Large Hydropower Projects: Renewable and Green?

Dominique Égré, Luc Gagnon and Joseph Milewski
Direction principale Planification stratégique et Environnement

There has been considerable debate about the definitions of "green" and "renewable" sources of energy in North America. Hydropower is either included or excluded in these definitions and distinctions are often made between large and small projects. These distinctions are based on the belief that small projects offer social and environmental advantages over large ones because they have a less imposing scale and usually affect only small waterways. According to this view, large hydroelectric projects are unacceptable because of their adverse social and environmental consequences.

This paper clarifies these issues by addressing the following questions:

1. Should hydro be included in Renewable Energy Portfolios?
2. Are distinctions between large and small hydroelectric projects justified?
3. By what means can hydro qualify as "green" power?

1. Should hydro be included in Renewable Energy Portfolios?

A scientific definition of *renewable*

The development of renewable energy fulfills many basic goals of sustainable development, notably because it does not consume our capital of natural resources. Accordingly, restructuring of the electricity sector often comprises mechanisms to support renewable sources of energy, including renewable energy portfolios which are designed to set a minimum level of renewable energy generation. However, definitions of renewable energy in policy documents or restructuring legislation generally reflect a negative perception of large hydroelectric developments. For instance, in the Clinton Administration's proposed Comprehensive Electricity Competition Act, only energy produced from solar, wind, geothermal or biomass sources are considered renewable. In California, electricity from hydroelectric plants of 30 MW or less is considered renewable, while Vermont sets the limit at 80 MW and Rhode Island at 100 MW, provided the project does not require the construction of a new dam.

This total or partial exclusion of hydroelectricity from renewable energy programs cannot be justified on scientific grounds. In fact, it is impossible to establish theoretical differences between hydropower and wind power, an energy source often considered as offering exceptional prospects for future development. Both are forms of indirect solar energy. Unlike fossil fuels, they do not

increase entropy: in other words they convert natural flows of unconcentrated energy in the form of wind or water into the useful form of electricity. Both have very short and efficient energy chains, again unlike fossil fuels which require multiple processing steps. For these reasons, all hydro projects, whatever their size, should be included in renewable energy portfolios.

Level of service

Each option for generating electricity has unique characteristics which must be considered in planning new supply. These considerations include capacity and energy output, dispatchability, cycling capability, ramp time and automatic generation control. In order to compare renewable resources on an equal footing it is essential to take into account the level of service provided.

For example, the electricity generated by wind farms is extremely variable; stability of supply must be provided by a supplementary source. The best backup option for wind is hydropower with a reservoir because it is renewable and capable of increasing or decreasing production rapidly to compensate for wind fluctuations. This being the case, it is impossible to consider wind power more renewable than the hydropower upon which its viability depends.

2. Are distinctions between large and small hydro installations justified?

Comparison per unit of energy

According to popular perception, large hydro projects have greater environmental impact than small projects. Actual comparisons based on units of energy produced demonstrate the fallacy of this perception: the impacts of a single large hydro project may be much less than the cumulative effect of several small projects yielding the same power and generating capacity. This is why:

Geometry tells us that a small object has a greater surface area in proportion to its volume than a large object. The difference may be significant: for instance, when the volume of a cube doubles, its surface area increases by only 60%. This implies that, all other things being equal, the land area inundated by 50 projects with a capacity of 20 MW each would be greater than the area inundated by a single 1000 MW project, although the total capacity is identical. In other words, in order to provide the same storage volume as a single large reservoir, many more rivers must be disturbed with greater impact on wildlife habitats. This theoretical consideration is supported by statistical analysis. The following table, based on existing hydro projects, shows that the average reservoir area is greater for small projects.

Average Size of Hydro Reservoir per Unit of Capacity[1]

Size of plants (MW)	Number of plants in category	Average size of reservoir per unit of power (ha/MW)
3000 to 18200	19	32
2000 to 2999	16	40
1000 to 1999	36	36
500 to 999	25	80
250 to 499	37	69
100 to 249	33	96
2 to 99	33	249

Because of this constraint, it is more difficult to design a small hydropower dam with enough stored water volume to meet peak demand and also avoid water spillage in times of flood. In a northern environment, water flow fluctuates significantly, with low flow in winter coinciding with peak electricity demand. Reservoirs are therefore essential for the purpose of storing water to satisfy demand. For instance, water flow on the Sainte-Marguerite River in Québec fluctuates from an average low in March of 20 m^3/s to an average high in May of 340 m^3/s. A 253 km^2 reservoir on this river provides a stored water volume which enables the 882 MW powerhouse to operate at full capacity when the demand for electricity is highest. Providing the same stored water volume by means of multiple small projects would require a much greater total reservoir area.

