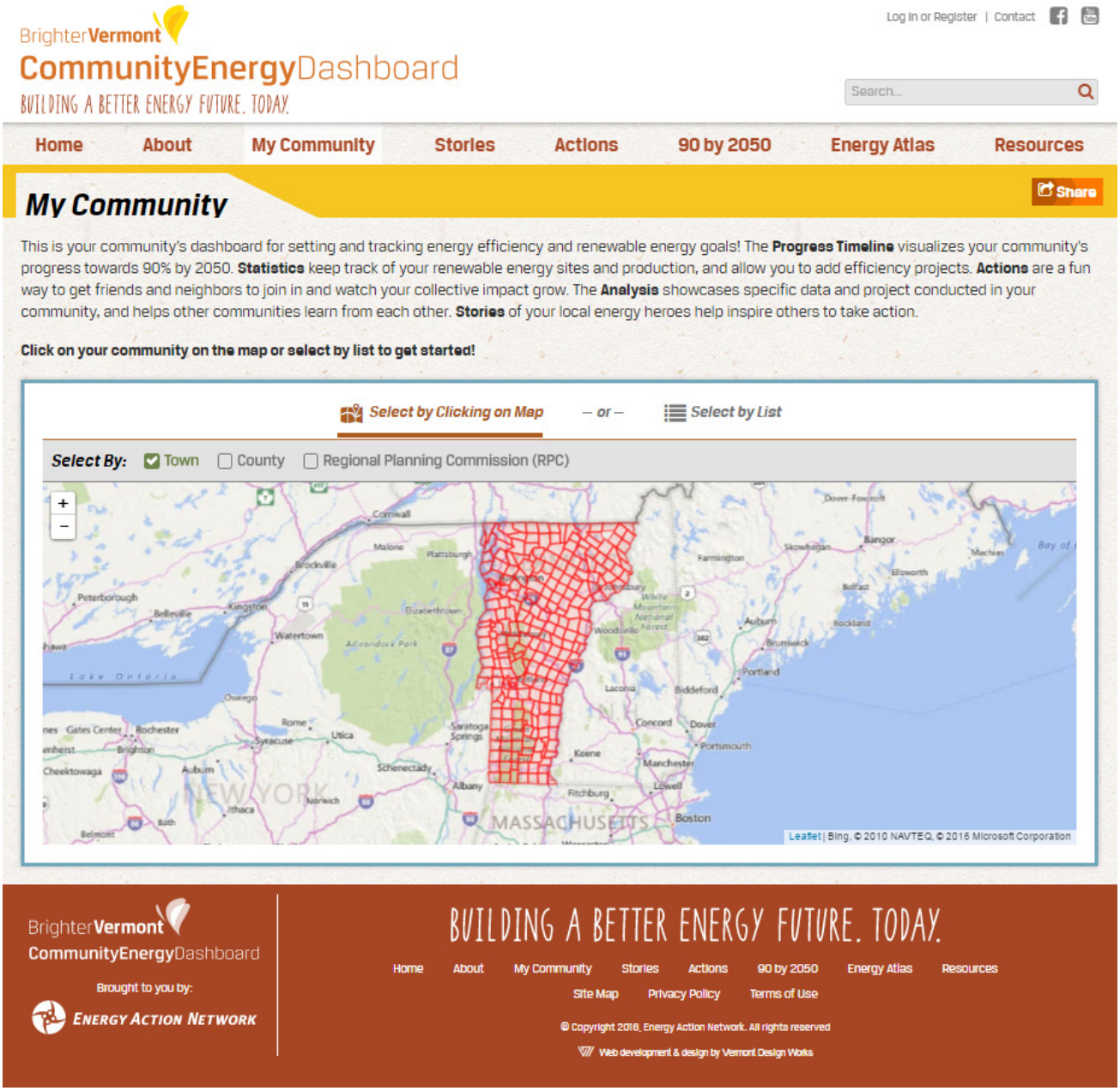
- **Progress Timeline:** A Progress Timeline for every community in Vermont allows Dashboard users to track community progress towards meeting 90% of local energy needs through efficiency and renewables by 2050. Each Progress Timeline includes heat and transportation calculations.

- **Actions:** Action "tiles" provide an interactive way for Dashboard users to add individual, business, municipal, school and farm actions in order to showcase the collective impact of their community.

COMMUNITY ENERGY DASHBOARD — HOMEPAGE

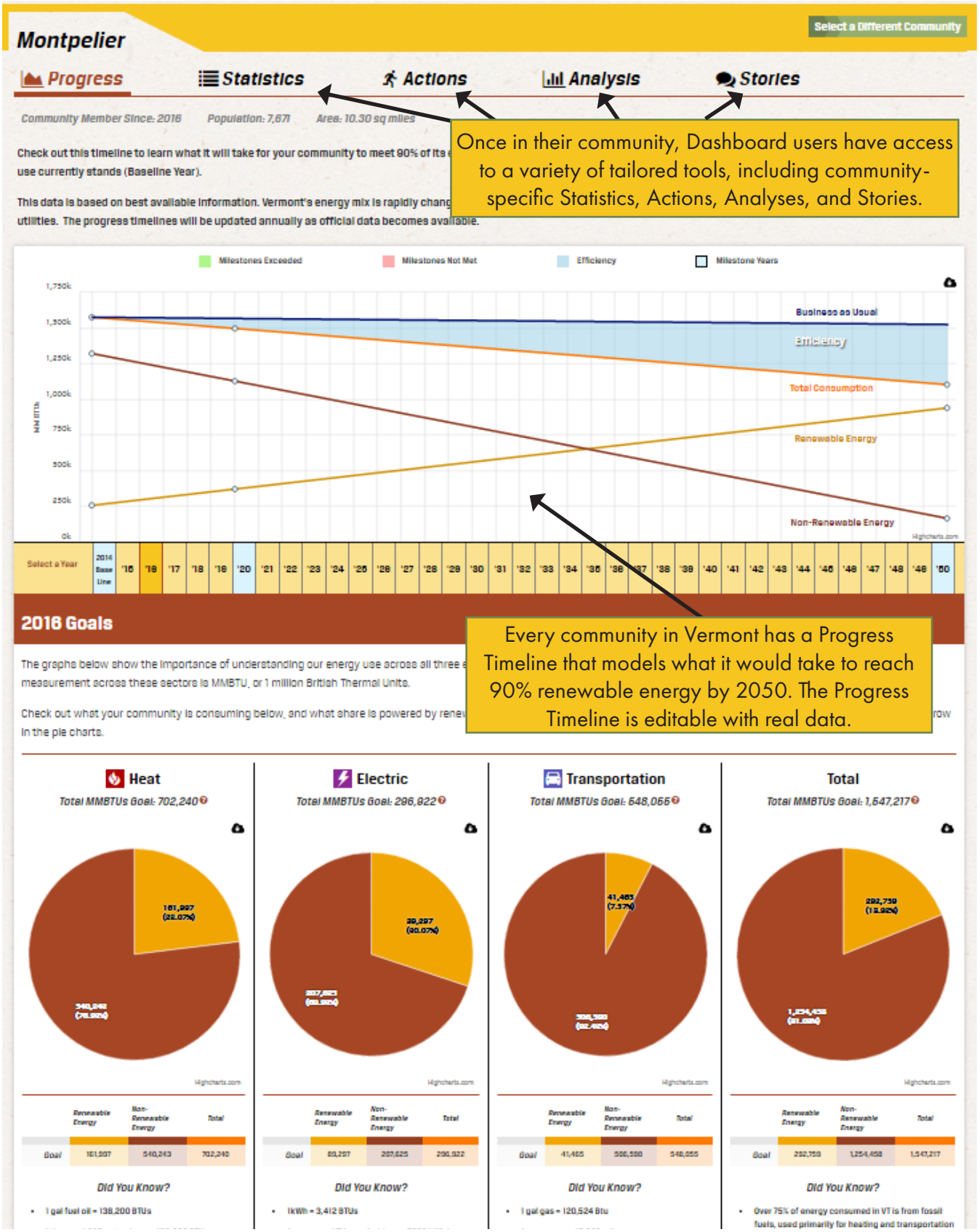
The Community Energy Dashboard homepage features a rotating Stories carousel; links to "Find Your Community!" and "Take Action!"; a rotating carousel of Actions taken by individuals, communities, and businesses; and navigation to all of the other pages on the website.

