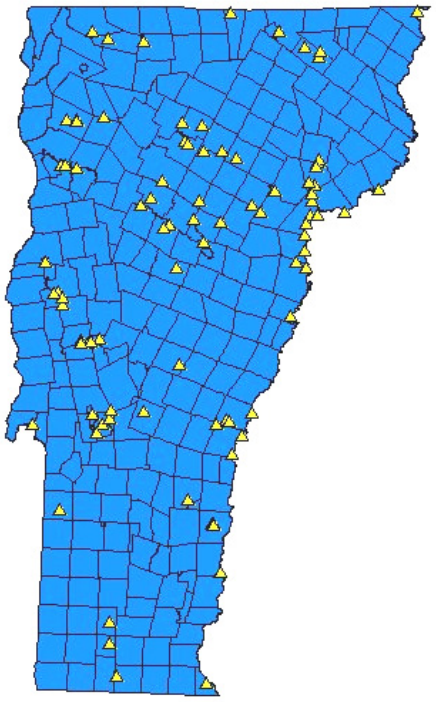
Hydroelectric Generation in Vermont

Introduction

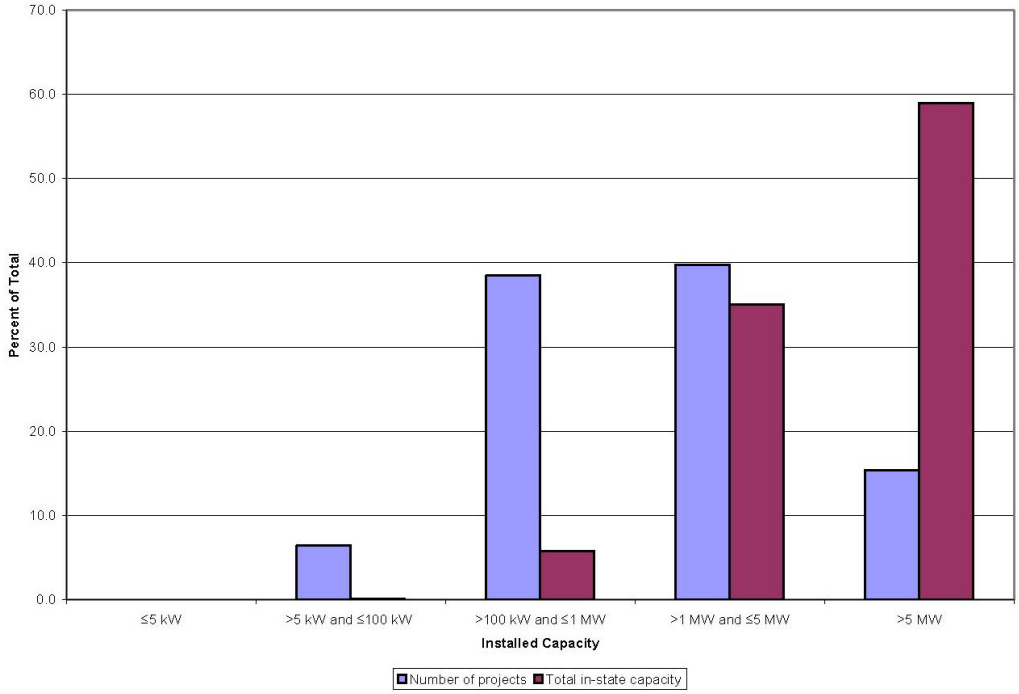
Both nationally and internationally, there has been increasing interest in developing and expanding hydroelectric facilities as part of any given entity's energy portfolio. These range from the local example of the proposal to install a generating facility at the falls in downtown Middlebury, to regional examples of the renewed interest in the Connecticut River dams and Vermont's partnership with hydroelectric generating facilities in Quebec and potentially Labrador, to the massive scale projects recently developed across the globe including the Three Gorges Dam in China and the Belo Monte Dam on the Amazon in Brazil. The reasons for the interest in hydroelectric generation center on the desire for less carbon-intensive energy supplies, the capacity of hydro to provide a larger and perhaps more reliable generation source as compared to solar or wind, and because they are viewed as less risky—and less problematic from a waste perspective—than nuclear plants. However, there are uncertainties surrounding the benefits of hydro as well. Large dams usually don't produce as many benefits as anticipated, cost more than planned, and—importantly for our course—have potential risks associated with climate change. Further, debates remain about whether hydropower should be considered a form of renewable energy (especially at certain scales).

