Developing Small Hydro in New Jersey

A contribution to the Energy Master Plan
And a brief to Assemblyman Upendra Chivukula,
Chairman, Telecommunications and Utilities Committee

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Abstract: *This paper summarizes the current state of knowledge regarding the potential for small and low-head hydro as a clean and renewable energy resource for New Jersey. It recommends the reclassification of small hydro, defined as hydroelectric power generation up to 30 MW, from Class II to Class I, and further actions to promote and utilize small hydro within the state. It is provided in response to a request for a submission on this topic to the Energy Master Plan working group, and as compendium of the analysis done in support of FDU's work with the NJ Legislature.*

New Jersey's draft Energy Master Plan, released in April of this year, does not address small hydro[2] as a significant source of clean, renewable energy. We have been asked to provide some input on the potential for small hydro, and how it should be treated in the context of the overall goals of the Renewable Portfolio Standard and greenhouse gas emission reductions embodied in the Global Warming Response Act and other legislation.

To respond to this, we have consulted authoritative sources on the potential for small hydro, analyzed alternative scenarios, and consulted with several authorities in the field.

It should also be disclosed that, through FDU's Sustainable Business Incubator program, we are supporting two small hydro enterprises, one with a patented turbine for efficient mini and micro generation, and one developing the engineering, financial, and business capabilities of realizing projects from 1 KW to 30 MW (considered the upper limit for small hydro generation). Supporting a policy and legislative environment favorable to small hydro is thus part of our Incubator's green economic development mandate; and it is also, in our view, good public policy. If small hydro generation facilities can alleviate some of the demand for increased centralized power production, provide reliable base generation capability, and be virtually free of carbon emissions, we believe this is a worthwhile addition to the combination of policies required to transition to a clean energy future.

According to the federal inventory of small and low-head hydropower potential provided by Doug Hall of the Idaho National Engineering and Environmental Laboratory, New Jersey has approximately 63

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[1] With materials provided by Pace Law Graduate Dana Hall; Tom Miesejeski of HydroCoil Power; Dr. Jonathan B. Rosefsky of HydroCoil Power; Doug Hall of INEEL; Matt Polsky of the Passaic River Coalition; Gerry Flach of Passaic County; and others, all of which contributions are gratefully acknowledged. All errors and opinions are the sole responsibility of the author, and the opinions expressed do not necessarily represent the views of ISE or of Fairleigh Dickinson University.

[2] By "small hydro" we mean hydroelectric power generation from 0 to 30 MW, including what is frequently described as "low-head" or "low-impact" hydro, mini- and micro-hydro, run-of-river applications, and other forms of power generation from liquid flows that may be enabled by the use of existing or the development of new technologies.

MW of *feasible* potential for small and low power hydro.[3] This is substantially more than the 22-30 MW capability estimate provided by the Board of Public Utilities, but it is still small relative to the total electricity generation required by homes and businesses in the state.

If fully utilized on a 24x365 basis, 63 MW of hydro could theoretically generate up to 552,000 MWh (or 552 GWh) of electricity; this compares to the roughly 83,000 GWh of electricity currently used annually in New Jersey, and the 80,000 GWh that remains the goal for electricity use in 2020; it represents less than one percent of the total requirement, and less than 4% of the anticipated generation by renewables in the state.

But surrounding states are estimated to have much a greater small hydro potential. According to the BPU, other states in our northeast region could have as much as 2200 MW of capacity, which could generate up to 19,272 GWh of electricity. If this potential were (a) fully exploited, and (b) entirely purchased by the state of New Jersey, it could completely fulfill the NJ RPS of 22.5% by 2020.

An opinion provided by Board staff to Assemblyman Chivukula's office dated May 15, 2008 states:

> Board staff supports the draft legislation's intended purpose: to spur the development of hydropower in New Jersey. The Garden State has a genuine opportunity to promote mini-hydro as a clean resource with a promising load factor (compared to most other renewables) and legislation seeks to capitalize on this opportunity. Still, staff has concerns about the proposed expansion of the Class I definition to include certain hydropower facilities – namely, that the bill as drafted could have the unintended, counterproductive consequence of swamping the Renewable Portfolio Standard (RPS) Class I Renewable Energy Certificate market.
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> So as not to run afoul of the commerce clause, New Jersey's RPS goal may be realized by any Class I renewable resource within PJM. The state have established the PJM-EIS Generator Attributes Tracking System (GATS) to track these green electricity certificates and to facilitate REC trading between and among the PJM states that have an RPS. Since power for New Jersey's electric market can be generated from anywhere within the PJM region, it was determined that the environmental benefits of Class I renewables could be provided from the same area. (PJM extends west to Illinois and south to Virginia and includes states in between.) The expansion of the definition of a Class I renewable resource to include mini-hydro could increase the supply of Class I RECs in the GATS market, which could subsequently lower the price of Class I RECs in GATS overall.[4]

We believe this scenario is highly unlikely, however. Other states are also seeking clean, renewable energy sources, and are likely to view their small hydropower capabilities as principally available to their own internal markets. This power would only be sold to New Jersey if we paid a substantial premium for it. This power would also only become available over time. Small hydro projects are subject to extensive regulatory and environmental requirements, and will likely come on stream in a piecemeal fashion.