COMMUNITY ENERGY DASHBOARD — MY COMMUNITY SELECTION

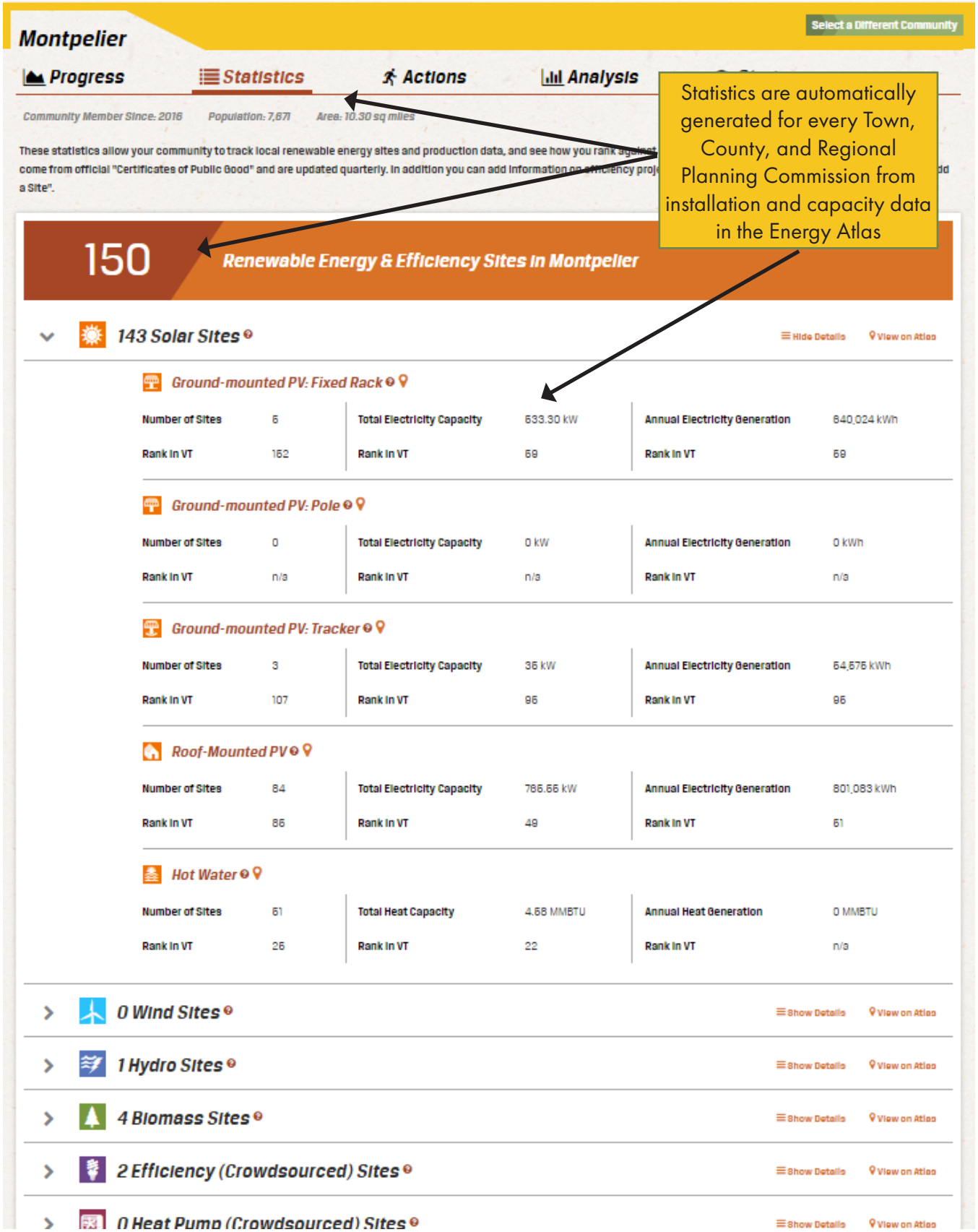


The My Community page features selection options for every Town, County, and Regional Planning Commission in Vermont. Users can select their community by clicking directly on the map or by selecting from a list.

