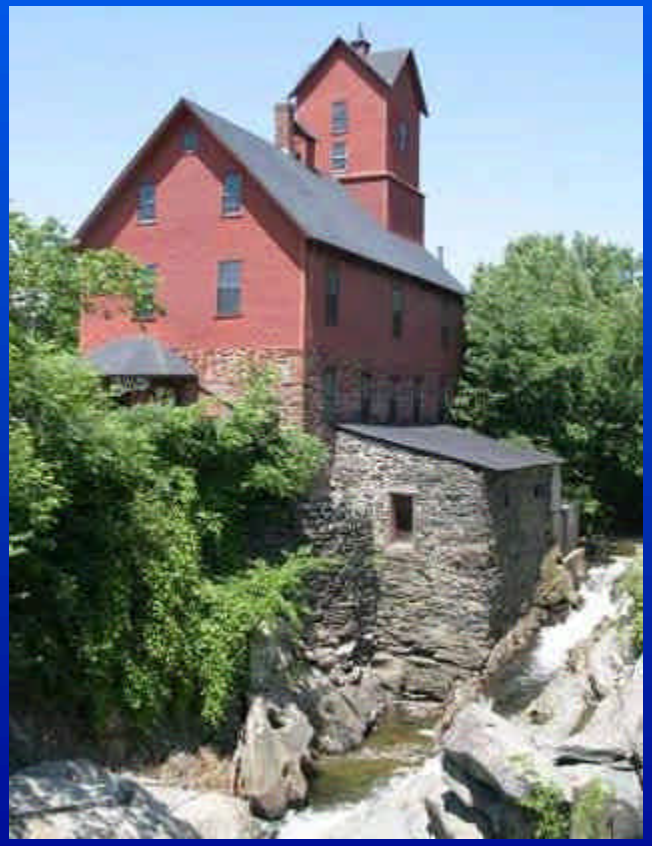
Renewable Energy Vermont Conference

Oct. 19, 2006



Renewable Solutions I

Small –hydro

The Cutting Edge

Hydro: Historic Power Source

- 18th – 20th century New England
  - Gristmills
  - Sawmills
  - Electric generation

On Vermont Waterways

Montpelier, 1821

In 1898:

74,376 HP by water wheels (approx. equal to 55 MW)

