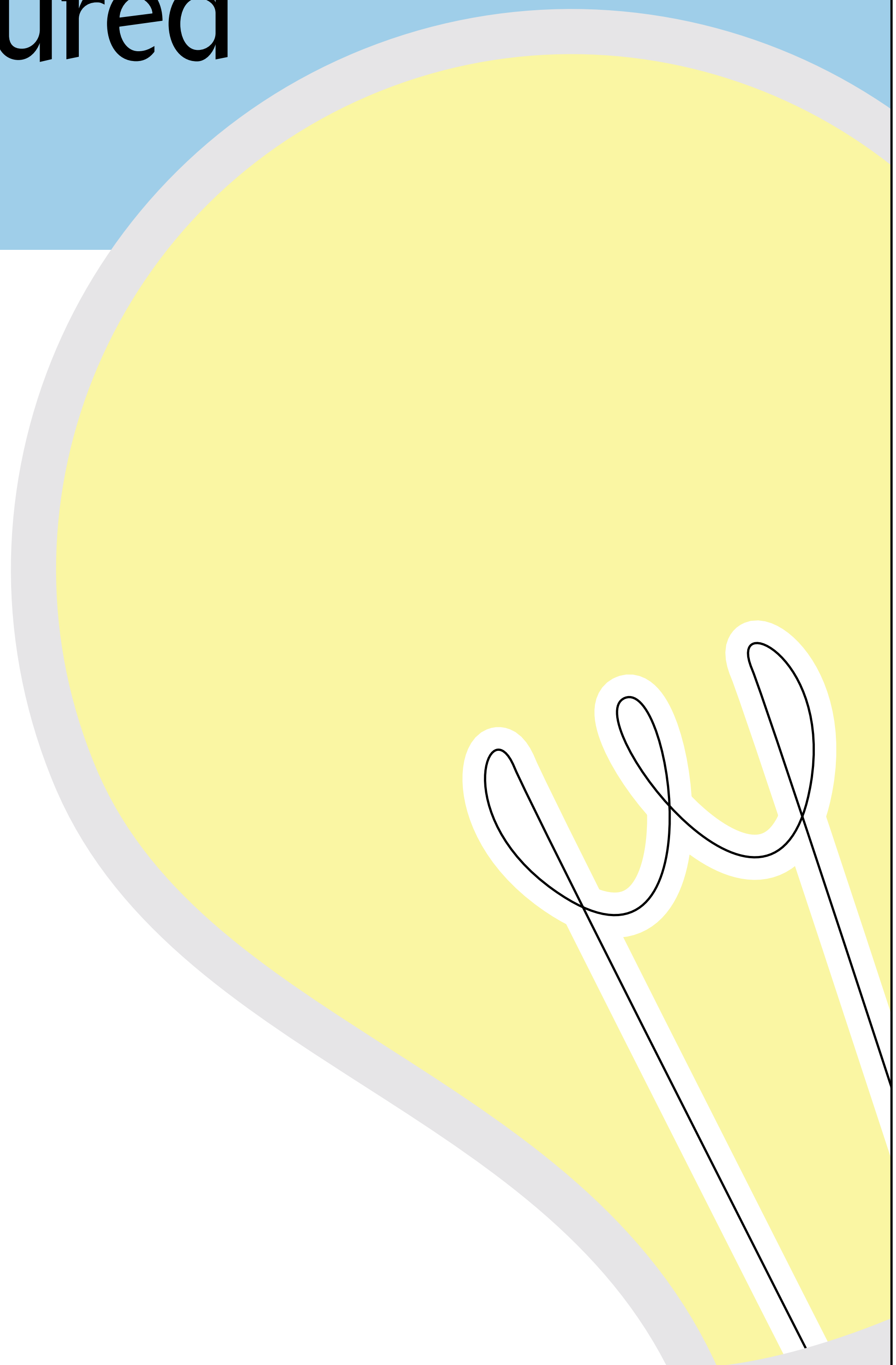
Restructured Rivers

Hydropower in the Era of Competitive Markets



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Restructured Rivers:
Hydropower in the Era of Competitive Markets
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International Rivers Network
Linking Human Rights and Environmental Protection

A Message from Juliette Majot

Executive Director, International Rivers Network

ABOUT IRN

International Rivers Network (IRN) is a nongovernmental organization which supports local communities working to protect and restore their rivers and catchments. Since 1986, IRN has worked to halt and reverse the degradation of river systems and to encourage equitable and sustainable methods of meeting needs for water, energy and flood management. We work to promote sound management of the planet's freshwater resources, to link environmental protection with human rights, to create a worldwide understanding of river ecology, and to reveal the interdependence of rivers' biological, physical and cultural aspects.

Through research into alternative energy generation, irrigation and flood management schemes, pressure for policy reform at international financial institutions such as the World Bank, and active media and educational campaigns around the world, IRN works to discourage investment in destructive large-scale river development while encouraging strategies that are more environmentally, socially and economically sound.

A MESSAGE FROM JULIETTE MAJOT
Executive Director, International Rivers Network

When California Governor Gray Davis switched on the lights of the official state Christmas tree in December 2000, he knew that a few short twinkles later, he'd switch them right back off again. Decorative lighting was the least of his worries. Without their own generators, schools, hospitals, factories, dot-coms and households could very well be hit by rolling blackouts. California's electricity supply simply was no longer reliable. In the state that had led the way in energy sector restructuring, where competition had been introduced in both wholesale and retail markets, the promise of less expensive electricity hadn't just fallen through, it had become a black comedy. Not only had the cost of electricity in some parts of the state doubled, there was a real possibility that no matter how much you paid (if you could afford it), there just wasn't enough electricity to go around. And no one, it seemed, from the Governor, to the electricity generators, to the electricity transmitters, to the federal energy regulators, to the consumer advocates could agree on what, precisely, had gone wrong or what needed to be done about it. By mid-April 2001 (the time of this writing), the credit ratings of the state's two largest utilities had been downgraded to "junk bond" status. Pacific Gas & Electric filed for Chapter 11 bankruptcy and some of California's leading Democrats had proposed that the state seize the utilities' hydropower assets — a system valued at an estimated $5 billion.

Just months earlier, across the Atlantic in London, Nelson Mandela had delivered his keynote address at the launch of the first independent assessment of the performance of large dams world wide. The report that Mandela was heralding was produced by the World Commission on Dams, a bipartisan and international group of experts with both pro- and anti-dam leanings. The report contained sobering news for dam proponents. Whether for irrigation, water supply, flood control or hydropower, big dams have underperformed against the targets originally established for them; an estimated 40 to 80 million people have been forcibly displaced to make way for them; environmental impacts have been profound; their capital costs have, on average, run about 50 percent over budget; and to make matters worse, it turns out that reservoirs, particularly those in tropical regions where the greatest percentage of new dams are "in the pipeline," emit significant amounts of greenhouse gases.

Greenhouse gases, were, during the very same moon, the subject of intense and acrimonious discussion among world leaders and their negotiating teams at the Hague as they attempted (and failed mightily) to establish the rules that the world must follow if we are to limit the amount of greenhouse gases entering the atmosphere and playing havoc with the climate. Disagreeing on nearly everything (other than the fact that climate change was real and bad), negotiators spent a good deal of time considering what types of energy projects should be encouraged through subsidies of many kinds, including trading carbon credits and the Clean Development Mechanism. Nuclear power took center stage as the most controversial energy source, and though no one can say with certainty, it is very likely that nuclear power will eventually be dropped from qualifying for such subsidies. Among the negotiators, however (and despite the clear findings of the World Commission on Dams just days before), large dams appeared to maintain an unearned and erroneous reputation as providing electricity that is "clean and green." Insiders suggested that the desire to build big dams was very much alive in the hearts and minds of world leaders at the Hague. Notable among the non-governmental participants at the conference were representatives from Hydro-Québec, whose current plans call for building a great many more dams to provide electricity not only for Canadians, but especially for energy gluttons to the south, in the U.S.

Building new big dams was certainly not on the mind of the Governor of California when he switched off the Christmas tree lights, even though the electricity supply in his state was unreliable. Nor is it currently on the mind of any governor in the United States. This is primarily because the U.S. experience with dams has borne out the same findings as the World Commission on Dams — measure their performance against targets, and with some notable exceptions, they fall short. The full environmental costs associated with dams have not only effectively ended attempts to build new projects on the poor sites that remain, but have also fed a growing movement to take them down and restore the rivers and fisheries whose devastation they brought about in the first place. And finally, as it so often does, it just comes right down to money. With the kinds of delays and cost overruns that controversy would guarantee, the restrictions on siting, design and operations required to avoid unacceptable ecological damage and the risks involved in changing and unpredictable hydrological conditions, the financial risks associated with building new dams in the U.S. appear to be overwhelming. The government won't pay for them and neither will most private investors.

Dams may be too expensive to build, but are existing projects too expensive to run? This depends, of course, on what you count as a cost. Considering costs in a traditional and narrow reckoning, dams, when compared to other electricity generators, produce low cost electricity once their capital costs are covered. Whereas one must pay for natural gas to fuel a gas turbine plant, the fuel for hydroelectric generation is the river itself, the water that flows through its turbines, and, as theory goes, this water is ... free. Of course, it isn't free. It is most often used at great cost to its other potential benefits, among them the value of a free-flowing and healthy river to its fisheries, the biodiversity of its watershed, the natural flood irrigation of its floodplains and the robust health of the coastline at its mouth. The blocking of a river by a dam, any dam, of any size or design, if not quantifiable in monetary terms, is certainly a costly venture.

While impacts vary from dam to dam depending on a number of variables, there are always impacts. Low impact is never to be confused with no impact, a concern that is borne out in the accompanying report of the Helios Centre. This report emerged from IRN's uneasiness about plans to certify some hydropower as "low impact." While we generally agreed that establishing criteria for low-impact certification might effectively enable consumers and governments to make distinctions critical to assessing such a complex energy option, were the criteria good enough? Did they really take true costs into consideration? For IRN, the distinction between low impact and no impact must be clear, for if the public falsely perceives all hydropower to be "clean and green," the promoters of hydropower-at-any-cost may, undeservedly, find a renewed sense of purpose, an outcome certainly unintended by the promoters of low-impact hydropower certification.

This report comes at a time when there is a downward turn in big dam construction worldwide, determined public campaigns to stop a number of new, large-scale dams from blocking rivers, and growing strength in dam-affected communities in their efforts to recover what they've already lost. Tenacious and thoughtful individuals and organisations are succeeding in decommissioning dams no longer useful and restoring their rivers and streams. These efforts signal hope to those facing the most dire and horrendous assault of big dams: hundreds of thousands living in India's Narmada Valley, where government officials of Gujarat are doing their best to ensure that a reservoir will stand where vibrant and ancient cultures could continue to flower; in China, where the magnificence of the Yangtze River's Three Gorges may be lost, along with cities and villages now called home by more than 1.5 million people; in Canada, where indigenous peoples continue to claim rights to their land, water, and livelihoods in the face of plans to harness it — all in the name of hydropower for export.

All of this (and there is much more) is directly influenced by what happens in the U.S., a country that is more a bullhorn than an island. If the U.S. is truly out of the dam building business at home, then we are obliged to be clear about why, just as we need to understand the reasoning behind Canada's plans for increasing hydropower. What happens in the U.S. (and, more generally, in what is commonly referred to as "the West") often affects — directly or indirectly — what happens throughout the world. For this reason alone, it is essential that Western approaches to hydropower take great care to ensure that all options are considered and that all costs are accounted for prior to making decisions that will affect river ecosystems. But to do so requires an intimate understanding — by decision-makers and stakeholders alike — of the context in which electricity decisions are made, and of the interactive effects of market and regulatory structures, on the one hand, and the unusual and complex characteristics of hydro projects, on the other.

It is primarily for this reason — to offer a clearer understanding of the way in which hydropower and electricity markets and regulation influence one another — that IRN has commissioned the accompanying report. In it, Philip Raphals of the Helios Centre has provided not only an understanding of the fundamental issues, but a discussion of the serious and complex technical, economic and regulatory challenges that we are facing. The report provides overviews of the electricity sector before and after restructuring and offers insights into the impact of restructuring on planning and implementation. Against this context, the report considers the implication of competition for the generation of thermal, nuclear, renewable and most importantly, hydropower. The report outlines and assesses the pros and cons of green power marketing, discusses the important (and often illusive) meaning of renewability, and presents a review of current green power certification systems and other mechanisms designed to promote low-impact generation. In addition, it provides an in-depth overview of the environmental and social impacts of hydropower, of which many people remain unaware.

The Helios Centre report arrives at a conclusion whose importance cannot be overstated: the distinct nature of hydropower is hardly being considered in the reframing of policies and practices aimed at creating competitive energy markets. Furthermore, it concludes that public review of project justification and long-term planning — which have largely been eliminated in the restructuring process — remain essential where hydropower is under consideration.

In many ways, hydropower itself, because of a set of qualities unique among electricity generation options, could be considered an orphan of sorts, a castaway from another time, hardly considered by those charged with defining the rules that will govern electricity generation and supply in the new millennium. While consumers in California have no doubt as to the failure of the specific restructuring rules adopted in their state, neither they, nor most consumers elsewhere, have an inkling about how hydropower does or does not fit into the picture. Even the World Commission on Dams chose not to explicitly consider the implications of competitive markets for hydropower planning, operations, development and, ultimately, decommissioning.

At a time when energy conservation should be on an upward trend, but is instead, on a downward one; when energy demand is going up; when climate change is emerging as a leading factor influencing electricity generation choice; when the science necessary to accurately measure greenhouse gas emissions from reservoirs is still in its infancy; when at last there is a definitive report from the World Commission on Dams stressing the need to consider all options prior to building new dams, and to address the problems of existing dams before building new ones; when consumers are given a choice to buy "green" power, but provided with inadequate information on which to base their choice; when electricity generating sources (and the impacts associated with them) are increasingly being built outside the country where the electricity is actually used; when, at last, more dams are coming down in the U.S. than are going up, it is time to understand what electricity restructuring means to our rivers and watersheds.

Offering this essential understanding is the raison d'être of the accompanying report commissioned by the International Rivers Network and written by Philip Raphals of the Helios Centre, an independent, non-profit research and consulting group.

We hope you will find this report and its findings helpful in grasping and understanding the complexities and considerations that must be part of our thinking as we move ahead. We certainly have.

Juliette Majot
International Rivers Network

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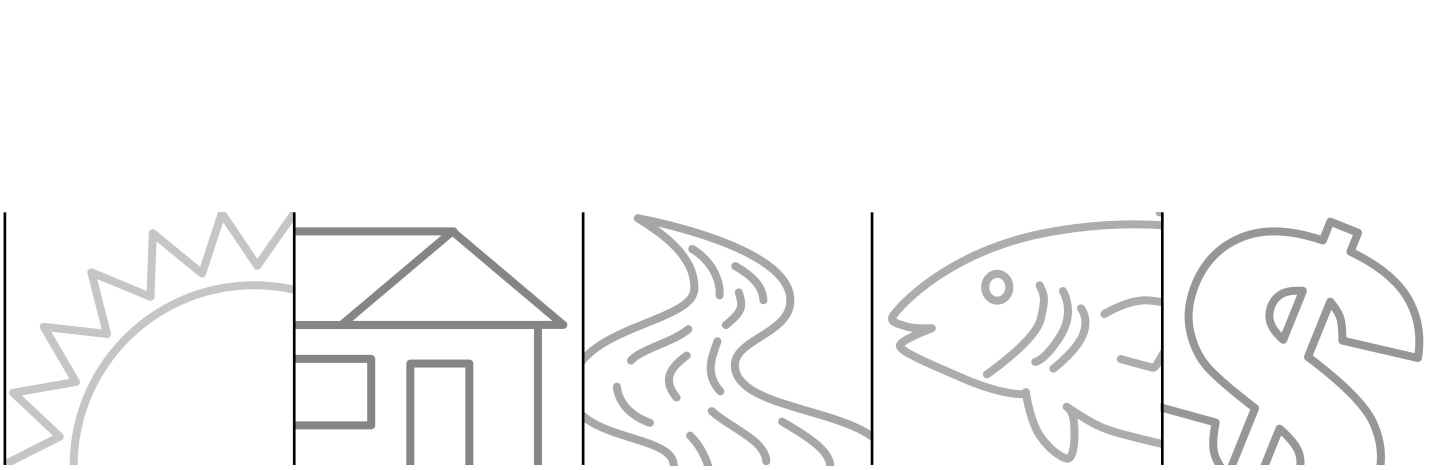
CENTRE for sustainable energy strategies

Restructured Rivers

Hydropower in the Era of Competitive Markets

by Philip Raphals

May 2001



Helios Centre

The Helios Centre is an independent non-profit energy research and consulting group. The Centre's expertise is focused primarily on utility regulation, competitive energy markets, energy efficiency and new energy technologies. The Centre prides itself on having a broad range of clients including governments and para-governmental bodies, environmental and consumer organizations, industrial end-users, independent power producers, utilities, First Nations and others. The Centre was founded in 1996 in Montréal, Québec (Canada).

Philip Raphals

Philip Raphals is Associate Director of the Helios Centre. He has authored numerous reports and provided expert testimony on such topics as utility regulation, hydroelectric power generation, energy policy and demand-side management, as well as having lectured on these and other topics at energy industry conferences throughout North America. Prior to joining the Helios Centre, Mr. Raphals was Associate Science Coordinator for the joint environmental review of the proposed 3,000 MW Great Whale hydroelectric project in northern Québec.

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I remain fully responsible for the paper's failings.

This paper is dedicated to Victor Olivier Raphals-Kath, who was gestating at the same time it was, and to his mother, Shelley Lynn Kath.

EXECUTIVE SUMMARY

Introduction

The electricity sector is currently undergoing a radical transformation. From a past dominated by regulated monopolies with long-term planning functions, it is quickly moving toward a competitive model, in which long-term planning is replaced by unrestricted interactions of market forces.

Moving from monopoly to competitive markets, the electricity sector's ongoing transformation has, and will continue to have, a tremendous effect on the amount and the types of generation resources that will be developed.

This is widely understood in the energy community. What is less understood is how **hydropower fits into the puzzle,** namely:

- What are the effects of restructuring on hydropower operations?
- What are its effects on the likelihood of new dams being built?
- What hydro projects, if any, should be considered "green?"
- How can the unusual and complex characteristics of hydropower be adequately taken into account?
- What information should consumers be provided concerning hydroelectric power sources?
- Will the externalities of hydropower be ignored in the new marketplace, allowing it to become a "free rider?"

The purpose of this report is to respond to these and many more questions about the role of hydropower in an emerging competitive electricity marketplace and, inversely, the effect of the new market paradigm on the future development and operations of hydropower facilities.

It must be noted that our response to these questions focusses primarily on North America, though we do so assuming that much of the discussion will nonetheless be relevant elsewhere. Furthermore, within North America, we draw heavily from California – a pioneer in the movement to restructure electricity markets, now deep in crisis – and Québec, the region most likely to develop major new hydro projects to serve competitive markets. Again, though our emphasis may be regional and continental, we are confident that the analyses and conclusions will resonate with readers in other countries and help them confront these issues as they arise in their different contexts.

PART I: RESTRUCTURING AND THE ENVIRONMENT

In Part I, we introduce the reader to the concept of competitive restructuring and to the various approaches being considered or applied to mitigate, within it, the environmental impacts of electricity.

In the past, electricity rates were set and electric systems were planned by monopolies, under the oversight of independent regulators. The past three decades have been marked by a series of methodological improvements in the planning process, culminating in what is often referred to as "Integrated Resource Planning" (IRP). IRP is a structured approach designed to determine the optimal solutions, from a societal perspective, to meeting future energy needs. It ensures that all options for balancing supply and demand are examined (including reducing demand), that each option's economic and environmental costs are fully considered, that the risks involved in each option are properly assessed and that the public participates fully in the decision-making process. Following a rigorous process, choices are made and portfolios of projects and programs are approved.

In the final analysis, the IRP process may well prove to have been the approach best suited to addressing the complex trade-offs between economic and environmental concerns inherent in long-term energy planning, at least where hydropower plants are concerned. Increasingly, however, as electricity markets move away from the model of regulated monopolies and embrace the idea of competitive markets, integrated planning is fast being eliminated, even in regions where competition has not yet been implemented. Inherent in the competitive model is the notion that market forces will suffice to ensure that rates are just and reasonable, and that those resources will be developed that best serve society's interests. This is based, however, on the assumption that market failings will be overcome. These failings include, though are not limited to, market power (the ability of players to manipulate market prices and profit from it, as has recently occurred most notably in California) and externalities (the environmental costs or benefits that do not enter into market transactions).

If deregulated prices are to remain at competitive levels, regulators and legislators must take great care in designing the rules that govern these markets. They must address issues including the divestiture of power plants from previously vertically-integrated monopolies, the design of short-term power auctions, enforcement mechanisms, regulatory independence, entry and exit barriers and a host of other complex concerns, all of which are bound to make the difference between the success and failure of newly competitive markets. Similarly, as we shall see below, if resource choices are to reflect societal interests, despite the presence of important externalities, new mechanisms must be designed to favour environmentally preferable generation.

A classic example of restructuring gone wrong can be found in California. While much concern was devoted in the design of the California market to preventing the exercise of market power by utilities, little attention was paid to its exercise by non-utility generators. As one economist noted, "if [generating] firms of noticeable size are not exercising market power, they are doing so out of the goodness of their heart, and against the interest of their shareholders." Largely in response to the current crisis in California power markets, many regions are revisiting previous decisions to move forward in the market restructuring process. Some are considering a return to strict regulation of utilities with monopoly franchise, and there is even some talk of nationalizing utility functions. The debate concerning regulated monopolies and unregulated markets is likely to continue for some time.

In the monopoly context, **environmental externalities** were considered explicitly (and thus internalized in the decision-making process, if not necessarily in prices) in the integrated resource planning process. It is widely assumed that competition in power markets implies not only an end to price regulation but also an end to coordinated, long-term planning. Ultimately, retail competition would imply that decisions are made not by one central body (the utility or its regulator), but by consumers themselves. Economic theory has it that in such a market, absent any market failures, the combined self-interest of all players will lead to choices that are in society's best interests (i.e., the market would lead to the very same choices that would be made under an ideal IRP process). Yet externalities represent a classical market failure, whose existence virtually ensures that markets will not achieve the least-cost solution to society's needs. For that reason, the advent of competition requires that, if energy decisions are truly to reflect the least-cost solutions, mechanisms must be developed to eliminate or mitigate environmental (and other) externalized costs.