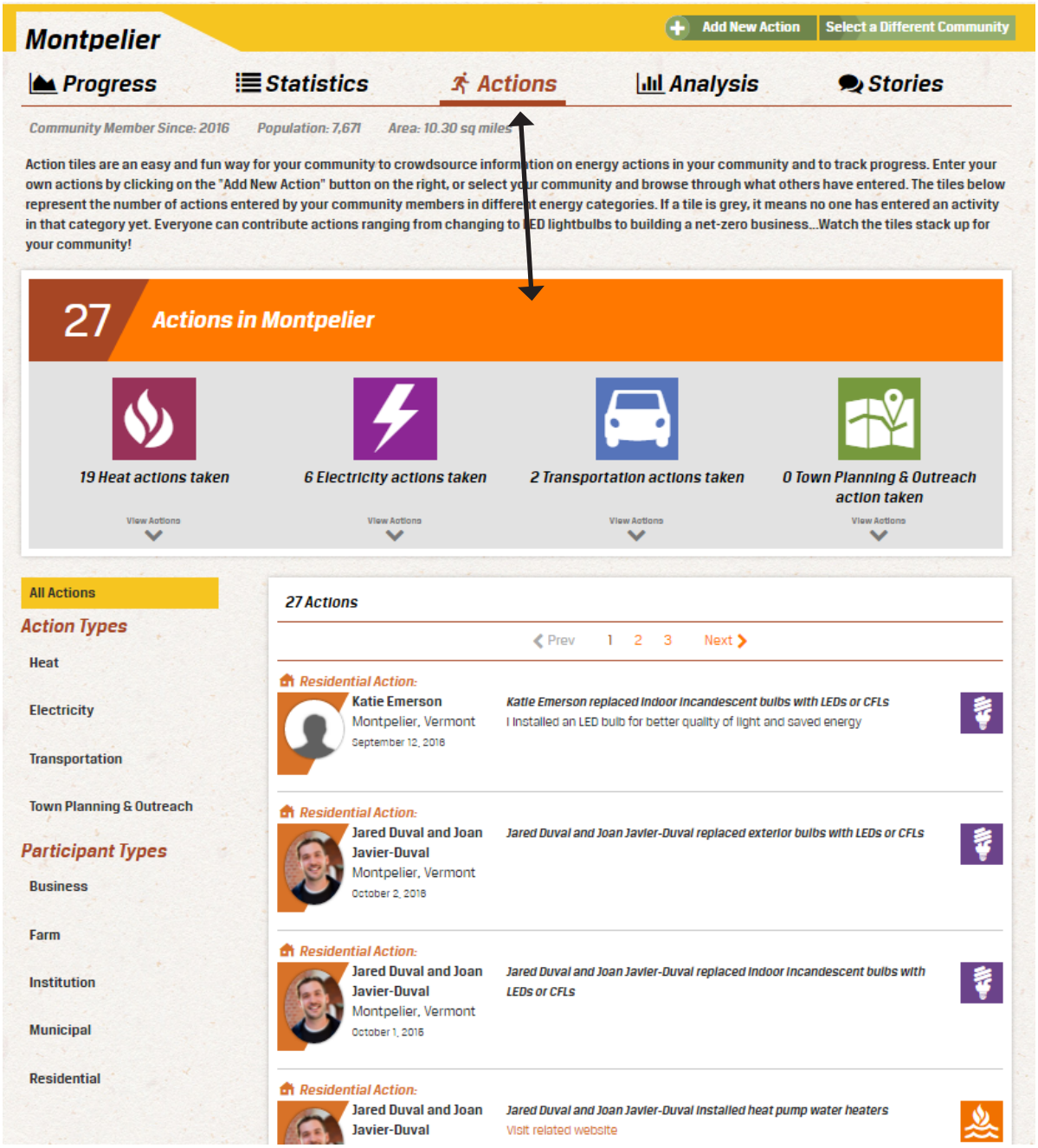
COMMUNITY ENERGY DASHBOARD — PROGRESS TIMELINE



COMMUNITY ENERGY DASHBOARD — COMMUNITY STATISTICS

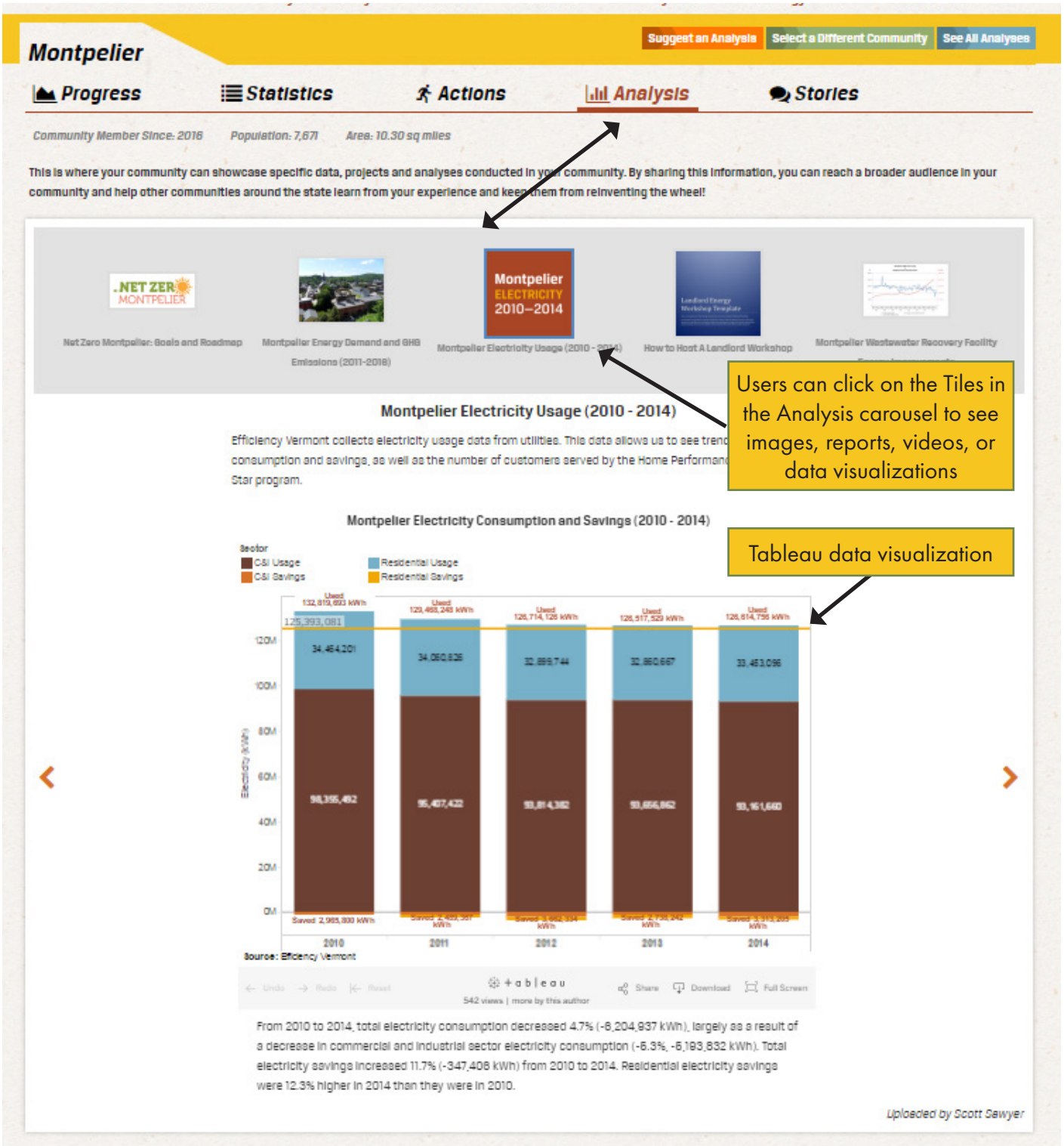


COMMUNITY ENERGY DASHBOARD — COMMUNITY ACTIONS



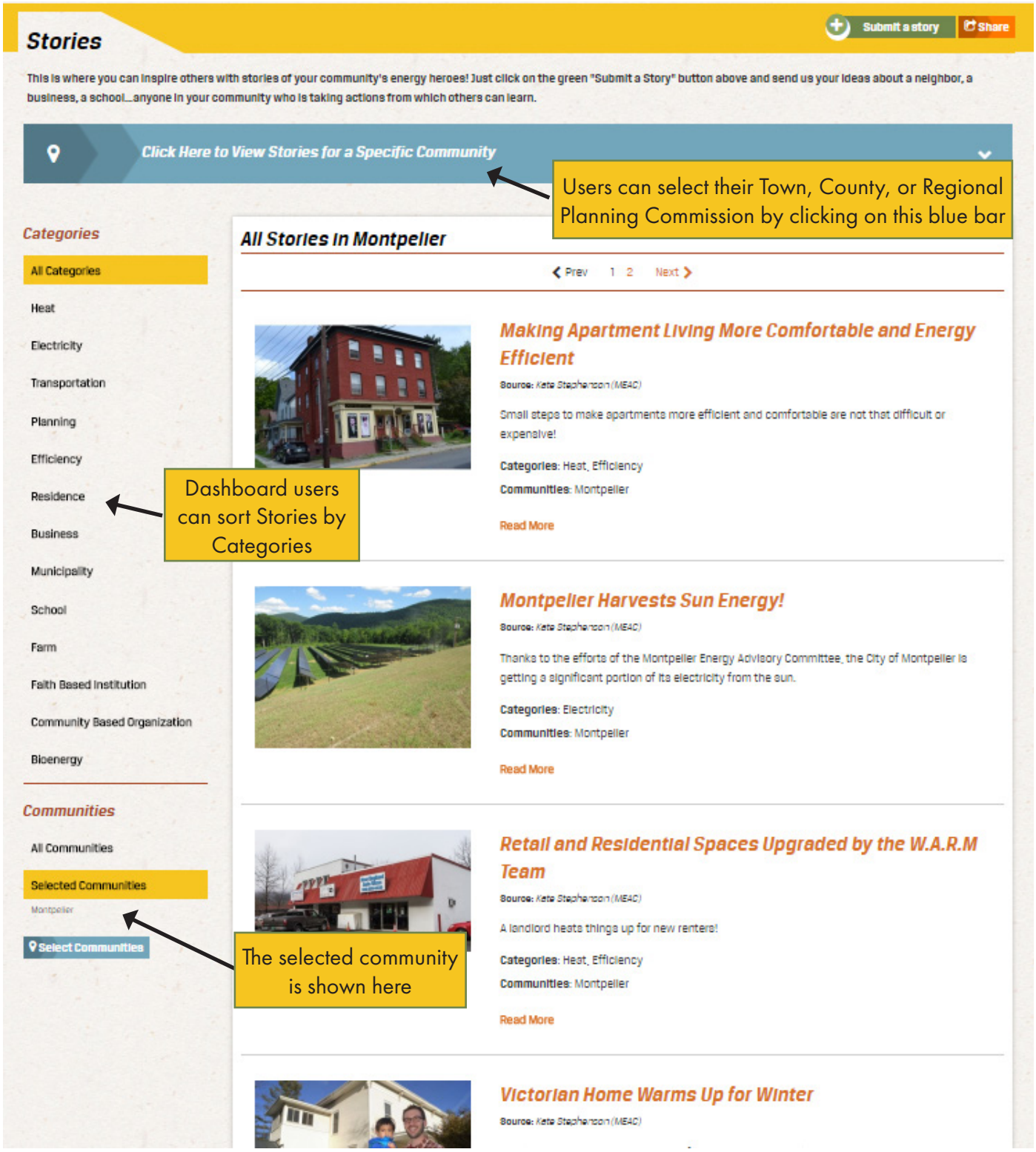
Dashboard users can click on a variety of Heat, Electricity, Transportation, and Town Planning & Outreach tiles to show that they have taken an Action. Actions can be sorted by Energy Type (i.e., Heat, Electricity) and by Participant Type (i.e., Business, Farm). The Actions are compiled for the community they live in, as well as the statewide total. Actions are also shown in a carousel on the homepage.

COMMUNITY ENERGY DASHBOARD — COMMUNITY ANALYSIS



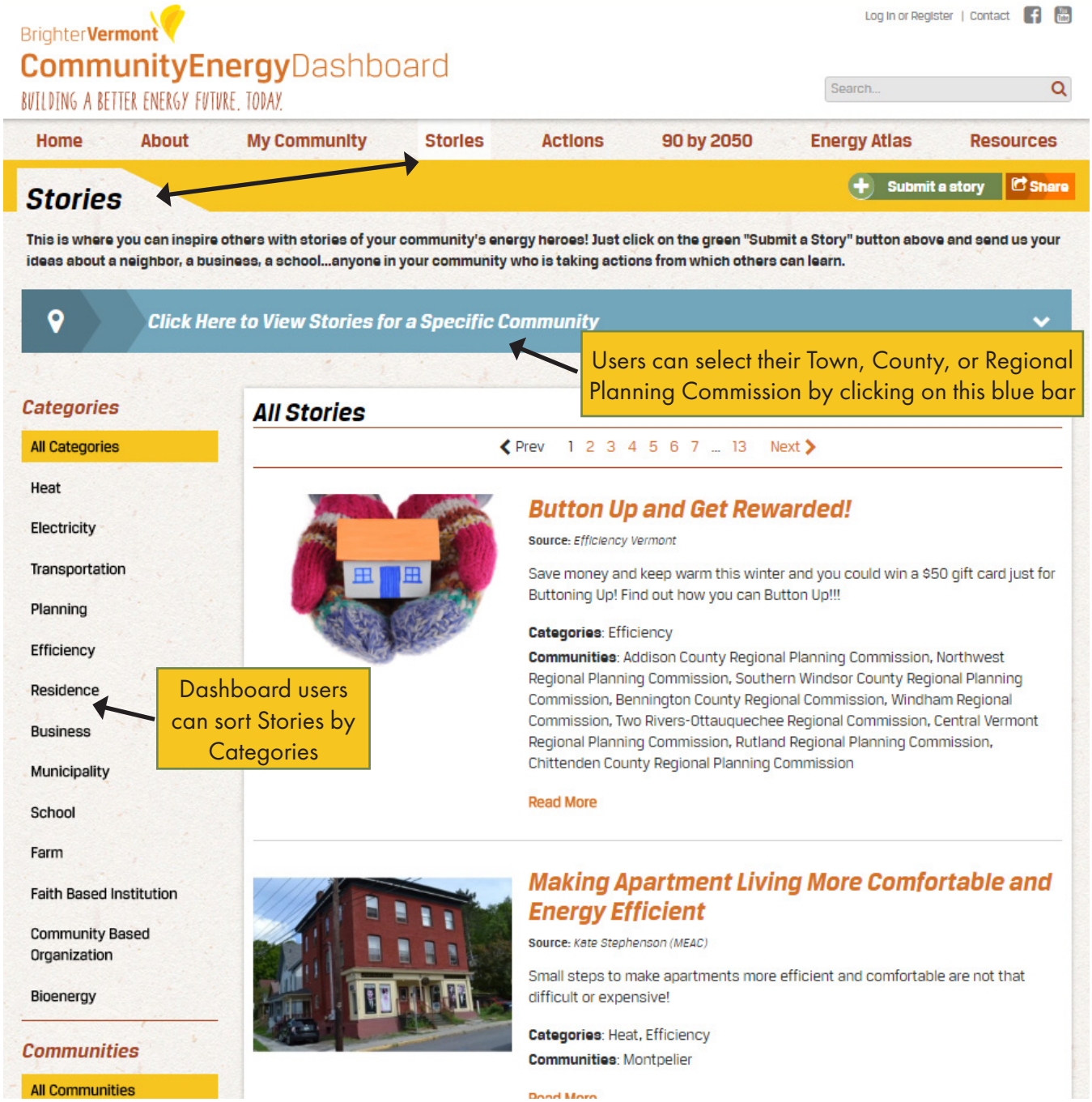
Every Town, County, and Regional Planning Commission has the ability to crowd source (i.e., upload) analyses that they have conducted for their community. Images, reports, videos, and Tableau data visualizations can all be uploaded.

COMMUNITY ENERGY DASHBOARD — COMMUNITY STORIES



Clicking on Stories while on a "My Community" page shows Dashboard users only stories about their community. In this case, Stories about Montpelier are shown.

COMMUNITY ENERGY DASHBOARD — STORIES LANDING PAGE



By default, the Stories landing page shows all Stories in Vermont in chronological order. Dashboard users can sort Stories by selecting one or several Communities or by clicking on Categories. Dashboard users can submit their own stories by clicking on the green button at the top right of the screen.

COMMUNITY ENERGY DASHBOARD — STORY DETAIL PAGE

Home | About | My Community | Stories | Actions | 90 by 2050 | Energy Atlas | Resources

Biodiesel Production at Borderview Farm

Submit a story | Share

View All Stories

Roger Rainville with BioPro 190 automated biodiesel processor at Borderview Farm. Photo credit: VSJF

Source: *Vermont Sustainable Jobs Fund*

Roger Rainville's dairy-turned-energy farm in Grand Isle County is a place where area dairy farmers, organic growers, and landowners have made biodiesel from their own locally-grown sunflower seeds.

In 2008, when diesel prices rose from $4 to $5 per gallon, Rainville began experimenting with farm-scale biodiesel production. With guidance from **University of Vermont (UVM) Extension** and grant funding from **Vermont Sustainable Jobs Fund's Vermont Bioenergy Initiative**, Rainville began planting sunflowers on a portion of his 214 acres and installing biodiesel processing equipment. Oilseed sunflowers (as opposed to confectionary sunflowers that are grown for eating) are the most popular oilseed crop in Vermont, with hundreds of acres planted statewide. The crop is grown in rotation with grains and grasses and yields high quantities of oil.