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[3] Appendix B-1, Final, "Assessment Results by State," Water Energy Resources of the United States with Emphasis on Low Head/Low Power Resources, Douglas G. Hall, INEEL and others, 2004, p.4.

[4] Moffo, Christopher to Hoover, David, Re: Comments on mini hydro bill, May 15, 2008. The email goes on to explain that "the value of RECs is, in part, what helps to finance the construction of renewable facilities like wind and biomass," and to argue that "*While a reduction in REC prices is good for the ratepayers* [my italics], an increase in Class I REC supplies and the decrease in the REC prices may reduce the number of Class I wind and sustainable biomass projects that may get constructed (since their financing would change)."

Moreover, if we are dealing with the entire PJM region,[5] the INEEL study projects that Maryland has 91 MW of feasible hydropower and Pennsylvania 953 MW; Illinois has 568, Indiana has 305, Ohio 319, Virginia 418, West Virginia 484, Michigan 133, North Carolina 348, Tennessee 655, Kentucky 518, and Delaware 6, while D.C. is not listed as having any; if all these are included, the total is almost 4800 MW.[6]

But even if we imagined that all of this capacity were developed and sold to New Jersey, it would have to be significantly less expensive on an as-delivered basis (taking into account transmission costs, grid expansion, etc.) than locally-generated wind, solar, or biomass-generated electricity in order to compete with these as part of the RPS. It is conventional to say that New Jersey's RPS of 22.5% by 2020 is "aggressive," and it is by comparison with the current state of renewable energy generation in the state; but it is not by comparison with other states, including e.g., Maine and Texas; and certainly not in comparison with some other countries such as New Zealand – or with the dramatic reductions in greenhouse gas emissions contemplated by 2050. And in any case the way to handle an increased potential availability of renewable energy resources is not to discourage or de-incentivize their development, but to raise the RPS goals. In order to protect the market for wind, biomass, etc. as some want to do, it would only be necessary to increase the RPS by 1% for every 1% of small hydro provided to the PJM grid.

Consequently we are recommending that small hydro, meaning facilities of less than 30 MW generating capacity, that meet stringent environmental standards, be reclassified as Class I rather than as Class II as hydropower is currently treated under EDECA, the Electric Discount and Energy Competition Act ("EDECA") of February 1999, which established the framework for our current policy.

While the exact value of this reclassification is impossible to determine, it has been stated that Class I RECs (renewable energy certificates) are currently selling at $15, compared to Class II RECs at 15¢. In addition to being fully included in the RPS, small hydro would then compete with other renewable technologies on an even playing field. Nevertheless, important regulatory obstacles, including at the federal level, still remain, making the realization of many small hydro projects costly and time-consuming.

A further concern stated in the BPU comments is as follows:

> Staff estimates that New Jersey's undeveloped potential for mini-hydro constitutes approximately 500 projects (totaling an estimated 22 MW). Excluding New Jersey, undeveloped potential across the PJM region is likely as high as 2,200 MW.[7] At 47 kW per installation across PJM's 2,222 MW of undeveloped potential, this is more than 47,000 installations. In the absence of a provision that specifies "NJ-only" mini-hydro – or some other qualifier in the proposed rule change – the PJM-wide 2,200 MW could reduce and perhaps eliminate the incentive the legislation intends to achieve for the estimated 500 projects in New Jersey.
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> What will be the impact to the New Jersey Class I REC price – not just on mini-hydro, but also wind and biomass? Staff anticipates price volatility that would result in the discounted value of the REC stream,

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[5] "PJM Interconnection is a regional transmission organization (RTO) that coordinates the movement of wholesale electricity in all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia." (http://www.pjm.com/about/overview.html)

[6] See footnote 3. The definition of "feasible hydropower" makes it a small percentage of the total available hydropower both in New Jersey and in these other states, but is the number we have used as the most comparable measurement.

[7] As noted earlier, both of these estimates appear to be low.

> less reliance as a tool to build new plants, and more as tool to maintain, operate and boost the performance of existing plants. (This latter point is not necessarily bad; rather, it is different than the existing policy.) Staff believes the renewable energy markets expecting a REC to support new investment would be at less risk of disruption by increasing the percentage of Class II required.
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> ***In sum, BPU staff agrees that it is in the State's interest to make mini-hydro a Class I renewable resource*** [emphasis added], but respectfully recommends that the legislation explicitly stress a focus on in-state mini-hydro facilities only. We recommend the addition of a provision that would require a certain percentage of distributive generation (DG), which supports local distribution systems, to the definition of Class I renewables. These facilities are typically referred to as "behind the meter" renewables because they are on the customer's side of the meter and not directly connected to the PJM transmission grid. This definition of DG renewables that support the local electric distribution system would, in addition to mini-hydro, include community wind and small farm-based sustainable biomass. BPU with PJM-EIS would have to develop a separate tracking system, but this approach would aid in the construction of in-state Class I renewables without running afoul of the commerce clause, without swamping the Class I REC market and without lowering the price of Class I RECs.[8]

Some of this goes beyond the concerns of the present paper, to address, e.g., the issue of community-scale projects from other sources, and other issues whose implications are fairly complex. However, it is our understanding that limiting projects to "behind the meter" applications under existing net-metering rules, (which limit projects to less than 2 MW, and to no more than the peak demand of the metered customer), is a major obstacle to community-scale projects. Requiring all small hydro projects to be "behind the meter" seriously disadvantages those projects that are not associated with existing riverfront homes or businesses with significant peak demand requirements; and does not recognize the long-standing historical decline of river-adjacent development (much of which has occurred following the decommissioning of small hydroelectric projects during the 1930s, when our present centralized-distribution system was codified in legislation).