In terms of the current status of hydroelectric power generation and use in Vermont, Renewable Energy Vermont provides the following summary: "Presently Vermont has 84 operating hydroelectric plants. They are distributed throughout the state, and are owned by public and private utilities, electric co-ops, companies and individuals. The plants have a total generating capacity of 190 megawatts (MW), and produce on average 12 percent of Vermont's kWh load. In addition there are several large projects on the Connecticut River, presently owned by a Canadian firm, which sells the electricity to southern New England. These dams could provide an additional 6 percent of Vermont's kWh load. Recently many Vermont utilities renewed a long-term contract to import hydropower from Hydro Quebec (through 2026). This will provide about 25 percent of Vermont's kWh load. Although the Hydro Quebec projects are quite large, with installed capacities of thousands of MW, it should be recognized that Quebec is our neighbor and part of our ecosystem".[i]



Vermont and Connecticut River Hydro Projects
(ANR 2008)

Size distribution of Existing Hydro projects in Vermont (ANR 2008)



For the most part, all environmentally and financially viable dam sites in Vermont have already been developed, with no new projects commissioned since 1993. Environmental concerns, a potentially costly and lengthy licensing process and difficult economics have been primarily responsible for the lack of new dams coming on line. There are, however, several dam sites that are working toward becoming operational in the next few years (e.g. in Jamaica, VT), and the state in general is looking towards increasing renewable energy generation in light of the impeding end of our contract with Vermont Yankee in 2012. If indeed Vermont Yankee's nuclear facility goes off line, we will need to replace the 34% of the state's power portfolio that Yankee currently represents. Replacing Vermont Yankee's contribution to the state's energy portfolio can be viewed as a short-term issue, but there is also a larger, more long-term, contextual question of how the state can or should transition its energy portfolio to incorporate more renewables.

There is significant interest in developing "community scale" hydro projects, particularly at municipal water supply systems and lake outflows, as alternatives to the large, utility-scale projects in the state's post-Vermont Yankee renewable energy portfolio. While there is no single definition for the size of a "community scale" hydro project, the Vermont Agency of Natural Resources (ANR), in its 2008 report *The Development of Small Hydroelectric Projects in Vermont,* recommends categorizing small hydroelectric projects according to generation capacity:

Mini-hydro – 101 kW to 1 MW
Micro-hydro – 6 kW to 100 kW
Pico-hydro – up to 5 kW [ii]

Small-scale hydro facilities are thought to offer several benefits over the more conventional large-scale projects, including:

- Small-scale hydro facilities bring the production of electricity closer to consumers and therefore reduce efficiency losses incurred during transmission across long-distance power lines.[iii]
- "Run-of-river" facilities allow rivers to retain their natural flow regime and may have fewer negative environmental and social impacts. Similarly, it may be possible to renovate or upgrade existing dams to provide new or increased capacity with relatively few negative impacts. In fact, ANR concurs with the certification criteria for Low Impact Hydropower (see Appendix J of 2008 ANR report) developed by the Low Impact Hydropower Institute (http://www.lowimpacthydro.org/), which include the goal of utilizing existing intact dams, so no new dams will be built for the purpose of hydroelectric power production, with preference given to dams that currently serve another purpose.

However, there is also much uncertainty over the ability of community-scale hydroelectric facilities to live up to their potential. For example:

- Estimates of potential capacity for new generating facilities and upgrading existing facilities vary widely. Existing estimates of additional capacity range widely, with the ANR's 25 MW on the low end for upgrading existing facilities and 434 MW on the high end (inclusive of new dam construction).[iv,v]
- There is no comprehensive assessment of the social and environmental risks of expanding the use of community-scale facilities.