24,048 HP by steam at 1552 manufacturing establishments

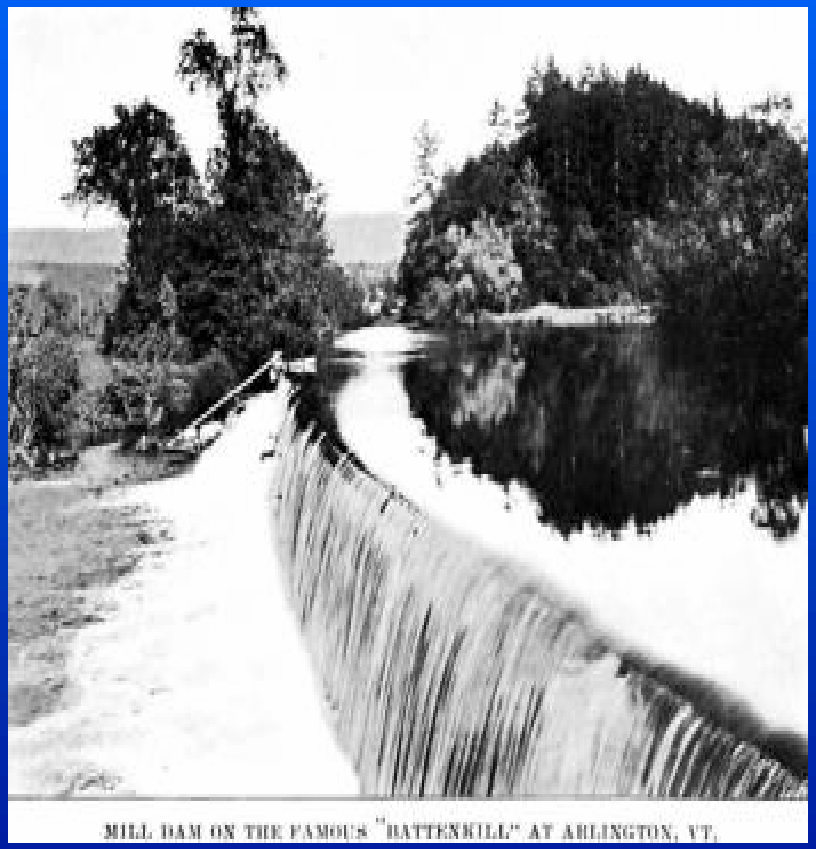
What goes around comes around

1898 - 55 MW @ 1552 plants

1908 - 127 MW

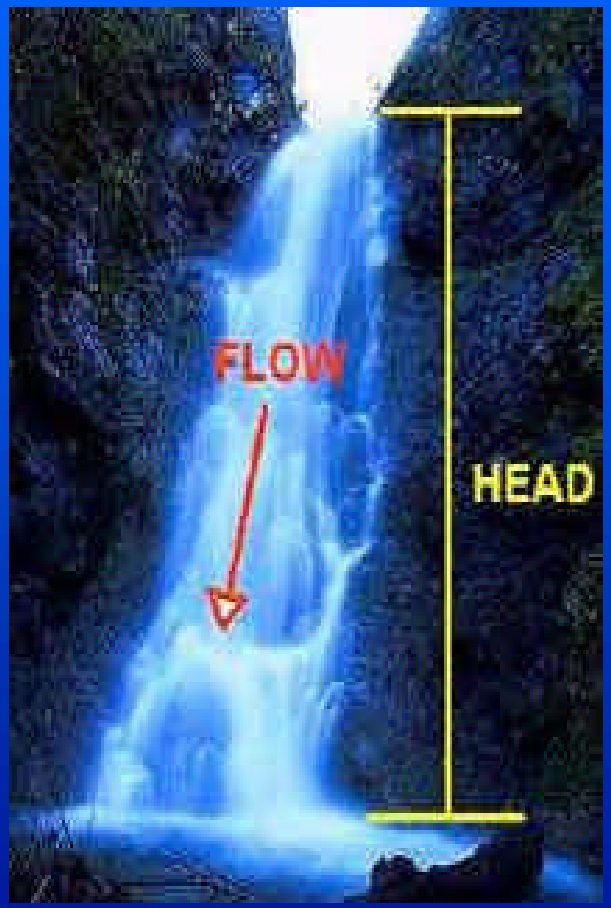
1914 estimate – 1492 MW potential

How Hydro Works


MILL DAM ON THE FAMOUS "BATTENKILL" AT ARLINGTON, VT.

Spinning Turbine transfers power for either mechanical use – mills- or power- hydroelectric

How Hydro Works



Determine the Potential

Need to know head and flow!

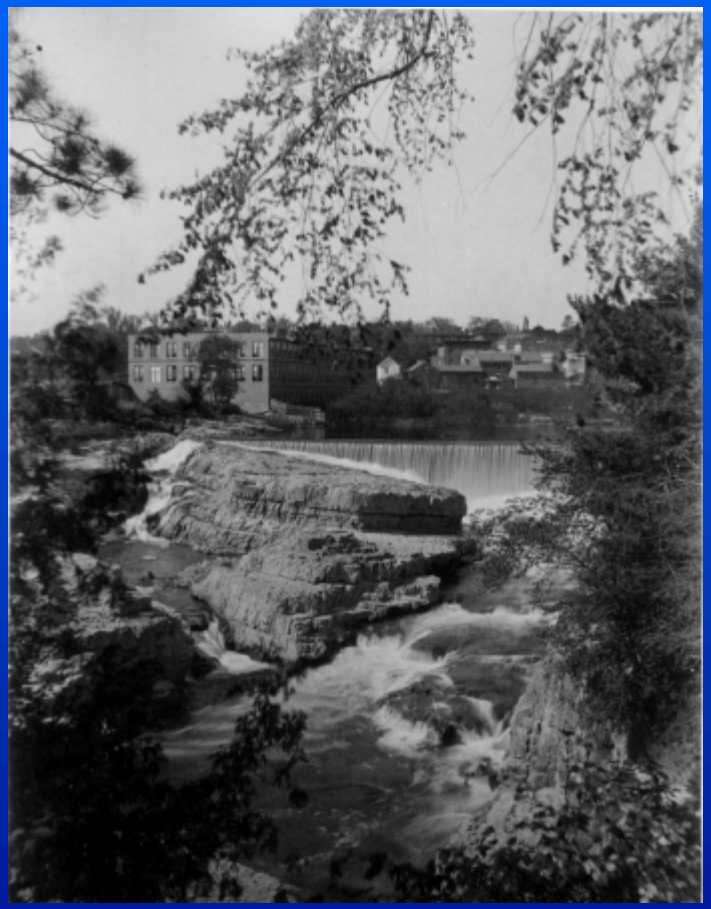
Flow (gpm) x Head (ft)/10=
Power (continuous watts)