Another significant failure of the market is its inability to provide consumers with full information regarding the benefits of energy efficiency improvements. An important function of the IRP process – and one that designers of competitive markets must concern themselves with – is to ensure that investments are made to reduce demand whenever this can be done at a lower cost than increasing electricity supply. As such, the least-cost energy portfolio from a societal perspective could, at least in theory, be identified and selected.

Among the great challenges facing those who regulate electricity markets is ensuring that the varied and complex externalities associated with hydropower projects are fully considered within the market itself, which we address in Part III. It is noteworthy, however, that the challenge is aggravated where transnational electricity trade is concerned, since every power transfer creates a corresponding transfer of environmental harm in the opposite direction. Failure to account for these exported externalities brings an entirely new concern – **environmental justice** – into play.

Recognizing that the energy sector contributes significantly to environmental degradation, many states, provinces and nations, as they move toward greater competition, are devoting considerable attention to designing and implementing such mechanisms. Although inconsistently applied across the patchwork of newly-deregulated markets, these mechanisms include:

- **"Public benefits" charges,** which are added to electric bills to finance energy conservation, green power, research and development and other "public goods;"
- **Green certification** procedures, designed to enable and support a private market for green power (similar to the private market for organic food, in which consumers voluntarily pay premiums for an environmental or health benefit);
- **Mandatory labelling** of environmental impacts on consumer bills, providing consumers with valuable information with which to choose among competing suppliers;
- **"Renewables portfolio standards" (RPS),** which require that each supplier include a certain amount of green power in its portfolio of energy resources (often through a flexible credit trading scheme);

- **Emissions caps** for fossil-fired plants, which can be applied either to each plant individually or, through tradable credit schemes, to an aggregate of plants; and

- A host of specific measures to facilitate **small-scale, "distributed" power generation** (for example, allowing the meter to turn backwards when rooftop solar panels generate more power than a home consumes).

These measures together can address many of the environmental implications of the move to competition. As laudable as these efforts may be, they have for most part been designed with little or no thought to the complex issues raised by hydropower. As a result, the externalities of hydropower are represented inadequately, if at all, in the design of these mechanisms, and their effect on existing and future hydropower resources is more the result of accident than design. While this oversight may be understandable in regions where new hydropower construction is unlikely, it is nevertheless problematic, in that continental market integration means that hydropower projects will play an increasingly important role in regions located hundreds of miles, or more, away from the dams themselves.

Explicit consideration of hydropower is critical for two reasons. First, because a hydro generator's operating characteristics and options differ from those of fossil plants, opening the door to entirely different ways to exercise market power. And second, because a hydroelectric dam's environmental attributes are also very different, and do not lend themselves to the simplistic, emissions-based approaches often used to regulate the impacts of gas, coal or oil-fired plants. In other words, for both economic and environmental reasons, neglecting the unique characteristics of hydropower projects will ultimately contribute to dysfunctional markets and resource choices that do not reflect the public interest.

PART II: HYDROPOWER AND THE ENVIRONMENT

In *Part II,* we introduce the reader to the issue of hydropower's environmental repercussions. We do so by addressing its impacts on ecosystems and human societies, as well as its contribution to global climate change. We then proceed to examine some of the factors that affect individual plants' impacts, i.e. the varying effects of specific operating choices and design characteristics.

Dams and their impacts

Hydropower's impacts on ecosystems are as varied as they are complex, and, according to an in-depth literature review carried out for the World Commission on Dams, are mostly negative. Dams affect both upstream and downstream ecosystems. Upstream impacts are mainly reservoir-related, and thus vary greatly depending on the reservoir's size, depth and operating regime. Downstream impacts are mainly related to changes in the distribution and timing of streamflows.

Upstream impacts

Upstream, dams' most obvious impacts are the replacement of rapids, riffles and pools with flat-water reservoirs, resulting in loss of habitat for those species adapted to fast-moving water. While this effect is local in the case of small hydro facilities, for large hydroelectric installations it can often result in extirpation of such species. Other "first order" impacts include modification of essential ecosystem processes such as sedimentation, nutrient regimes, water temperature and chemistry.

These physical changes in turn affect plant life, in what are known as "second order" impacts. Impoundment often leads to a boom in phytoplankton populations, which is followed by a crash several years later. At the same time, shallow areas are often colonized by higher plants, which may slow flows and provide habitat for parasites. Riparian vegetation can be affected, often dramatically, by fluctuations in water levels. When these fluctuations are out of sync with seasonal rhythms, the drawdown zone can remain virtually barren.

Changes in plant life in turn affect animal populations ("third order" impacts). The effect of lost habitat varies greatly, depending on the area flooded and its importance in the larger ecosystem. Reservoir operating regimes that involve significant drawdown affect many species, including molluscs, fish and birds. The degree of impact depends on the extent of the drawdown, its frequency and its timing with respect to natural cycles. Even dams referred to as "run-of-the-river" can have impoundments and flow modifications that significantly harm aquatic plants and the animal species that depend on them.

Downstream impacts

Downstream impacts can be thought of using the same categories. First order downstream impacts include changes in water quality, temperature and sedimentation, as well as changes in streamflow — variation in the temporal pattern of flows or even their total elimination, in the case of some river diversions. Natural flows vary greatly on a daily, seasonal and annual basis, and resident species are adapted to these fluctuations. This variation is itself of great importance in sustaining a diverse ecosystem, even apart from the minimum flows required by certain species. Most hydroelectric dams are operated in a manner that produces a well-defined pattern of daily, weekly or seasonal variation. However, as these patterns are related to power needs rather than to the local hydrological cycle, there is little chance that local flora and fauna will be able to adapt to them.

Impacts on riparian plant communities downstream (second order impacts) depend on the interaction of the flooding and sedimentation patterns created by the dam and its management. Once again, flow variations out of sync with natural rhythms can create conditions in which native vegetation cannot survive.

The degree to which the first and second order impacts of any given hydro development affect invertebrates, fish, birds and mammals depends on the scale of the intervention and on the degree to which those species are adapted to take advantage of the particular features of the local ecosystem which have been lost. A voluminous literature demonstrates that dams can harm many species of fish that inhabit affected rivers and their estuaries, birds and mammals that rely on watershed habitat, and even seals, whales and other marine species that can be affected by altered estuarine flows.

Biodiversity

This review of the ecological impacts of dams would not be complete without addressing the question of biodiversity. The natural world is characterized not only by large numbers of living individuals and communities, but also by the *diversity* of those communities, consisting both of species diversity and of genetic diversity within a species. It is thus important to ask not only how a dam affects the populations of one or more key species, but also how it affects biodiversity in the watershed or region.

According to a recent study, the rate of extinctions for freshwater animals in North America is 1,000 times higher than the background rate of extinction — of the same order of magnitude as the extinction rate in tropical rainforests. Other studies estimate that as many as 20-35% of freshwater fish species are extinct, endangered or vulnerable. Dams have been directly implicated in reductions of biodiversity in fish and molluscs. Through the extirpation of local populations, they can also reduce genetic diversity within a species.

Impacts on human societies

Finally, dams affect human societies as well. These impacts occur at the level of individuals, families, communities, ethnic groups and indigenous nations; they can affect health, happiness, social cohesion and identity, as well as economic activities, both subsistence and commercial.

The most important social impact is of course displacement, but loss of access to resources is also of great significance. While those who are directly evicted from their homes are the most obvious victims of dam construction, a substantial part of the social impacts of dams derives directly from their ecosystem impacts, and thus can be thought of as a “fourth order” impact, following the schema described above. Indirect social impacts are thus borne by those whose livelihoods and cultures are dependent on healthy riverine ecosystems. These include commercial fishermen and ecotourism operators, but the brunt of these impacts are felt by the subsistence economies of indigenous and peasant communities.

Climate change

While the ecosystem impacts of dams are widely recognized, their role in global climate change is not. It was long assumed that, since hydropower does not involve the combustion of fossil fuels, it would not contribute in any way to global warming. However, as broad scientific consensus has emerged that reservoirs are in fact significant emitters of CO_2 and methane.

Early estimates of GHG emissions from reservoirs were theoretical, based on assumptions about the amount of flooded biomass, the rate of degradation, and other factors. In recent years, however, direct evidence of substantial greenhouse gas emissions from reservoirs has emerged from research teams working in Canada, Finland, Brazil and French Guyana.

While some issues remain controversial, many areas of agreement have emerged. In early 2000, the World Commission on Dams convened a workshop that brought together the leading researchers in this field from around the world, including those directly associated with or employed by the hydro industry. Following the workshop, a consensus statement was issued, which indicated agreement on a number of issues. Among other points, it was agreed: that all reservoirs emit greenhouse gases, and continue to do so for decades, at least; that GHG emissions result not only from flooded biomass, but also from carbon transported by the river from the catchment area; and that the methodologies currently used to account for methane emissions significantly underestimate the climate change impact of reservoirs over the first several decades.

While researchers agree that all reservoirs emit GHGs, climate change scenarios of the IPCC and national greenhouse gas inventories still fail to take these emissions into account. For example, it is estimate that Canada's GHG emissions would increase by 3% if reservoir emissions were included, and that its energy sector emissions would increase by 17%.

If GHG emissions from reservoirs were simply due to the degradation of flooded biomass, these emissions would inevitably diminish as that biomass was consumed. Recent research makes this assumption untenable, however. The WCD consensus statement recognizes that emissions are based not only on the carbon in the flooded biomass, but also on the degradation of organic debris swept downriver from the catchment area, which is then trapped in the reservoir and slowly digested by bacteria. The initial assumption that emissions would taper off over time is thus unfounded.

An important component of the GHG emissions from reservoirs is due to methane, a very potent greenhouse gas. The global warming impact of methane is usually described in terms of its 100-year "Global Warming Potential" (GWP), currently estimated at 21. This figure represents the comparative impacts, 100 years later, of a one-time ("pulse") emission of a ton of methane and one of CO_2. Since methane is oxidized to CO_2 in the atmosphere over a relatively short period, the longer the period used, the lower the GWP. Using a 20-year period, the GWP is 56; for one year, it is 91.

If methane emissions were indeed a one-time event (even if spread out over several decades), resulting from the degradation of the soils, plants and other biomass submerged when the reservoir was impounded, this "pulse" approach might well be appropriate. However, to the extent that emissions are continuous, an entirely different methodology is required.

Using a recent model for assessing the climate change impact of continuous emissions of methane compared to CO_2, it was determined that, after 100 years, the cumulative climate impact of constant methane emissions is almost **40 times** greater than those of an equivalent amount of constant CO_2 emissions. Using this value — which is double the 100-year GWP for methane — increases the net GHG emissions from temperate and boreal reservoirs by about 50%, from deep tropical reservoirs by 25%, and from shallow tropical reservoirs by 90%.

Thus, emissions from boreal reservoirs range up to 90g CO_2-equivalent per kWh, and those from tropical reservoirs range from 250 to 5,700g/kWh, or more. In contrast, CO_2 emissions from state-of-the-art natural gas fired combined cycle plants are between 300 and 400g/kWh, though net emissions can be much lower when the heat from such facilities is put to use (cogeneration).

While methane only represents a fraction of global GHG emissions, controlling those emissions is seen by some as the key to a global climate change strategy. James Hansen of NASA's Goddard Institute for Space Studies has suggested that a 30% reduction in methane emissions over the next 50 years represents the best chance to tame human-induced climate change. Such a scenario is probably incompatible with the development of large new hydropower developments, especially in the tropics, ironically proposed by some as the solution to global warming.

These findings have significant implications for policy-makers, especially as regards the implementation of the Kyoto Protocol, one important feature of which is the Clean Development Mechanism (CDM). Once implemented, the CDM would allow credits resulting from emissions reductions in developing countries to be applied to emissions reduction commitments of developed and transition countries.

The hydropower industry, supported by the governments of the U.S. and Canada, is urging that hydro projects be deemed eligible for the CDM, hoping thereby to overcome the difficulty of obtaining private sector financing for large-scale hydro projects in developing countries. Others, however, argue that because of the significant environmental impacts associated with large-scale hydropower, it should not be eligible under the CDM, even if it were judged to meet the other criteria.

While it has long been assumed that developing new hydropower resources in developing countries would inevitably result in significant climate change benefits when compared to the energy alternatives that would otherwise be developed, the findings described here cast serious doubt on this assumption. As we have seen, GHG emissions from tropical hydro developments are in the best cases only slightly lower than those of efficient thermal power, and in many cases are several times greater. Generally speaking, the methane emissions from tropical hydropower are such that it should no longer be thought of as a low-GHG resource. Thus, the logic of subsidizing and encouraging tropical hydropower developments via the Clean Development Mechanism is increasingly untenable.

Factors affecting the impacts of hydropower

Clearly, the actual impacts of individual hydro projects will depend on their precise design and operating characteristics. The most important distinction concerns the amount and type of storage (impoundment). "Run-of-the-river" projects, though they often involve some storage, generally have far lesser impacts than do projects with significant reservoirs.

Design choices

The environmental impacts of hydro projects are in most cases linked far more to the plant's physical presence than to its operating characteristics. This fact alone requires a special degree of thoughtfulness and consultation prior to approving projects whose impacts, unlike those of a gas-fired plant, for example, cannot easily be lessened by simply choosing to reduce fuel input. For **storage hydro** (projects with reservoirs), the extent of the impacts depend on whether or not river diversions are used to increase the available water, the extent of flooding, whether or not the reservoir is one of a chain and the height of the dam.

It is important to realize that these design choices are suggested — but not dictated — by the physical and hydrological characteristics of site itself. In a monopoly/planning context, the regulator must ensure that environmental impacts are taken into account, requiring developers to choose lower-impact designs even if they result in increased unit costs. Even in the absence of an integrated planning process, the right to build can still be conditioned on project design that minimizes environmental impacts. Furthermore, developers will have an economic incentive to design projects that can obtain certification as "low impact" power, since certification will increase the value of the power produced by the facility.

In recent years, the assumption that small hydro facilities are environmentally benign has been subject to considerable scrutiny. It is increasingly clear that small dams are responsible for substantial environmental harm. A vigorous movement has arisen in the United States to substantially modify the way dams are operated in order to mitigate their impacts, or, in some cases, to remove them.

Far from accepting the intuitive notion that small dams are less destructive than large ones, some now take the opposite position, arguing that, because a small reservoir has a higher ratio of surface area to volume, it takes a much greater reservoir area to generate a given amount of power from small plants than from large ones.

This argument is misleading in several ways. First, the comparison addresses reservoir size, which is proportional to storage capacity, not to energy production. Storage capacity undoubtedly confers important power benefits but, as we have seen, such regulation also comes at an environmental price, which is not factored into this simplistic comparison. No satisfactory indicator has yet been developed to reflect the varied and complex impacts of hydropower, making any straightforward comparison of a given project's power benefits to its environmental costs impossible.

Furthermore, many large facilities affect entire watershed ecosystems in ways that small facilities do not, resulting in ecological impacts that are not only quantitatively more severe, but qualitatively as well. While the impacts of small dams can be very significant, the gravest environmental and social impacts, such as relocation of communities and extirpation of native species are primarily associated with large hydro.

Unfortunately, planning processes designed to address these complexities have largely disappeared thanks to competitive restructuring of the electricity sector. Developing mechanisms that can function within a competitive electricity market to ensure that inappropriate hydro projects are not built remains one of the great challenges of electricity restructuring.

Operating regimes

The regime under which a hydro facility is operated can also substantially affect its environmental impacts, though perhaps to a lesser extent than design choices. Generally speaking, the greater the drawdown and the more its frequency and timing are out of sync with natural rhythms, the greater the ecological impacts on the reservoir and its surroundings. Downstream, impacts are related to flows below or above those provided by the natural regime, and to flow variations unconnected to natural rhythms.

Defining a low-impact flow regime thus involves specifying not only minimum flows but also seasonal limits and ramp rates. More sophisticated flow regimes modulate the required flows depending on whether it is a wet or dry year, and provide for seasonal flood flows as well.

Various measures have been developed and implemented in different regions to mitigate the environmental impacts of hydropower development, with varying degrees of success. The effectiveness of these measures is often hard to assess, as post-construction monitoring often leaves much to be desired. Studies suggest, however, that the net benefits of mitigation efforts tend to be small compared to the environmental impacts they seek to mitigate, and the costs of more effective measures are often prohibitive. In some cases, the ongoing impacts are judged to be so severe, and the benefits so small, as to justify decommissioning.

More and more, it is recognized that the most effective ways to mitigate these impacts is to avoid creating them in the first place. Thus, many of the most effective so-called mitigation measures are in reality lower-impact choices with regard to the siting, design or operating regime of the planned hydropower facility.

PART III: ADDRESSING THE IMPACTS OF HYDROPOWER IN A COMPETITIVE ENVIRONMENT

Part I demonstrated how restructuring of the electricity sector has interfered dramatically with the mechanisms established in the 80s and 90s to take environmental and social issues ("externalities") into account in the choice of energy resources. In their place, a number of distinct mechanisms have been proposed and/or put in place to minimize the environmental costs of electric service.

Many of these measures were conceived and implemented to ensure that restructuring does not aggravate the environmental harm caused by fossil fuel fired generation. Others are designed to stimulate the development of low-impact generating technologies like wind and solar power that in the long run probably represent the best hope for reducing the environmental consequences of electric generation. The most important of these measures are the "renewables portfolio standard" and, more broadly, the labelling and certification processes developed to stimulate the green power market.

As we have seen, the complexities of hydropower were far from the minds of the architects of these measures. Nevertheless, depending on how they are implemented, they can have a considerable influence on the fate and fortunes of existing hydropower installations and on the extent of new hydropower developments.

Green power market certification

Restructuring is radically transforming the electric power industry. Should this process reach its logical conclusion, electric supplies will be chosen by consumers, not utilities, and decisions about future resources will be made not by a regulatory planning process, but rather — like in other competitive industries — by private companies making at-risk investments, based on their own estimations of future consumer demand and preferences.

The arrival of competitive markets and subsequent market fragmentation allows environmentally-concerned consumers to "vote with their pocketbooks" by choosing to avoid certain energy sources or to support others. As with all "green marketing," however, reliable criteria are required to prevent unsubstantiated claims. A number of complementary and/or competing green power certification systems have been established in the U.S. and Canada.

From its earliest beginnings, green power proponents recognized that distinctions should be made between better and worse hydropower. While many jurisdictions have adopted a size-based threshold (e.g., under 30 MW), this approach is increasingly recognized to be inadequate. Since, as we have seen, not all small hydro projects are environmentally benign, it follows that low-impact certification should be based on the environmental profile of each project. Ideally, the criteria for determining whether or not a given hydro facility should be treated as a low-impact electricity source should be straightforward, objective and applicable to all projects regardless of their geographical location. Unfortunately, this goal seems at present all but unattainable.

In the U.S., the Low Impact Hydropower Institute (LIHI) has developed a coherent set of criteria supported by a transparent review process. The Institute is still in its infancy, and many problems remain to be resolved. However, it seems likely that LIHI certifica tion will become the standard for determining which hydro facilities in the U.S. can be characterized as "low-impact."

However, because the LIHI criteria rely directly on specific U.S. administrative and regulatory processes, they cannot be applied to projects in Canada or in other countries without very substantial modification, if at all. Nor can they be applied to proposed new facilities in the U.S., as they were designed to promote low-impact *operation* of existing facilities.

In Canada, new draft criteria for the quasi-governmental EcoLogo have been developed which, unlike the LIHI criteria, can be applied to new projects as well as existing ones. However, unlike LIHI, the EcoLogo guidelines do not actually indicate how a project is to be evaluated, nor do they provide any mechanism for public involvement or oversight. As a result, it remains an open question whether or not these guidelines can and will be applied in a coherent, objective and credible fashion.

To the extent that the growing green power market begins to offer substantial and reliable premiums to certified generators over and above the prices for system power, the financial incentives it will provide for certifiable generation will be significant. Green power marketing will thus provide positive incentives for the development of new wind, solar and other certifiable facilities. While the LIHI process will provide incentives for existing hydro operators to reduce impacts by improving their operating regimes, it will (by design) not incent the construction of new power dams.

EcoLogo certification, on the other hand, will almost certainly provide incentives for the damming of undeveloped rivers. Based on the draft Guidelines, it appears that certification would be denied to any projects that create significant ecological or social impacts. In practice, of course, that will depend on the wording of the final Guidelines as well as on the integrity of the review procedures set up by TerraChoice, the firm that manages the EcoLogo for Environment Canada. In this regard, the absence of any provisions allowing for public participation in the review process is cause for serious concern. Finally, it should be noted that the draft EcoLogo guidelines are at present stalled due to opposition from the Canadian hydro industry.

The life-cycle analysis methodology proposed by Scientific Certification Systems (SCS) might at first glance seem to offer a way out of this tangled situation. However, a careful review of the way SCS has implemented this approach reveals a failure to provide any reasonable estimate of the actual impacts of a hydro facility. Indeed, while the very notion of life-cycle analysis implies an attempt to include all direct and indirect impacts caused by each energy resource, the SCS implementation fails to address many of hydropower's most important impacts. While in the long run the life-cycle approach may prove viable, it provides no magic solution to the inherent problem of estimating the actual impacts of a given hydropower facility. A credible implementation will require a far more sophisticated approach to hydro impacts.

In the medium term, it appears that LIHI will become the standard for hydro certification in the U.S. and EcoLogo in Canada. Mutual recognition might eventually provide a basis for harmonization between the two countries, but this seems unlikely as long as there is no transparent and consensus-based process for addressing the certification of Canadian hydro projects, and as long as the approach to new construction remains so different.

Environmental disclosure (labelling)

Green power certification lets customers identify "premium" green power, but how much of an improvement is it over "system power?" In order to make this comparison, consumers need substantive information regarding the environmental impacts of the other power products offered in the marketplace. This need cannot be met through a voluntary certification system, since generators that don't expect to be certified would have no interest in reporting their emissions or other impacts. It is thus incumbent upon regulators and legislators to ensure that a system of mandatory impact disclosure is established. This need for reliable information has fostered the movement to require environmental disclosure, or labelling, for power products.

