Sustainable Energy in Hartland, 2008

Historical Perspective

Only 100 years ago “alternative” energy meant "rock" oil, and a person had to go out of their way to use it. At the time Americans relied on wood to supply about 25% of their energy needs, while water power provided about 13% and coal about 63% (for railroad engines, steamships, and industry such as steel making). The automobile began to gain popularity with the introduction of the Model T in 1908. Use of electricity grew with the building of dams (such as the Hoover Dam in 1935) and the Rural Electrification Act in 1936. However, it wasn't until post World War II that the modern view of energy was formed.

With the passage of the GI Bill in 1944 making housing affordable, and the Interstate Highway Act of 1956 opening up the countryside, railroad stops were exchanged for “Levittowns” and unintended sprawl. The Price Anderson act of 1957 opened up the building of nuclear power plants by limiting an owner's liability in the event of a major catastrophe, and combined with massive tax breaks for oil companies, gave us the energy situation we presently have. Now that it appears oil will have a relatively short place in history of about 150 years, we need to work on its shortcomings and move on to more sustainable sources of energy. As proven by many other countries, it is possible to live quite well and have a lower carbon footprint on the earth. Renewable energy is more secure, and promotes local business -- studies have indicated that 85 percent of the price of standard energy leaves the community.

Conservation vs. Power Generation

Using the Standard Test Conditions for electric solar panels of 1000 watts per square meter (a sunny day at the beach), Hartland's 28,544 acres in bright sun are receiving an immense 115,517 Megawatts of energy. This is equal to 186 Vermont Yankee power plants (after the output increase). Most of our technologies for harvesting this renewable energy can convert only 5-20 percent of this to a form we want, such as heat or electricity -- compare this to a regular power company where about 1/3 of the available energy is lost in generation, 1/3 lost in transmission to the user, and almost 1/3 lost in the final appliance, (such as standard light bulbs, which produce 10 percent light and 90 percent heat).

This means energy conservation and efficiency is always the first step, whether a person is making their own power or buying it. The average Vermont house can easily save 20-30 percent on heating fuel or electricity, and do it for much less than the cost of a renewable energy system. The U.S. Environmental Protection Agency (EPA) has done a study on buildings and found a 4 to 1 range in energy use due solely to the operator of the building and how they ran it. EPA’s Energy Star® program (http://www.energystar.gov/) is one of several organizations striving for “net zero” energy use in housing by 2030 (achievable through efficiency and renewable methods and materials). A similar program exists in Europe called “Passivehouse” (with a house that generates more energy than it uses called *Passivehouse plus*). The main difference between the two is that the *Passivehouse* places more emphasis on efficiency, (such as consumption limits) while Energy Star allows additional power generation (e.g., installing more solar panels).

Having many small power producers (e.g., solar panels, hydropower, and windmills) inherently fits renewable energy, reducing transmission distances, making power production more robust, and averaging out differences in weather and equipment downtime. At the utility scale, this is known as distributed generation and depending on management, could help remove the problems associated with one central power plant which result in outages or price fluctuations. The US has a very inadequate power transmission grid. Therefore, distributed generation would reduce the grid bottleneck and help prevent major new transmission lines from being built locally in Vermont.

Although solar and wind energy are intermittent and could benefit from advances in batteries, generally their power production occurs during the daytime which is when energy is most needed and can be used without storage. Residents who would like to disconnect from the grid entirely and use a battery-based system, should consider staying on the grid because batteries add another level of expense and maintenance to alternative energy production systems. There is a loss of about 10 percent of the energy during charging and discharging, and any energy that is fed back to the grid will displace energy from less desirable generation sources. Unless a lot of power is needed during a power outage, use the grid provides a better alternative to battery technology. For computers, etc., that need to be shut down in an orderly fashion, a small uninterruptible power supply will be much cheaper than a battery bank.

Solar

Vermont is one of the cloudiest states, but it receives twice the yearly average sunlight (170 watts per square meter) that Germany does (80-90 w/sq m). Germany currently has about 3811 Megawatts of solar panels installed, which generated 3.5 Gigawatt hours last year -- Vermont uses about 7 Gigawatt hours per year for the whole state.

Solar energy applications in Vermont have demonstrated the ability to produce more electricity than they can use. Sometimes, depending on utility programs, the applications actually sell excess power back to the grid. The payback on the expense of installing the solar system is a factor. Payback is very dependant on the individual situation (e.g., time of use pattern, efficiency measures, size and layout of the installation, local cost of avoided energy), and an estimate is necessary.

The best use of solar is passive heating, which requires attention to window glazing, size, direction, roof overhang shading and building insulation. When it is properly designed and constructed, the whole house is like a sunny corner of a room. Passive solar concepts include conventional systems for backup heat, and rely on the occupant to manage operation of elements that are not automated (a.k.a., powered).