500 gpm x 50 ft/10 =
2500 watts or 2.5 kW
(ballpark!)

Simple Proven Technology

- High Efficiency (70 –90%) best of all energy technologies.
- High capacity factor (>50%), compared with 10% solar and 30% for wind.
- Proven technology, engineered to last for more than 50 years.
- Run of the River avoids problems associated with store and release.

Hydro Opportunity-Scaled to Vermont



Large Hydro>100MW

Small Hydro = 1-5 MW

Mini Hydro = 100 kW-1 MW

Micro = 5 - 100 kW

Pico = <5kW

Issues and Options

1. Turbine choices - determined by head. Least expensive systems to develop are high-head systems.
2. Dam and civil works requirements?
3. Connect to the Grid? Or not?
4. Regulatory process
5. Cost

Turbine Choices

- Low Head = Reaction Turbine
  - Usually submerged
  - Typically used in Vermont mills
- High Head = Impulse Turbines
  - Turn by water hitting the wheel

Vermont Was Built on Hydro

Vermont has over 1000 *existing* dams.

- Many will NEVER be removed.
- Need to assess conditions & permit requirements.

Opportunities without dams:

- Damless diversion.
- Conduits.

Dams Have Benefits

- Flood control
- Recreation
- Water supply
- Fish and Wildlife

(VTDFW owns majority of state-owned dams)

- Historic value
- Economic - Mill dams
- Keep native fish population discrete from stocked population

Dams Have Liabilities

- Block fish passage-fish can't get upstream. Many fish ladders don't work.
- Fish can get entrained in turbine downstream-need screening.
- Engineered, can breach.
- Store and release hydro can change flows dramatically. Alternately drying up and flooding river.
- Backwater effects-no longer free flowing river.

Low Impact Hydro Institute

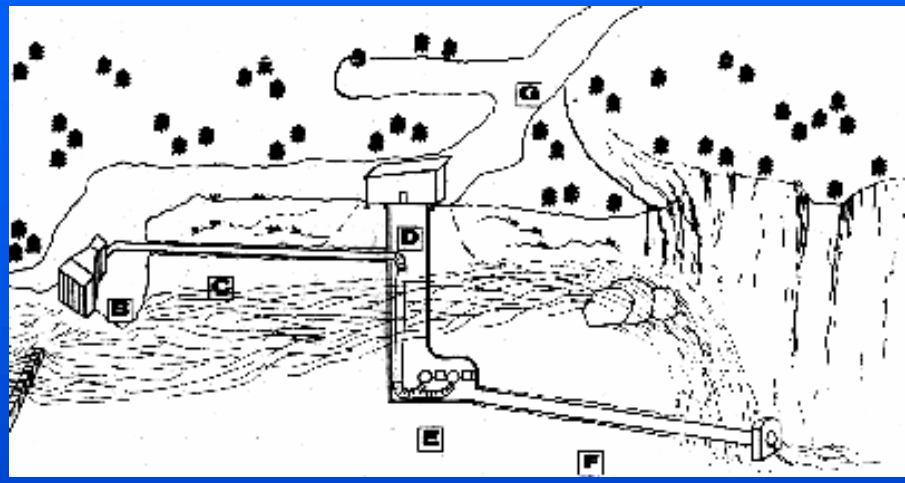
The Low Impact Hydropower Institute (LIHI) is a non-profit organization dedicated to reducing the impacts of hydropower generation through the certification of environmentally responsible, "low impact" hydropower.