There are many options for configuring mandatory labels. Most focus almost exclusively on air emissions. Indeed, in most jurisdictions, all hydropower is lumped together in a single category without distinction. This approach is clearly inadequate to represent the actual environmental and social impacts of the hydro component of system power.

Ideally, environmental disclosure statements would distinguish hydropower projects that have achieved low-impact certification from those that have not. There are important practical obstacles to such an approach, however, in that it would require official recognition of a particular certification regime.

Despite the well-known limitations of size-based distinctions, breaking down the hydro component by size or by storage capacity (e.g., run-of-the-river vs. storage hydro, or finer distinctions) would nevertheless provide the consumer with a somewhat better understanding of the source of power, and thus would contribute further to the goals of environmental disclosure.

A better approach would be one based on an index that integrated the various impacts of hydropower into a single scale, but the challenges in developing such an index are enormous. It would have to be based on readily available objective information, but nevertheless provide a reasonably accurate indication of the project's environmental and social impacts. If such an index were developed that could achieve broad support, it would open the way for an intellectually coherent approach to addressing hydropower in a market environment. However, the challenges — both technical and political — of developing such an index should not be underestimated.

Renewables portfolio standard

The so-called "renewables portfolio standard" (RPS) has proven itself to be one of the most viable mechanisms to promote low-impact generation in the context of competitive power markets. Its underlying purpose is to promote investment in new technologies which have extremely low environmental impacts and are not yet commercially competitive, but are expected to become so once they achieve technological and commercial maturity.

To the extent that hydropower is made eligible, owners of hydro facilities will benefit from a guaranteed market for their product at premium prices. Thus, it is not surprising that the Canadian hydropower industry — represented at times by trade associations such as the Canadian Electrical Association, at times by the Government of Canada, and most frequently by Hydro-Québec — have in one way or another been present in many of the technical debates over these measures in the U.S., whether at the state or federal level.

Much ink has been spilled over whether or not hydropower is "renewable." Strictly speaking, there is little doubt that there are ways in which hydropower is renewable (insofar as a hydro facility generates electricity from the hydrological cycle, without consuming fuel), just as there are ways in which it is not (insofar as it results in the loss of irreplaceable resources). Ultimately, however, this debate is misguided. Depletion of fossil resources is not in itself an environmental issue, but merely a convenient proxy for environmental damage. As with any other policy tool, RPS eligibility should be based on the policy's goals and objectives.

The RPS is a policy tool designed to support generation technologies that are judged to be environmentally preferable and unable to compete in the marketplace. Given these objectives, it is hard to see why hydropower should be made eligible for RPS at all. With some exceptions its environmental profile is far from exemplary, and it is a mature and commercially competitive technology. In any case, the broad societal consensus favouring the development of new wind and solar power that has led to the popularity of the RPS concept in the first place almost certainly does not extend to the development of new hydro projects.

Hydropower and the future of planning

Competitive electricity markets generally rely on individual companies to make decisions about building new generation based on their own perception of commercial risk. The theory, of course, is that, once prices are determined by supply and demand, the "invisible hand of the market" will ensure that the optimal level of generation is built. To the extent that environmental externalities are internalized through appropriate fiscal or market-based mechanisms, the invisible hand will also ensure that environmental damage is kept to the optimal ("economically efficient") level.

The events still unfolding in California — where, in the words of one wag, "the invisible hand was caught in the cookie jar" — have cast doubt on the market's ability to keep the lights on and to keep prices at reasonable levels. According to economic theory, markets lead to economically efficient results only when they are free of barriers to competition such as market power and externalities. The challenge in California is primarily one of market power, but the substantial externalities associated with the massive environmental impacts caused by electricity generation and transmission must also be internalized if competitive electricity markets are to function properly.

Most of the market-based mechanisms that have been developed in the restructuring process are designed to internalize the externalities of fossil fuel based generation. They consequently ignore the environmental costs associated with hydropower. In many cases, these ecological costs go unstudied, unquantified, unmonetized and uninternalized. While environmental mitigation measures or compensation payments may internalize some of these costs, the rest are simply absorbed by riverine ecosystems and by the peoples who depend on them.

Therefore, despite the widespread belief that market-based mechanisms mitigate the environmental consequences of electricity restructuring, they largely fail to do so for hydropower. Thanks largely to the lack of interest in hydropower on the part of the architects of competitive electricity markets (and in part to the focussed, behind-the-scenes lobbying of the hydro industry), these mechanisms contribute primarily to augmenting hydropower's market advantage rather than mitigating it.

Competitive markets thus remain incapable of ensuring that the construction of new hydropower facilities is limited to those that are in the public interest. On the contrary, leaving these decisions to the market virtually ensures that projects will be built, or will continue to operate, whose costs to society exceed their benefits.

For all these reasons, non-market interventions such as planning are still required. Thus, the World Commission on Dams concluded that a comprehensive and inclusive planning process is essential to making appropriate decisions about dams. While not explicitly acknowledged, the process it proposes closely resembles integrated resource planning (IRP). Precisely because hydropower projects represent such a complex mix of economic, environmental and social factors, integrated planning processes are needed in order to compare them on an objective basis with other supply- and demand-side alternatives to meeting energy needs.

Despite its dramatic failure to resolve the debate over new supply in California in the early 1990s, IRP has worked reasonably well in some jurisdictions. In fact, its potential for addressing the hard questions posed by hydro projects had only begun to be exploited when it was hit by the restructuring juggernaut.

While vigorous retail competition would indeed make true IRP impossible, the existence of competitive *wholesale* markets does not. To the extent that a utility has access to a wholesale market, it may well choose to buy power to meet its customers' needs, rather than generating it. However, regulators can still require that the utility choose those resources with the least social cost — taking into account their environmental and social costs as well as financial ones.

In some jurisdictions, however, utilities have been in such a hurry to abandon integrated planning processes that they have managed to eliminate them even when retail competition is no more than a vague future possibility. Utilities have traditionally been hostile to public oversight and regulatory control, accepting it as a necessary evil that softens public resentment over controversial projects and that allows them to avoid sole responsibility when things go wrong. Given the limited degree of public involvement in the complexities of energy regulation, it should come as no surprise that an oversimplified notion of competition has provided an excuse to jettison these structures altogether. The case of Québec, the region in North America with the greatest potential for and interest in building new dams, is an eloquent example of this phenomenon.

Thanks to Hydro-Québec's implacable opposition to any regulatory involvement in its generation activities, the thousands of megawatts of new hydro projects that Hydro-Québec intends to build to serve the U.S. market will not be subject to any public review process empowered to weigh their expected commercial benefits against their financial risks and environmental and social cost. While only a few years ago it was said that the era of big dams was over, it appears rather that, from Hydro-Québec's perspective, it is the era of public involvement in planning that is over.

The North American electric industry restructuring has thus led to the disappearance of public involvement in most decisions about building new hydro facilities. In so doing, it has rendered inoperative the tools developed in the preceding decade to balance economic, environmental and social concerns in planning and authorizing such projects.

These tools, of course, need to be adapted to work in a competitive environment. Much work remains to be done to reconcile competitive market structures with the need for planning — both to avoid price volatility resulting from drastic shifts in the supply-demand balance, and to ensure that resources with high environmental costs are developed only if they are in the public interest.

Conclusion

Restructuring has led to the implementation of a number of mechanisms designed to ensure that it does not aggravate the environmental harm caused by electric generation. By oversight more than by design, these mechanisms fail to adequately represent the environmental and social impacts of hydropower. As a result, these mechanisms inevitably tilt the decision-making field to favour hydropower in relation to other energy resources, thereby increasing the total environmental burden caused by providing energy services to the public.

This failure is largely the result of the way these mechanisms are implemented. Considerable improvement is therefore possible, but only if a real effort is made to ensure that restructuring does not promote inappropriate hydro development.

At the same time, we have seen that restructuring affects not only the operation and disposition of existing hydro facilities, but also the context in which decisions about new developments are made. While the operating regimes of some facilities may be improved by owners seeking green marketing certification, worsening of operating regimes following divestiture and consequent deregulation may well be a more significant result.

The disappearance of integrated resource planning and of virtually all public involvement in decision-making in those few areas where substantial new hydro projects are likely is probably the single most significant consequence of restructuring insofar as hydropower is concerned.

If the costs and benefits of hydropower are to be properly accounted for in the future, decision makers and stakeholders will have to take greater care both in evaluating the implications of proposed market structures for the environment in all its aspects, and in designing an appropriate combination of market mechanisms and regulatory controls to internalize the externalities of hydropower. Doing so will require some degree of long-term planning, irrespective of market restructuring, as well as careful and sophisticated consideration of hydropower's distinct characteristics in designing mitigative mechanisms. While these problems are not insurmountable, much work remains.

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INTRODUCTION

The last ten years have seen two great debates, deeply inter-related but also very distinct, taking place on a global scale. One concerns the structure of the electric industry, the respective roles of competition and regulation, how prices for electricity are set and how choices are made about generating it. The other concerns the pros and cons of dams, both large and small, for, among other purposes, the generation of electricity.

Each of these debates is highly technical, the domain of an army of specialists in a host of different fields deliberating questions of substance and methodology, which only rarely reach the wider public. And, remarkably, these two debates have gone on in almost total abstraction from one another.

While the environmental consequences of restructuring have aroused considerable interest, the complexities of hydropower have remained curiously absent from these debates. In years of feverish activity on issues from market design to stranded costs to tradable credits for air emissions, hydro has for the most part fallen through the cracks.

At the same time, for the biologists, limnologists, ecologists, sociologists, environmental assessment specialists and environmental and social activists around the world who have been deeply involved in debates about dams, arcane questions of bidding rules, market power and transmission pricing seem to be of little relevance. Even in the landmark report of the World Commission on Dams (surely the most thorough assessment of the costs and benefits of large dams to date), the implications of power sector restructuring were given only limited attention.

One underlying purpose of this paper is to begin to break down this separation. These two debates are not only relevant to each other, they are essential to one another. The goals of restructuring cannot be achieved without dealing adequately with the environment, and that requires thinking through the implications of competitive energy markets for hydropower, both new and old. In the same way, it is impossible to decide "what to do about" large and small dams without understanding the massive changes currently taking place in the electric systems within which those dams currently operate.

Competitive markets are in many ways incompatible with planning processes that, in the past, ensured careful review of the justification for new power plants as the optimal choice to meet forecast demand. As regulated monopolies give way to competitive electricity markets, new tools and mechanisms are being developed to limit the environmental consequences of electricity generation. This paper's other goal is thus to provide an overview of the difficult issues that arise in attempting to apply these tools to hydropower, and to offer recommendations regarding their implementation.

In the North American context, the restructuring movement has been initiated and driven by the United States. These developments have direct consequences in Canada, especially with regard to new hydro development. While it is hoped that it will be of broader interest and use, the focus of this paper is thus limited to these two countries, with particular attention to Québec and California.

Parts I and II of this paper are intended to introduce the energy restructuring and dam debates to each other. Active participants in the restructuring debate may find Part I to be a brief and oversimplified summary of its evolution, just as those who are preoccupied with the dam debate may be dissatisfied with the cursory presentation of the controversial aspects of hydropower in Part II. These two lengthy introductions are necessary preludes, however, to Part III, which attempts to provide a critical overview of the various policy tools and mechanisms available to account for the environmental and social impacts of hydropower in a restructured, competitive electricity market. Are these tools adequate to ensure that the externalities of hydropower are not ignored in the new restructured electricity markets? Can they be adapted to better reflect the externalities of hydropower? Are other mechanisms needed? We hope, at the very least, to shed a bit of light on these difficult questions.

Part I
Restructuring and the Environment

PART I: RESTRUCTURING AND THE ENVIRONMENT

It is widely recognized that power generation is one of the most significant sources of environmental harm in modern industrial society. Over the last few decades, enormous efforts have been devoted to finding less environmentally destructive ways to meet society's energy needs.

Central to these efforts has been the recognition that the environmental harm caused by electricity generation is in fact one of its costs. However, unlike the direct costs which are incurred by the generator and charged to its customers, environmental costs are primarily borne by third parties. In economic language, these costs are "external" to the seller's balance sheet and thus to the transaction — these external costs are also called "externalities." Unless these costs are "internalized," the most economically efficient outcome will not necessarily be the best one for society as a whole.

The environmental impacts of power generation vary both in type and in intensity, depending on how the power is generated. Coal plants pollute the air with sulphur and nitrogen emissions (SO_X and NO_X) as well as particulates; these costs are borne not by the owner of the power plant but by its immediate neighbours and by those who live downwind. These plants also emit carbon dioxide (CO_2), thus contributing to global warming, creating environmental costs that are borne not only by the plant's immediate neighbours but also by the entire planet. The less efficiently the plant produces electricity, the greater the emissions per kilowatthour (kWh).

On a life-cycle basis, coal power has other externalities as well. Coal mines can do irreparable harm to local ecosystems, and coal mining is a dangerous occupation. Runoff from the mines can damage fish and riverine ecosystems, and coal plants themselves cause thermal pollution to waterways used for cooling systems.

A coal company might spend a considerable amount of money trying to reduce these impacts — it might, for example, landscape around the mine, pay for expensive air filtration systems to protect the miners, and pay their medical costs and disability benefits. To the extent that it does so, these costs are "internalized" into the price of the coal it sells, and thus indirectly into the price of the electricity generated from it. However, while such investments may reduce the harm caused to the affected individuals and communities, they may not eliminate them entirely. To the extent that they do not, the environmental and social costs which are *not* internalized into the price remain as externalities. Compensation payments to affected individuals and communities are another way to partially internalize the environmental costs of power generation, but some externalities inevitably remain.[1]

Other generating technologies have different environmental costs. The externalities of modern natural gas (methane) plants are similar in kind to those of coal plants, but of much lesser quantity, in that they produce much lower levels of NO_X and of CO_2 per unit of energy produced. "Upstream" externalities related to gas exploration, extraction, processing and transmission, are borne by the ecosystems and communities that surround them.[2] As well, since methane is a potent contributor to global warming, gas that is inadvertently leaked to the atmosphere in these various operations constitutes an externality borne by all.

The impacts of nuclear power and of hydropower are very different in nature than those of thermal power generation. Nuclear power involves radioactive hazards in mining, transportation of fuel and in the disposal of spent fuel, as well as the risk of catastrophic events like those at Chernobyl and at Three Mile Island. The contaminated reactor site itself represents another very significant externality that is both environmental and, to the extent that decommissioning costs will eventually be picked up by the taxpayer[3] and that waste disposal technologies fail to completely eliminate the risk of future environmental harm, financial.

[1] Economists disagree, as do many stakeholders, as to the extent to which monetary rewards can fully compensate environmental degradation, since they are generally premised upon the notion that the value of ecosystem health is limited to its value for human beings. To the extent that one recognizes value in nature for its own sake, financial compensation will always remain inadequate.

[2] Burning natural gas produces virtually no sulphur emissions, but substantial amounts can be released in extraction and processing.

[3] All nuclear utilities carry decommissioning as a liability on their books, and U.S. utilities are required by law to set aside funds out of operating revenues. However, for some Canadian utilities, most prominently Ontario Hydro, decommissioning remains for the most part an unfunded liability.

The impacts of hydropower are of a different nature entirely, involving loss of terrestrial ecosystems to flooding, dramatic disruption of riverine ecosystems and complex impacts on the societies that use these resources. To a much greater extent than any other generating technology, the impacts of hydropower vary depending on the site, the project's design and the way it is operated; because of the complex interactions in the affected ecosystems, they are also much more difficult to predict and assess.

Indeed, hydropower bears certain similarities to nuclear power in that its life-cycle air emissions may be relatively minor, and decommissioning costs represent a significant economic and environmental externality. Not coincidentally, these two resources were singled out in the 2000 election platform of the U.S. Republican Party, which accused the Clinton Administration of "turn[ing] its back on the two sources that produce virtually all of the nation's emission-free power: nuclear and hydro."[4]

One of the themes underlying this report is the importance and difficulty of comparing the environmental and economic characteristics of diverse ways of meeting a growing population's need for energy services. The structural changes that are taking place in the electric industry, with competitive markets replacing regulated monopolies for many aspects of electricity service, profoundly affect the tools available to ensure that the environmental impacts of power generation are kept to a minimum. We shall explore in detail the mechanisms developed first in a monopoly context and then in a competitive environment to try to minimize the environmental impacts of power generation.

Because the environmental externalities of power generation are so varied, there is no simple way to integrate them into the decision-making process. In the 1970s and 80s, sophisticated techniques were developed to integrate externalities into utilities' decisions about how to meet growing demand for electricity in their service territories. These approaches are described in Chapter 1.

During this same period, competitive forces were growing in the U.S. electric industry. In the 1990s, these forces exploded into a movement to completely restructure the electric industry by replacing vertically integrated utilities with competitive markets. While the ongoing energy crisis in California represents a watershed event in their evolution, competitive energy markets are in all likelihood here to stay. The evolution of this movement is described in Chapter 2.

This restructuring process has many implications for energy choices. To the extent that structural changes allow individual consumers to choose the supplier of the electricity they consume, the planning procedures developed earlier can no longer be applied. Even where choice of supplier is not permitted, integrated planning in many cases has fallen into disfavour. Thus, even prior to any intervention, restructuring affects the planning process and the choice of resources. Furthermore, it greatly facilitates interregional power transfers, as described in Chapter 3.

Finally, it is widely recognized that, in a restructured environment, where energy choices are based almost exclusively on price, economic pressures can easily lead to results that are not in the public interest — e.g., by favouring increased generation from old, highly polluting coal plants. As a result, market-compatible mechanisms have been developed to favour "environmentally friendly" generation. These are presented briefly in Chapter 4. Issues concerning the application of some of these measures to hydropower are discussed in detail in Part III. Finally, in the concluding chapter, we will revisit the issue of planning.

[4] Republican Platform 2000, *American Partners in Conservation and Preservation: Stewardship of Our Natural Resources.* <http://www.rnc.org/2000/2000platform6>

1. Energy planning in a monopoly context

For most of the twentieth century, the North American electric industry was dominated by vertically integrated utilities.[5] In order to meet their obligation to serve, these vertically integrated utilities had to forecast future energy needs and plan both their generation systems (or their power purchases) and their transmission systems to meet these needs. The economics of electricity generation reflected considerable economies of scale, meaning that it was far less costly, on average, to build a single large power plant than many small ones. Furthermore, marginal costs were generally rising, meaning that each power plant cost more than the one before it. Utility rates were typically based on meeting the costs incurred to serve its customers, plus a reasonable return on investors' equity ("cost-of-service ratemaking").

As part of its planning process, a utility would prepare a range of forecasts of future load growth[6] and compare the costs of the various ways it could go about meeting those energy needs. The resulting "least-cost plan" would be the one that minimizes the cost of meeting energy needs.

As the sophistication of energy planning increased, due in part to increasing public involvement in regulatory proceedings, least-cost planning evolved as well. One important change concerned utility expenditures to reduce energy consumption ("demand-side management," or DSM). Since marginal costs were expected to keep rising, future increases in electricity demand would eventually translate into rate increases for all. In such a context, it is in everyone's interest to restrain future load growth.

When a utility spends money to convince its customers to use less energy, or to use it more efficiently, these additional costs must be recovered through rates. In many cases, the DSM-induced rate increases will be lower than they would have been if new power plants had been built to meet the increased demand. In other cases, per-kilowatthour (kWh) rates might be higher than they would have been without DSM, but due to reduced consumption, the average customer's bill would go down. In putting the emphasis on minimizing customers' bills rather than their rates, this new planning approach sought to ensure that new power plants would not be built if cost-effective energy efficiency investments could be undertaken instead.

Together with other innovations, these methods gradually coalesced into an approach known as Integrated Resource Planning (IRP). IRP was defined in the U.S. *Energy Policy Act* of 1992 (often referred to as "EPAct") as follows:

> [A] planning and selection process for new energy resources that evaluates the full range of alternatives, including new generating capacity, power purchases, energy conservation and efficiency, cogeneration and district heating and cooling applications, and renewable energy resources, in order to provide adequate and reliable service to its electric customers at the lowest system cost. The process shall take into account necessary features for system operation, such as diversity, reliability, dispatchability, and other factors of risk; shall take into account the ability to verify energy savings achieved through energy conservation and efficiency and the projected durability of such savings measured over time; and shall treat demand and supply resources on a consistent and integrated basis.[7]

While this definition fails to include reference to the environmental costs of power production, by that time most state IRP rules did. Indeed, planners and regulators agreed that minimizing dollar costs at the expense of environmental costs was not necessarily in society's best interest. Rather, they concluded that the public interest is best served if electric power needs are met at "least societal cost," taking into account non-monetary costs as well.

Thus, IRP can be thought of as a process that starts with an estimation of the utility's future loads and assesses the options to meet those loads, choosing the one that best serves society's long-term interests. Since electricity demand evolves gradually over time, the least social cost solution will rarely consist of a single power plant; rather, it will usually consist of a sequence of actions that can be thought of as a "port-

5 "Vertical integration" refers to the integration of generation, transmission and distribution functions in a single company. Traditionally, most utilities had a legal monopoly in each of these domains, as well as the obligation to serve all customers within their monopoly "service territories."

6 "Load" refers to consumers' electrical demand.

7 United States Government, *Energy Policy Act of 1992*, s. 111(d). This section of the Act, which required state regulators to consider using IRP in state energy planning, has in many ways been overshadowed by Title VII, which paved the way for full-scale competitive restructuring, as described in Chapter 3.

folio" of energy resources. The goal of IRP is to optimize this portfolio, to meet future needs, taking into account the economic, environmental and reliability characteristics of each resource as well as the many uncertainties involved (see Box 1).

Conducting this type of planning is extremely complex. First, there is the peculiar nature of electricity itself, which, unlike any other commodity, must be produced at the same moment it is consumed. Second, there is the highly uncertain nature of load forecasts combined with the relatively long periods of time required to plan, site and build power plants (and, to a lesser extent, to design and implement energy efficiency programs). A third factor is the uncertainty in predicting actual energy savings from energy efficiency programs. Finally, it is complex because of the very different types of non-monetary costs (externalities) associated with the different options that must be compared.