Currently there are 5 solar electric and 21 solar hot water installations in Hartland. The equipment for both types has been slowly improving since the 1970's first systems, and price has also slowly improved (e.g., 20 years ago solar electric panels cost $300 for a 50 watt size, now they cost $900 for a 200 watt size, or 25 percent cheaper per watt). Anyone thinking of a system should first make sure they have direct sun exposure from at least 9 am to 3 pm (more sun means shorter payback). To offset the expense, shop for tax credits (see www.dsireusa.org), state incentives (see

www.efficiencyvermont.com) and package price and reputable installers (see www.energy.sourceguides.com, or Home Power magazine, available at the library). Old utility bills for electric or fuel bills for hot water are required to help size the system. Usually the greatest return on investment is a system that supplies almost all the demand and uses the grid/or water heater to supply the peak usage in winter when the sun is weak.

Most systems are mounted on a building (racks are even available that clamp onto standing seam roofing seam fins), but solar electric systems that can be mounted on a rack that tracks the sun through the day will produce about 50 percent more electricity. Also, electrical systems need to be wired to code (NEC article 690), with a disconnect on grid-tied systems for emergency personnel.

There have been studies that show that in a climate like ours, solar hot water flat plate style collectors and vacuum tube style collectors both produce about the same total amount of heat. The vacuum tubes are better insulated, but they don't shed snow cover as well as the flat surface units do.

Wind

Hartland does not have enough wind to support a commercial wind turbine or wind farm, however there are some more exposed spots higher in altitude, mostly on the west side of town, that a farmer or homeowner might wish to put up a residential size unit.

An anemometer should be put up first to measure and verify the wind regime at the site. Because Hartland is listed in an area that has valleys, winds may be concentrated that can increase the strength of variable gusts, which is hard on a windmill and may affect the choice of machine and site.

With modern blade design, a windmill is about as loud as the wind, but quieter than the wind whistling in trees. There has been concern that windmills kill birds, but this has been found to be a special case (e.g., where lattice style towers were installed in mountain passes in California's migratory flyways). In response to the bird issue, almost all windmills now use a monopole type tower with no perch spots. They are also less prone to vandalism or people getting hurt from climbing them. The greatest environmental threat found (based on studies done at Green Mountain Power's wind farm in Searsburg, Vt., that were applied to proposed wind farms in the Green Mountains), appears to be habitat fragmentation (see the VERA reports at www.northeastwind.com), which could affect the territories of high altitude bear or some birds.

At the state level, site selection processes have identified that Vermont has a potential 6000 MW of wind power (equal to 10 Vermont Yankee plants), and a process is going on to exclude sensitive and unfeasible sites. One potential goal is to generate 20 percent of the state's electricity from wind, which would require 46 miles of ridgeline (out of a total of 517), (see the VPIRG report "A decade of change"), and there has been discussion about linking them to some ski areas. Two images help put wind farms in perspective -- the cover of the VPIRG report (downloadable at www.vpirg.org) has a simulation of the proposed Sheffield wind farm; and Sabra Fields has done a print (viewable and for sale at www.nrgsystems.com).

Hartland does not currently have zoning, but if it does come to pass, small windmills (under 20 feet diameter) are exempted under 24 VSA Section 4409(e) unless a code is specifically written for them.

Wood

A venerable energy source, akin to hayfields and gardens, wood heat is a way of life. It is carbon neutral, and with controls on exploitation and deforestation will remain a local (indigenous) resource for our lifetime. Contrast this fuel source with heating oil, which consumes Vermont incomes at a rate of about $800 million a year and sends that investment outside of the state. However, as the energy picture changes and wood is asked to fill in for other sources, it will be necessary to do a responsible and sustainable job.

At a state level (for which there are good figures), Vermont's forests have 4340 trillion BTUs (279.3 million dry tons) in all above ground biomass, and an annual net growth of 60.9 trillion BTUs (a growth rate of 2.2 percent of the live biomass with a mortality rate of 0.5 percent). We currently harvest 18.5 trillion BTUs (882,201 cords) of wood, not including logging residue. For comparison, Vermont uses 96.0 trillion BTUs of petroleum each year. So while the current wood harvest could easily be doubled, our petroleum use is 1.5 times the forest growth and if switched over would cause a forest decline. Depending on the growth of oil use (e.g., stays level, or increases with population), it would be 37.9 to 54 years before the forest would be clear-cut, so wood cannot be the only answer for energy.