Low Impact Criteria

1. No negative impact to threatened or endangered species
2. No adverse impact to cultural resources
3. Not recommended for dam removal
4. Allows for recreation
5. River flows healthy for fish
6. Not contribute to impaired water quality
7. Allows fish to pass, fish not entrained
8. Protects watershed

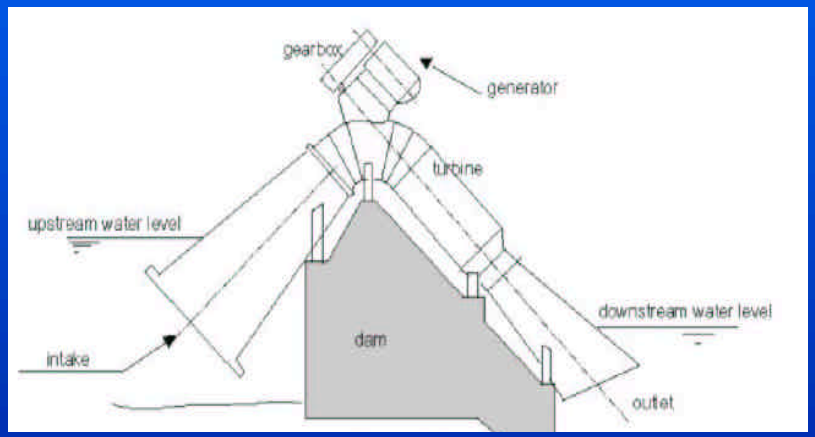
Damless Diversion-old and new

256 B.C, Dujiangyan China
40%/60% water division
Shared resource



Tazimina Alaska
Iliamna-ewhalen-
Nondalton Electric
824 kW

Retrofit Historic Mill Dams



Costs

Water to Wire package $850 - $1,100 kW.

Approximate all installation costs $1500 - $2,500 KW(per Mike Scarzello, CVPS).

Smaller systems can be much more expensive per kW.

Big cost is permitting and protection mitigation and enhancement.

Regulatory Requirements

FERC license or exemption need OK from:

- ✓ Vt. Dept. of Environmental Conservation – Dam Safety, Water Quality Division,Hydrology, Wetlands, Lakes, River Management;
- ✓ Vt. Dept. of Fish and Wildlife - Fisheries, Wildlife, Non-game and natural heritage;
- ✓ Vt. Division for Historic Preservation (SHPO);
- ✓ Vt.Public Service Board; &.
- ✓ Vt. Dept. of Public Service.
- ✓ U.S. Fish and Wildlife Service;

Regulatory “Opportunities”

No state jurisdiction on watersheds less than 10 sq. mi.Title 10 ch 41 § 1021.

No FERC license required for farm ponds.

No dam removal in Vermont unless PSB has review.

ANR Procedure for Determining Acceptable Minimum Stream Flows

- Adopted in 1993
- Uses USFWS NE Flow Policy:
  - Flow Standards based on seasonal median flows
  - Alternatively, applicants may do site specific studies
- *De Minimis* Withdrawals
  - No permit required for withdrawal rates less than 5% of 7Q10 or less than .005 x drainage area (mi^2)

Slide from Brian Fitzgerald ANR

Regulatory Concerns

- Must meet state 401 water quality certification or can meet flow guidelines of state.
- Typically, state requires minimum flows in bypass.
- Retrofits are possible for fish passage.