As previously stated, we do not believe it is possible or desirable to limit the reclassification of small hydro to in-state projects, nor do we believe that the development of small hydro in NJ or in the PJM will "swamp" the Class I REC market. The existence of small hydro potential in other states also does not, in our view, affect the cost-effectiveness of in-state projects, which will depend to a much greater degree on the specific characteristics of each installation, including water flow, distance from interconnection, etc. In our view, the goal of the reclassification is to remove obstacles to the development of small hydro, including the requirement that each project be certified by the DEP Commissioner (over and above the normal environmental requirements to which such projects are subject under other regulations), and to have specific small hydro projects compete with other projects on a level playing field.

At the same time, we do agree that the BPU and other state agencies should seek to promote small hydro in New Jersey in other ways as well. It is worth recognizing that many of New Jersey's rivers and waterfalls were harnessed for energy prior to the development of the central grid system in the 1930s, and existing dams and sluiceways can likely be used without significant additional environmental hazard. The Great Falls in Paterson continue to produce 11 MW from an installation that is now several decades old, and could probably be expanded and upgraded to at least twice that. Many run-of-river projects and other innovative applications that are environmentally and socially benign, essentially noiseless, capable of more or less continuous base load generation, and much less costly than, e.g.,

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[8] See footnote 4.

current solar photovoltaics, should in our view be promoted while other technologies such as nanosolar, PV printing, and photosynthesis-based systems are continuing to be developed to be more cost-effective.

Most small hydro applications will need to be carefully reviewed and assessed before installations can proceed; but there are clearly ways of generating hydroelectricity that are not simply environmentally benign, in contrast to big hydro, but are indeed ecologically restorative. If a portion of the revenue generated by hydroelectricity flowing to dam owners (including local government entities) is used to support dam maintenance, river restoration, and fish ladders and other environmental improvements are provided in order to make small hydro installations truly sustainable, this form of energy can be considered amongst the most cost-effective and the most environmentally benign approaches to electricity generation.

As previously noted elsewhere, FEMA maintains a database of more than 78,000 dams of 12' or higher, a majority of which could be electrified (that is, harnessed to generate electricity), and a number of which have been used to generate power in the past. And this may only be a portion of the available resource. HydroCoil turbines are designed to take advantage of lower heads (6' or higher), and run-of-river applications; other devices are being developed that may be efficient at an even smaller scale. And turbines can also be used in water company conduits, effluent pipes, and other applications to obtain electrical energy from fluid motion and serve as pressure relief valves, ultimately offering the possibility of using water that has been pumped to and stored in reservoirs and water towers for meeting peak demand as well as providing consistent base load generation, along with other non-energy related benefits. This potential is outside of all previous forecasts of hydroelectric potential, and has not yet been fully estimated.

Overall, total U.S. nascent potential is estimated to be 100,000 - 300,000 MW of new hydroelectric generation opportunity. Doug Hall at the INL has said in the recent past that there is a potential for developing around 100,000 MW of electricity through fully developing US waterways/dams. A U.S. DOE document mentions around 300,000 MW potential, for developing small and low head hydro nationwide. With either figure, it is still a very considerable sum of electricity from a clean, renewable source--equivalent to 100 million to 300 million kilowatts. The average home requires about 2 to 2.5 kW of electrical generating capacity to supply its typical requirements. In theory, therefore, the electricity needs of the approximately 100 million existing U.S. households (excluding commercial uses) could potentially be met from hydro alone, though in reality of course the *feasible* development of hydroelectricity is much less. But it should not be forgotten that hydro is by far the largest source of clean and renewable energy both in the U.S. and elsewhere in the world, and represents a largely overlooked resource in the modern quest for energy independence and greenhouse gas reduction.

NJ's Energy Master Plan

New Jersey's draft Energy Master Plan, released in April of this year, is intended to be "a road map to guide us toward a future with adequate, reliable energy supplies that are both environmentally responsible and competitively priced."

Its principal (and recognized) deficiency is that it does not address the energy requirements of the transportation sector, which is to be discussed in a separate document to be released this fall. However, as noted in our prior statement on the Master Plan (J. Cloud, May 27, 2008), and by others including Ralph Izzo, president of PSEG (NJ's largest utility), the starting point for any discussion of addressing the reduction of New Jersey's greenhouse gas emissions from transportation is the electrification of the transportation sector, which means that the demand for electricity is likely to rise more quickly than is contemplated in the EMP. Consequently the proposed strategies for reducing electrical demand, and increasing the percentages from renewables, are likely to be insufficient to meet the real needs of the coming decades.