Whatever the methodology used to account for externalities, the integrated planning process must inevitably address the following issues:

- the range of forecasts of future needs,

- the feasibility, projected cost and environmental impacts of available generating alternatives, such as nuclear, coal, oil, natural gas, hydropower, wind, geothermal or solar power. For most of these resources, the costs and impacts are for the most part generic. For hydropower, however (and to a lesser extent for wind and geothermal power), both the costs and the impacts are highly site-specific. As a result, relatively detailed information regarding the proposed projects is essential for the resource planning process,

- the economic and environmental costs of new transmission lines needed for each of these possible resources,

- the availability, cost and environmental and social impacts attributable to power imports, and

- the feasibility, cost and potential energy and capacity savings of a range of energy efficiency and conservation measures.

Optimizing these choices on a strictly economic basis is already a difficult undertaking, but taking environmental and social impacts into account compounds the problem, especially when hydropower is one of the options. However, the modern regulatory process — with expert testimony, cross-examination, and full participation by all interested parties, supported by intervenor funding or cost awards for public-interest participants — at least provides a venue in which such complex issues can be addressed. Furthermore, widespread use of "collaboratives"[8] and other approaches to early stakeholder involvement often help ensure that no valid concerns are neglected. For all its flaws, a system whereby an independent regulator must approve each utility's integrated resource plan after full public hearings is probably the one best suited to assessing the complex trade-offs between economic and environmental costs and benefits involved in long-term energy planning (see Chapter 11).

Whichever tools are chosen, the purpose of these methods is the same: to help decision-makers choose wisely among the many possible ways of meeting society's future energy needs.

[8] Collaboratives give stakeholder representatives a direct role in consensus decision making. A good example is the British Columbia *Electricity Conservation Potential Review, 1998-2010,* carried out by a 15-member collaborative committee. (The Federal Energy Regulatory Commission's Alternative Licensing Process (18 CFR Parts 4 and 375) is often referred to as a "collaborative" process as well.) An over-reliance on collaboratives can be problematic as well, as they only represent the interests of those present. See Peter A. Bradford, "Searching the Foreseeable Past: Three Mile Island, California and the Restructuring of the U.S. Electric Industry," presented at the Pace Environmental Law Review 2000 Symposium, *Electricity Restructuring at a Crossroads: Consumer and Environmental Implications* (10 November 2000).

Box 1: Integrated Resource Planning: Integrating Environmental Externalities Into Decision Making

The many jurisdictions that have required utilities to practice IRP have developed different approaches to integrating environmental externalities into the decision-making process. These approaches can be separated into those that express environmental costs in monetary terms ("monetization") and those that do not. In most jurisdictions, monetization has involved the determination of "adders" – dollar values representing environmental costs which are to be added to the financial cost of each generating option before they are compared on a "least cost" basis. These adders can either be based on "damage costs" (estimates of the actual monetary value of the damage caused by different environmental stressors) or on "control costs" (estimates of the cost of controlling or avoiding the environmental harm).

In each case, the estimation process is difficult and subject to large uncertainties, which, in a public process, translates into controversy. Some impacts, such as sulphate emissions from a thermal power plant, can be easily quantified (tons SOx per GWh) – though these levels may change over time, as fuel quality changes and the plant itself ages. Since damage costs (e.g., the harm sulphates cause to human health, to urban infrastructure and to natural ecosystems) are very hard to evaluate, many jurisdictions base their evaluations on control costs (the cost of adding scrubbers, or the cost differential compared to a cleaner natural gas plant) instead.[9]

However, other types of impacts, and in particular those associated with hydropower, such as changes in landscapes, reduction in biodiversity or harm to Native peoples' traditional livelihoods are virtually impossible to quantify, much less to monetize. Putting a dollar value on damage to a commercial or even a recreational fishery with methodologies such as contingent valuation (which estimate values based on people's preferences, on the amounts they say they would be willing to pay to avoid a given impact, or on the amounts they actually spend on recreational pursuits), provides results that are far from satisfactory, as are attempts to quantify non-power benefits such as recreation. Assessment of cumulative impacts also remains exceedingly problematic.

These difficulties have led some jurisdictions to turn instead to qualitative techniques in order to integrate diverse types of externalities into the decision-making process. There are many variants of these methods, known by such names generally as multi-criteria decision making, multiple accounts evaluation and multiple-attribute trade-off analysis. For example, rather than reducing all impacts to a single common denominator (money), multiple accounts evaluation multi-criteria approaches keep tallies of the various types of costs as several distinct "accounts." Thus, each supply-side (generating) or demand-side (conservation, efficiency or load management) option could be characterized by its score on a variety of accounts such as financial cost, air pollution, greenhouse gas emissions, ecosystem damage and disruption to Native societies. No explicit weighting is given to the different accounts, as would be necessary if they were all to be "collapsed" into a single score. However, scores can be summed within an account, to compare different portfolios of resource options that the utility could use to respond to its evolving energy needs. Multiple account evaluation thus provides a way to summarize the financial and environmental costs of a complex range of options, enabling subjective evaluation by a stakeholder group or a decision-maker.

Even more sophisticated procedures have also been developed, such as the "multiple-attribute trade-off analysis" developed by the Analysis Group for Regional Electricity Alternatives (AGREA) at the Massachusetts Institute of Technology in the early 1990s. This approach uses sophisticated computer modelling to explore the economic and environmental implications of different resource strategies under a variety of possible futures. The results are provided to a stakeholder group in an iterative process that seeks consensus around a set of strategies that will meet energy needs at the lowest social cost, taking the many uncertainties into account.[10]

9 To avoid lengthy technical debates over these values, some jurisdictions have selected adder values without trying to determine actual damage or control costs.

10 For a detailed description of this approach, see AGREA, *Final Report for Phase One: The Commonwealth Electric Open Planning Project,* Commonwealth Electric and M.I.T. Energy Laboratory (1991); C.J. Andrews, "Spurring Inventiveness by Analyzing Tradeoffs: A Public Look at New England's Energy Alternatives," *Environmental Impact Assessment Review* (1992).

2. Competitive restructuring of the electricity industry

2.1 Competitive wholesale markets

2.1.1 Evolution

By the mid 1990s, just as IRP had become standard practice in a large number of North American jurisdictions, a massive change began to sweep across the electric power industry: the shift toward competitive markets.

The industry structure built around vertically integrated monopolies was based on the notion that the electric power industry is a natural monopoly. For transmission and distribution, this logic remains for the most part unchallenged. Since it would be enormously wasteful for competing companies to build their own set of wires and poles, one company normally holds an exclusive franchise to perform these services.[11] As a general rule, transmission and distribution prices are therefore fixed by a regulator, who is mandated to ensure that they are just and reasonable.[12]

Until recently, a similar logic applied to generation. Because large power plants had much lower unit costs than small ones (economy of scale), it was more economically efficient for a single company to build a large power plant than for competing companies to each build smaller plants. Thus, it was in society's interest to grant a monopoly franchise to a single generating company, rather than to encourage competition among several firms. However, advances in gas turbine technology in the late 1980s created a situation where, for the first time, the most cost-effective generating technologies could be implemented on a smaller scale. Thus, it was no longer correct to describe generation as a *natural* monopoly; it became possible to conceive of a competitive market for electric power.

In fact, the move toward competitive power markets has its roots in legislative and regulatory changes in the late 1970s designed to promote non-utility generation. The most important was the *Public Utilities Regulatory Policies Act* of 1978 (PURPA), adopted under the Carter administration.[13] PURPA required utilities to purchase power from so-called "qualifying facilities" at rates based on the utility's avoided costs (the cost the utility would otherwise have to pay to generate or purchase power).[14] It led to the rapid development of large amounts of non-utility generation, without which the move to competition might never have occurred.

At the same time, another driving force gained significance in the U.S., this time regulatory and political. In the 1970s and 80s, many U.S. utilities had embraced nuclear power, but the dreams of power "too cheap to meter" quickly disappeared. Instead, faced with dedicated grassroots political opposition and wave after wave of technical difficulties, the cost of nuclear power spiralled ever higher.

While bankruptcies were rare, regulated electricity rates climbed rapidly as the high costs of the nuclear plants entered the rate base, just as inexpensive, small-scale gas turbines became commercially available. Before long, industrial consumers began to clamour for the right to buy power directly from new, independent power producers, to import power from neighbouring regions or to install their own on-site power plants in order to avoid the high rates of their local utilities.

In the United States, the confluence of these two historical developments led to the adoption by Congress of the *Energy Policy Act* of 1992 (EPAct). This landmark legislation mandated the Federal Energy Regulatory Commission (FERC) to create conditions which would allow a competitive market in electricity generation to flourish.[15] At the same time, it recognized that drastic changes to the way the transmission system is managed would be fundamental to the establishment of such a market.

Under the mandate created by the EPAct, FERC has issued a number of important rulings to further the development of competitive wholesale energy markets in the U.S., of which the most important are Order 888 and Order 2000 (see Box 2).

11 Some jurisdictions are now attempting to introduce competition and eliminate the need for monopoly franchises even for some of these "wires" services.

12 The Federal Energy Regulatory Commission (FERC), which regulates most high-voltage transmission in the U.S., has recently begun to authorize "merchant" transmission lines, for which rates are not based on the cost of service.

13 Even before PURPA, the State of California in 1976 had enacted legislation promoting the development of non-utility sources of electricity.

14 PURPA also had provisions to promote renewable and high-efficiency energy sources.

15 Somewhat paradoxically, while the pro-competition parts of the EPAct set in motion a chain of events that would eventually make IRP irrelevant in much of the U.S., Section 111 also required its use in order to encourage DSM. See note 7, above.

Box 2: FERC Orders 888 and 2000

Order 888, issued in 1995, was predicated on the understanding that the primary impediment to the development of a fully competitive market in electric energy was the ability of vertically integrated utilities to use their control over their transmission systems to hinder transactions that were not in their interests (or not in the interests of their marketing affiliates). It required utilities to offer open access to their transmission systems, at non-discriminatory rates and conditions, and called for "functional separation" between their transmission and energy marketing functions. FERC judged that such functional unbundling would be adequate to create confidence on the part of other users of the transmission system that they were being treated fairly, and that the transmission operator would not unduly favour its own marketing affiliates at the expense of other users. At the same time, it favoured, but did not require, the creation of Independent System Operators (ISO). An ISO is a non-profit organization that controls and operates, but does not own, a transmission system.

In rejecting demands that vertically integrated utilities be broken up, FERC took a calculated risk – that these halfway measures would be good enough to allow competition to take root. Order 888 did in fact result in an explosion of restructuring activity, but it gradually became clear that vertically integrated utilities were still able to use their control over transmission lines to their own advantage. In response, FERC began the process which led to the issuance of Order 2000 in December 1999.

In it, FERC acknowledges that Order 888 was not entirely successful, and that there remain significant barriers and impediments to fully competitive electricity markets. The Order strongly favours the creation of "regional transmission organizations" (RTOs), regional bodies that would control and operate the transmission systems of the utilities located within their territories, while remaining independent of control by any company that generates or sells power. The intent is to ensure that the transmission system – the most critical element to a truly competitive market – cannot be used to favour the interests of its owners and their affiliates.

EPAct thus initiated a shift away from the historic regime whereby prices for electrical energy were fixed by a regulator based on the generator's costs toward a new regime where energy prices would be determined by market forces (supply and demand). With a competitive market slowly taking form, private companies began to build power plants without any long-term commitment for the purchase of their output. Instead, power from these "merchant" plants would be sold on the open market, at the best price that could be obtained. (A brief explanation of how such a market functions is found in the next section).

Gradually, as the impediments to wholesale competition decreased, more and more companies have obtained the financing necessary to build merchant plants. In the regions of the U.S. with the most vigorous wholesale power markets, the vast majority of power plants for which permits have been requested are indeed merchant plants.

While FERC stopped well short of requiring integrated utilities to divest themselves of their generation assets, many state restructuring settlements have required precisely that. Thus, more and more, generating assets are being sold off, either to independent companies or to unregulated affiliates of the parent utilities. In some cases, the utilities' unregulated affiliates have purchased new generating assets in another region. For example, as Pacific Gas and Electric (PG&E), a regulated utility based in San Francisco, has sold off most of its generating assets to non-regulated companies, its non-regulated affiliate PG&E National Energy Group (NEG) has become a major player in U.S. energy markets. PG&E NEG now owns some 7,000 megawatts (MW) of generation and has over 10,000 MW of new plants in development and construction, much of it in the Northeast.[16]

2.1.2 Understanding spot markets

The centrepiece of the restructured electricity market is the spot market, or power exchange ("PX"). While electricity spot markets have existed for a long time, in the past, they were a necessary but minor part of the industry structure. Under restructuring, however, the spot market plays the central role of both ensuring balance of supply and demand and determining the ever-changing price (and value) of electricity. The amount

16 See http://www.pgecorp.com/overview/neg.html.

Box 3: Generation Costs

The total costs incurred by a power producer can be broken down as follows:

Full cost = capital costs + fixed operating costs + variable operating costs

Capital costs consist of interest costs and the expected return on equity for the capital invested in building the power plant.

Fixed operating costs are all those operating costs (e.g., labour, maintenance, and, for hydropower, ongoing mitigation and monitoring costs) which must be paid whether or not the plant is in use.

Variable operating costs are all those costs which vary with the amount of power generating, and which thus are avoided when the plant is idle (fuel costs and some operating and maintenance costs).

of energy transacted in these markets is increasing rapidly, as is its influence on all power sales.

A typical power exchange holds a daily auction for every hour of the following day.[17] By 11am of each day, every generator in the area must advise the PX of the amount of power it is willing and able to provide for each hour of the next day, and the minimum price at which it is willing to do so. At the same time, buyers (large consumers and distribution companies) must also indicate their expected hourly power needs. For each hour, the PX stacks the bids in order of price (the merit order) and determines which generators will operate during that hour (the hourly dispatch). The price of the most expensive generator dispatched for that hour becomes the system price (the market clearing price), paid by all buyers to all sellers during that hour.

The market price will thus depend on the demand in any given hour. The higher the demand, the more the dispatcher will have to call upon plants higher up in the merit order, and the higher the market clearing price for that hour.

This market clearing price system, whereby all producers receive the hourly clearing price for all the power they provide during that hour and all wholesale purchasers pay that same price for all the power they receive, is meant to eliminate incentives for “gaming.” If each generator were instead paid the price that it bid, the average price for the hour would indeed be lower (since only the “marginal generator” — the most expensive one included in the dispatch — would receive the cut-off price), but generators would inevitably bid strategically, based on their estimates of what the market would bear. The market clearing price system is meant to eliminate this incentive for strategic bidding, since a generator’s revenues are not determined by its bid (as long as it does not bid so high as to be cut out of the dispatch). The idea is to give generators an incentive to bid each plant’s output at its variable operating cost (see Box 3). As we shall see in Section 2.3, however, the market crisis in California has cast grave doubts on the effectiveness of these incentives, and hence on the adequacy of the market clearing price system.

During periods when the supply of low-variable-cost power exceeds demand, the market clearing price will be equal to the typical generator’s variable costs, and thus far below its “full” costs. Thus, during periods of surplus, power prices will be well below the rates that would have been charged under traditional regulation, where rates were designed to ensure that utilities recovered their full costs (including a reasonable return on equity).

However, during periods of shortage, when even the plants with the highest variable costs are needed to meet demand, the market clearing price will be high, and even the generators with low fixed and variable costs will obtain that same high price. During those periods, power prices under restructuring will be considerably higher than they would have been under traditional regulation — even without strategic bidding or market manipulation.

In theory, those high price periods should provide the incentive for generators to build new power plants, which in turn will drive prices back down. While these prospects of low-cost power have driven the restruc-

17 In practice, there are many variations on the simple model presented here.

turing movement, it is often forgotten that high-price periods are an essential part of the dynamic the market clearing-price system creates. Indeed, price volatility is an essential part of all commodity markets.

Since the summer of 1998, when severe price spikes occurred in the Midwest following a relatively minor transmission outage,[18] price volatility in wholesale markets has been a subject of concern. The summer of 2000 saw the issue explode into the political arena as electricity prices skyrocketed in California and in the U.S. Northeast, just as some residential and commercial consumers were actually beginning to pay electricity rates based on prices in the wholesale market. The issues raised by these events are discussed briefly in Section 2.3.

2.2 Retail competition

Following upon the opening of the U.S. wholesale electricity market with Order 888, a number of states began to adopt and implement restructuring processes designed to allow individual consumers to choose their electricity provider. California was the first state to adopt restructuring legislation in 1996. Since then, 24 states have gone the same route,[19] and all but eight of the rest have embarked upon the restructuring process. In Canada, Ontario and Alberta are in the process of opening their retail markets.

The idea of individual consumers choosing their electricity supplier may at first be difficult to grasp. In many ways, it is similar to what has occurred in the telecommunications industry after the break-up of the Bell System's vertically integrated monopoly: even though we all continue to use the infrastructure of the local service provider, we are free to contract with any one of the many companies offering long-distance service. Even when there is competition for local service, there is still a monopoly wires company that owns and maintains the local lines.

When we consume electricity, we are drawing from a common pool in which the output of all generators currently on-line is inextricably mingled. Choosing a supplier is thus not a matter of choosing the manufacturer of the product one consumes, but rather of choosing the producer who will have the obligation to replenish the pool for the amounts one draws from it.

Virtually every electricity consumer is, or until recently was, served by a utility with a monopoly franchise. That company thus enters the competitive marketplace with an enormous advantage in the competition for customers. While different states have chosen different mechanisms to try to open the retail market to competition, in each one only a small proportion of electricity customers have switched to an alternate supplier.

Many industry observers believe that the benefits of competition will only be realized once there is a vigorous and fully competitive retail market. With the possible exception of Pennsylvania, no such market yet exists in North America.[20] In the states that now allow retail choice, the number of consumers taking advantage of it is so small that the utilities continue to enjoy a *de facto* monopoly. Absent vigorous retail competition, we may be left with the many downsides of competition detailed in this paper, but with none of the corresponding benefits, such as lower prices and a thriving green power market.

The debates over whether or not to proceed to retail competition (also referred to as retail choice, retail access and retail wheeling) and, if so, how to do so are extremely complex. As we shall see below, the introduction of retail access radically alters the means available to integrate environmental issues into energy choices, and is thus of central importance to our concerns here. The details of its implementation, thankfully, are not.

18 FERC, *Staff Report to the Federal Energy Regulatory Commission on the Causes of Wholesale Electric Pricing Abnormalities in the Midwest During June 1998 (*22 September 1998).

19 Including New York State, where restructuring took place through regulatory action without legislative involvement. An updated map can be found at: http://www.eia.doe.gov/cneaf/electricity/chg_str/regmap.html.

20 In Pennsylvania, some 550,000 customers with a combined load of 6,000 MW have switched providers, more than in the rest of the U.S. put together. According to John Hanger, executive director of PennFuture and a former member of the Pennsylvania Public Utilities Commission, this is because it is the only state to have made pro-competitive policy choices in implementing retail access (e.g., setting the "shopping credit" high enough to give consumers a real incentive to switch suppliers). John Hanger, "Policy Options for Dealing with Wholesale Market Failure," presentation at the Pace Environmental Law Review 2000 Symposium, *Electricity Restructuring at a Crossroads: Consumer and Environmental Implications* (10 November 2000).

2.3 Market dysfunction

The events we have described seem to portray a steady and inexorable progression toward fully competitive, deregulated electricity markets. However, a series of price spikes starting in 1998 in the Midwest and continuing in the Northeast and most recently and spectacularly in California have cast grave shadows over the rosy future promised by restructuring's proponents, driving wholesale buyers to the brink of bankruptcy and providing windfall profits to generators.[21]

When California set out to restructure its electricity sector in 1996, the expected benefits were to result from consumers' direct access to the wholesale electricity market, which would provide them relief from high retail rates charged by the incumbent utilities, based on cost-of-service pricing. At the same time, wholesale prices were expected to diminish, due to increased efficiencies resulting from competitive forces.

It didn't work out that way. Revenues to generators rose 276% to $28 billion in 2000, from $7.4 billion in 1999.[22] By mid-February 2001 California's electric supply was so unreliable that the state had experienced weeks of stage 3 alerts and rolling blackouts, two of California's largest investor-owned utilities were facing insolvency, Governor Gray Davis had signed legislation authorizing the state to purchase power on behalf of the utilities (as it was already doing, using emergency powers), and calls were being heard in the State capital for the creation of a State Power Authority to generate and purchase power. Meanwhile, Californians struggled to understand the confusing and contradictory reports and interpretations of why they no longer had a reliable and affordable electricity supply. The California energy crisis has taken on dramatic proportions, not only for California, but for the entire Western region and indeed for the U.S. power industry as a whole.

Under California's restructuring legislation AB1890, utilities' rates had been frozen at artificially high levels in order to pay down stranded costs and to protect consumers against the exercise of market power by the utilities which then controlled the vast majority of generation in the California market. As the utilities divested their power plants, they were bought up by independent generating companies (many of which were affiliated with utilities in other states, just as the non-regulated affiliates of the California utilities were buying up power plants in other regions). And, as wholesale prices began to skyrocket, the rate freeze began to have an effect very different from what was intended, preventing those same utilities from recovering from consumers the cost of power purchased on their behalf.

The utilities were thus caught in a vice largely of their own making. Not surprisingly, California ratepayers have been extremely reticent about throwing them a lifeline of even a "modest" rate increase — even though that would hardly make a dent in the financial hole in which the utilities find themselves.

What led to those astronomical wholesale prices in the first place? At first, in the summer of 2000, the price spikes were blamed on supply shortages resulting from hot weather, plant outages, transmission constraints and low water conditions in the Pacific Northwest (from which California imports a substantial portion of its energy supply). Careful analysis demonstrated, however, that only the exercise of significant market power by generators — not only through bidding behaviour, but also by withholding capacity from the market — could explain these events. In the words of Robert McCullough:

> The bottom line is straightforward — the California market was characterized by large, enduring deviations from traditional utility practice. Generators did not generate. Peakers did not peak. Emergencies appeared to lack solid justification. All of the evidence is consistent with a major, sustained exercise of market power.[23]

McCullough concluded that "The ISO's [Independent System Operator's] complex and secretive operations have provided a petri dish for collusive behavior."