Projects in this class will be conducted in collaboration with the Vermont Agency of Natural Resources, Energize Vermont, and ISciences.

- State level questions will focus on identifying when and where hydroelectric projects make sense in terms of economic efficiency, generation capacity, and social and environmental considerations. These questions about hydropower are important as the state considers all potential renewable energy sources to both offset Vermont Yankee contributions and increase the renewable energy percentage of the state's power portfolio since hydropower is just one the many types of renewable energy projects competing for the same support and resources.
- Looking globally, work with ISciences will first identify risks to hydropower from climate change impacts, such as how changing water distribution patterns affect generation capacity and how more frequent natural disasters affect dam safety. The project group will then seek to categorize strengths and weaknesses of how different scales of hydropower facilities can adapt to climate change.

Project #1. Increasing Hydro Capacity from Efficiency Improvements at Existing Generating Sites

The Agency of Natural Resources (ANR) estimated in 2008 that Vermont could add an additional 25 MW of hydroelectric generation to its renewable energy portfolio assuming new development is limited to sites where there are existing dams.[vi] The Vermont Department of Public Service's March 2011 draft of a statewide comprehensive energy plan acknowledges that additional study is needed to develop accurate estimates. It quotes the ANR's 2008 report stating, "…a better estimate of the developable hydroelectric capacity in Vermont is needed. The legislature should consider funding for the Agency, Department of Public Service, and Public Service Board to collaborate on an update of the 1980 New England River Basins Commission study to identify the most viable sites for small hydropower development at existing dams. This update is essential for identifying the best opportunities statewide, both ecologically and economically, for new hydropower development."

More specifically, the state thinks that improving efficiency at existing hyrdroelectric generating facilities could yield another several megawatts of power (possibly on the order of 10s of MW), but there are currently no estimates of this. The DPS report again quotes the ANR's 2008 report stating:

> The Department of Public Service should work with Vermont utilities to investigate additional opportunities for increasing hydropower production at existing operating sites. Several of the assessments of undeveloped hydropower capacity note that there is untapped potential at existing hydroelectric facilities. This potential could be realized with more efficient turbines, small turbines at the dams that utilize bypass flows, and turbines that can operate efficiently over a wider range of flows. In many cases, an increase in production should be possible without changing the current operating requirements, essentially increasing energy production without additional environmental impacts. Further study is needed to determine the feasibility of this option. Vermont's utilities indicate that they have made some initial progress toward improving the operation of existing facilities in recent years. There are, however, indications that further cost-effective improvements are available and deserve further study.

The state and environmental advocates alike are interested in assessing this potential because of the assumed minimal environmental impacts of these upgrades, and an overall recommendation from the March 2011 draft of the statewide energy plan states, "Vermont electric utilities and developers should pursue environmentally and financially sound in-state hydroelectric projects and improvements to existing facilities." Further, the state sees upgrades to existing facilities as one of the best opportunities to increase hydroelectric generation.

This project will develop case studies on efficiency upgrades that factor in available technology, cost/benefit analyses, and data from any studies on the ecological impacts of upgrades to contribute to the state's estimates of potential new capacity based on efficiency upgrades. The state's 2 largest utilities, Green Mountain Power (GMP) and Central Vermont Public Service (CVPS) will be primary contacts for instate case studies. For specific examples, you will draw on the approximately 6 sites where plants have implemented efficiency upgrades and work with the utilities to identify any current sites that are being considered for upgrades. You can and should also research and include examples from elsewhere in the New England region. Research questions include:

- How should upgrades be implemented in an economically efficient manner?
- What is the range of potential increase in generation yield per unit investment?

- What are the environmental, social and economic costs and benefits of upgrading existing small hydroelectric dams through efficiency improvements and renovating existing small non-hydro dams to create new generating capacity?

Answers to these questions will help inform the broader policy discussion over the role existing dams should play in Vermont's renewable energy future.