Relevant Categories

Farm

Bioenergy

Communities

Grand Isle County

Alburgh

Action Date

Jan 2009

Highlights:

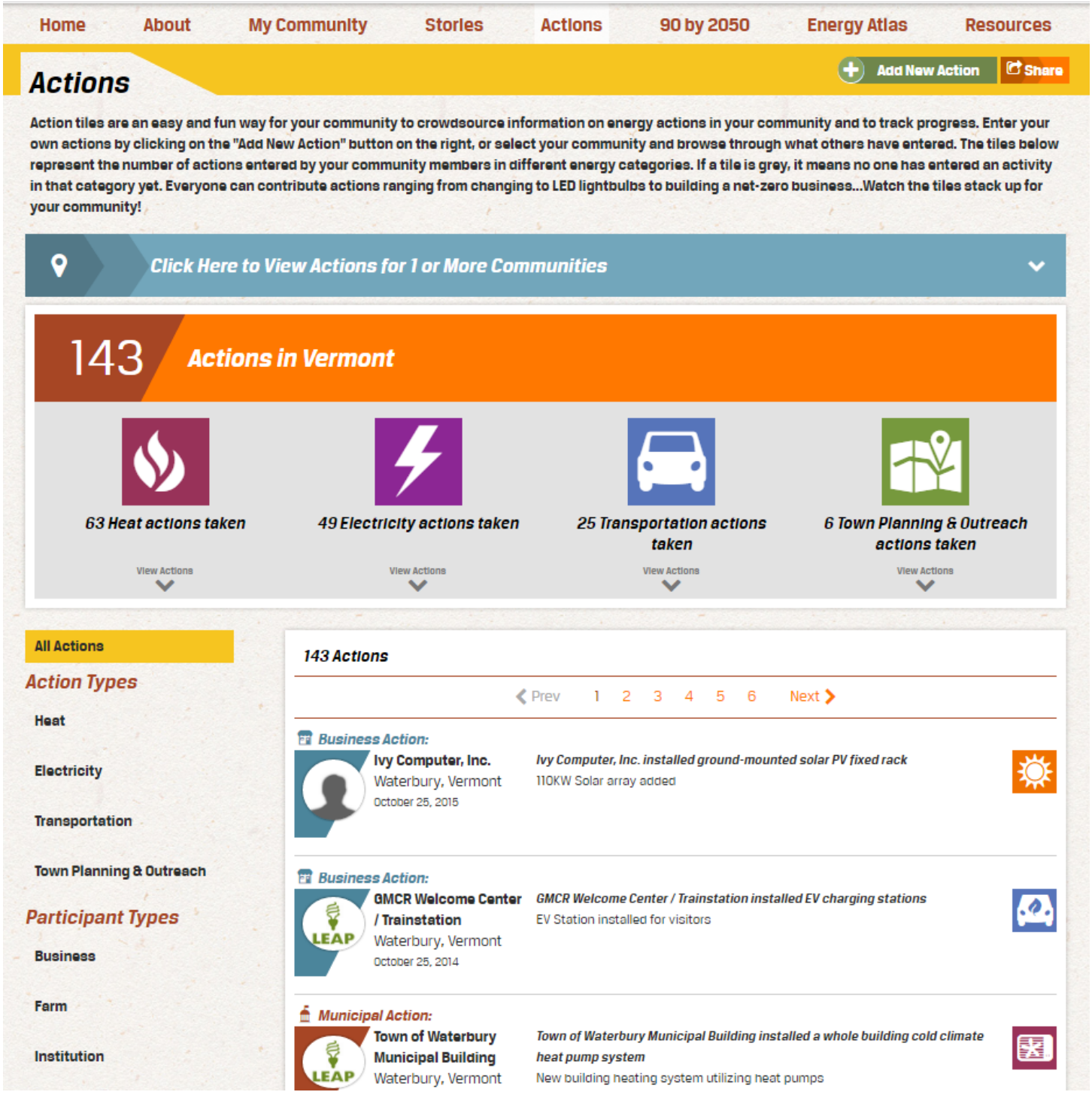
- Cost of biodiesel production = $2.29 per gallon
- Seed meal used as a co-product for livestock feed or crop fertilizer
- Central processing facility and shared equipment use maximizes efficiency for neighboring farms

Harvesting, Cleaning, and Pressing

Following harvest with a combine, a seed cleaner and grain dryer are used to prepare the seeds for storage in a 200-ton grain bin prior to processing. A flex auger system moves the seeds from the storage bin into hoppers on each press, and screw augers push the seed through a narrow dye at the front of the press. Extracted oil oozes from the side of the barrel and is collected in settling tanks while pelletized meal is pushed through the dye at the front and is stored in one-ton

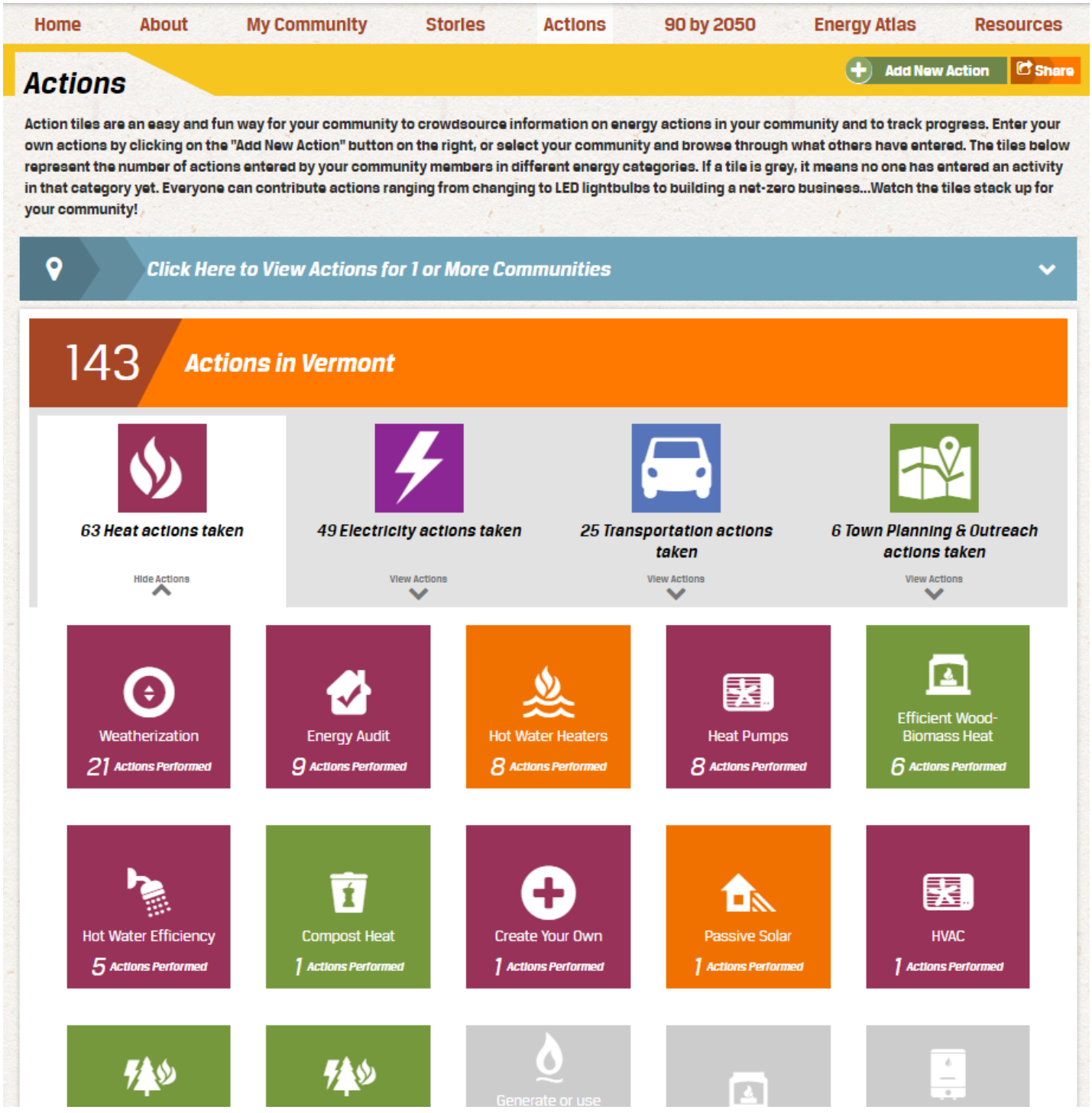
Clicking on a Story takes Dashboard users to a detail page that includes text and a photo or a video.

COMMUNITY ENERGY DASHBOARD — ACTIONS LANDING PAGE



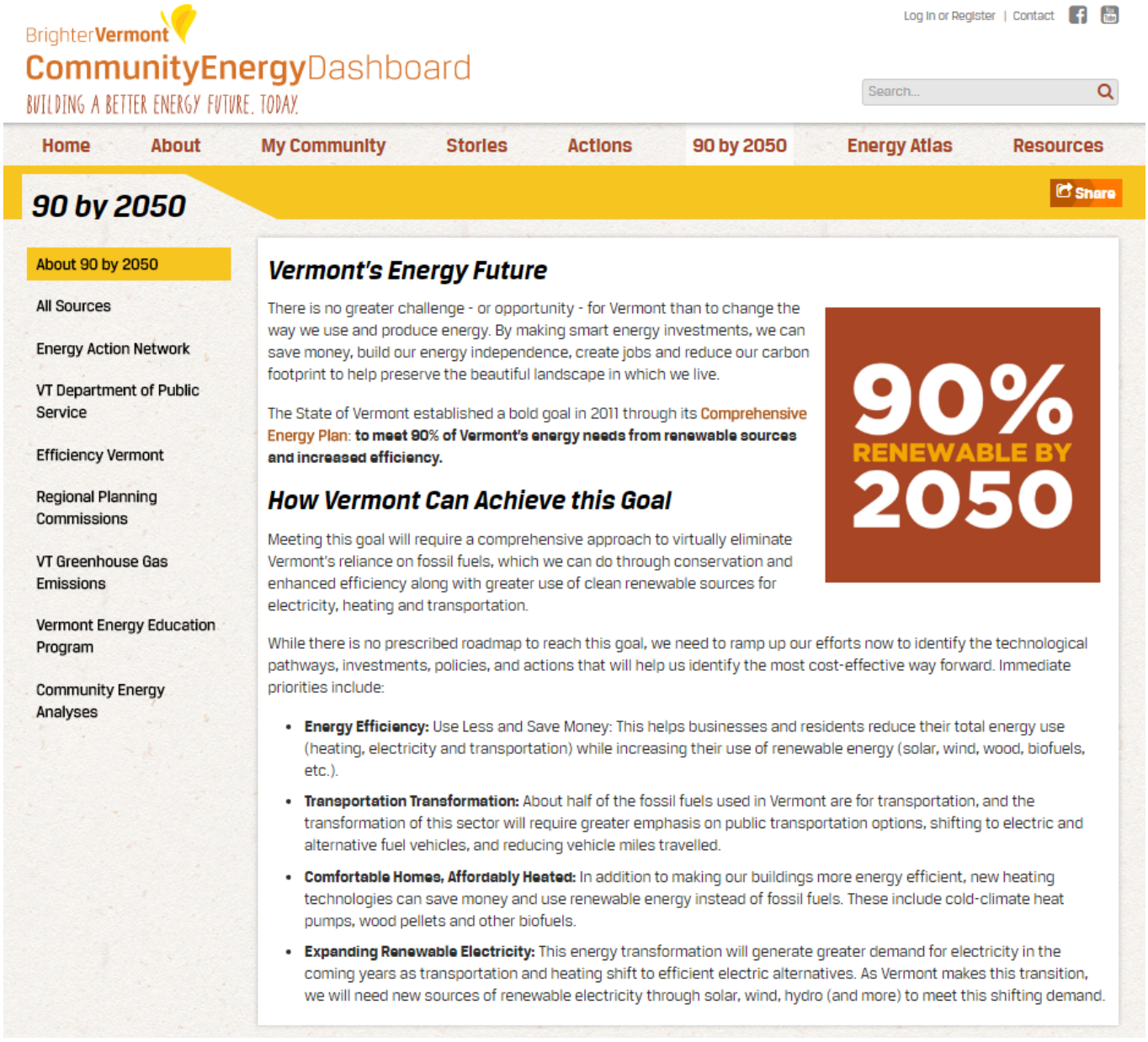
The Actions landing page shows all crowd sourced Actions entered by Dashboard users. Actions are categorized by Heat, Electricity, Transportation, and Town Planning & Outreach, as well as by Participant Type (i.e., Business, Farm).