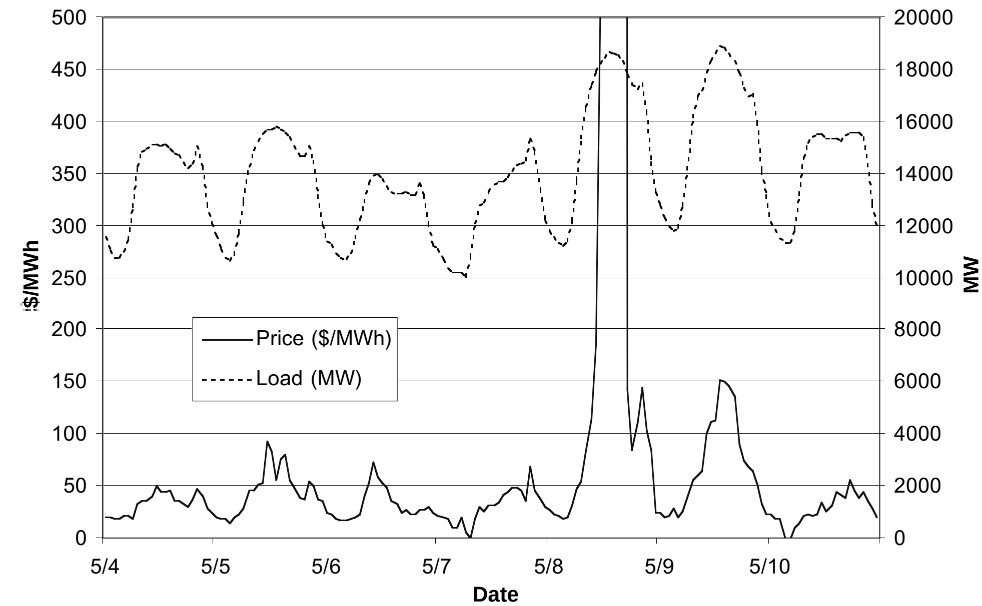
To a certain extent, price spikes are an indication that the market is doing its job. The purpose of a spot market is to create price signals whereby prices increase when demand increases relative to supply, and vice versa. According to theory, shortage leads to high prices, which leads to new entrants, which leads to lower prices. Thus, it is argued, any attempt to cap

21 In February 2001, the province of British Columbia announced a $404 million (CDN) rebate and conservation program to distribute to B.C. citizens the windfall profits from its power sales to California, including rebates of up to $300 per family.

22 As reported by Rick Jurgans, *Contra Costa Times* (4 February 2001).

23 Robert McCullough, "Price Spike Tsunami: How Market Power Soaked California," *Public Utilities Fortnightly* (1 January 2001), p. 22.

Graph 1: NE-ISO Prices, Week of 4 May 2000



or otherwise prevent price spikes will only prevent the market from self-correcting by providing new supply.[24] However, this mechanism can only function properly when no firm is capable of manipulating markets to its own advantage, (exercising “market power”).[25] There can be little doubt that “gaming” of the market process by generators has contributed substantially to the amplitude of the price spikes in California.

Indeed, economist Severin Borenstein has noted that, “if firms of noticeable size are not exercising market power, they are doing so out of the goodness of their heart, and against the interest of their shareholders.”[26] While price spikes have indeed occurred, at moments when supplies were tightest, that fact alone is insufficient to explain their size. This applies to price spikes not just in California, but elsewhere as well. To illustrate this point, Graph 1 shows the system load and market clearing price for the New England ISO for the week of 4 May 2000.

Each day, as load increased, the market clearing price did as well, varying between $15 and $80/MWh. On 8 May, however, the price jumped in the space of a few hours to $6,000 per MWh, as seen in Graph 2.

Electricity demand did indeed reach new highs during this unseasonably hot week in May, but this fact alone cannot explain the price spikes. As the first chart shows, demand reached the same level the next day, but prices only rose to $150.

FERC carried out an investigation of the 8 May price spike in New England, and found it to be the result of “inappropriate bidding rules.” Under these rules, sources outside the region have to be dispatched, even if out of merit order, when reserves fail to meet required levels. Since unanticipated generator outages had resulted in a 736 MW shortfall in reserves, the ISO accepted a bid from outside the region for 300 MW at $6,000/MWh.[27]

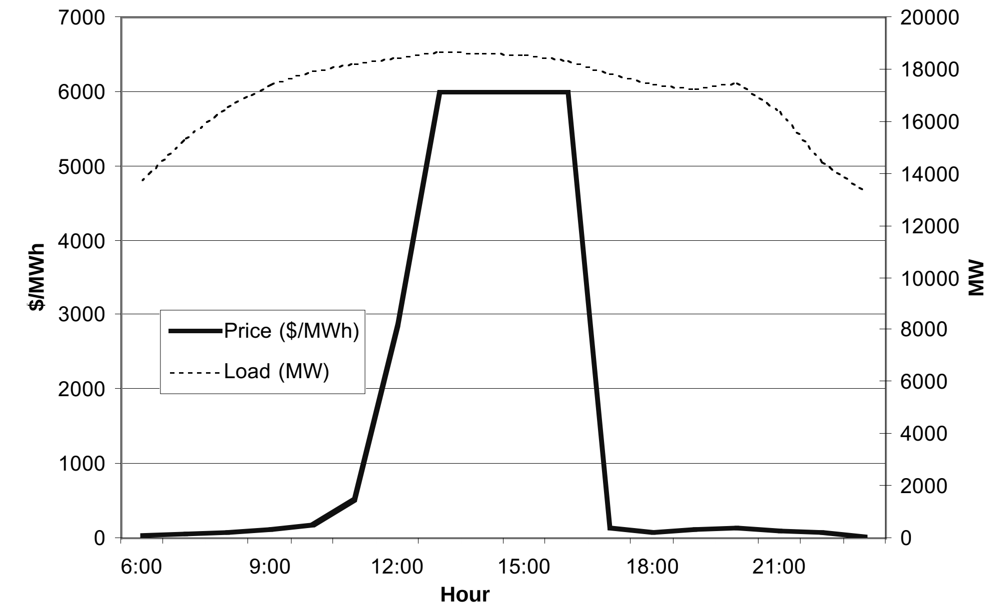
24 A more sophisticated market design with a separate capacity market, such as that used in the Pennsylvania-New Jersey-Maryland (PJM) region, is meant to provide these price signals to induce adequate generation supply without price spikes. Steven Stoft, *PJM's Capacity Market in a Price-Spike World,* U.C. Berkeley, Program on Workable Energy Regulation, PWP-077 (7 May 2000). Others, however, have argued that capacity markets only provide additional revenues to existing revenues during periods of scarcity, without creating an effective to build new generation. See, for example, Alexander Galatic, Director of Market Development, Strategic Energy, comments at FERC technical conference on California Market Monitoring (23 January 2001).

25 The larger a firm's share of the market, the greater the likelihood that it can exercise market power.

26 “Electricity Restructuring: Deregulation or Re-regulation?” (February 2000), p. 9, quoted in Michael Kahn, Chairman, California Electricity Oversight Board and Loretta Lynch, President, California Public Utilities Commission, *California's Electricity Options and Challenges: Report to Governor Gray Davis* (2 August 2000).

27 FERC, *Investigation of Bulk Power Markets: Northeast Region* (1 November 2000), pp. 53-54.

Graph 2: NE-ISO Prices, 8 May 2000



FERC did not identify the source of that bid, or explain how the bid price of $6,000 might have been arrived at. It is quite clear that this astronomical price ($6 per kWh) is not the actual marginal cost for any generator. According to many analysts, this alone is proof that generators are exercising market power. Others argue, however, that generators should be free to charge what the market will bear. In either case, it means that generators are not all following the logic described above, with each bidding its marginal cost of generation — which was the very basis for the belief that the market clearing price system would produce lower power costs than did cost-of-service regulation.

The problems in California, however, are far more severe. The messy jurisdictional divide in the U.S. with respect to electricity regulation means that both state and federal institutions bear some of the responsibility. While the market structures were designed at the state level, it is FERC that ultimately has jurisdiction over wholesale electricity markets. Thus, no firm can participate in the wholesale power market unless FERC has determined that it is unable to exercise market power.[28] However, the tools used by FERC to assess market power — so-called "hub-and-spoke" analysis — are woefully inadequate for the task. Even FERC Commissioner William Massey has described this tool as an "anachronism."[29]

However, on a day-to-day basis, it is the California ISO, created under FERC's jurisdiction, that is charged with monitoring the market to ensure that it remains free of abuse. In its November 2000 analysis of the California situation, FERC found that the "seriously flawed" market structure and rules of the Cal-ISO made it possible for sellers to exercise market power when supply is tight, which in turn resulted in "unjust and unreasonable rates."[30]

To remedy the situation, it recommended, first of all, eliminating the requirement, designed to mitigate the market power of the three California utilities, that they sell all their power into and buy all their power from the power exchange. However, as long-term prices reflect expectations of prices in the short-term market, signing long-term contracts when the market is at its peak would probably only result in locking in the exaggerated prices (and profits) we see today.

Secondly, FERC ordered that, if bids greater than $150/MWh are dispatched, they nevertheless will not set the clearing price for all generators. This allows the state to make emergency purchases when neces-

28 Each firm must obtain authorization from FERC to transact at market-based rates, or "power marketer authorization" (PMA).

29 William Massey, "Three Messages from Volatile Electric Markets," Energy Bar Association Mid-Year 2000 Program (17 November 2000).

30 FERC, *Market Order Proposing Remedies for California's Wholesale Electrics,* Docket EL00-95-000 (1 November 2000), p. 3.

sary without creating a windfall for all generators, creating an important exception to the market clearing price system.

Finally, it ordered that the boards of the ISO and the power exchange be replaced with an independent, "non-stakeholder" board, made up of individuals not related to market participants.[31]

What is remarkable is that, having found that rates were "unjust and unreasonable," FERC did not go farther to remedy the situation. No generator can participate in the wholesale market without "power marketer authorization," and it can't obtain that unless FERC is convinced that it does not have the ability to manipulate market prices to its own benefit. FERC's presumption that market rates are just and reasonable is predicated on its conclusion that no generator has the ability to exercise market power.[32]

Having found that market power is being exercised, and that the rates set by the market are not just and reasonable, FERC would appear to be acknowledging that it has failed at this statutory responsibility. Indeed, Southern California Edison filed a writ of mandamus in the federal court of appeal on these grounds, asking that the court order the Commission to set just and reasonable rates on the basis of costs — i.e., return to cost-of-service ratemaking.[33]

The California Public Utilities Commission joined the proceeding, arguing that "California will suffer irreparable harm if the FERC orders at issue are not immediately reversed. It is critical that the court act promptly to require FERC to do its duty under the law."[34] The motion was rejected without oral argument; the court indicated, however, that it expects FERC to rule on SCE's rehearing petition in a timely fashion. Once it does so, the question could then be returned to the courts.

California's regulators have taken the position that the state's problems ultimately result from federal jurisdiction over the wholesale electricity market. In a joint report issued in August 2000, the heads of the CPUC and the Electricity Oversight Board argued that the problems cannot be solved without redrawing the lines between federal and state power in the regulation of California's wholesale electricity market:

> FERC does not have comprehensive oversight of California's interrelated electric system. Accordingly, it cannot weigh the public policy options that might be available to affect development of each component part of the system — transmission, generation, distribution — and the costs and advantages of choosing among such alternatives as new construction, new rules, new programs or technical innovations. FERC cannot, for example, choose between the construction of an emergency peaking plant versus a substation upgrade according to the relative costs and benefits of each, when markets fail to respond to a need. It cannot address a regional transmission problem by funding investments in energy efficiency resources even if transmission facilities are more expensive. While no single agency, state or federal, may be in a position to regulate all parts of the electric system equally and comprehensively, the current structure is too fractured to assure California interests are promoted and protected.[35]

They recommended a greatly enhanced role for state regulation, including oversight over generation planning, reliability and pricing.

Meanwhile, other voices in California are also clamouring for radical change — with proposals ranging from re-monopolization with cost-of-service regulation to nationalization. These debates are affecting events far outside California's borders, bringing the restructuring bandwagon to a screeching halt in many parts of the U.S. Several states have already suspended their restructuring processes, waiting for resolution of the issues raised by the California events before proceeding farther.

Given the dramatic structural changes that have taken place in the last few years, it is probably impossible to put the toothpaste back in the tube and return to a system of regulated, vertically-integrated monopolies. Nevertheless, it is clear that the road to a fully competitive and deregulated electricity market

31 FERC stopped short of suggesting that the current boards are in a conflict of interest, as did the joint report of the CPUC and the Oversight Board. Kahn and Lynch, see note 26.

32 The Grand Council of the Crees (of Québec) and New England Coalition for Energy Efficiency and the Environment argued before the U.S. Court of Appeal (D.C. Circuit) that FERC exceeded its jurisdiction in assuming that market-based rates are just and reasonable; the Court rejected the appeal on a question of standing, without ever addressing the substantive arguments.

33 "SCE Seeks Legal Remedies Against Federal Regulators; D.C. Circuit Court Orders FERC to Reply by Jan. 2," Southern California Edison press release (29 December 2001).

34 *Ibid.* The proceeding was also joined by The Utility Reform Network (TURN), a California consumer group.

35 Kahn and Lynch, see note 26.

will be far from smooth. Innovative proposals are beginning to emerge as to what aspects of electricity markets should be regulated, and in what manner, to best protect the public interest. In any event, there is no doubt that the debate over deregulation and re-regulation of electricity markets will go on for several years to come.

2.4 Competition in other countries

Many other countries have gone through, or are in the midst of, similar restructuring processes to the one described here. Some, such as Norway, the U.K., Chile, Argentina and New Zealand, began the process earlier and moved faster to full retail competition. Others, such as the other countries of the European Community, are following more slowly. In all these countries, the main driver has been pressure (mainly from industrial users) for lower prices, combined (in some cases more than others) with a market ideology inimical to regulated monopolies.

It thus stands to reason that enthusiasm for restructuring tends to be greater in areas where the electricity rates are high. This is true both within countries and between them. In the U.S., for instance, the restructuring movement has been largely based in California and in the Northeast, the two regions with the highest rates (largely due to their earlier investments in nuclear power). Low-cost states such as those of the Southeast and the Pacific Northwest have been distinctly less enthusiastic about restructuring, in part due to the real concerns that their rates will increase as broad regional markets form. The recent events in California have only reinforced these concerns.

The same dynamic can also be seen in Canada. Ontario — faced with the highest power rates in the country, due to its reliance on nuclear power — is in the process of dismantling its state-owned monopoly and establishing retail competition. Alberta, however, is an exception: a low-cost region thanks to its enormous oil and gas reserves, it was the first province to restructure its wholesale electricity system in 1996. Alberta established innovative mechanisms to protect its consumers from rate increases, but, like California, has nevertheless seen dramatic increases in wholesale power prices in recent months. In both Ontario and Alberta, the opening of retail competition has been delayed several times.

On the other hand, the provinces of Québec, Manitoba and British Columbia, where the power supply is almost exclusively hydraulic, have made no real moves toward competition. They have sought, instead, to take advantage of the comfort of state-owned monopoly utilities at home to penetrate even further into the American export market. This strategy has been attacked in the U.S. by the Natural Resources Defense Council (NRDC), which has accused Hydro-Québec of engaging in anti-competitive practices by using subsidized power to undersell the competition in the U.S.

In the rest of the world, however, the restructuring dynamic has been very different. In many developing countries, power prices have remained far below the levels that would be necessary to provide a reasonable return on the asset base, or even to recover its costs. In countries that have faced enormous price increases due to currency devaluation in recent years, price controls for staple foods, electricity and other essentials have constituted an essential part, if not the entirety, of the “social safety net.” However, this has led to a situation where state-owned utilities are unable to finance new investments through rates — and this at a time when demand is growing rapidly and reliable electric service is essential to economic development.

In this context, international institutions such as the World Bank and the IMF have strongly promoted privatization and restructuring of government-owned electric utilities, in order to create an environment that encourages private foreign capital investment in new energy infrastructure.[36] While the resulting competitive system is the same as in developed countries, the motivation (and the rate impact) is entirely different.

In many jurisdictions that have not (or have not yet) embraced competitive electricity markets, traditional regulatory tools continue to be entirely appropriate, though not always fully developed. Unfortunately, the restructuring “trend” has led in some cases to the weakening or even the dismantling of these regulatory tools, even though the monopoly context remains. A good example is the case of Québec, described in Box 4 on p. 29.

[36] See, e.g., World Bank, *Power Sector Reform in Developing Countries and the Role of the World Bank,* Occasional Paper No. 9 (1996).

3. Implications of electricity restructuring

3.1 ... for energy planning and the environment

Electric industry restructuring profoundly changes the context in which decisions are made about energy resources. In the monopoly world, these decisions were made by vertically integrated utilities which were fully subject to regulatory control. It was in this environment that integrated resources planning developed as the tool of choice to ensure that energy choices were made in the public interest.

Under retail competition, however, the ultimate decision of whose electricity and what electricity should be consumed is made by the end-use consumer, not by the distributor or the regulator. Thus, the question is no longer whether the utility's energy choices are in the public interest, but rather which energy product is most attractive to consumers. While this freedom of choice is in many ways desirable, it has one important downside — in relieving the regulator of the power to approve plant construction or power purchase decisions, it also eliminates the planning tools that had been developed over the years to balance supply and demand while limiting the damage done to the environment by electricity generation.[37]

This is less true in an environment where competition is limited to wholesale markets, i.e., where regulated distribution utilities are responsible for acquiring the electricity used by their customers. The regulator can still weigh the social and environmental characteristics of competing options before deciding, on behalf of all the distributors' clients, how their energy needs should be met.[38] Even so, generating options rejected by the energy regulator as too environmentally harmful can still be developed for sale in other jurisdictions, eliminating the regulator's ability to limit excessive environmental impacts from electricity generation.

In practice, however, many jurisdictions jettisoned their integrated energy planning processes at the first hint of competition, well before retail customers were given the opportunity to choose their suppliers. In some areas, this has been driven by concern that utilities would be hampered in their competition with non-utility generators if they were subject to planning requirements and other obligations that their competitors did not have to bear.[39] In others, such as Québec, where Hydro-Québec faces no significant competition in the foreseeable future, it is better explained by the utility's desire to avoid the public accountability implicit in the planning process.

Once fully implemented, competitive markets are in many ways incompatible with planning processes that, in the past, ensured careful review of the justification for new power plants as the optimal choice to meet forecast demand. If different firms are to compete for the right to serve electricity consumers over a vast geographic area, they expect to have the opportunity to build power plants based on their own estimation of the projects' risks and benefits. If a firm makes a poor commercial decision, it will lose money, either because its operating costs are so high that it is not dispatched and sits idle much of the time (in the case of fossil fuel plant), or because its capital costs are too high relative to the value of the power it produces (in the case of a wind or hydro plant).

While in other industries stranded investments may have few implications beyond private financial loss, the great externalities of many electricity investments means that third parties or the public as a whole can be the losers as well. As such, a stranded hydroelectric or nuclear project will continue to impose its externalities on society and the environment until (and perhaps after) it is decommissioned, whether or not it is earning a profit for its owners or even generating electricity at all.[40]

The process of opening markets to competition also has broader environmental consequences, tending to relegate environmental and other non-market considerations to the sidelines. This trend is almost inevitable in a movement whose primary goal is to lower rates and increase customer choice, and whose emphasis is

[37] The recent events in California have served to rekindle interest in generation planning, even in a competitive context, as discussed in Section 11.1.

[38] Assuming, that is, that its constitutive legislation allows it to do so.

[39] See, e.g., California Public Utilities Commission, Division of Strategic Planning, *California's Electric Services Industry: Perspectives on the Past, Strategies for the Future* (3 February 1993).

[40] Since the marginal operating costs of a hydro plant are near zero, it will keep generating electricity even if its capital costs cannot be recovered in the marketplace. If the plant's operator can't meet his debt payments and goes into bankruptcy, the plant will presumably be sold for a price that allows its new owner to operate profitably, even if that price represents a deep discount from its book value.

placed squarely on developing markets, often at the expense of taking externalities into account.[41]

Furthermore, restructuring necessarily implies a fragmentation of decision-making power — a large number of competing generators, an independent transmission authority, a regulated distributor, a market operator, one or many power exchanges, et cetera — thereby inhibiting any serious efforts at addressing complex issues from a broad, integrated perspective.[42]

It is thus imperative to develop new and effective policies to deal with the environmental consequences of electricity generation, transmission and distribution in a competitive environment.

3.2 ... for resource selection

Before we turn to policy approaches that can be used to minimize the environmental impacts of generation in a competitive environment, it is important to understand the complex mix of incentives and disincentives for various types of resources that are implicit in the restructured market. In the following sections, we will briefly examine the ways that competitive markets affect resources such as conservation, intermittent renewables (wind and solar), fossil fuel generation, nuclear power and hydropower.

3.2.1 Conservation and energy efficiency

It has long been recognized that programs designed to reduce energy needs represent an environmentally beneficial and, in many cases, cost-effective alternative to building new power plants. Such programs can incite people to be more careful in the way they use energy, offer them financial assistance in making their homes and businesses more energy efficient (for example, by improving insulation or by installing high-efficiency appliances) or help them find ways to shift energy usage from on-peak to off-peak periods. Together, these types of measures have come to be known as demand-side management, or DSM.

Over the past two decades, it has become apparent that traditional regulation creates many *dis*incentives to DSM. In the short term, DSM adds to utilities' costs while reducing their sales volumes and hence their revenues. In the longer term, it diminishes the need for new power plants, transmission and/or distribution lines. Under the traditional regulatory approach whereby utilities' rates are based on a fixed rate of return on their capital investments, this is *not* in the utility's financial interest (since new capital assets virtually guarantee greater profits), even though it may well be in the *ratepayer's* interest.

The failure of early attempts to force utilities to take actions that harmed their own financial interests led to the development of new regulatory tools designed to align the utilities' interest with the public interest. Complex mechanisms for cost recovery, lost revenue recovery and shareholder incentives were designed and implemented, and, in consequence, many utilities began investing heavily in energy efficiency as a means to balance supply and demand. These mechanisms — and the significant utility spending on DSM that they helped bring about — were to a large extent the crown jewels of the environmental movement's regulatory efforts. With the advent of retail competition, however, these mechanisms become increasingly obsolete. Indeed, the mere threat that utilities might eventually have to face competition caused their DSM spending to plummet nearly as fast as it rose, as seen in Graph 3.