Project #2. Framework for an Ecological "Alternatives Analysis" for New Hydro Development

A more complete understanding of the environmental consequences of upgrading existing dams for new generating capacity can better inform the state's project review process. There are currently approximately 1100 records in the state's dam inventory, and many are currently not used for any purpose. As discussed above, developing new hydro generation facilities at existing dams could serve as a significant opportunity to increase renewable energy generation with relatively low negative environmental impacts. However, these assumptions about the potential environmental impacts have yet to be evaluated comprehensively.

Currently, the state's project review process considers proposals for new hydro development on a case by case basis, primarily based on whether or not the completed project will meet state water quality standards under the Clean Water Act. There is no opportunity in the state's review process to compare the impacts on the ecosystem of alternative options for using the site. Alternatives could include leaving the site as it is or removing the dam. There is also no opportunity to evaluate the cumulative impacts of the project proposal on ecosystem services other than water quality. However, these considerations are important for Vermont to make informed decisions about which projects should move forward and how.

This project will develop a policy brief informed by a thorough literature review of the potential ecological impacts of installing hydroelectric generating capacity at existing dam sites that will help inform both policy and public investment decisions. Based on this review, you will look specifically at the following questions for a Vermont-specific context:

1) Are the energy gains of a given new generation project "worth" the ecological impacts?
2) If a site wasn't developed for hydro power, how else might it be used? For example, would it be a candidate for dam removal and stream restoration?
3) What should the threshold / criterion be to weigh questions 1 & 2 and determine which projects are worth moving ahead with for hydro development and which ones are not?
4) What legislation is needed to include this type of alternatives assessment in the state's project review and permitting process?

To answer these questions the project group will examine a subset of potential new generating sites (at existing small dams). The group will have to consider how criteria may vary according to the location and the scale / size of the project.

Project #3. Global Assessment of Hydropower Vulnerability to Climate Changes

ISciences—working internationally with an office in Burlington, Vermont—conducts research to improve clients' understanding of sustainable development, human security and the environment. Their analyses, based on scientific and statistical datasets and image interpretation, influence major policy decisions at some of the world's largest companies and at the highest reaches of government. While not solely focused on water issues, they are interested in global water systems, issues of surplus and drought, patterns of water availability, how these patterns affect the potential for conflict to arise, improving trans-boundary water management, and how climate and population trends relate to water issues. See www.isciences.com for more background.

ISciences is interested in how global power generation will be affected by changes in climate patterns since almost all power generation methods have vulnerabilities due to their water requirements. Specifically related to our course theme, you will focus on hydropower vulnerabilities by:

1) Developing a scheme to classify the vulnerability of different scales of hydropower to different kinds of climate events. Are large scale hydroelectric facilities more or less able to adapt to drought, flooding, or changes in types and timing of precipitation events? Are small scale facilities more or less able to adapt to the same set of climate parameters?
2) Identifying global trends in hydropower—what portions of countries' power portfolios come from hydropower, what are the proportions of large vs. small scale hydro in a given country's power mix, and which countries are most heavily invested in hydropower?
3) What disruptions and difficulties are countries already facing due to the impacts of climate change on hydropower facilities? What were the events? What scale of hydropower was impacted most by these events? If no disruptions have occurred yet, where do you predict disruptions will occur?

The project group will answer these questions by looking at case studies of countries with extensive existing hydropower developments. Based on your above vulnerability assessment and research your resulting product should allow for your classification scheme to be replicated and applied more broadly, allowing countries facing climate change to better plan their hydropower—or other water dependent power generation— development.

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[i] http://www.revermont.org/main/technology/hydro/

[ii] http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_smallhydroreport.pdf, ANR 2008

[iii] http://www.revermont.org/main/technology/hydro/

[iv] http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_smallhydroreport.pdf

[v] http://vtpeakoil.net/docs/Barg_testimony.pdf

[vi] http://publicservice.vermont.gov/pub/state-plans/CEP_2011_Working_Draft_3-14-11.pdf