Permitting Costs

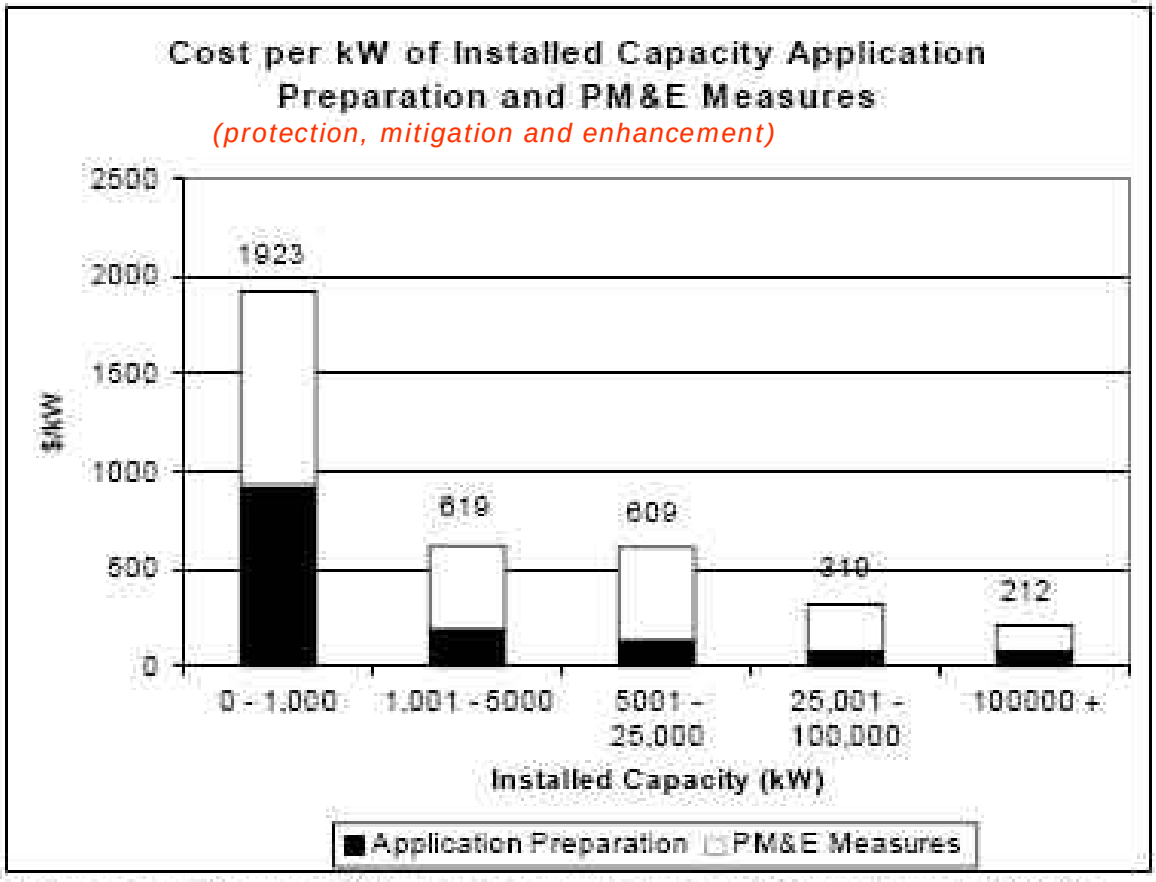


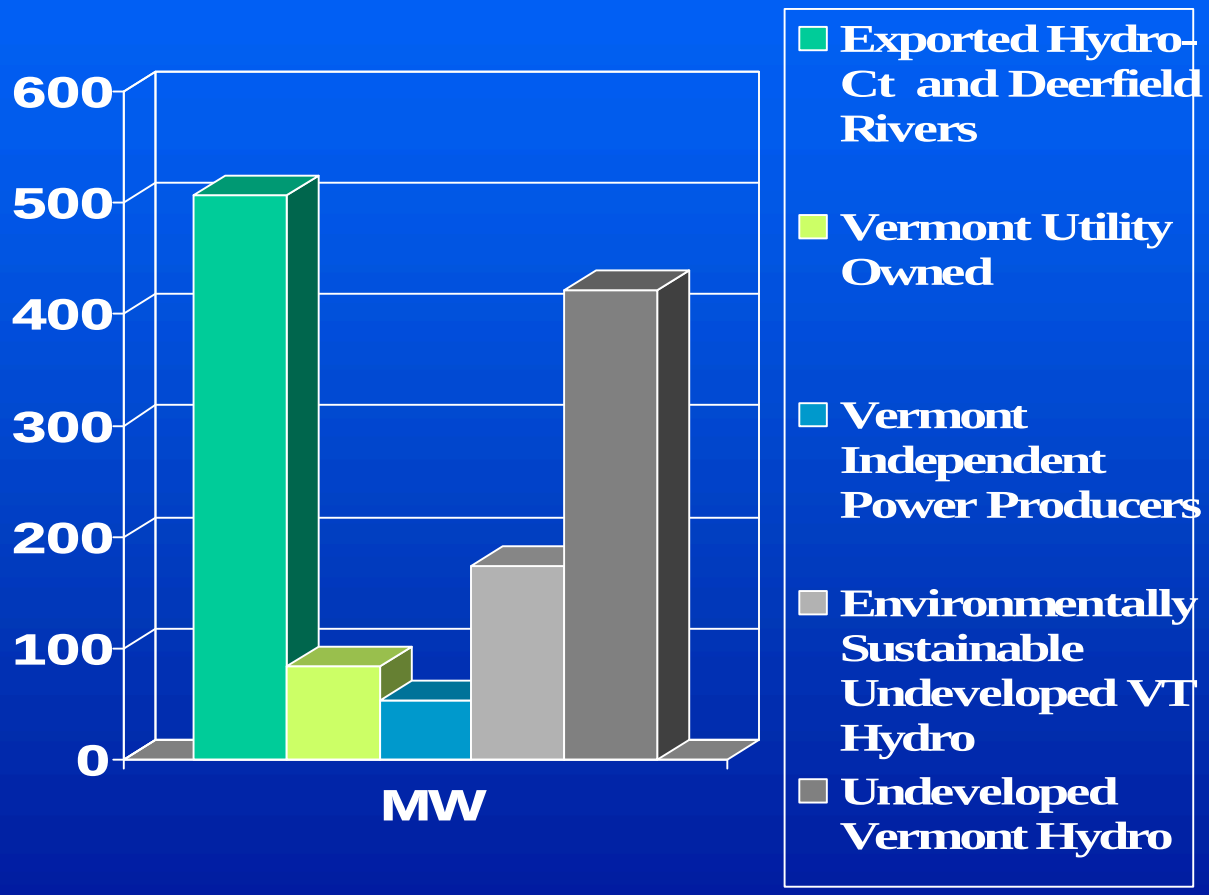
Figure 5 Cost ($ per kW of Installed Capacity) Application Preparation and PM&E Measures.

From FERC-2001 Report on Hydroelectric Licensing Policies, Procedures and Regulations Comprehensive Review and Recommendations Pursuant to Section 603 of the Energy Act of 2000

Ideas for Incentives

1. Easier permitting. England reduces requirements for <500KW
2. England offers grants of £1.000 per kW to max of £5,000 per project.
3. Municipalities receive grants of up to 50% of project costs up to £100,000.