To avoid the difficulties of storing water, some small hydro projects are run-of-river constructions. This type of project, however, cannot provide the same level of service as a hydroelectric plant with a reservoir. Run-of-river plants must be coupled with other generating plants in order to meet seasonal and daily demand fluctuations. Whatever the supplementary energy source, its impact too must be taken into account, as for the backup systems for wind power.

In summary, although it is obvious that a small intervention will have less impacts on habitat than a large one, the true comparison lies in the energy and power requirements which must be met. From this standpoint, the impacts of a single large project may be significantly less than the cumulative impact of many small projects, given the diversity of ecosystems that will be affected by small projects and the much greater total area inundated.

Impacts of hydropower are site-specific

Beyond the debate over the size of installations, follow-up studies of hydroelectric projects show that the most fundamental determinant of the nature and magnitude of impacts are the specific site conditions. Whether the dam is large or small, "the most effective environmental and social

[1] Goodland, Robert. *How to Distinguish Better Hydros from Worse: the Environmental Sustainability Challenge for the Hydro Industry.* The World Bank. 1995.

mitigation measure is good site selection, to ensure that the proposed dam is inherently benign in the first place"[2].

It is sometimes argued that only run-of-river plants, and projects which provide additional capacity at an already existing site, should be considered renewable. In this case also, the characteristics of a specific site are the most important factors in determining the nature and magnitude of the impacts. Adding capacity at an existing plant may involve river flow variations and consequent impact downstream. A run-of-river plant may have significant impacts if it entails the dredging of a canal or the diversion of a river. Moreover, such projects cannot meet fluctuations in electricity demand as can a hydroelectric plant with a reservoir.

3. By what means can hydro qualify as "Green" Power?

The size criterion is a very poor indicator of the environmental impacts of a hydropower facility

As a result of legislation on electricity restructuring, a growing number of customers will be offered a choice in their electricity supply. Utilities and independent marketers have already begun to act on widespread public support for environmentally benign products by offering "green" solar, wind, geothermal, biomass and hydro electricity. Voluntary certification and verification programs have been set up in order to assure consumers that their "green" purchases really do contribute to a cleaner energy system.

Eligibility requirements to qualify as "green" energy under these programs have generally been defined on the basis of project size for hydropower, using an arbitrary cutoff (usually 30 MW). However, American Rivers, a leading environmental organization, and Green Mountain Energy Resources, a leading supplier in the emerging green power market, have recently recognized that the size criterion "is a very poor indicator of the environmental impacts of a hydropower facility"[3]. They have identified six key goals which provide a reasonable determination of whether a hydropower facility has low impacts on the environment. These concern fish populations, river flow, water quality, flooding of wildlife habitats, cultural resources and recreation. They have also established objective criteria to address these six goals. These criteria correspond to state-of-the-art mitigation or enhancement measures which are generally applied in the industry or which are part of government requirements.

Moreover, the Green-e Program administered by the Center for Resources Solutions has certified green power packages which include large hydro, such as Green Mountain's Enviro Blend and PG&E Energy Services' Clean Choice 50.

---

[2] Ledec, George, Juan David Quintero and Maria Clara Mejia. *Good Dams and Bad Dams: Environmental and Social Criteria for Choosing Hydroelectric Project Sites*. The World Bank. October 1997.

[3] American Rivers. *Hydropower as a Low Impact Electric Generation Source*, Draft dated September, 1998. (www.amrivers.org/green.html)

The environmental review process: a basis for inclusion of hydroelectricity in the definition of "green" energy

Canada's environmental legislation provides for a comprehensive assessment of all environmental issues. It covers all stages of a project (selection of alternatives, impact of the selected alternative, impact of construction activities, mitigation and enhancement measures, monitoring) and provides for the participation of all parties involved in a project, including the population which might be affected. Under this legislation, a licence to undertake a project means, given its specific site conditions and technical characteristics, that it has been judged environmentally and socially acceptable. In the case of large hydroelectric projects, which generally give rise to much debate among government organizations, environmental groups and the population concerned, implementation of this legislation is very strict.

This thorough process can be relied upon to determine whether projects qualify for a "green" energy logo. Provided that they have a licence under the environmental legislation, hydro projects, irrespective of size, would qualify as "green". This approach has already been adopted by the state of Connecticut in its restructuring legislation.

January 1999