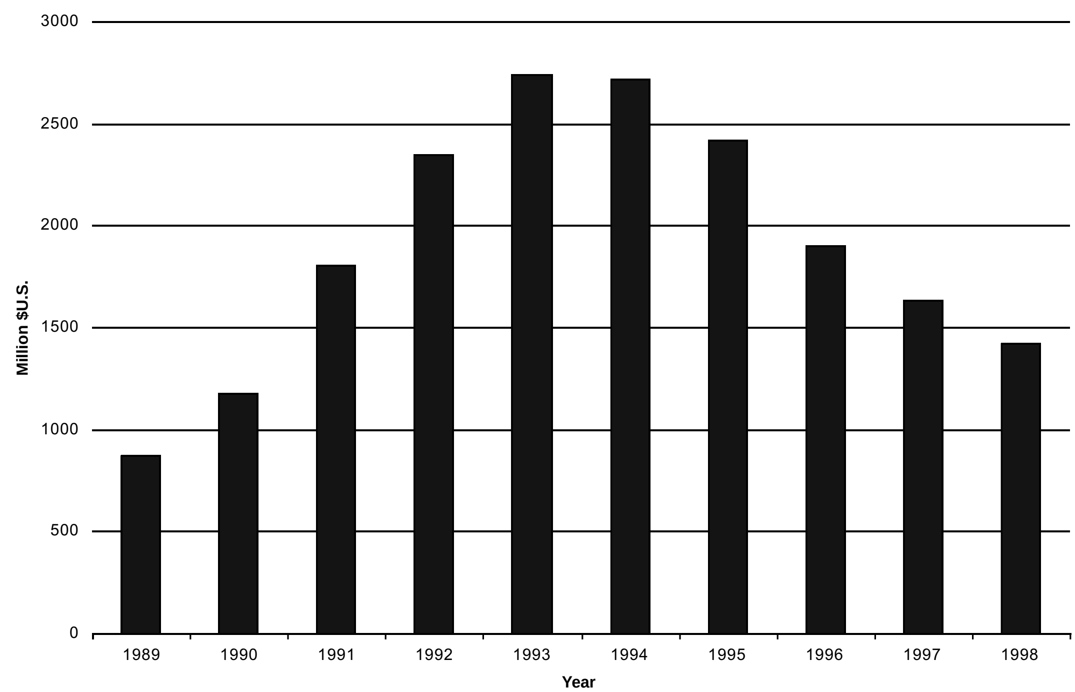
One reason is that the utilities rushed to cut costs and non-core activities so that, when consumers were eventually allowed to choose their suppliers, they would be able to offer competitive rates. Substantial DSM programs do raise rates (although the typical ratepayer's *bills* go down), and, as we have seen, rate relief was the primary driver behind industry restructuring. But, insofar as the programs are attributed to the *distribution* activities of the utility (as opposed to generation), this argument carries little weight. Even after restructuring, distribution utilities remain regulated monopolies. As such, the same cost recovery, lost revenue recovery and shareholder incentive mechanisms mentioned earlier can be applied to them, ensuring that they can profit from improving their customers' energy efficiency.[43] However, sensitive to political trends, many regulators have shied away from obliging even the remaining monopoly utilities to invest significantly in demand-side management

[41] This effect is counteracted, of course, by the subset of consumers willing to pay more for environmentally preferable power. This so-called "green power market" is discussed in Chapter 8.

[42] As we shall see, the disjunction between transmission and generation planning is particularly problematic.

[43] Indeed, integrated resource planning could continue to be practiced at the distributor level, taking into account the full generation, transmission and distribution costs that DSM programs could avoid.

Graph 3: Utility Efficiency Spending in the U.S. 1989-1999[44]



opportunities, even when they would reduce the economic and environmental costs of energy service.

Another reason that integrated utilities dislike traditional energy efficiency programs is that customers own the associated capital equipment (energy efficient refrigerators or motors, for example), unlike power plants, which remain property of the utilities. Since the utilities don't own the assets, and since recovery of the investment costs through rates is spread over several years, the mere possibility that captive customers could switch suppliers has in many cases been enough to sour utilities' appetites for this type of program.[45]

For similar reasons, independent electricity marketers in a customer-choice environment are unlikely to offer capital-intensive DSM programs like rebates for energy-efficient appliances. Consumers are unlikely to commit to a single supplier for any significant length of time, and certainly not for five- or ten-year payback periods required to tap into many of the most interesting efficiency opportunities. At best, the result is energy efficiency cream-skimming, with programs and offers primarily limited either to financing or to symbolic, low-cost gifts and rebates.[46]

Some proponents of retail competition argue that DSM will actually increase under competition, with marketers offering DSM services as well as kilowatthours to their potential customers.[47] Indeed, large commercial and industrial customers are increasingly being offered long-term energy service contracts in which it is in the provider's interest to implement all cost-effective DSM measures. It is far less obvious, however, that similar opportunities will be made available to residential consumers, or to small- or medium-sized businesses.

An interesting development in this regard is the creation of Efficiency Vermont, an independent utility dedicated to providing energy efficiency services

44 Philippe Dunsky, *L'efficacité énergétique: manuel de référence pour la régulation des marchés monopolistiques et concurrentiel*, Montréal, Helios Centre, for the Agence de l'efficacité énergétique du Québec (January 2000), p. 33.

45 In some jurisdictions, unrecovered costs for past DSM programs have been treated as stranded costs.

46 For example, some service providers now offer customers a free compact fluorescent light bulb as a sign-up bonus.

47 See, e.g., Walt Patterson, "Energy 21: Making The World Work," Institute of Energy Melchett Lecture, London Planetarium (22 June 2000).

throughout the state. This "conservco" approach[48] is meant to avoid the conflict of interest inherent in asking electric utilities to spend money to reduce the sales of their core product. Efficiency Vermont is operated by the Vermont Energy Efficiency Corporation, a not-for-profit energy services organization, which will consolidate the energy efficiency programs already offered by Vermont utilities and offer new ones on a statewide basis. It is funded by an "energy efficiency charge" on customers' bills, ranging from 0 to 2.5%. The "conservco" model has been discussed for many years as the most elegant solution to providing energy efficiency services in a restructured environment, but Vermont is the first jurisdiction to put it into practice in North America.[49]

In theory, it should be possible to bid demand-side resources into a spot market the same way generating resources are bid. Thus, an energy services company that had made appropriate arrangements with energy consumers could offer to reduce load by a certain number of megawatts whenever prices surpassed a given level. This "demand-responsive load" would allow the consumer to benefit from high market prices (by reducing consumption) in the same way as a generator does — for example, by saving $6 a kilowatt-hour on his or her electricity bill by shutting off the air conditioner during price spikes.

In fact, recent studies demonstrate that demand-side bidding would create very substantial benefits for all electricity consumers. Studies of the California and PJM[50] markets show that, by lowering the supply curve, energy efficiency investments can lower the market clearing price dramatically, especially on-peak.[51]

In practice, however, demand-side bidding has yet to become a reality. The problems — including the need for sophisticated meters, real-time mechanisms to reduce demand on short notice and to confirm that the reductions actually took place — are complex, but soluble. In the near term, however, demand-side bidding will almost certainly be limited to large consumers.

3.2.2 Wind, solar and other intermittent renewables

Under the traditional monopoly paradigm and the resource planning process described earlier, regulators could order utilities to acquire set quantities of electricity from "green" power sources like wind or solar. Under a competitive retail market structure, the utilities no longer purchase power on behalf of customers. Rather, customers contract with any of a host of retailers — marketers, brokers, aggregators and even generators — whose only obligation is to ensure that a generator somewhere supplies the power they consume.

Under the new paradigm, intermittent renewables like wind and solar power face significant hurdles. Foremost among these hurdles is the difficulty of obtaining the transmission services they require at a reasonable price. Under the pricing paradigm established by FERC, transmission services are priced based on capacity reservations, not on the amount of energy actually transmitted. In other words, a generator will reserve a certain amount of transmission "space" for use in a given hour in the near future. Since intermittent resources like wind have low capacity factors[52] (~25-35%) and are relatively unpredictable, a wind generator may only use a third or a quarter of the transmission capacity it needs to reserve, thus tripling or quadrupling its average per unit transmission costs.[53] Furthermore, while transmission is usually priced on a "postage-stamp" basis,[54] if it is priced according to location or distance from load, intermittents such as wind may be forced

48 In restructuring jargon, integrated utilities can be broken down into a "genco," a "transco" and a "disco." Removing conservation activities from the disco and entrusting them to a free-standing entity results in a "conservco."

49 A similar entity, the Energy Savings Trust, exists in Great Britain.

50 PJM Interconnection, L.L.C. serves New Jersey, Delaware, the District of Columbia, much of Pennsylvania and Maryland and parts of Virginia.

51 William B. Marcus, JBS Energy Inc., "Valuing Load Reduction in Restructured Markets," presentation at the Pace Environmental Law Review 2000 Symposium, *Electricity Restructuring at a Crossroads: Consumer and Environmental Implications* (10 November 2000).

52 A generator's capacity factor is equal to its total output in a given year divided by the amount it would generate if it ran at full capacity all the time.

53 Advanced computer modelling has recently demonstrated that 24-hour wind output forecasts can be reasonably accurate when combining a large number of turbines. Forecasting beyond 24 hours, irrespective of wind farm size, remains inherently inaccurate. Solar resource forecasting is somewhat more feasible. Philippe Dunsky, "Keeping the Promise: Making Renewables Portfolio Standards Work," Conference Proceedings, *WindPower '99*, Burlington, Vermont.

54 Under "postage-stamp" pricing, the rate is the same, regardless of how far the energy is to be transmitted.

to pay yet higher per unit costs, as they often are located far from load centres.[55] Yet other factors — such as the inability to time sales to take advantage of market price fluctuations or to avoid transmission congestion and risk premiums due to the capital-intensive nature of renewable technologies — may compound these problems.

3.2.3 Fossil fuel generation

Restructuring provides a particularly favourable environment for two different types of fossil generation, at the opposite poles of the environmental spectrum: old coal plants and new natural gas plants.

Old coal plants are in a very comfortable situation because, generally speaking, the vast majority of their capital costs have already been paid off through the depreciation charges that were built into regulated rates. In the U.S., many old coal plants, especially in the Midwest, which have been operating for many years at considerably less than their full capacity are shielded from the more stringent air emissions requirements of recent years by the "grandfather clause" of the *Clean Air Act.* The marginal cost of increasing the output of such a plant is extremely low. Owners can thus bid very low prices into the power exchange. When demand is low and coal producers are the marginal generator, they earn a modest return; when demand is high, and the clearing price is set by oil- or gas-fired generators, they can make windfall profits. To the extent that transmission capacity is available at a reasonable price, they can sell this cheap, dirty power in distant markets as well. It is thus not surprising that these old plants are not being retired as originally expected.[56]

New natural gas plants also benefit from restructuring, though for very different reasons. While fuel costs are relatively high, the capital costs of building these plants are very low, as is the time needed for construction. Where capacity is tight and building new merchant plants appears profitable, natural gas, whether single cycle (peaking plants) or combined cycle (baseload), is clearly the fuel of choice. Requests for permits to build some 10,000 MW of new gas plants by 2004 are currently on file in New England, with similar quantities in California and several other regions.

A great deal of effort on the part of the U.S. environmental community has gone into trying to neutralize the benefits of restructuring for coal generation and to strengthen those for gas generation. It is well known that an large percentage of electricity-related air pollution in the U.S. is caused by just a small fraction of the power plants, and great efforts are being made to shut these plants down or require them to undergo major environmental retrofits. So far, however, these efforts have not been successful.

At the same time as it has benefited these highly polluting plants, restructuring is also providing an important boost for on-site thermal power. On-site power, usually known as distributed generation, can include everything from natural gas plants at industrial sites that also provide steam heat for industrial processes, to small-scale turbines at commercial sites, to fuel-cell and photovoltaic generation at the residential level. The potential of distributed generation at the to revolutionize the electricity industry is becoming increasingly clear. However, from an environmental perspective, it is not an unmitigated blessing. The same measures that allow a residential consumer to install solar panels and sell the excedent back to the utility may also allow a hospital to run its inefficient and highly polluting diesel backup generator on a continuous basis.

As well shall see in Section 4.6, a number of regulatory steps are required before distributed generation can fully reap the benefits of competitive markets.

3.2.4 Nuclear power

Even without restructuring, the possibilities for construction of new nuclear power plants in the U.S. are slim, due to the unsolved problem of waste disposal and the deep public distrust of this technology. Restructuring is viewed by many as the last nail in the nuclear coffin, as the enormous capital costs of building a new nuclear plant are probably prohibitive without the ability to recover the costs from captive ratepayers.

Existing nuclear plants, however, benefit substantially from restructuring. Most state restructuring settlements provide for recovery of most if not all of the remaining portion of their stranded costs, usually

55 This may in fact represent an advantage for other intermittent resources like solar power, more likely to be produced near load centres.

56 The State of New York has recently filed several lawsuits charging that a number of coal plants in the Midwest have illegally increased their capacities — which should terminate their "grandfather" exemptions — without installing the anti-pollution equipment required to meet *Clean Air Act* standards.

through an additional charge added to transmission prices.[57] Once relieved of these massive debt charges, nuclear plants are in fact quite competitive. While their labour and other operating costs are much higher than those of other types of power plants, their generating costs are low, just over 2 cents per kWh in 1998.[58]

Thus, a nuclear plant that has already benefitted from stranded cost recovery is a valuable generating asset, as attested to by the high prices for which such plants have been sold in recent years. The external trust funds maintained by nuclear operators for decommissioning expenses are also a valuable asset, as long as the plant can be operated for its original planned life or longer.[59] Under these conditions, the market offers considerable incentives for owners to seek relicensing on aging plants and to delay their decommissioning as long as possible. Indeed, if the recent high wholesale prices continue, some observers suggest that proposals for new nuclear plants may appear again in the coming decade.

3.2.5 Hydropower

3.2.5.1 Hydropower and spot markets

As we have seen, the market clearing price system used in spot markets is meant to ensure that generators offer power at their variable operating cost, regardless of the capital costs associated with their facilities. Virtually all of the costs associated with hydropower, however, are capital costs or fixed operating costs;[60] its variable operating costs are near-zero.

For this reason, hydro facilities are often thought of as "price-takers," in effect bidding their full output at a minimal price, and receiving the clearing price that is set by whatever (thermal) unit is on the margin (the highest-priced unit to be dispatched).

This simple model may well describe the bidding behaviour of a run-of-the-river hydro plant that has no choice but to sell into the spot market. However, for large hydro generators that have considerable reservoir storage and the possibility of selling their power into several distinct markets, the situation is very different.

First of all, reservoir storage means that the operator of a merchant hydro plant can choose when to sell his power. Every other type of power plant has an inherent interest in generating at full capacity for as many hours of the year as possible; as long as the market price is high enough to cover their fuel and operating costs, every additional dollar of revenue contributes to fixed costs and profit.

Most hydro facilities, on the other hand, cannot run at full capacity all year round. Their total annual production is limited by hydraulic inflows; unless they are designed to provide no peaking capacity whatsoever, this means that they will inevitably run at reduced capacity for many hours in the year.[61]

Thus, while the total annual production of a thermal unit diminishes each day it does not run, that of a hydro unit does not. If a hydro producer decides not to sell at a particular moment, the water will remain in the reservoir, to be sold at a future time. In other words, thermal generators cannot make today's sales tomorrow; they can reduce their sales, but not defer them. In contrast, hydro generators' ability to defer sales gives them an important strategic advantage in the marketplace.

It is thus incorrect to think of hydro producers as passive participants in a spot market where the price is set by thermal generators. Thanks to their unique ability to defer sales, hydro generators can and do bid strategically, based on their own estimates of the future value of the water stored in their reservoirs.

[57] As former chair of the New York Public Service Commission Peter Bradford has pointed out, the utilities struck a very favorable deal in getting their putative stranded costs compensated before any assets were actually stranded. See note 8.

[58] Nuclear Energy Institute. <http://www.nei.org/doc.asp?catnum=2&catid=49>

[59] See Bruce Biewald and David White, *Stranded Nuclear Waste: Implications of Electric Industry Deregulation for Nuclear Plant Retirements and Funding Decommissioning and Spent Fuel*, Synapse Energy Economics, Inc. (15 January 1999).

[60] Fixed operating costs include, among other things, the costs of compliance with regulatory requirements, which in some cases can be quite significant.

[61] Their flexibility may of course be limited by long-term power purchase agreements or by environmental flow requirements that may apply. The relationships between installed capacity, annual production and reservoir capacity are discussed at greater length in Chapter 7, below.

Insofar as a hydro generator “withholds” power during low-price periods and sells when prices are high, its behaviour will mirror that of a peaking plant. Because a hydro operator cannot be expected to sell power on a continuous basis, the fact that it voluntarily reduces its sales does not constitute evidence of the exercise of market power — as it would for a thermal generator.[62] Even if the reduction is during high-price periods and has the effect of driving prices still higher, there is no way to know if it was for legitimate reasons (e.g., increased local demand, low reservoir levels or better prices in a neighbouring market) or for illegitimate ones (intent to increase the market price for the remaining sales).

Furthermore, the ease with which a hydro producer can modify its output and hence affect market prices can open the door to the more sophisticated exercise of market power. Enron Power Marketing Inc. and Coral Power recently protested to FERC that Hydro-Québec routinely manipulates the market price in New York and New England. According to their protest, Hydro-Québec can affect the market prices by modifying the amount of energy it offers for sale in each market, allowing its American affiliate, H.Q. Energy Services (U.S.) Inc. (HQES) to profit by arbitraging between the real-time and forward markets. When Hydro-Québec withholds exports, prices rise in both the real-time and forward markets. HQES then sells power in the forward market; before the contracts go to delivery, Hydro-Québec increases its exports, driving down the prices HQES has to pay to fulfill its forward contracts. The result, according to the protest, is that Hydro-Québec and its marketing affiliate realize far greater revenues than they would have if Hydro-Québec had not driven up forward prices.[63] FERC has yet to address these allegations.

We have already pointed out that the hub-and-spoke methodology used by FERC is far too simplistic to capture the opportunities for the exercise of market power in modern power markets. It is even more inadequate in the face of the subtle strategies available to large hydro generators interconnected to several distinct markets.

3.2.5.2 New hydro facilities

Despite the great advantages that hydropower enjoys in competitive markets, financing new generation remains problematic, due to the very high capital required and the long planning and construction periods.[64] Furthermore, the disappearance of long-term power purchase agreements in favour of the short-term market[65] makes it even more difficult to find risk capital for a major hydro project. For this reason, many analysts expected restructuring to mean the end of large hydropower construction in North America.

This prediction, based on the logic of private capital markets, fails when applied to Canada’s provincial governments and their wholly-owned (“Crown”) utilities. Thanks to loan guarantees backed by these governments’ taxation powers, Canadian Crown utilities can borrow billions of dollars at low rates, regardless of project risk.[66] Consequently, as we shall see, the opening of U.S. wholesale and retail markets has triggered a “gold rush” response among Canadian hydro utilities.[67]

From an environmental perspective, the quasi-permanent nature of hydropower facilities combined with the profound landscape alterations they cause make them fundamentally different from most other types of generation. While wind plants require large areas, they do not interfere greatly with other types of land use (e.g., agriculture), and while thermal power plants are often unsightly, they only produce air emissions to the extent that the plant is producing electricity.

62 The simplest way for a generator with a large market share to exercise market power is by withholding some of his capacity in order to drive up the price he obtains for the rest of it.

63 *Protest of Enron Power Marketing Inc. and Coral Power, L.L.C.*, FERC, Docket No. ER97-851-012 (7 December 2000).

64 The hydro industry, however, is making a concerted effort to reduce these delays. In Canada, the industry is pressing for regulatory modifications to accelerate approval of new hydro projects. In the U.S., where the primary concern is with relicensing existing plants rather than authorizing construction of new ones, several bills have been proposed to streamline the relicensing process.

65 Recent events in California are unlikely to reverse this trend.

66 Access to loan guarantees and thus to low-cost capital is meant to allow Crown utilities to make large-scale investments that will yield benefits far into the future. The downside, however, is that it also obliges the taxpayer to subsidize investments that private capital might shun as excessively risky.

67 See Charlie Higley, *Dammed Deregulation: How Deregulation of the Electric Power Industry Could Affect the Nation’s Rivers,* Public Citizen’s Critical Mass Energy Project (June 1999); Philip Raphals, *Competitive Electric Power Markets: Implications for New Hydroelectric Development in Canada,* Helios Centre (November 1997); and Section 3.3.2, below.

In this sense, nuclear power is more similar to thermal power than to hydro: its most important environmental impact is proportional to the amount it is used. Nuclear plants which are built but never used (e.g., the Shoreham plant on Long Island, New York) represent an enormous waste of money, and, of course, do incur the "life-cycle" impacts related to the construction materials and fuels, but if they produce no electricity they produce no nuclear wastes.

With hydro stations, however, much of the environmental harm is linked to the plant's physical presence, and not to its operations. Thus, in the same way that the plant's construction costs are, from an economic point of view, "sunk costs" that do not vary with the plant's generation, so its environmental costs are also to a large extent incurred when the plant is built and continue as long as the dam blocks the river. That said, there are often important ways in which these impacts can be reduced by modifying the way the plant is operated, or of course by removing it entirely (decommissioning).

3.2.5.3 Existing hydro facilities

As noted earlier, many restructuring settlements require divestiture of the utility's generation assets. This is particularly significant when those assets include hydro facilities, because it means removing them from oversight by an energy regulator that historically played an important role in ensuring that they were operated in the public interest.

The most important example to date of such a divestiture scheme is that of San Francisco-based Pacific Gas and Electric (PG&E). The PG&E hydro system is extensive, made up of 174 dams in 16 watersheds, including 68 power plants producing almost 3,900 MW, together with 140,000 acres of surrounding lands in the Sierra Nevada Mountains.

The PG&E dam divestiture is extremely controversial in California, and remains unresolved. At the time of this writing, with utilities on the brink of bankruptcy, the California Legislature has approved, and Governor Davis has signed, legislation barring utilities from selling off their remaining assets, including their hydropower systems. In the face of California's energy crisis some Democrats in the State Assembly have gone so far as to propose that the state seize these valuable assets, which just last year the utilities hoped to auction off for some $5 billion.