COMMUNITY ENERGY DASHBOARD — ACTIONS DETAIL PAGE

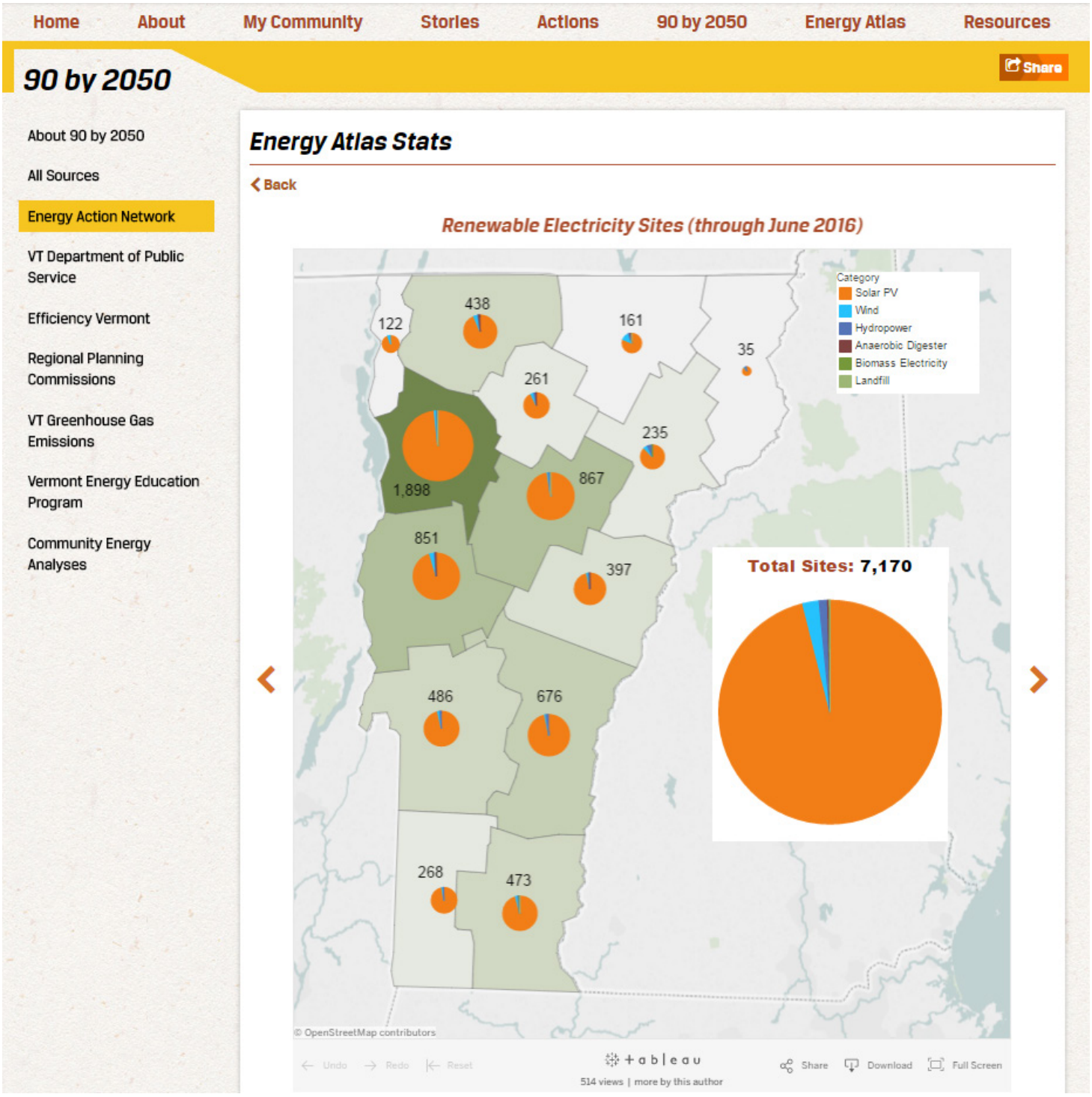


Clicking on one of the major energy Action tiles reveals the subset of related Actions that Dashboard users have taken. Actions are shown from most to least, and greyed out tiles show Actions that have not been taken yet.

COMMUNITY ENERGY DASHBOARD — 90 BY 2050 LANDING PAGE

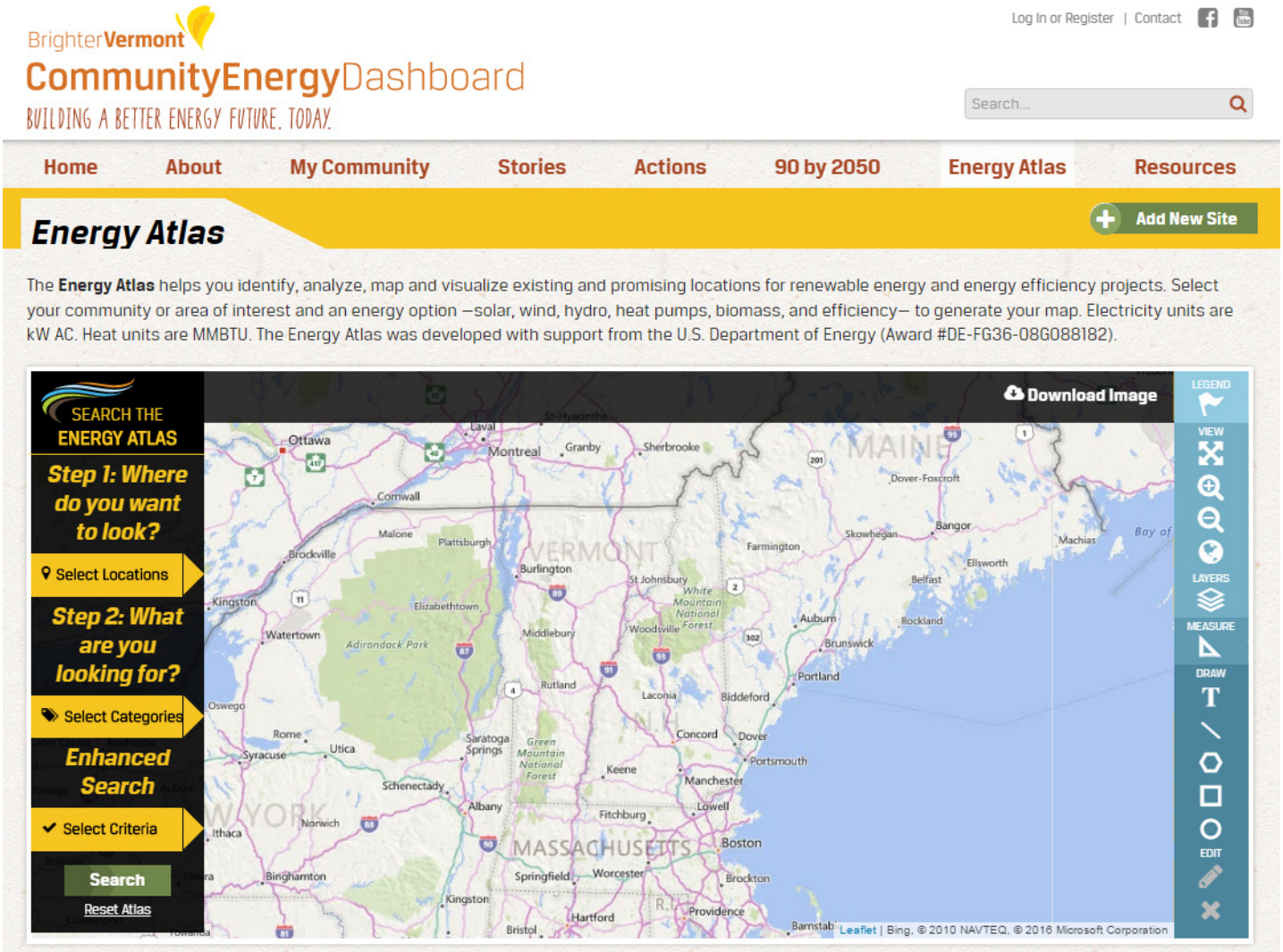


The State of Vermont has a bold goal: to meet 90% of its energy needs through increased efficiency and renewable sources by 2050. The 90 by 2050 landing page showcases big picture data analyses conducted by energy organizations in Vermont.