The broad statement of goals remains, however, valid. The principal challenges facing the state in addressing its energy future are (1) using energy more efficiently, so as to reduce the demand relative to the total output of goods and services, and (2) providing an ever-increasing share of the energy supply from clean, renewable sources. Other options – such as increasing the use of natural gas compared to oil or coal – may be useful as stop-gap measures; and additional steps such as the development of carbon sequestration technologies may be relevant to the issue of climate change. But the broad picture has to be one of focusing on conservation and renewables as the cornerstones of a sustainable energy future, both for New Jersey and for the world.

In this context, the development of additional small hydro resources is a limited but still important and previously unexamined contribution to the second of these two objectives. Like other renewables, hydro power does not entail either the depletion of limited fossil resources or the emission of CO2 or other greenhouse gases, and In some circumstances, the spray of water exiting microhydro turbines may actually improve the quality of water by aerating it. Small hydro usually is a form of *distributed generation*, which is to say that it involves many small installations based on the variable location of the resource. Many of these can be fed in "behind the meter," and should qualify for net metering; others may not, e.g., standalone 3-20 MW systems, but all should qualify for Class I RECs if they are providing energy that is as clean and renewable as any other.

The draft Master Plan notes (p.40):

> New Jersey's electric generation fleet has changed over time, with plants fueled by natural gas generating a larger share of the State's electricity generation. Figure 7 illustrates the cost for each type of plant to generate one megawatt-hour of electricity, and how plants are called upon to provide electricity to the grid in order of their increasing costs as the demand for electricity increases.
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> Hydroelectric plants generate that megawatt-hour at the lowest cost, followed by nuclear and coal. Combined-cycle plants, which use a natural gas-fueled combustion turbine to generate electricity, and then recover heat from the turbine exhaust to generate steam that can be used to generate more electricity, are next in line. (p.41) [9]

Inevitably, however, the generation cost of small hydro will be higher than that of large-scale hydropower facilities, though perhaps still cheaper than wind or solar at current rates, and at a much lower environmental cost. Moreover, the relative economics can be expected to change over time, based on technological refinements in all of the renewable technologies and changes in regulatory regimes – as well as governmental incentives.

And regardless of the kind of renewable source, as the Master Plan notes:

> Obtaining more of our electricity from renewable sources means a reduced reliance on fossil fuel based electricity generation and therefore less emissions of carbon dioxide. (p.23)

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[9] We question whether nuclear and coal are less costly than co-generation when the costs of waste disposal, greenhouse gas removal, and plan decommissioning are included, but this does not detract from the statement that hydroelectricity is cheaper even when these costs are not fully accounted for. In addition, many experts now believe that wind energy is competitive with these traditional sources.

The fact that the small hydro resources of other states will also be favored as Class I should not be an argument against reclassification. Other states also have much greater wind capabilities, but they are not thereby excluded. Surely it is preferable to buy renewable energy from out of state rather than buying fossil energy either locally or from other states. There seems to us no basis for differentiating or disadvantaging small hydro relative to other renewable resources. Moreover, there will still remain a number of other administrative hurdles to be overcome, at both federal and state levels, which could also be greatly minimized (while still fully protecting the environment) by policy and legislative support for this renewable energy technology.

Net metering of Hydroelectric Power in other states (updated 7/7/08):

HYDROELECTRIC NET METERING LAWS AND REGULATIONS [10]

State	How net metering is provided	What kind of hydro power	Website
Arkansas	Statute Arkansas Code § 23-18-603 et seq.	Hydro electric	
Colorado	**Statute 4 CCR 723-3, Rule 3664**	**Small hydro**	**http://www.dora.state.co.us/puc/rulemaking/Amendment37.htm**
Connecticut	Statute Conn. Gen. Stat. § 16-243h	Hydro electric	
Delaware	**26 Del. C. § 1014(d) CDR 10-800-049**	**Small hydro**	
Washington DC	DC ST § 34-1518 CDCR 15-900	Hydro electric	http://dceo.dc.gov/dceo/cwp/view,a,3,q,601821.asp
Hawaii	HRS § 269-101 et seq.	Hydro electric	http://www.hawaii.gov/dbedt/info/energy
Idaho	Approved Tariff	Hydro electric	http://www.avistautilities.com/assets/tariffs/id/ID_063.pdf
Indiana	**170 IAC 4-4.2**	**Small hydro**	
Iowa	Iowa Code § 476.41 et seq. IAC § 199-15.11(5)	Hydro electric	
Louisiana		**Small hydro**	
Maine	CMR 65-407-313	Hydro electric	
Massachusetts	Statute: M.G.L. ch. 164, § 1G Regulation: 220 CMR 11.04	naturally flowing water and hydro electric	

[10] Data compiled by Dana Hall from the Database of State Incentives for Renewables & Efficiency at http://www.dsireusa.org/.