Pellet stoves have high efficiency ratings, burn clean, and are automatic, but require power to operate. Wood stoves are currently available with efficiency ratings of 80%, and emissions of 1 gram or under. These designs are a derivative of versions built to relieve the intense air pollution in Pacific Northwest valleys. A stove that is 80% efficient will use about half the wood that an old, non-airtight, about 40%-efficient stove does. Also, pellet and woodchip furnaces sized for small commercial buildings and schools are rapidly improving, along with a recognized need for fuel distribution networks. It has been shown that the most carbon is stored by a forest if it is not cut at all, but clean, efficient wood burning appliances and sustainable forestry represent an important part of the future.

There are several dozen students from high schools in the Montpelier area that have been lobbying the lawmakers for energy efficiency, who have developed a plan for growing and distributing switchgrass pellets in Vermont, which is currently being grown in New York and used onsite. Switchgrass would help take pressure off the forests and could become an important farm crop, however switchgrass has high levels of silicates (dirt) and corrosive potassium and chlorine acidic gases, which will require a new generation of pellet stoves with stainless steel burner assemblies.

Water

Historically waterpower has been a basic energy source for Hartland, with about 46 mills from 1763 to present. Most of these were about 10-20 feet in diameter and would have produced about 5-15 horsepower. Today there are 3 privately owned larger

hydroelectric facilities (Martinsville Hydro, North Hartland Dam Hydro, Ottauquechee Woolen Mill Hydro), which generate a total of 6.7 Megawatts of electricity. Hartland uses only about 3 Megawatts, which means that it is an electricity exporter. These 3 sites are the high power locations in town, there are other possible locations but the amount of water and the drop will limit most of them to only 2-10 horsepower, or 1-7 Kilowatts of output. A license from the Federal Energy Regulatory Commission is necessary to sell power, and private use systems may also need a license (see www.ferc.gov/industries/hydropower.asp or the Vermont Agency of Natural Resources). Vermont just passed Act 208 (2006) allowing net metering of microhydro, (the power can be sold to the grid similar to solar and wind generators), but in recognition of how important streams are to many things besides power, all hydro facilities will still have to meet Agency of Natural Resources/Federal 401 water quality regulations.

Biofuels

The only biofuel (besides ethanol blended into gasoline for emissions control) currently available in our area is biodiesel. At time of this report, it is only available at a few gas stations such as Dan and Whit's (Norwich) and Flemings (Chesterfield, NH). Commercial biodiesel is not local, but it is carbon neutral. Biodiesel tends to gel at low temperatures, so it is sold blended with regular diesel, usually around 20 percent (B20). It is also an excellent solvent, which may lead to two problems for people switching older vehicles to it. First, it dissolves old gum and varnish in the fuel system which can clog the fuel filter, requiring more frequent replacement of the fuel filter. Second, it can swell some types of rubber used in fuel systems used before 1993. Usually it takes 100 percent biodiesel to swell these hoses or seals to the point where they don't work and need to be replaced, and with B20 only a monitoring program on old parts is sufficient.

There is an experimental oil-producing algae project in Barre which could help reduce CO_2 emissions because the algae can feed on the output gases of a power plant.

Geothermal

Strictly speaking there is no geothermal energy source in Hartland. Applications have been successful in Iceland or the US west where water at boiling point is drawn from hot springs and used to directly heat buildings. The closest geothermal source is in Bellows Falls, where there is a well in the center of town that has an estimated 70 degree water temperature (it grows bacteria and cannot be used for drinking water).

In Hartland, the ground temperature can be classed as ambient (40 to 50 degrees), and a heat pump is needed to concentrate enough heat from the earth to warm a building. Heat pumps can be thought of as an air conditioner that is run in reverse. This is energy efficient, because for every unit of energy put in to run the heat pump, 3 to 4 will be returned as heat.

As of this writing, a study is in process to determine if the large shallow aquifer next to the Hartland Fire Station and Hartland Town Garage could be used as a heat source with heat pumps to heat the two buildings instead of oil. Residential and commercial

systems in New Hampshire are also demonstrating efficiency levels that are an improvement over the alternative fuel oil systems.

Resources

For more information on any of the topics above, please refer to the following resources:

- www.vecan.net -- local and state energy committees, activities, calculators and information
- www.efficiencyvermont.com -- statewide efficiency programs and renewables tax credit information
- www.rerc-vt.org – Efficiency Vermont renewables site
- www.revermont.org -- renewables business network
- www.energy.sourceguide.com -- renewables buyers guide
- www.energystar.gov -- tax credits
- www.dsireusa.org -- incentives and credits
- www.serg-info.org -- local energy group
- www.anr.state.vt.us/dec/permit_hb/index.htm -- ANR permit handbook (applies to water power)
- www.anr.state.vt.us/dec/ead/pa/index.htm -- ANR permit specialist advisor (applies to water power)
- Home Power magazine -- available at the town library