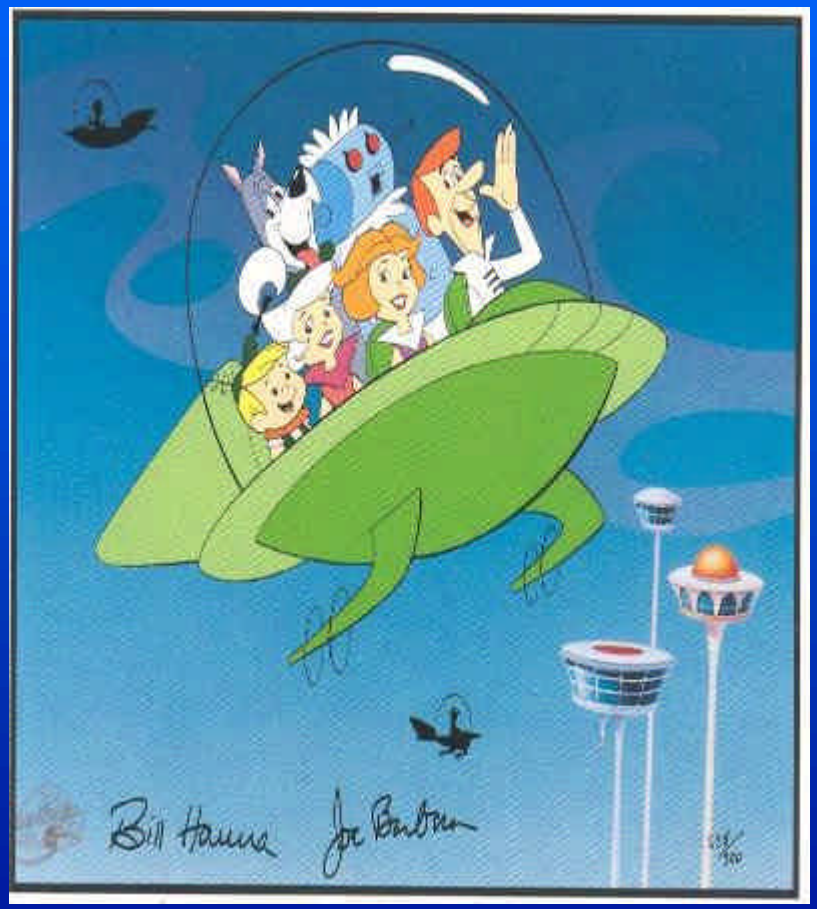
Vermont's Hydro Potential



Vermont's Hydro Potential

- Encourage small & micro-hydro;
- Assume low-impact;
- Create incentives;
- Multiple uses of public resource
- Facilitate permitting of small hydro

What goes around comes around



2006 - 702 MW @95 plants (per ANR)

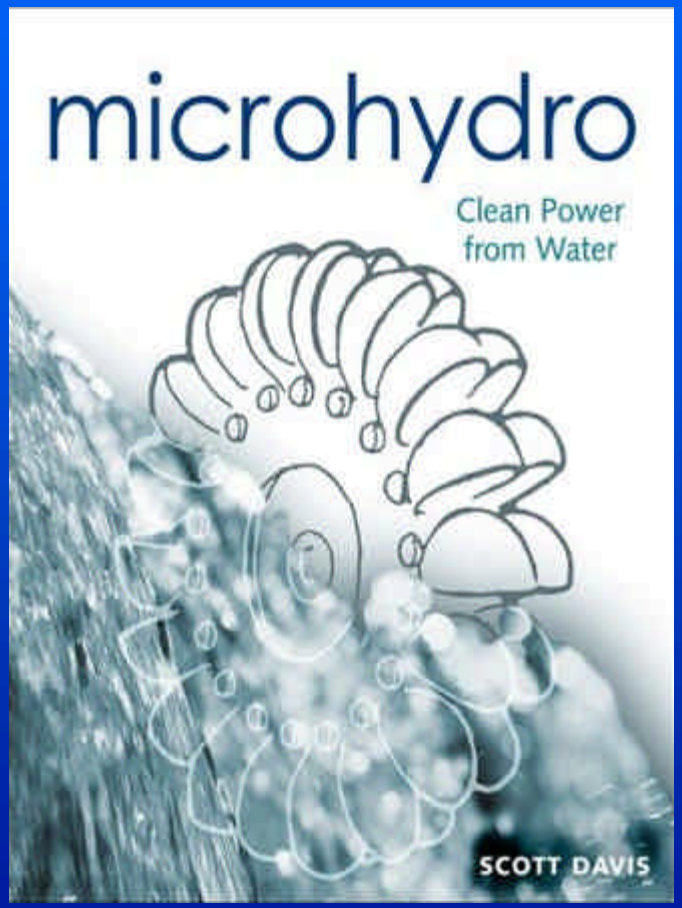
506 MW currently exported

Est. of undeveloped potential at existing dams

421 MW

174 MW environmentally sustainable

Resources



European Small Hydro Association
www.esha.be

Other web sites

http://www.microhydropower.net/

http://www1.eere.energy.gov/windandhydro/

"This white coal from hydro-electric development, free from smoke, soot and cinders….are today producing power sufficient to displace the use of a million tons of black coal annually, and this power can readily be distributed to every small and large town ……and thus revive the hundreds of small factories, which were formerly the hives of industry in so many of our small villages…Again how differently, financially, for our people and state, if this $5,000,000 now paid annually to the coal producers of Pennsylvania and Ohio should be produced and kept within our borders."

Vermont Governor John A. Mead - 1912

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