Public ownership of the hydro system had long been advocated by some consumer and environmental groups, since the dams and reservoirs it includes affect not just power but also irrigation, recreation, and fisheries. Until the current crisis, however, these efforts had garnered little support. Instead, a settlement agreement was negotiated in the summer of 2000 between PG&E, The Utility Reform Network (TURN) and a number of other consumer groups. Under the terms of the settlement, PG&E would have paid $35.55 million up-front, plus $2.37 million per year for 35 years, into an Environmental Improvement Fund (EIF), along with funding other conservation mechanisms. The EIF, which was to be administered by a non-profit governing body, would be used for purchasing "supplemental flow releases" from the hydro projects, above and beyond those currently required by FERC or those currently practiced.[68]

This proposed settlement agreement was quickly denounced by a number of environmental groups. Environmental Defense (ED) and the California Hydropower Reform Coalition (CHRC) put forth an alternate proposal asking the California Public Utilities Commission (CPUC) to:

- complete its ongoing environmental review of the PG&E hydropower system,
- require, as a condition of any transfer or sale, that the new owners bring all projects into compliance with the *Clean Water Act* and the standards of the State Water Resources Control Board,
- establish a fund of at least $400 million to "buy water back from the hydropower projects, in order to increase the amount of water that stays in the rivers,"
- establish a governing structure that provides for public involvement and public access to information, and
- ensure that any new owners (including a PG&E subsidiary) agree to comply with environmental standards and policies identified by the state as a condition of sale or transfer.[69]

68 PG&E, *Draft Settlement Agreement For Valuation And Disposition Of Hydroelectric Assets,* Appendix G, s. 5.8. The fund could also be required to pay for decommissioning expenses, at the utility's option.

69 Environmental Defense and California Hydropower Reform Coalition, *Power Play: The Sale of PG&E's Hydropower System and the Future of California's River* (July 2000).

While the ED/CHRC proposal is far more demanding than the one negotiated with TURN *et al*., it is based on the same mechanism — establishing a fund to let the river "buy back" flows from power generation. This is, of course, over and above whatever flows might be required by FERC — either now or when the facilities eventually come up for relicensing.[70] Nevertheless, it represents a marked and potentially significant change from the existing approach to flow regulation, which until now has been based on biological requirements, not on economics. The California energy crisis may have stopped this proposal in its tracks, but, because it is so compatible with market structure, it is almost certain to reappear elsewhere.

When selling into a competitive market, hydro operators have an incentive to produce power when prices are highest. Under this type of "buy-back" approach, this incentive will influence the "environmental agent" as well. The agent's funds will buy considerably more flows if used off-peak than if used during periods of peak demand. Furthermore, if market prices increase in the future, the buying power of the environmental agent will fall.

As long as the flows purchased with these funds are additional to those required under the *Clean Water Act* and the *Federal Power Act* (FPA), they represent a net benefit. Insofar as they create incentives to maximize the hydro system's contribution to meeting peak demand, they will undoubtedly be applauded by energy regulators. However, as a model for future "market-based" flow regulation, buy-back funds should be approached with caution — especially in jurisdictions where the protections of the *Clean Water Act* and the FPA do not apply.

3.2.5.4 Adding power turbines to existing dams

While there is widespread agreement that there is likely to be little if any new hydropower development in the U.S., the move to competitive wholesale power markets is likely to increase interest in adding turbines to existing dams. The dramatic increases in wholesale power prices observed recently can only contribute to this effect.

Fewer than 3% of the 76,000 dams in the United States have generating equipment installed.[71] More and more, developers are showing interest in retrofitting those that do not with power turbines. Notably, Universal Electric Power Corp. of Ohio has filed 149 applications for preliminary permits with FERC, totalling 1,168 MW of generating capacity.[72]

Despite the obvious benefits of this type of project, concerns have been raised both by agencies that own and operate dams and by environmental groups — the former because they may lose control over future developments at their dams, the latter because they might lead to increased flow modifications or interfere with decommissioning efforts that would restore the river to its natural conditions. The Low Impact Hydropower Institute, which has established criteria for determining what hydropower should be eligible for sale in the green power market (discussed in detail in Section 8.3.1), is currently exploring the possibility of expanding its certification program to address new hydropower at existing dams.[73]

3.3 ... for large-scale inter-regional power transfers

3.3.1 Transmission issues

With a fully competitive wholesale market, the market price in a local power exchange would (in theory) reflect the various marginal generation costs of energy suppliers bidding into it from across a wide region. Whenever a region of high electricity prices adjoins one of low prices, one can assume that there is a transmission constraint between them — physical limitations that prevent transactions that otherwise would be in the economic interests of both the buyer and the seller. For more distant generators, the cost of their bids would also reflect transmission costs, including losses. Otherwise, inter-regional sales would equalize prices. It is only when transmission constraints limit such transactions that a price differential between regions can, in theory, be maintained.

70 PG&E has not relicensed any of its projects in recent years, though two settlement agreements have been signed. Some 45 licenses in California involving 150 dams are coming up for relicensing over the next 15 years. Nineteen of these belong to PG&E, accounting for more than half of its installed hydro capacity. Stephen Wald, California Hydropower Reform Coalition, pers. comm.

71 Michael Sale, Oak Ridge National Laboratory, pers. comm.

72 Using a proprietary family of turbines designed to accommodate a wide range of head and flow rates, UEP would locate turbines on the face of an existing dam or on the riverbank near the discharge area, with water siphoned over the top of the dam.

73 Lydia Grimm, Executive Director, Low Impact Hydropower Institute, pers. comm.

Once efficient electricity spot markets are operating nation- or continent-wide, the price of bulk electricity would thus vary from region to region due only to transmission costs —assuming that adequate transmission capacity is available. Hence the general excitement that the prospect of open markets has generated in high-cost regions, and the trepidation it causes in regions with lower-cost power.

This trepidation is due not only to concerns that restructuring will lead to price increases, but also to concerns that it will lead to the construction of new high-voltage lines to facilitate these exchanges. Influential voices are now insisting that new incentives are needed to facilitate the construction of additional transmission lines, and that regulatory procedures must be changed to keep local opposition from blocking it. Those same voices tend to argue that wholesale customers should only be charged a small portion (if any) of the embedded cost of the transmission system.

In the monopoly context, integrated planning made it possible to examine generation and transmission options at the same time, in the search for those options with the lowest overall cost to society. One of the inadvertent costs of restructuring is the disjunction of generation and transmission planning. Intricate mechanisms are being developed to create appropriate price signals to drive transmission development, but even if they work as planned, they offer no provision for taking into account the externalities of transmission construction.

Industry attempts to build major new transmission lines that are needed to facilitate large-scale inter-regional power transfers have already provoked intense public controversy. One example is the Arrowhead-Weston line, a 220-mile-long 345-kV line through northern Minnesota and Wisconsin, designed in large part to allow hydropower from Manitoba to reach urban markets in southern Wisconsin. Another is the Sonora-Arizona Interconnection Project, proposed by the Public Service Company of New Mexico, which involves construction and operation of one or two high voltage transmission lines (within a single right-of-way) through remote areas of Arizona and New Mexico to create a new transmission corridor to Mexico.[74]

Similarly, Hydro-Québec's American subsidiary TransÉnergie U.S. Ltd. is seeking to build a 26-mile high-voltage transmission line underneath Long Island Sound, to bring power from Connecticut to Long Island. The proposed line would be built on a strictly "merchant" basis; the innovative tariff has already been approved by FERC.[75] Siting hearings in New York and Connecticut are currently underway.

It is hard enough to persuade communities to accept the construction of new transmission lines when they are necessary to meet their energy needs. When the new lines provide no local benefit at all, however, serving only to link high-cost neighbours on one side to low-cost neighbours on the other, the potential for opposition is even greater. It is thus not surprising that some industry advocates have called for federal preemption of state siting authority.

3.3.2 Generation issues

In addition to the transmission problem, large-scale power transfers imply that the electricity consumed in one region is often generated in another. Since all power generation has an environmental cost, this implies that much of the environmental cost related to one region's energy consumption is borne by another.[76] Thus, every power transfer creates a corresponding transfer of environmental harm in the opposite direction. In the words of Arturo Gándara of the University of California at Davis:

> [T]he importation of power results in the exportation of its environmental burden, and the exportation of power results in the importation of an environmental burden. [77]

Using examples from both the Mexican and Canadian borders, Gándara demonstrates that electricity imports and exports have significant environmental impacts for the exporting country which are not internalized

74 Information on this project is posted by the Department of Energy at: http://projects.battelle.org/pnmeis/. See also Alan Weisman, "Power Trip – The Coming Darkness of Electricity Deregulation," *Harper's Magazine,* Vol. 301, No. 1805 (October 2000).

75 FERC, *Order Approving Proposal Subject to Conditions,* Docket ER00-1-000 (1 June 2000).

76 Exceptions include global impacts such as climate change, air pollution that is transported into the importing region by prevailing winds and impacts on migratory birds, among others.

77 Arturo Gándara, "United States-Mexico Electricity Transfers: of Alien Electrons and the Migration of Undocumented Environmental Burdens," *Energy Law Journal,* Vol. 16, No. 1 (1995).

or otherwise accounted for in the importing country.[78] Thus, for example, air pollution is created in Texas to generate electricity that is exported to Mexico. Similarly, the enormous environmental and social costs related to large-scale hydroelectric developments in Canada, largely devoted to exporting electricity to the U.S., are not accounted for in the U.S. From the perspective of U.S. power consumers, both before and after restructuring, this is power uncontaminated by any environmental cost, despite the enormous impacts caused by its generation.

For Gándara, this situation reflects a troubling national policy:

> It is a welcome mat for undocumented alien electrons — but only insofar as they leave the environmental burdens they generate at home. This hypocritical stance of enjoying the benefits of electricity generation while others bear the environmental cost places a strain not only on the rationalization of electricity generation and distribution in North America, but on the moral underpinnings of the environmental ethic. It raises serious questions of environmental justice when the cost of hydroelectric development in Canada are imposed on the Cree Indians and the cost of thermal electric development are imposed on the United States-Mexico border region, a chronically economically disadvantaged region. It will lead to what Gunner Myrdal has called "moral overstrain," that disparity between high ideals and low achievement.[79]

He thus proposes that the U.S. Congress amend the *Federal Power Act* to require authorization for power imports,[80] which would be granted only on the condition that the power did not result in the creation of unacceptable environmental impacts. He considers such a step necessary in order "to effectuate some consistent national notion of the public interest with respect to power consumed in this country," lest the environmental impacts of the imported power "remain out of sight and out of our collective concern."[81]

Such a proposal resembles, but goes far beyond, one that was introduced in the New York State Legislature in 1992. In the heat of the debate over the construction of the Great Whale Project, which would, in large measure, have been dedicated to serving two long-term contracts with the New York Power Authority,[82] the late Rep. William Hoyt (D), together with Senator Franz Leichter (R), introduced legislation to prohibit power imports unless the generating facility had undergone environmental assessment substantially equivalent to that which would be required for a similar project in the U.S.

These concerns about exporting externalities are not merely theoretical. Canada's three largest government-owned hydro utilities (B.C. Hydro, Manitoba Hydro and Hydro-Québec) are all, to one degree or another, focussing their future development on market opportunities in the U.S. Of the three utilities, by far the most ambitious is Hydro-Québec.

In 1997, Hydro-Québec announced that it would build almost 30 TWh (close to 6,000 MW) of new hydroelectric supply by 2010.[83] Analysis of projected energy needs in Québec made clear that the bulk of this new generation would serve exports to the U.S., as seen in Graph 4.[84] Hydro-Québec has only recently made public the list of projects included in this objective. It includes major projects such as the Lower Churchill in Labrador, the diversion of both the Rupert River and the headwaters of the Great Whale River into the La Grande project and the diversion of the Carheil and Pekans Rivers (tributaries of the salmon-rich Moisie) into the Sainte-Marguerite project, as well as half a dozen other generation and diversion projects.

78 Of course, the job creation benefits are also shifted to the exporting country.

79 Gándara, see note 77, p. 58, footnotes omitted.

80 A permit from the Department of Energy is already required to export electricity from the U.S. under section 202(e) of the FPA.

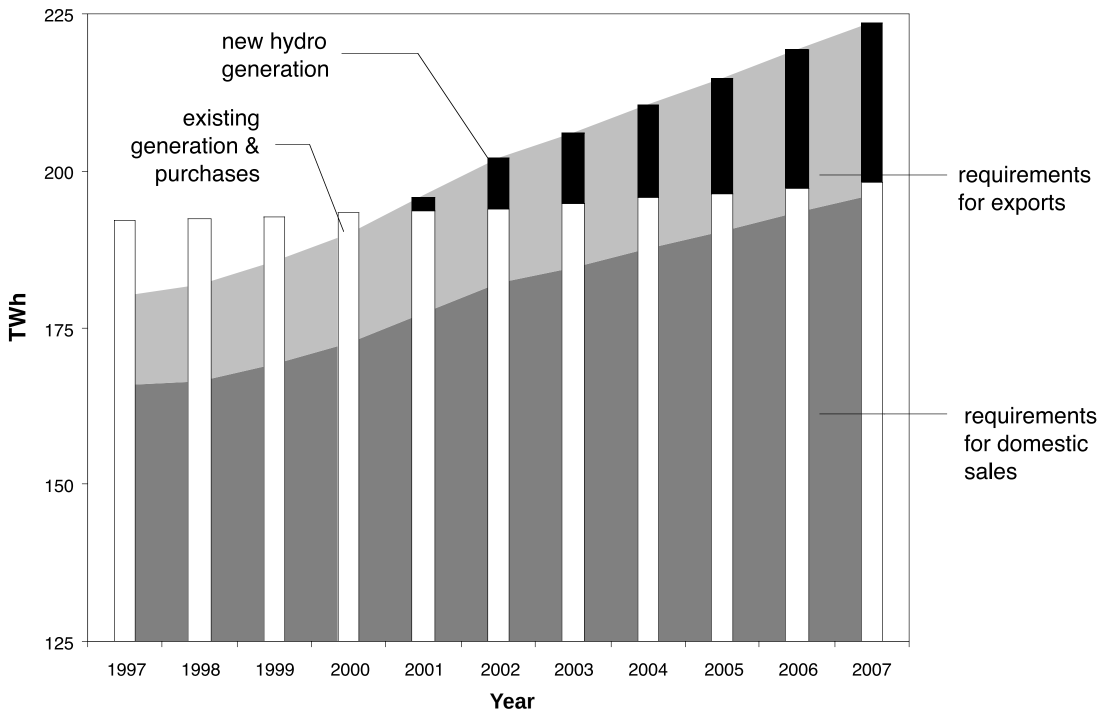
81 Gándara, see note 77, p. 55. It is far from obvious whether or not such an initiative would survive a challenge under NAFTA. See Section 10.1, below.

82 The Great Whale project, a 3,000 MW mega-development in northern Québec that would have substantially affected wildlife from whales to caribou to endangered species of migratory birds, was cancelled shortly after NYPA withdrew from the contract.

83 Hydro-Québec, *Strategic Plan 1998-2002.*

84 See also Philip Raphals and P. Dunsky, *Les chiffres derrière le Plan — Analyse des éléments quantitatifs du Plan stratégique 1998-2002 d'Hydro-Québec* (Helios Montréal Centre, February 1998).

Graph 4: HQ 1998 Strategic Plan, Projected Exports and New Hydro Projects



Source: Philip Raphals, "Exports in the Hydro-Québec Generation System," 22 January 1999.

While the new expansion program has taken far longer to get under way than originally announced, company executives have made it clear that the long-term plan remains essentially unchanged. Indeed, the Government of Québec recently adopted legislation designed in large part to facilitate these expansion plans (see Box 4).

The California energy crisis, combined with fears that the same thing could happen in the Northeast and in other regions, could well increase pressure for new hydro development in Canada and in particular in Québec. Despite the multiple and complex causes of this crisis, which include defective market design, inadequate market monitoring and the near abandonment of energy efficiency investment in recent years, at the political level, many still believe the problem to be simply one of inadequate supply. Thus, President George W. Bush recently stated that the issue for both Mexico and the United States is that "we need more supply."[85]

While Bush's first choice is to expand domestic energy production in the U.S., it would be no surprise if he were to ask Canada to increase its exports of both gas and electricity. Surprisingly, this option is still seen as free of environmental consequences. In a recent editorial, the *Washington Post* asked: "Where there is [environmental] risk, would Americans rather take a chance on damaging the environment or depending more on Canadian imports?"[86]

Such imports, of course, are in no way free of environmental impacts, but those impacts remain largely hidden from U.S. consumers. In Gándara's terms, as Canada's energy exports increase, it will import the environmental burden resulting from the ever-increasing consumption of electricity in the U.S.

85 "Amigos say they want to work with Canada," *The Montréal Gazette* (17 February 2001), p. A22.

86 "The Energy Equation," *Washington Post* (5 February 2001), p. A18.

Box 4: Québec Energy Policy

Energy policy in Québec has been largely shaped by the spectacular failure of Hydro-Québec's plans to build the Great Whale project in Northern Québec in the early 1990s. The project was met with virulent opposition from the Cree Indians and from the U.S. environmental movement and was cancelled in 1994 after the New York Power Authority withdrew from long-term contracts to purchase 1,800 MW from Hydro-Québec.

In subsequent years, Québec undertook to adopt a more democratic approach to decision making in the energy sector. Until then, decisions were made unilaterally by Hydro-Québec and approved by its sole shareholder, the Government of Québec. There was no independent regulator and no public planning process, and any recommendations resulting from environmental assessment were (and are) entirely subject to the discretion of the Administration.

In 1995, the Government of Québec held a massive consultation process, the "public debate on energy." The unanimous report, signed by environmentalists, Native leaders, consumer advocates and executives of Hydro-Québec and other energy companies, recommended the creation of a new, independent energy regulator, the *Régie de l'énergie*. For the first time in Québec, there would be a forum for technical debate and for public involvement in decision making regarding massive new energy developments. In 1996, the Government of Québec adopted legislation creating just such a regulator, along the lines proposed by the public debate report. The Régie was to be a quasi-judicial body with decision-making powers not only over rates, but also over approval of Hydro-Québec's planning and its decisions to build new dams and transmission lines.

However, the Régie was never able to assume these powers. More than three years after it came into existence, the Régie still had not adopted the regulations needed to allow it to exercise its powers over Hydro-Québec's planning and generation activities, due to the unrelenting opposition of Hydro-Québec to any exercise by the Régie of its jurisdiction over generation.

Finally, in the spring of 2000, the Government of Québec – Hydro-Québec's sole shareholder – forced a bill through the legislature that removed these powers altogether from the Régie.[87] As a result, all public input into Hydro-Québec's generation planning has been eliminated – even the consultation processes deemed inadequate by the Public Debate panel.[88] While regulatory approval is still needed for electricity purchases, the Régie has only rudimentary oversight powers, and contracts must be awarded based on the lowest price.

The door is thus open for precisely the kind of transfer referred to by Gándara, whereby the U.S. will export to Québec the environmental burden resulting from its ever-increasing consumption of electricity.

87 Bill 116, *An Act to amend the Act respecting the Régie de l'énergie and other legislative provisions.*

88 There remains a purely consultative environmental hearing process, which has no mandate to review Hydro-Québec's planning. The limitations of this hearing process is described briefly on p. 72.

4. Measures to reduce environmental impacts of generation in a competitive context

As we have seen, restructuring by its very nature frustrates many of the mechanisms that had been developed to minimize the environmental costs of meeting energy needs. Competitive markets render inoperable many of the complex planning methods so meticulously developed to integrate environmental costs and benefits into the decision-making process, as well as the mechanisms aimed at placing energy efficiency and conservation on a level playing field with supply-side resources.

By reducing the role of energy regulators in deciding how to meet energy needs and in determining the conditions applied to generators, restructuring results in increased reliance on environmental regulation *per se* to reduce the externalities of power generation. In the United States, legislation such as the *Clean Air Act*, the *Clean Water Act*, the *Endangered Species Act* and the environmental provisions of the *Federal Power Act* (as amended) provide a substantial framework for the exercise of this role.

In Canada, the situation is very different. Generally speaking, Canadian environmental legislation is more procedural than substantive, with few hard-and-fast standards and much room for ministerial discretion.[89] As such, it is hard to see how it can carry the full burden of minimizing the externalities of power generation.

Furthermore, environmental regulation is primarily oriented toward blocking unacceptable projects, rather than toward selecting the options that meet energy needs at least cost to society. To fill this gap, a number of new legislative and regulatory measures have been developed to mitigate the environmentally damaging consequences of electricity generation in a competitive context. These tools are intended to help guide the new power markets toward lower-impact generation, but are very different from those developed in the context of regulated monopolies. Some are designed to increase the costs for environmentally harmful generators, thereby internalizing environmental costs.[90] Others address consumers, either obliging or inciting them to purchase power that is less environmentally damaging. Such measures include obligatory labelling, which informs consumers in general terms of the environmental characteristics of the power they are purchasing, and "green power" marketing, which invites consumers to pay a premium for electricity from environmentally preferable sources.

The implementation of several of these measures raises important issues with respect to hydropower. These are addressed in detail in Part III of this report.

4.1 DSM and the public benefits charge

Perhaps the broadest of these mechanisms is the "public benefits charge" (also known as a "system benefits charge"). To compensate for the drastic decline in utility-sponsored DSM spending that has accompanied restructuring, many states and countries have enacted legislation or regulations creating a public benefits charge (PBC): a small charge added to customers' bills to support DSM programs, new renewable technologies and other "public benefits."[91] Given the very slow development of DSM offerings by for-profit energy service companies, it now appears that the PBC will be virtually the sole source of funding for energy-efficiency investments in the coming years.

A PBC can be applied as a percentage of the customer's energy bill, as a set per-kWh rate or as a fixed dollar amount.[92] Revenues can be transferred to any of a number of entities (e.g., the remaining monopoly utilities, an independent body or government agencies). In Vermont, as noted earlier, PBC funds have been transferred to the new conservation utility, Efficiency Vermont. In New York State, most of the funds have been transferred to the New York State Energy Research and Development Agency (NYSER-

89 One notable exception is the *Fisheries Act*, which prohibits "any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat" (s. 35(1)). However, even there, s. 35(2) allows the Minister to override this prohibition on a discretionary basis.

90 E.g., environmental regulations that oblige thermal generators to spend more to reduce emissions, or emissions trading systems (for SO_X, NO_X or greenhouse gases) that in the long run are intended to have the same effect.

91 The California PBC is broken down as follows: roughly 45% is dedicated to demand-side management, nearly 30% to enhance the short-term position of green power technologies, some 10% for R&D, primarily into advanced green power technologies and slightly more than 15% for low-income customer support.