Michigan	Michigan PSC Order, Case No. U-14346	Hydro electric	http://www.michigan.gov/netmetering
Minnesota	Minn. Stat. § 216B.164 Minn. R. 7835.3300	Hydro electric	
Missouri	SB 54 of 2007	Hydro electric	
Montana	Mont. Code § 69-8-601 et seq.	Hydro electric	http://www.deq.state.mt.us/Energy/Renewable/NetMeterRenew.asp
Nevada	NRS 704.766 et seq. NAC 704.8901 et seq.	Hydro electric	http://pucweb1.state.nv.us/PUCN/RenewableEnergy.aspx
New Hampshire	New Hampshire Statutes § 362-A:9 N.H. Admin. Rules, Puc 900	Hydro electric	http://nh.gov/oep/programs/energy/RenewableEnergyIncentives.htm
New Mexico	17.9.571.7 NMAC et seq. New Mexico PRC Order, Case No. 2847 17.9.570 NMAC	Hydro electric	
North Carolina	**NCUC Order, Docket No. E-100, Sub 83**	**Small hydro electric**	
North Dakota	ND Administrative Code 69-09-07-09	Hydro electric	
Ohio	ORC 4928.67 OAC 4901:1-10-28 OAC 4901:1-21-13	Hydro electric	http://www.puc.state.oh.us/PUCO/Consumer/zinformation.cfm?doc_id=346
Oklahoma	O.A.C. § 165:40-9	Hydro electric	
Oregon	OR Revised Statutes 757.300 Or. Admin. R. 860-039 Or. Admin. R. 860-022-0075	Hydro electric	
Pennsylvania	73 P.S. § 1648.1 et seq. 52 Pa. Code Chapter 75, Subchapter B	Hydro electric	
Rhode Island	Rhode Island PUC Order, Docket No. 2710 R.I. Gen. Laws § 39-1-	Hydro electric	http://www.riseo.state.ri.us/riref/information/using.html

	27.7 R.I. Gen. Laws § 39-26-6		
Texas	Austin Ordinance No. 030908-04 - Distributed Generation from Renewable Sources Rider	Hydro electric	http://www.austinenergy.com/About%20Us/Rates/distributedGenerationFromRenewableSources.htm
Vermont	**2008 Vermont Laws No. 92 (S. 209)** (H-675 was killed, S-209 instead addresses the issues raised in H-675)	**Small hydro electric**	**http://publicservice.vermont.gov/energy-efficiency/ee_netmetering.html30** **S-209 was signed by Governor Douglas in March, 2008**

Other studies used in preparing this assessment:

Low Impact Hydropower Statutory Questions in New Jersey (Dana Hall, March 28, 2008)

This brief, originally prepared at our request by Dana Hall, then a graduate law student at Pace University, was submitted in support of our recommendation to reclassify small hydro under New Jersey law. For the full text, See Appendix A: LowImpactHydroInNJLaw.pdf

The questions addressed in the brief are:

1. What is low impact hydropower?
2. How is low impact hydropower treated under existing NJ law?
3. What would be the impact of reclassifying as Class I
4. What is the timeframe of a change?
5. What else needs to change?
6. Who is involved?
7. What other laws are involved outside of EDECA?
8. How should the change in law address environmental impact?
9. Permitting and licensing
10. Balancing impact and efficiency of process

Key finding:

> …it is apparent that all hydropower projects, be they a 100 MW dam or a 10 kW damless diversion system, are only eligible to be considered personally by the DEP commissioner as a Class II renewable energy, and never a Class I. These two requirements, of location where retail competition is allowed, and personal approval by the commissioner are extremely limiting and burdensome for those who wish to pursue small hydropower projects. Further, the categorization as a Class II renewable energy prevents the facility from benefiting from the generation of Class I RECs and net-metering, two extremely valuable tools designed to grow the state's supply of renewable energy.

BPU Assessment of New Jersey State Dam Hydropower Potential (Jaclyn Trzaska and Chris Haun, NJ BPU, undated)

Key findings:

> Hydroelectric power is a clean, efficient, reliable and flexible source of energy. In the United States, 9% of electricity is produced using renewable resources. Hydroelectricity is dominant, accounting for 6.5%. In New Jersey, only about 2% of electricity is generated by renewable resources, and hydropower accounts for only 0.07%. A Department of Energy study in 1996 indicated that there is about 9.4MW of undeveloped hydropower potential in the state[11]. Most of this potential (97%) is located in minor basins, not on the Delaware River. There are also 469 small hydropower sites with a total of 22MW of undeveloped potential. These sites have an average potential capacity of only 47kW per site and limited commercial value. The majority are located in Burlington (2.1MW), Gloucester (1.4MW), Morris (2.6MW), Passaic (1.4MW) and Sussex (3MW) counties.
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> We use New Jersey Department of Environmental Protection dam data to contact dam sites around the state and question their use of and potential interest in hydroelectric power. Our results indicate that there are no easy answers to the development of hydroelectric power in New Jersey … a multi-level approach, including economic incentives and education will be necessary. We found that, overall, 27% of dam sites would be interested in pursuing hydroelectric power generation and that for sites between 10 and 40 feet, 35% of sites are interested. Furthermore, a majority of sites that do not currently produce hydroelectric power feel that their sites are not suitable for it (61%). This would likely need to be verified as many people who responded admitted to be only somewhat knowledgeable on the matter.

In addition, this study provides an extensive list of hydropower resources, for dam owners and others interested in developing this resource. For reasons stated above, however, we believe this underestimates the potential in New Jersey.