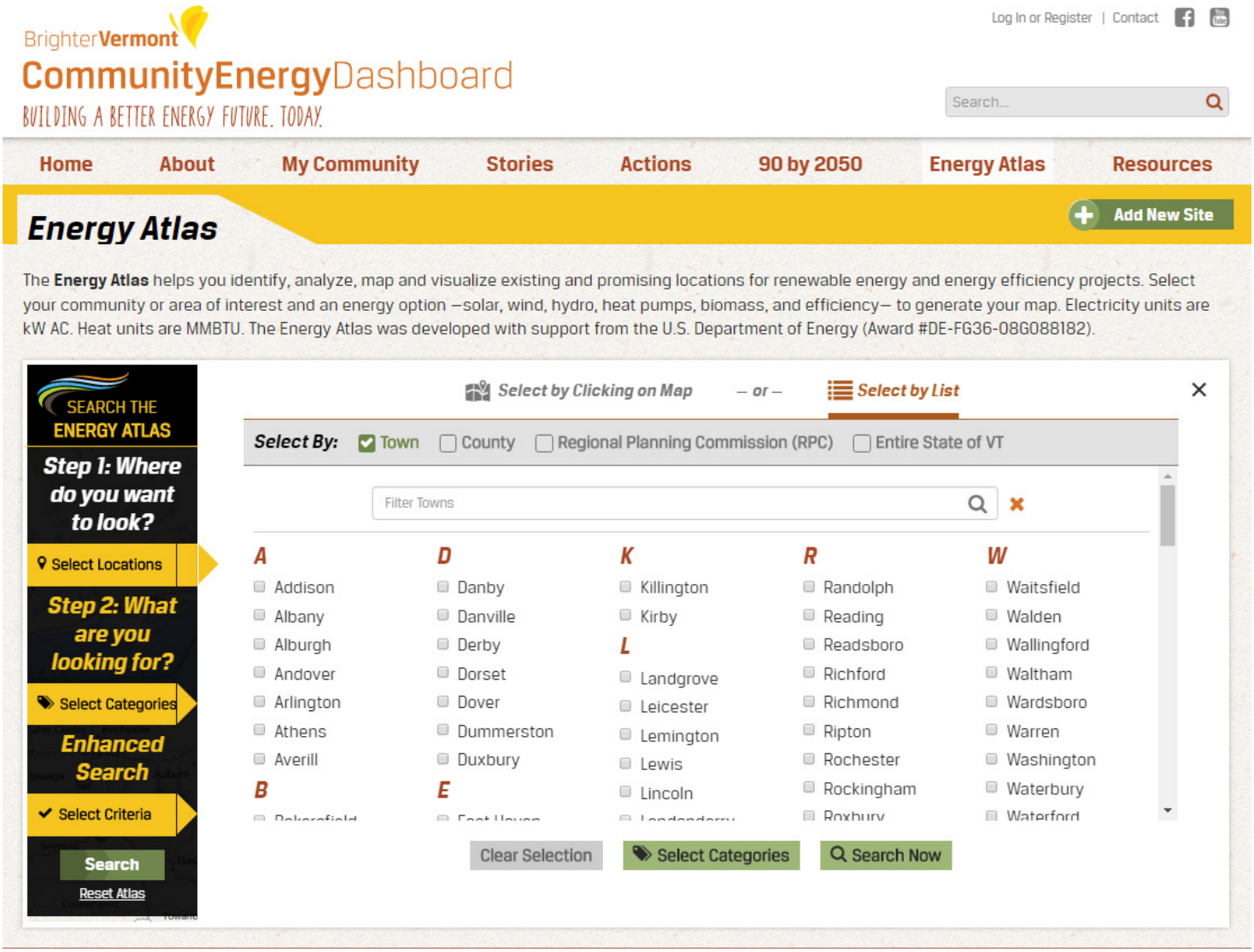
Graphics, including images, videos, and Tableau data visualizations can be uploaded to the 90 by 2050 pages. In this case, statistics from the Energy Atlas are used to provide a Statewide Summary of renewable electricity sites by county and energy category.

COMMUNITY ENERGY DASHBOARD — ENERGY ATLAS



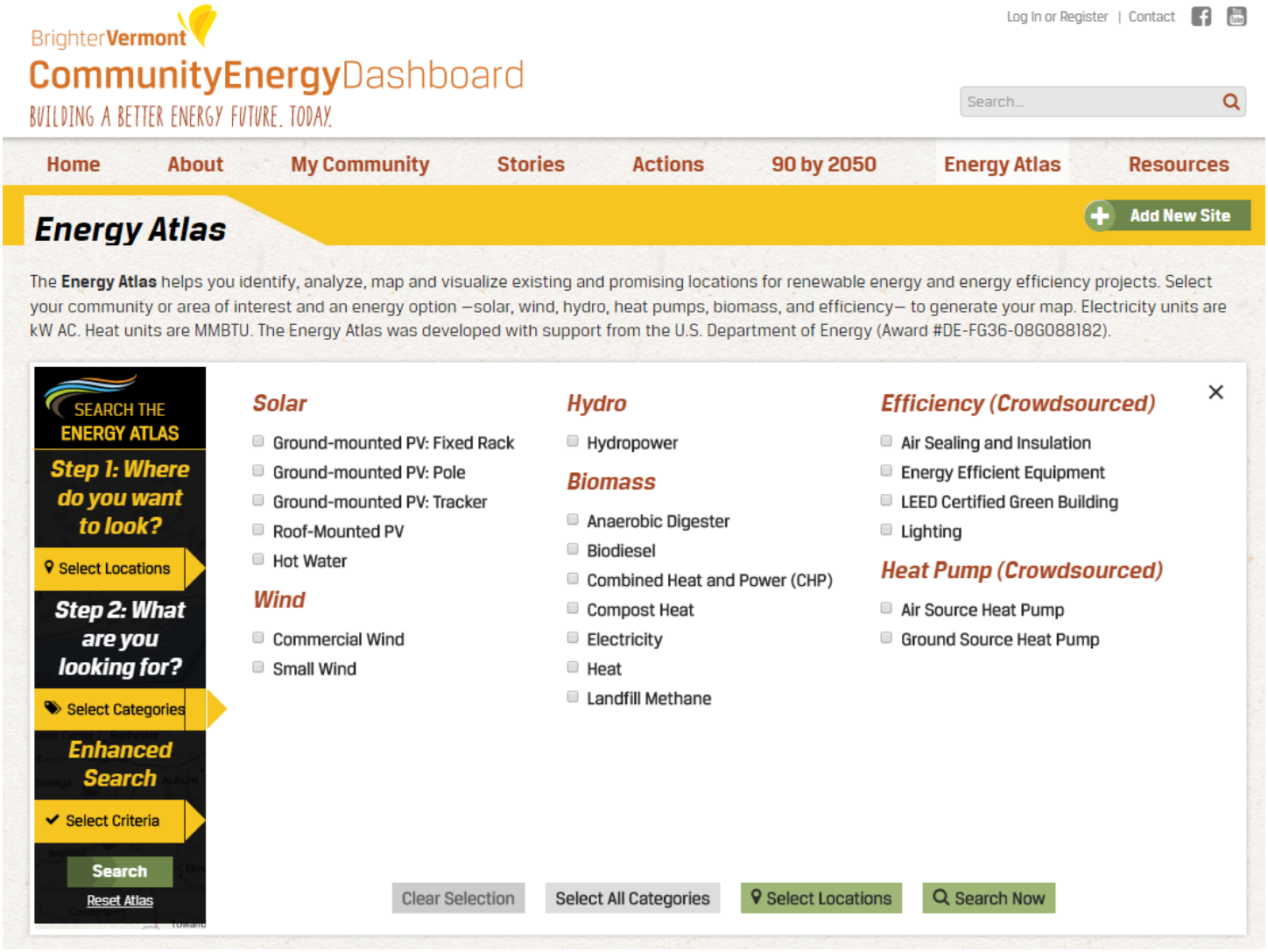
The Energy Atlas is now a major component of the Community Energy Dashboard. Data for all of the "sites" that appear on the map are collected from "certificates of public good" issued by the Vermont Public Service Board, the Vermont Dam Inventory, AgSTAR, and crowdsourcing. The sites database is a major content generator for the Dashboard. Beyond populating the Atlas, it provides Statistics for every community in Vermont, it helps to update the Progress Timeline, and data from the sites database is used to generate 90 by 2050 data visualizations.

COMMUNITY ENERGY DASHBOARD — ENERGY ATLAS SELECT LOCATIONS



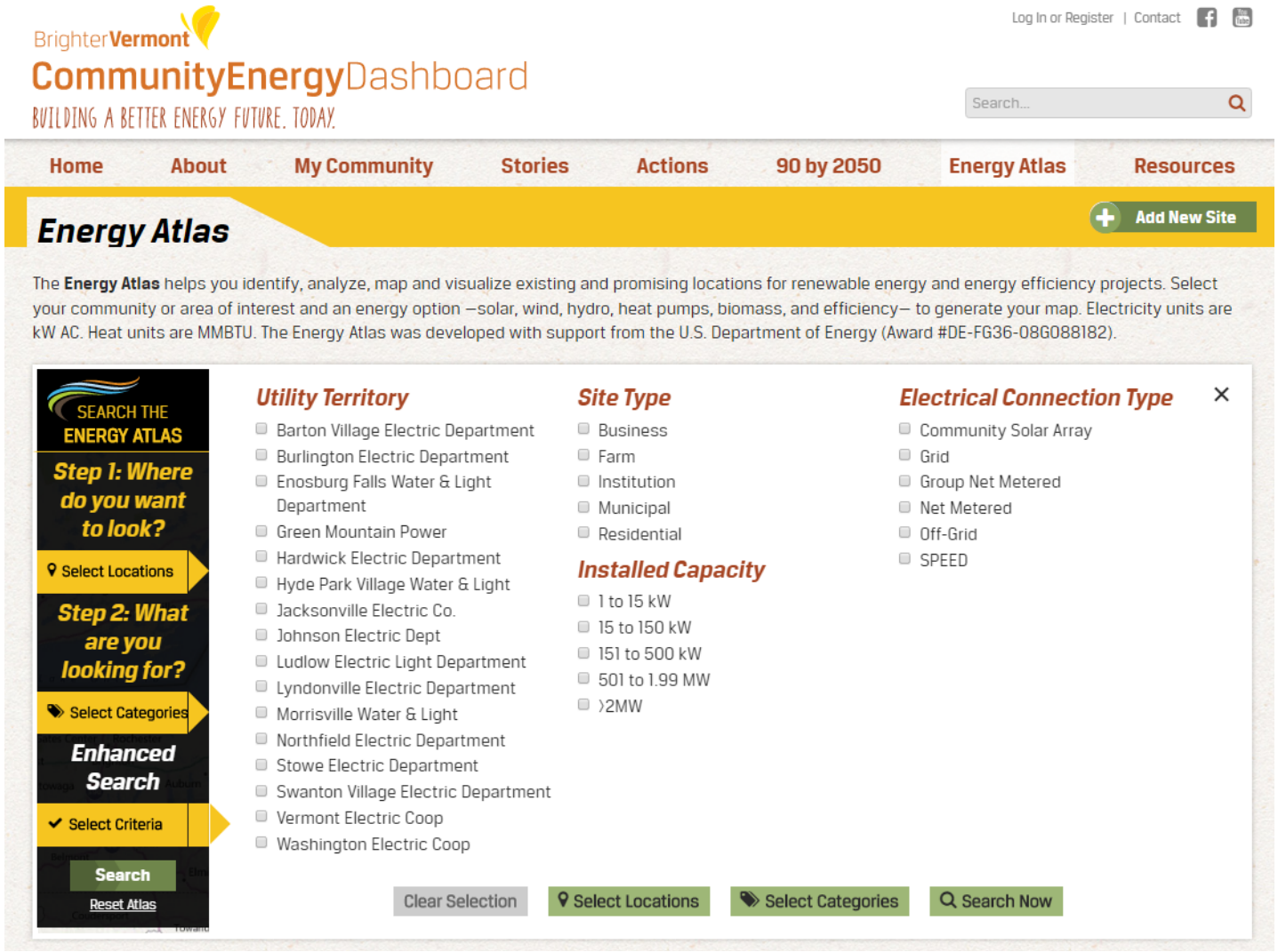
Dashboard users can select their community by clicking directly on the map or by selecting from a list. Dashboard users can start typing the name of their community using a filter tool to find their community more quickly. Users can click the green boxes in this window to select Energy Categories or generate a map immediately. They can also click on the yellow boxes to the left to select Energy Categories or Enhanced Search Criteria.

COMMUNITY ENERGY DASHBOARD — ENERGY ATLAS SELECT CATEGORIES

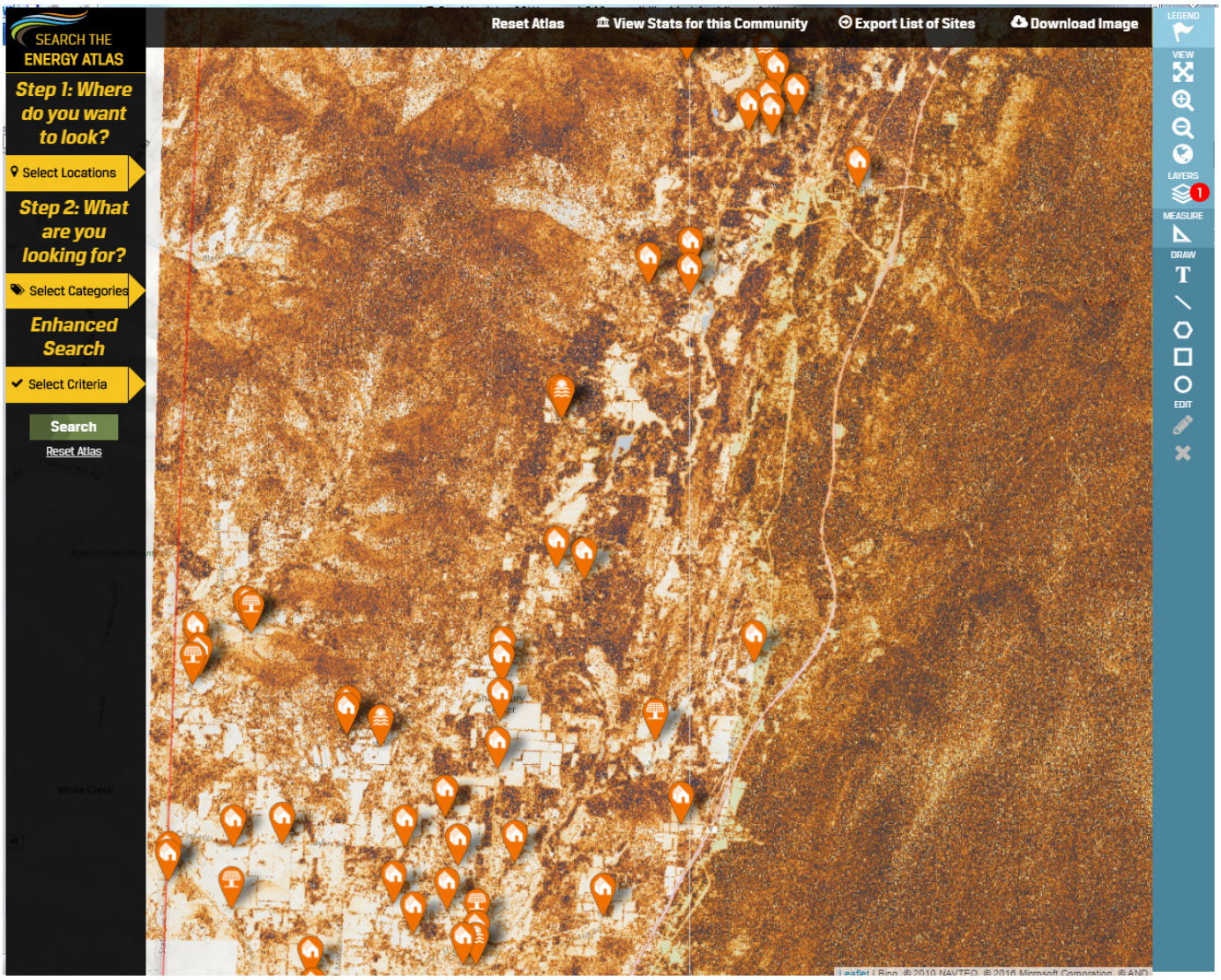


After selecting an area, Dashboard users can select one or many Energy Categories. This is an improvement over the original Energy Atlas, which allowed for selecting only one community at a time.

COMMUNITY ENERGY DASHBOARD — ENERGY ATLAS ENHANCED SEARCH



Dashboard users can select additional criteria to sort their results, including utility territory, site type (e.g., Farm, Residential), and system size.



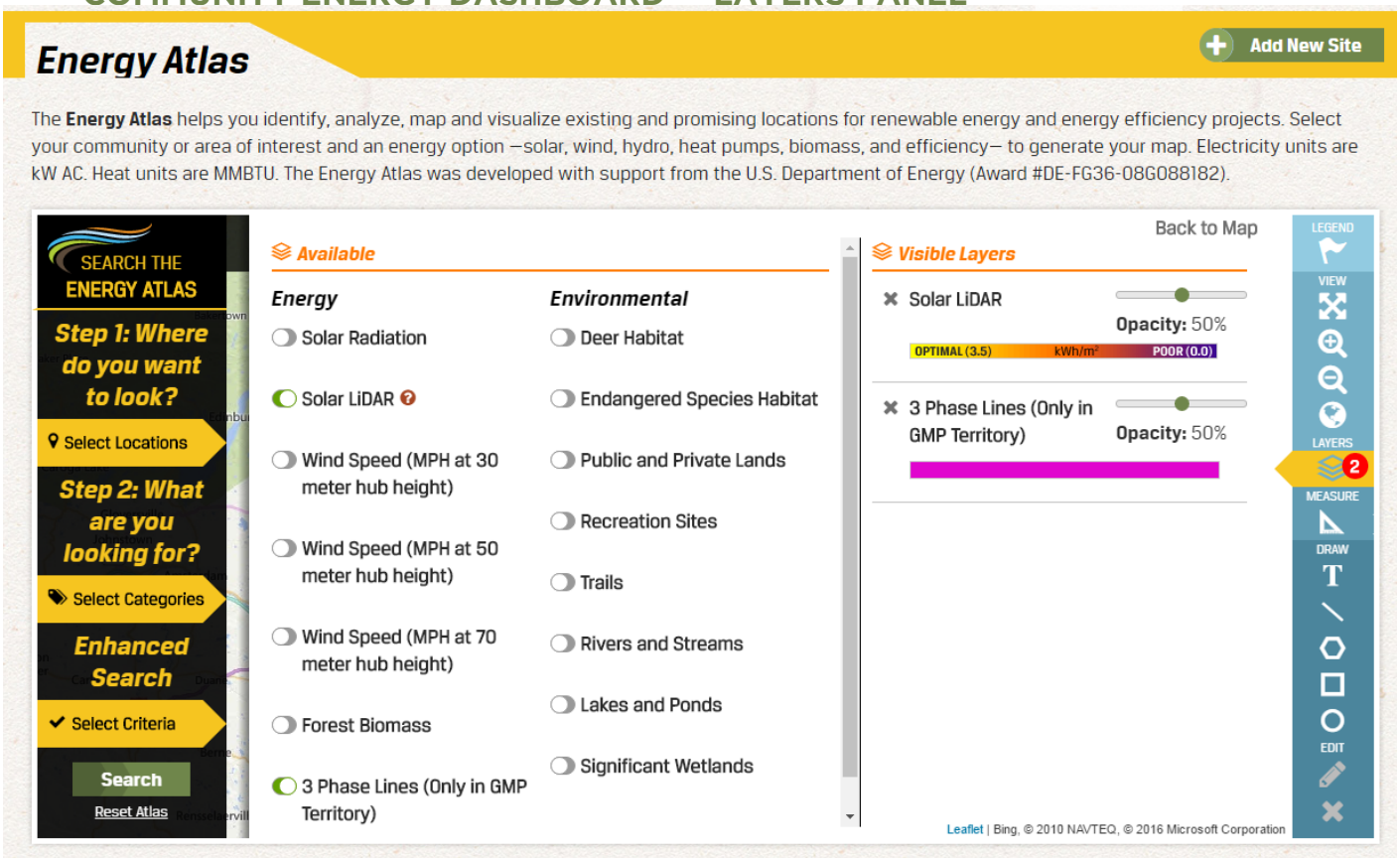
In this example, Bennington County has been selected as the area, and all solar types have been selected as the energy category. The fullscreen view switch has been toggled on.