A Case Study in Immediate Opportunity: Electrifying the Passaic River (Tom Miezejeski, 6/25/08)

> The Passaic River has a watershed area of almost 800 square miles and flows on the edge of or flows through 6 counties in North Jersey. For most of its length it is the county line separating one county from another. Most of the other small hydro opportunities in the eastern part of New Jersey are on tributaries of the Passaic River.
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> The Passaic River has tremendous potential for hydropower. This is due to the significant flow of the river. There are 20 dams on the river from its source in Mendham to just above the Great Falls. There are three dams that combined could produce over 6 MW of power.
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> The Dundee Lake Dam in Clifton, is rated at 1750 kW. Over $3 million was recently spent to renovate this dam. Thus, it should be in excellent condition and all spending could focus on installing power production equipment. The dam is owned by the North Jersey District Water Supply.
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> The Beatties Mill Dam in Wayne is rated at 2400 kW. The dam is owned by the Passaic Valley Water Commission.
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> The existing power house at the Great Falls in Paterson produces 11 MW of electricity. This power is produced from water that runs through a penstock at the top of the escarpment to the base of the falls. There is a 12 foot high dam, the Great Falls Dam, that is located on the river just before it reaches the

[11] Conner, A.M. and J.E. Francfort. U.S. Hydropower Resource Assessment for New Jersey. U.S. Department of Energy. Contract DE-AC07-94ID13223. March, 1996.

falls. We could not find any official estimates of the power potential of this dam, but our estimate is that it could be about 1000 kW. This dam is owned by the Paterson Municipal Utilities Authority.

These three dams can be best exploited by electric generating equipment that is already on the market. However, based on a meeting with the town engineer for Paterson who also works for other water companies there is a huge potential for HydroCoil turbines in the water distribution system of these companies. In addition to exploiting the flow of water in conduits, HydroCoil units can be used as pressure reducers as water branches off from the large high pressure mains to smaller distribution pipes.

The remaining 17 dams range in height from 6 feet to 18 feet. Only two of these dams are rated for power production. The Van Dorans Mill Dam in Bernards Township at 16.4 KW and the Washington Corner Dam in Mendham at 34 KW. The dam is owned by County of Morris Park Commission. It is at a historic mill on Route 24. In our view all the other dams have a potential of less than 50KW.

There is one dam in the Hackensack - Res#2 dam in Union City and owned by United Water of New Jersey. Since this dam is in Union City the flow has got to be very high. I have uncovered some very interesting technology for very low head application as little as 6 feet but as they require a lot of volume this technology may be of most use in those areas just before the river reaches Newark Bay.

There are several places along the river where the water drops significantly over a short distance. These locations could be suited to run-of-river applications, where the water is diverted into a penstock and then through a small power house. These sites would not divert the entire river and may not operate at all during the drier months of the year. However, since civil works would be minimal there would still be a good ROI.

Since the river runs through many areas where industry is located on both banks of the river, there is a good potential to sell power directly to industrial customers thus eliminating the need to connect to the grid, which in turn will significantly reduce or eliminate the need for FERC permits. In addition HydroCoil units in conduits may not even require state permits. (Miezejeski, email 6/25/08).

It should be noted that the Passaic River has serious garbage and floating trash issues, as documented by the Passaic River Coalition and the Passaic Valley Sewage Authority amongst others, which may cause problems for smaller hydroelectric units and require additional screening and object removal. At the same time, the value of the hydroelectric resource may both encourage and contribute to the cost of cleaning up the river, a desirable environmental goal in itself.

Selected Media Coverage

U.S. on the Verge of a Small Hydro Boom?

http://www.renewableenergyworld.com/rea/news/podcast?id=51835
New Hampshire, United States [RenewableEnergyWorld.com]

Think the hydropower resource in the U.S. is all dried up? Not even close. According to the Idaho National Laboratory (INL), there are still about 100,000 megawatts of hydro resources available in this country.

Doug Hall, Program Manager for the INL Water Energy Program, tells us about how what types of technologies the industry may use to exploit this resource in a more sustainable way.

National Hydropower Association Executive Director Linda Church Ciocci talks about the slow regulatory process at FERC and MMS, what kind of national incentives the industry relies on and how perceptions of the industry are changing within the government.

...In fact, large hydroelectric dams above 30 megawatts (MW) only make up 8% of the total hydropower plant population in the U.S., according to the Hydroelectric Power Resources Assessment Database. The other 80% of plants in the U.S. are low power (under 1 MW) or small hydro (between 1 MW and 30 MW).

...Few Americans understand the dynamics of the industry, which has given hydropower a "black eye," says Doug Hall, Program Manager of the Idaho National Laboratory's Water Energy Program. Misperceptions about the country's portfolio of projects has also lead people to believe that hydro resources are all used up. That's far from the truth, he says.

INL released a study in 2006 that identified 130,000 stream reaches around the country that are suitable for projects between 10 kilowatts (kW) and 30 MW. While the study estimates those sites to hold around 100,000 MW of annual capacity, a more realistic estimate is around 30,000 MW of annual capacity when considering technological and environmental limitations at each site. Even with such restrictions, these projects could increase U.S. hydroelectric generation by more than 50%, according to the study.

...For Lori Barg, Chief Executive of Community Hydro in Plainfield, Vermont, encouraging developers to use these methods should be a priority for every state. Unfortunately, she's doing business in a state that hasn't seen a new grid-connected hydroelectric facility built in 20 years. That's because the slow, expensive permitting process makes projects economically unfeasible, she says.

According to Barg, obtaining federal and state permits can add $2,000 per installed kW for a small hydro system, a figure that she calls "a project killer." This is partly because Vermont does not have a standardized permitting procedure.

"Obtaining the necessary permits is such a deterrent. It's important to have regulations, but I find myself having to go through 12 different agencies just to get a project off the ground. It doesn't make sense and it's not allowing Vermont to develop it's abundant hydro resources," Barg says.

Community Hydro develops energy recovery systems for municipal water treatment facilities, upgrades old mill dams into electrical generation facilities and installs damless diversion systems, which she says "are the way to go" for the least environmental impact. Currently, the company is developing projects in Washington State and New Hampshire, but is only doing feasibility assessments in Vermont.

Barg is working with the Vermont legislature to craft a cohesive rule-making process for water-flow and environmental-impact permits in the state. Legislators have agreed to "evaluate the need for a rule-making process," which she hopes will begin this June. In the meantime, Barg has multiple megawatts worth of projects waiting to be developed around the state.

"This process is somewhat impacted by the idea that hydro projects flood the land or take people's property and create major disturbances. I don't work on that level," Barg says. "We are very important from a distributed energy standpoint, and I hope we get recognized as such."

... There is a need to bring more clean hydroelectricity online as quickly as possible while also ensuring development is done in an environmentally-friendly way, says NHA's Ciocci.

http://www.renewableenergyworld.com/rea/news/story?id=51858

The Undeveloped
Hydroelectric Potential of Vermont

Prepared for and available from:

Vermont Department of Public Service

Lori Barg Community Hydro113 Bartlett Rd Plainfield, VT 05667802-454-8458
www.communityhydro.biz

January 31, 2007

Hydro was the economic backbone of Vermont. Over 2000 mills:

- o saw mills
- o grist mills
- o woolen mills
- o bobbin mills
- o fishing pole mills
- o small industry

Hydro: Redevelopment - not new development
In 1898:

- o 74,376 HP by water wheels (approx. equal to 55 MW)
- o 24,048 HP by steam at 1552 manufacturing establishments

Study relied on 17 existing data sources -no new work:

o Excel spreadsheet was built from ANR databases. Can be imported into GIS.
o Vermont Dam Inventory (VDI) -1210 dams -170 breached.
o Hydro. MDB -includes hydro without dams.
o Interestingly enough:
○ 1914: estimate of 1492 MW (2,000,000 HP) of undeveloped hydro potential in the State (Industrial Vermont)
○ 2006: 1022 MW of undeveloped hydro potential in the State (Department of Energy).

DOE sites rely on damless diversion: near natural falls or using natural gradient -Example: Twinfield School (on Virtual Hydropower Prospector): A diversion project will provide all the power for the school - $60,000 annually - 90 KW.

Why so many dams? Dams Have benefits

- Flood control
- Recreation
- Water supply
- Fish and Wildlife (VTDFW owns majority of state-owned dams –no fish passage installed)
- Historic value
- Economic - Mill dams
- Keep native fish population discrete from stocked population

(Full presentation available on request)

Comments from Dr. J.B. Rosefsky, based on the June 20, 2008 issue of the Phila. Inquirer:

What we need for microhydro.

"...Congress [may decide] to extend a tax credit, enabling firms to recoup 30% of a commercial system's cost."

Would certainly help sale of microhydro turbines.

"NJ solar rebates...are oversubscribed. Applicants are being put in a queue for next year's funds."

How soon will we be able to access such funds, for hydro?

"One financial benefit of solar is its predictability. The system has a set cost up front; after that, the fuel--sunlight--is free."

Predictable during sunlit waking hours. But the sun is rarely up when I go to sleep at night. It's all about utilization rates: 60-100% for hydro; but 25% for wind, 12% for solar according to the NJ BPU.

"Nationwide, solar remiains tiny. It is one-fifth the size of wind power, accounting for a fractioni of 1% of the nation's energy supply."

Lots of investment $ going into solar. We need to re-educate legislators and the public on lower cost and high utilization rate of micro-hydro. While maintaining state waterway flood control infrastructure/dams.

"As of March, more than $220 million in [NJ] state rebates had helped nearly 3000 systems, capable of delivering 54 megawatts of power." And, at "Stable Flats, a 70-unit residential development in Northern Liberties where plans call for a $2 million, 260 kW system to make the power."

This is where the tires hit the road: an average of 18 kW per solar system installed [54,000 kW divided by 3000 systems]. About 3-4 kW per residential unit. And about $8000 per kW cost. The HydroCoil turbine is tailored for the up to 100 kw market, and at a much better cost/kW. The time to move is now--category 1 in NJ, state incentives, federal rebates, state grants, FERC facilitation, expanded utility reverse metering coverage, customers, municipalities, distributors, installers!!

(Source: J. Rosefsky, email June 25, 2008)

Proposed Congressional Action (6/25/08)

Water Power: $40 million, rejecting the President's $7 million cut and $30 million above 2008, to research new ways of generating power from water flow. This is on top of the $319 million for upgrades to existing hydropower dams funded under the Army Corps.