Improved Solar Data

Highly accurate elevation data created using an airborne optical technique known as LIDAR (Light Detection and Ranging) is analyzed in concert with local shading, seasonal sun angles, day length and general climate and sun availability conditions relative to Vermont. The resulting data layer provides a level of accuracy that it is orders of magnitude greater than the ESRI Solar Radiation tool. The state currently has 45% coverage of this valuable resource with the Vermont LiDAR Initiative actively planning to acquire the remainder. The Dashboard will

replace the solar data layers created with the ESRI Solar Radiation tool with the LIDAR data as it becomes increasingly available.

COMMUNITY ENERGY DASHBOARD — LAYERS PANEL

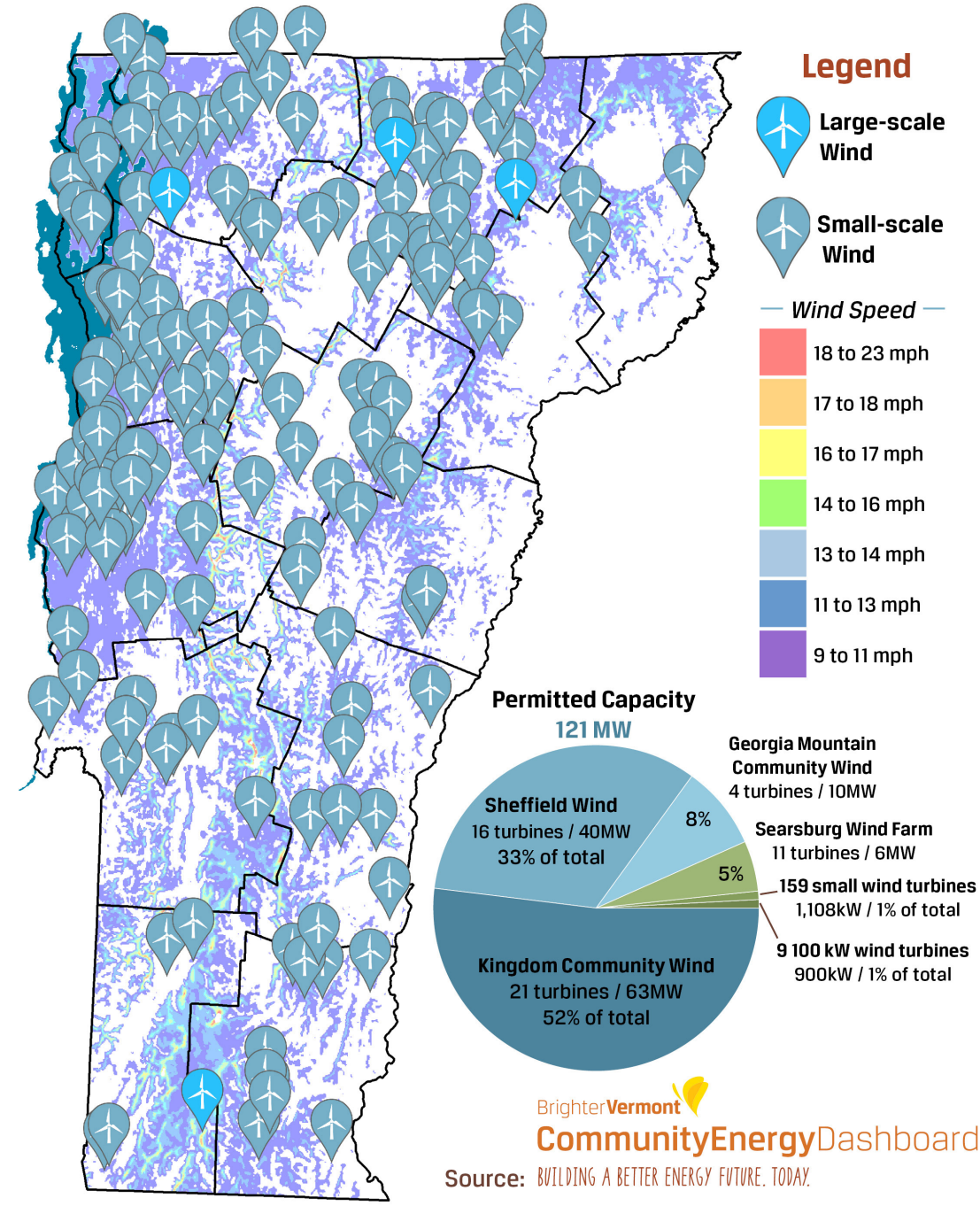


Dashboard users can view the Data Layers that are turned on and adjust their opacity. Drawing and labeling tools are also available in the blue toolbar on the right side of the screen.

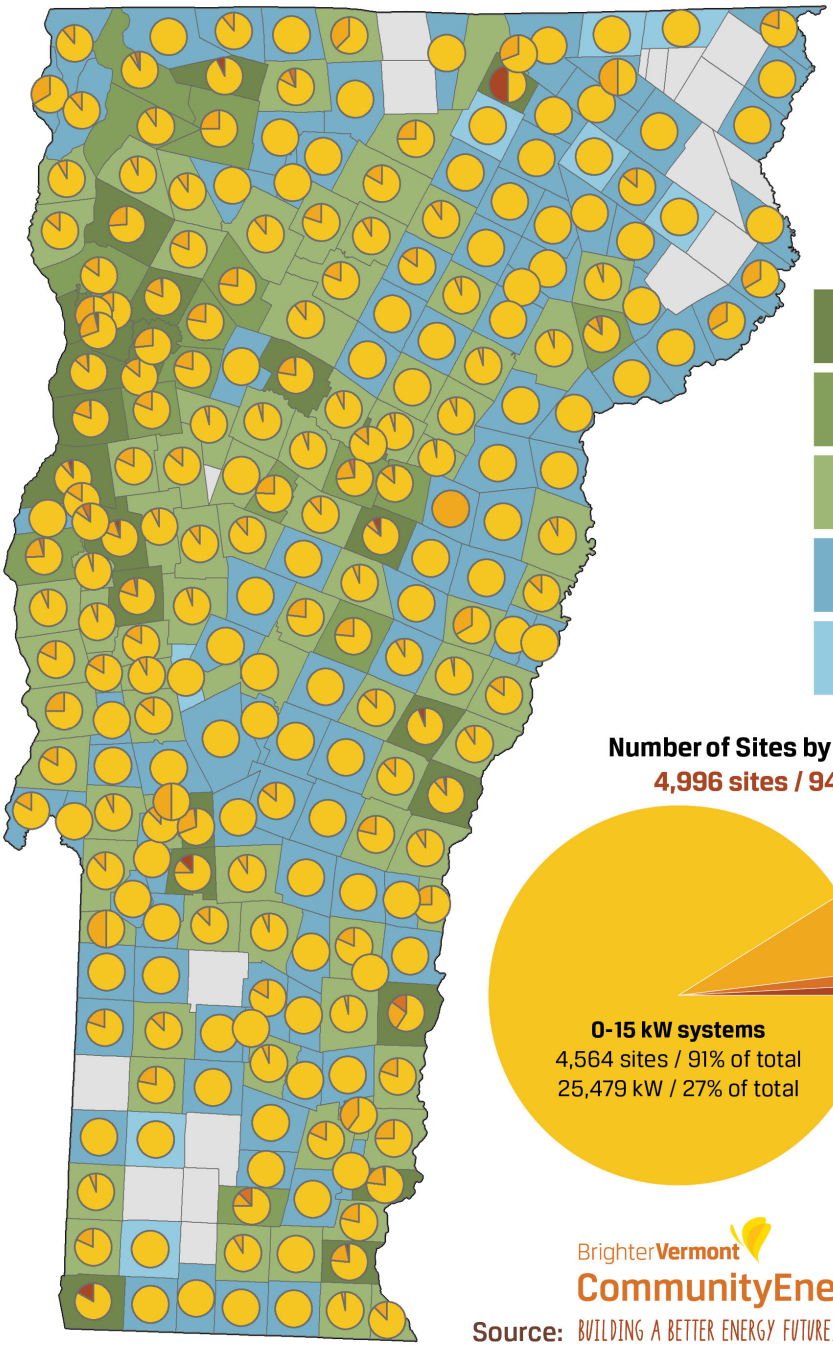
The robust installed renewable energy sites database behind the scenes—created by VSJF for the Energy Atlas—also allows EAN and VSJF to create graphically interesting reports and infographics.

September 2015

All Vermont Wind Projects



All Solar PV by Town



Note: this map only depicts the location of generation sites and does not account for capacity factors, renewable energy credits sold, or ownership of systems.

Many more solar projects—representing thousands of kilowatts— have been permitted but not yet built.

Legend

- 1,001 - 8,000 kW
- 501 - 1,000 kW
- 101 - 500 kW
- 6 - 100 kW
- 1 - 5 kW

Number of Sites by System Size

4,996 sites / 94,860 kW

0-15 kW systems
4,564 sites / 91% of total
25,479 kW / 27% of total

15-150 kW systems
346 sites / 7% of total
19,054 kW / 20% of total

150-500 kW systems
56 sites / 1% of total
8,734 kW / 9% of total

›500 kW systems
30 sites / 0.6% of total
41,593kW / 44% of total

BrighterVermont
CommunityEnergyDashboard

Source: BUILDING A BETTER ENERGY FUTURE. TODAY.

NEXT STEPS

The Energy Action Network (EAN) is diligently working with the Vermont Department of Public Service, Vermont Energy and Climate Action Network (VECAN), town energy committees, Vermont Energy Investment Corporation, Efficiency Vermont, Green Mountain Power, municipal governments, and regional planning commissions to roll out the Dashboard. Many presentations, webinars, and hands-on tutorials have been provided since the launch of the website in May 2016.

Going forward, EAN will continue to build the capacity of these organizations to make full use of the Dashboard to document their progress toward meeting 90% of Vermont's energy needs through increased efficiency and renewable sources by 2050. In many respects, the mapping, data visualization, statistical analysis, and storytelling functions of the Dashboard make it the centerpiece of Vermont's 90 by 2050 agenda. It will increasingly help inform the siting guidelines recently passed as Vermont Act 174, which call for more community input.

Many enhancements are envisioned to continue to make the Dashboard user friendly and intuitive, including the ability to bulk upload Actions, the addition of other suitability layers (e.g., floodways), and the inclusion of data and analysis about climate change.

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