(Source: *Appropriations Committee approves Innovation Agenda Funding*, Melissa.Shannon@mail.house.gov)

Example operators and installations

While many people think of hydropower in terms of the large conventional projects such as the Hoover Dam, the Tennessee Valley Authority, or Quebec's enormous hydro projects; but in reality, most existing hydroelectric installations are less than 30 MW.

Here's one example:

> Enel North America's Northeastern Operations include 45 hydro and wind projects totaling 175.7 MW in Connecticut, Maine, Massachusetts, New Hampshire, New York, Pennsylvania, and Vermont.

A complete listing of Enel's Northeastern projects is presented here:

State	Project Name	Renewable	Status	Capacity (MW)
Connecticut	Kinneytown	Hydro	Operating	2.4
	Willimantic I	Hydro	Operating	0.8
	Willimantic II	Hydro	Operating	0.8
Maine	Salmon Falls	Hydro	Operating	1.2
Massachusetts	**Boott**	Hydro	Operating	24.8
	Crescent	Hydro	Operating	1.5
	Glendale	Hydro	Operating	0.7
	Lawrence	Hydro	Operating	16.8
New Hampshire	Great Falls Lower	Hydro	Operating	1.3
	Hillsborough	Hydro	Operating	1.2
	Kelley's Falls	Hydro	Operating	0.5
	Lower Valley	Hydro	Operating	0.9
	Mascoma	Hydro	Operating	1.5
	Rollinsford	Hydro	Operating	1.5
	Sweetwater	Hydro	Operating	0.9
	West Hopkinton	Hydro	Operating	1.0
	Woodsville	Hydro	Operating	0.4
New York	Copenhagen	Hydro	Operating	3.3
	Denley Dam	Hydro	Operating	1.5
	Dexter	Hydro	Operating	4.3
	Diamond Island	Hydro	Operating	1.2
	Fenner Windpower	Wind	Operating	30.0
	Fowler #7	Hydro	Operating	0.9
	Goodyear Lake	Hydro	Operating	1.3
	Groveville	Hydro	Operating	1.2
	Hailesboro #3	Hydro	Operating	0.9
	Hailesboro #4	Hydro	Operating	1.8
	Hailesboro #6	Hydro	Operating	0.9
	High Falls	Hydro	Operating	1.8
	LaChute Lower	Hydro	Operating	3.6
	LaChute Upper	Hydro	Operating	4.9
	Lower Saranac	Hydro	Operating	9.3
	Port Leyden	Hydro	Operating	2.0
	Pyrites	Hydro	Operating	8.2
	Rock Island	Hydro	Operating	1.9
	Theresa	Hydro	Operating	1.3
	Victory Mill	Hyrdo	Operating	1.7
	Walden	Hydro	Operating	2.8
	Wethersfield Windpower	Wind	Operating	6.6
Pennsylvania	Beaver Valley	Hydro	Operating	1.3
Vermont	Barnet	Hydro	Operating	0.5
	Deweys Mills	Hydro	Operating	1.9
	Newbury	Hydro	Operating	0.4
	Ottauquechee	Hydro	Operating	1.9
	Sheldon Springs	Hydro	Operating	25.0

Conclusion

We believe that the potential for small hydro in NJ has been significantly underestimated, and needs to include a much wider range of opportunities, given advances in technology and the potential for exploiting additional resources in an environmentally friendly manner. For example, it should be noted that "very low head technology and hydrokinetic technology can capture significant amounts of energy with no impact on fish, recreation or navigation. Since the basic principles of physics involved in hydropower make it so much more efficient than solar and to a lesser degree wind, people will find many ways to capture this energy if the economic incentive is there and the regulation is proportional to any possible negative effects of these applications." (Miezejeski, email, 7/7/08)

While the potential for small hydro in New Jersey may seem relatively small in comparison to other sources of renewable energy – wind, for example, where New Jersey is estimated to have at least 300 MW of developable wind onshore, and several thousand offshore – it is important to bear in mind that not all MW are equal. A wind turbine rated as 1 MW capacity may operate at this capacity for only a few hours a day. Hydroelectric turbines are expected to operate more than 90% of the time (allowing for maintenance, etc.), and can therefore be considered part of base load generation, thereby displacing an equal quantity of traditional fossil-fuel generation.

Purchasing small hydro capacity from other states means that those dollars do flow out of state; but so do dollars for most of the traditional fossil-fuel generation. If part of the objective is also to bring clean, renewable energy to the citizens of New Jersey at the lowest price, small hydro is an appropriate policy option. It may also lessen the need for the sorts of extremely costly infrastructure upgrades, such as the proposed Susquehanna-North Jersey transmission line (likely to cost nearly $1 billion) needed to bring electricity from coal in West Virginia, Pennsylvania, and Ohio.

On balance, therefore, it seems that small hydro should be treated as just as desirable as other Class I renewables.

In summary, this analysis recommends that small hydro (defined here as projects under 30 MW, which all of the NJ's projects would be) be reclassified from Class II to Class I, and other incentives be introduced to encourage the utilization of small hydro opportunities in New Jersey and advantage the purchase of power derived small hydro from other states in comparison with electricity generated from nonrenewable sources.

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