92 A PBC is referred to as "non-bypassable" if it is charged when the consumer buys power from an alternate supplier or even, in some cases, self-generates.

DA). Many variations of the PBC can be found, depending on choices made at the local, regional or national level.

4.2 Green power marketing

By allowing consumers to choose their power supplier, retail access allows environmentally-concerned consumers to "vote with their pocketbooks" by avoiding certain energy sources in favour of others. While the market obstacles are significant, some believe that customer choice may in fact enhance the economic attractiveness of green power sources, including intermittents such as wind and solar power.

Thanks to these customers, renewables can have a significant marketing advantage, and many believe that green power marketing will play an important role in the electricity markets of the future. Still, given the higher costs of most green power resources and the many indirect obstacles they face, the ability of green power to grow beyond a niche market is uncertain at best.[93]

Green power markets cannot hope to succeed, however, without structures in place to protect consumers from false or misleading claims and to help them navigate a marketplace filled with confusing, competing and overlapping claims. Since the consumer cannot directly examine the product being sold, certification is even more essential for a vigorous green power market than it is for marketing other "green" products. A number of complementary and/or competing green power certification systems have been established in the U.S. and Canada. These will be discussed in detail in Chapter 8.

4.3 Mandatory environmental disclosure (labelling)

While green power certification lets customers identify "premium" green power, in order to evaluate its significance they need substantive information regarding the environmental impacts of the other power products offered in the marketplace. This cannot be addressed by a voluntary certification system, since generators that don't expect to be certified have no interest in reporting their emissions or other impacts. Reliable information is an essential element of effective competition, so it is incumbent upon regulators and legislators to ensure that a system of mandatory disclosure is established. There are many options for configuring mandatory labels. As we shall see in Chapter 9, the appropriate treatment of hydroelectric resources is among the most contentious issues.

4.4 Renewables Portfolio Standard (RPS)

Among the key market mechanisms for fostering development of new low-impact power technologies within the competitive marketplace is the "renewables portfolio standard" (RPS), also known as a "generation portfolio standard" (GPS). These standards require that a certain percentage of power sold or generated in a given jurisdiction be derived from environmentally preferable energy resources.

In a sense, an RPS is simply a renewables quota or "set-aside" reconfigured to function in the competitive marketplace, with a degree of flexibility absent from the set-aside approach.[94] Its key objective is to ensure a guaranteed market for environmentally superior energy products while minimizing the costs of doing so.

The RPS approach has rapidly won favour in many states and countries throughout the industrialized world. In the U.S., RPS legislation has already been enacted in several states and is currently under consideration in many others, as well as in a variety of federal restructuring bills. Similar legislation also exists in a number of European countries, and the European Union is on the verge of adopting a continent-wide RPS. Other countries are also looking into the RPS model.

The controversial role of hydropower in the RPS is discussed in Chapter 10.

4.5 Emissions caps and "cap and trade" mechanisms

Part of the "doctrine" of restructuring is the notion that, since electricity is a commodity and generators are "manufacturers," it is not the role of an economic regulator to dictate the appropriate degree of environmental protection. Short of drastic fiscal reform,

[93] The California energy crisis has also dealt a major blow to green power marketing, as high wholesale power prices forced several green power companies out of business.

[94] Since, under retail competition, consumers are free to leave the distribution utility, a traditional set-aside approach that required the utility to build or acquire low-impact power would place it at a competitive disadvantage, compared to independent generators that had no such obligation.

economists tend to prefer an approach to environmental regulation based on economy-wide environmental standards combined with mechanisms that allow market forces to determine the appropriate level of environmental protection for each power plant.

As noted earlier, market restructuring opens the door for highly polluting coal plants to substantially increase their output, therefore increasing both greenhouse gas and noxious air emissions. While the U.S. Clean Air Act established maximum permissible emissions for several pollutants, it provided for the "grandfathering" of plants that were already in operation when it was passed. As a result, the most heavily polluting power plants in the U.S. are largely unaffected by this essential legislation. In response, many environmental groups in the U.S. and Canada have lobbied for stringent emission caps to accompany any restructuring legislation.

There are many different types of caps. One approach is to cap the emissions on each and every unit, which would require that offending plants either be retrofitted or shut down. Another is to cap the overall portfolio of each generation company, providing them the flexibility to identify and choose the cheapest pollution reduction solutions while maintaining overall policy objectives.

Yet others favour industry-wide "cap-and-trade" mechanisms, whereby a fixed number of tradeable emissions authorizations are issued. If a company wishes to emit more than its allowance, it must purchase allowances from others, creating a "secondary market" in these allowances. The idea is to incent those firms that can reduce emissions efficiently to do so, since they can sell their allowances to pay for the reductions. Other firms, for whom emissions reductions would be very costly, can continue to emit, purchasing allowances on the open market instead. In theory, the overall cost to society of meeting emissions reductions targets by this means would be lower than if each firm were required to reduce emissions, regardless of the cost.

Emissions caps, allowances and cap-and-trade systems have been, or are in the process of being, established in a large number of jurisdictions. In the U.S., the regulations to the *Clean Air Act* create a cap-and-trade mechanism for SO_X. A similar regime is in place for NO_X in the U.S. Northeast, and efforts are being made to expand this across the country. Similar mechanisms are currently being designed to implement the greenhouse gas emissions reductions under the Kyoto Protocol. While some are still optimistic that these mechanisms will eventually lead to significant reductions in air emissions, critics maintain that these programs merely provide a "license to pollute." Furthermore, in allowing emissions to be shifted from one locality to another, they ignore local environmental and social impacts, which may be severe.[95]

While these measures address a pressing environmental problem, at the same time, they may create inappropriate benefits for hydropower, nuclear and other non-fossil generators, insofar as they are not combined with other measures to internalize the very different externalities of these other technologies.

4.6 Measures to facilitate distributed generation

It is now widely recognized that the electricity industry is experiencing a shift away from economies of scale and towards economies of scope. Practically, this means that new, small-scale power generation technologies are fast becoming competitive with centralized, grid-based power. Such "distributed generation" (DG) technologies range from solar panels and small wind turbines to micro-gas turbines, fuel cells, flywheels and others. While very different in size and nature, they all share the common characteristic of allowing individual consumers to become, in effect, self-generators and potentially net generators, insofar as they produce more power than they use.

Distributed generation has the potential to radically alter the current centralized approach to electricity delivery. For example, customers may install fuel cells to meet their baseload power needs, yet continue to rely on the grid for peak power. Others might install solar photovoltaic panels on their roofs, rely on the grid for power on cloudy days and at night, and sell their power to the grid when they're not home to consume the power they generate on a sunny day (in effect using the grid as a virtual storage device).

95 A recent study by the Harvard School of Public Health attributed 159 premature deaths and many thousands of asthma attacks in New England to two coal-fired power plants in Massachusetts. It found that 20% of the health impact occurs on the 8% of the region's population that lives within 30 miles of the facilities. J. Levy, J.D. Spengler, D. Hlinka and D. Sullivan, "Estimated Public Health Impacts of Criteria Pollutant Air Emissions from the Salem Harbor and Brayton Point Power Plant," (May 2000). <http://www.hsph.harvard.edu/papers/plant/plant.pdf>

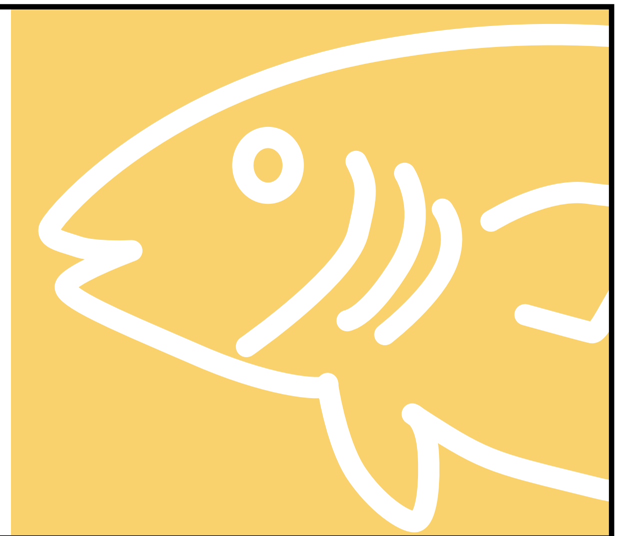
Establishing an interactive grid in which DG and central power can comfortably coexist will be critical to the success of these new power technologies.

Unfortunately, because the regulatory framework governing electricity generation and trade evolved without thought to distributed generation, new interconnection standards and rules are needed to let individuals hook their DG units into the grid and "run the meter backward." Many utilities actively discourage DG by charging extremely high fees for backup power or by requiring DG to conform to technical and legal requirements designed for connecting a large-scale power plant to the grid.

Establishing simplified, standard interconnection and net metering rules is an essential first step before distributed generation can "crack" the new marketplace. A number of early initiatives are already moving forward, including the recent development of simplified standards in Texas, California and New York, and, perhaps most importantly, the Institute of Electrical and Electronic Engineers (IEEE). With interconnection standards and simplified net metering arrangements in place, distributed generation technologies could begin to occupy a greater place in the overall electricity generation market, eventually displacing significant existing capacity.

As the regulatory framework for DG evolves, however, ways must be found to ensure that it does not promote generation with unacceptable environmental impacts.

Part II
Hydropower and the Environment



PART II: HYDROPOWER AND THE ENVIRONMENT

Debates about restructuring in the U.S. and in much of the rest of the world have largely ignored the issues surrounding hydropower. There are many reasons for this. Restructuring has primarily taken root in areas with high-priced electricity, which are, to a large extent, those which made significant investments in nuclear power. On the contrary, regions in which hydropower makes up a large part of the energy mix tend to be low-price regions, and therefore stay out of the restructuring debate.

The restructuring debate has largely focussed on the economic and environmental issues surrounding thermal power, which is "on the margin" (the most likely candidate for building additional supply) in high-price regions. Indeed, the market clearing-price system was conceived for thermal-dominated grids, and makes far less sense for hydro or for intermittent renewables like wind and solar. As the market clearing price is normally based on the operating costs of the marginal generator, it would be impossible to determine a market price by this mechanism in a purely hydro environment, since the variable costs of hydropower are virtually nil.[96]

In fact, the differences between hydro and thermal systems are many and deep. Unlike thermal systems, where planners need only ensure that installed capacity is adequate to meet peak demand, planners in a hydro systems must also worry about having enough energy (in the form of hydraulic inflows) to meet annual energy requirements. On many different levels, managing a hydro system raises different problems from a thermal system, and leads to different solutions. For policy-makers deep in the minutia of establishing a functional retail competition framework, these issues may be uncomfortable and unwelcome, so it is no surprise that restructuring has largely ignored hydropower — in its market structures, in its analysis of market power and in its mechanisms to protect the environment.[97] In Part I, we sought to introduce the theory and practice of restructuring to those who have taken part in the debates over dams and hydropower; in Part II, we shall try to introduce hydropower to those who participate in the debates on restructuring.

The purpose of this section is therefore to present an overview of the impacts of hydropower and of the design and operational choices that affect those impacts. Introducing hydropower, however, is a herculean task, as each of these issues is the subject of a vast literature. Hydropower is by its very nature site-specific, and most of its literature is site-specific as well. In Chapter 5, we will provide a brief overview of the impacts of dams on ecosystems, biodiversity and human societies. In Chapter 6, we will look at their impacts on the climate (global warming). Finally, in Chapter 7, we shall explore the factors that contribute to increasing or diminishing the impacts of a project, including site, design, operating regime and mitigation measures.

[96] This problem is explored in P. Dunsky and P. Raphals, "Challenges for effective competition in large-hydro dominated markets: the case of Québec," in *Deregulation of Electric Utilities*, Georges Zaccour (ed.) (Kluwer Academic Publishers, 1998). An innovative solution has been proposed by two Brazilian economists: Antonio Estache and Martin Rodriguez-Pardina, "The Real Possibility of Competitive Generation Markets in Hydro Systems — The Case of Brazil," *Public Policy for the Private Sector,* Note No. 106 (February 1997). <http://www.worldbank.org/html/fpd/notes/106/106estac.pdf>

[97] While this is true in North America, these questions have been addressed in greater depth in countries with hydro-based electric systems, notably New Zealand, Norway and Brazil.

5. Dams and their impacts

This chapter provides a summary analysis of the impacts of dams on ecosystems, biodiversity and societies.

It should be noted that the literature described in this chapter for the most part refers to dams in general and not exclusively to hydropower. Many dams around the world are multi-purpose, providing some combination of irrigation, flood control, recreation and power generation. As noted earlier, only a small proportion of dams in the U.S. produce electricity; the proportion is undoubtedly higher in Canada, but precise data are not available.

5.1 Ecosystem impacts

The impacts of dams on ecosystems are "profound, complex, varied, multiple and mostly negative."[98] Large dams have increased sevenfold since the 1950s, and nearly 60 percent of the world's largest 237 rivers are strongly or moderately fragmented by dams, diversions and canals. Dams now impound 14 percent of the world's runoff, and, on almost every continent, river modification has affected natural flows to the point where many no longer reach the ocean during dry season. This is the case for the Colorado, Huang-He (Yellow), Indus, Ganges, Nile, Sir Darya and the Amu Darya rivers.[99]

A 1994 survey of large river systems in the northern third of the world demonstrated the extraordinary degree to which dams affect the world's rivers:

> Large areas in the northern third of the world completely lack unregulated LRSs [large river systems]. Although river exploitation may have different effect in different rivers, some inevitable consequences stand out. For example, several types of important habitats, such as waterfalls, rapids, and floodplain wetlands, may disappear from entire regions. The loss of waterfalls and rapids indicates the loss of numerous species of plants and animals specific to running waters. Wetland losses are especially serious in dry areas where alternative habitats are scarce. As a result of habitat destruction and obstruction to organism dispersal, many riverine species may have become extinct over vast areas, whereas populations of others have become fragmented and run the risk of future extinctions.[100]

Many standard references exist that catalogue the potential impacts of dams on plant and animal life and on ecosystems as a whole.[101] A study commissioned by the World Commission on Dams (WCD) presents an encyclopaedic compendium of current research on the many different aspects of ecosystem impacts.[102]

The following sections examine the ecological effects of dams, first by looking at higher-level impacts, then looking in more detail at the specific upstream and downstream impacts of dams.

5.1.1 Flow Regimes

The natural flow regime represents perhaps the most important driving force in a river ecosystem because it sustains key natural processes. For example, natural flows maintain the dynamic geomorphology of the channel and floodplain through erosion and deposition; connect the main channel with surrounding terrestrial areas during floods, sustain the quality of water on which native organisms depend, facilitate nutrient flows along the river corridor and between river and upland areas, and help regulate the life cycles of river organisms.

98 G. Bergkamp, P. Dugan and J. McNeely, *Dams, Ecosystem Functions and Environmental Restoration,* Draft Thematic Review prepared for the World Commission on Dams (10 March 2000).

99 World Resources Institute, *World Resources 2000-2001, People and Ecosystems: the Fraying Web of Life* (2000), p. 16.

100 Mats Dynesius and C. Nilsson, "Fragmentation and Flow Regulation of River Systems in the Northern Third of the World," *Science*, Vol. 26 (4 November 1994), p. 759.

101 Some standard references include: R.M. Baxter, "Environmental Effects of Dams and Impoundments," *Annual Review of Ecology and Systematics,* Vol. 8 (1977); P. Calow and G.E. Petts (eds.), *The Rivers Handbook: Hydrological and Ecological Principles, Vol. 2* (Wiley & Sons, Chichester, UK, 1994); E. Goldsmith and N. Hildyard, *The Social and Environmental Effects of Large Dams* (Sierra Club Books, San Francisco, USA, 1984); W.J. Junk, P.B. Bayley and R.E. Sparks, "The flood pulse concept in river-floodplain systems", in D.P. Dodge (ed.), "Proceedings of the international large river symposium," Canadian Special Publication, *Fisheries and Aquatic Science 106 (*Ontario, Canada, 1989); F.K. Ligon, W.E. Dietrich and W.J. Trush, "Downstream ecological effects of dams", *BioScience,* Vol. 45 (1995); Patrick McCully, *Silenced Rivers: the Ecology of and Politics of Large Dams* (Zed Books, 1996); G.E. Petts, *Impounded Rivers: Perspectives for Ecological Management* (Wiley & Sons, Chichester, UK, 1984); J.V. Ward and J.A. Stanford (eds.), *The Ecology of Regulated Streams* (Plenum, New York 1979).

102 Bergkamp *et al.*, see note 98. When not otherwise referenced, information in this section is derived from this compendium.

Every natural river ecosystem has evolved to take advantage of the physical characteristics and processes that formed, and continue to shape, the river basin. A healthy, functioning river ecosystem requires maintaining not only the integrity of the resident biotic communities and their habitats, but also the natural processes that sustain them. Any modification to a river that modifies these parameters inevitably affects the river ecosystem.

Dams are intended to alter the natural distribution and timing of streamflows. As such, they also alter essential processes for river ecosystems. By changing the pattern of downstream flow (i.e., intensity, timing and frequency), they modify sediment and nutrient regimes and alter water temperature and chemistry. These parameters are the basic building blocks of freshwater ecosystems and when these change, many species, habitats and functions that depend directly or indirectly on these forces decline or disappear.

In a study of northern California rivers, Power *et al*. found that dams disrupt food web dynamics of river ecosystems by reducing or eliminating flow variability.[103] Ecologists have long recognized that spatial heterogeneity and temporal fluctuations play important roles in maintaining the richness and complexity of biotic communities.[104] Natural flow variation gives riverine predators periodic access to their prey, while preventing them from over-harvesting. In heterogeneous, fluctuating environments, predators are less likely to overeat and exterminate their prey.

Competitors that dominate under certain conditions are likely to lose their advantage when conditions vary, before they can exclude lesser competitors from the food web. Modeling performed in Power's study showed that river food chains could sustain top predators only when the river biota had periodic access to floodplains. When flow alteration or levees prevented spillover onto floodplains, the model predicts that only two of the original four trophic levels would persist.[105]

The construction of dams and of ancillary infrastructure also fragments river ecosystems.[106] Rivers divided by dams are no longer single ecosystems.[107] In effect, dams generally split rivers into three different, and in many ways separate, ecosystems:

- a downstream section, where a flow regime bearing little or no relation to the one to which native species are adapted affects sedimentation and nutrient supply as well as aquatic conditions,

- a reservoir ecosystem, which is entirely different from the previous river ecosystem. Storage reservoirs flood terrestrial ecosystems, killing terrestrial plants and displacing animals. Because many species prefer valley bottoms, large-scale impoundment may eliminate unique wildlife habitats and extinguish entire populations of endangered species,[108] and

- an upstream river ecosystem that no longer benefits from biotic and nutrient links with downstream, especially when migratory species are present. For example, dam-induced loss of salmon runs that once utilized upper river reaches for spawning (and dying) deprives those aquatic and terrestrial areas of significant amounts of nutrients and a key source of food for up to 40 species of wildlife, including bald eagles and bears.[109] In North American coastal streams, nutrients derived from decaying salmon carcasses supply up to 40% of nitrogen in the aquatic food chain and 20% of nitrogen found in riparian foliage. Nitrogen from salmon has also been found in vegetation up to 500 metres from the stream.

Multiple dams on a river significantly aggravate the impact on ecosystems. A single dam often affects fish migration, and multiple dams can worsen this situation dramatically. Even when individual dams do not affect large numbers of fish, chains of dams can cumulatively prove a great obstacle to the survival of native

103 M. Power, W. Dietrich and J Finlay, "Dams and downstream aquatic biodiversity: potential food web consequences of hydrologic and geomorphic change," *Environmental Management*, Vol. 20, No. 6 (1996).

104 V.H. Resh, A.V. Brown, A.P. Covich, M.E. Gurtz, H.W. Li, G.W. Minshall, S.R. Reice, A.L. Sheldon, B. Wallace and R.C. Wissmar, "The role of disturbance in stream ecology," *Journal of the North American Benthological Society*, Vol. 7, No. 4 (1988).

105 The number of trophic levels in a food web is one indicator of biodiversity. P.L. Angermeier and J.R. Karr, "Biological integrity versus biological diversity as policy directives," *BioScience*,Vol. 44 (1994).

106 On the consequences of fragmentation, see N. Alfonso and D. McAllister, *Biodiversity and the Great Whale Hydroelectric Project*, Great Whale Environmental Assessment: Background Paper No. 11, Great Whale Public Review Support Office (1994), pp. 17-18 and 39; Bergkamp, see note 98.

107 Dr. David Tolmazin, formerly of the Ukrainian Academy of Sciences, as quoted in E. Goldsmith and N. Hildyard, *The Social and Environmental Effects of Large Dams*, see note 101.

108 Dynesius and Nilsson, see note 100.

109 S. Watkinson, "Life after death: the importance of salmon carcasses to British Columbia's watersheds," *Arctic*, Vol. 53, No. 1 (2000), p. 92.

Table 1: Orders of Impacts

Location in Relation to Dam	Category of Impact	Impact
Upstream	First Order	Habitat modification Modification of thermal regime Accumulation of sediment in the reservoir Water quality changes Erosion
	Second Order	Changes in plankton and periphyton communities and populations Changes in aquatic macrophyte communities and populations Riparian vegetation inundated/modified
	Third Order	Communities of invertebrates, fish, birds and mammals affected by altered ecosystem characteristics and processes
Downstream	First Order	Daily, seasonal and annual flows modified Water quality changes Sediment flows reduced Changes to channel, floodplain and delta morphology
	Second Order	Changes in plankton and periphyton communities and populations Changes in aquatic macrophyte communities and populations Riparian and floodplain vegetation affected by altered flows
	Third Order	Communities of invertebrates, fish, birds and mammals affected by altered ecosystem characteristics and processes Estuaries negatively affected by loss nutrient and sediment sources and beneficial effects of flooding Marine systems negatively affected by loss of nutrient and sediment and degradation of marine organism breeding areas

fish stocks. In the Northern hemisphere, dams impact 77% of the largest rivers; on many rivers, the headwaters are the only fully natural reaches.[110]

To make sense of the numerous interconnected physical and biological effects of dams, river ecologists have developed a framework that distinguishes impacts upstream of the dam (reservoir and flooded streambeds) from those downstream, and distinguishes three distinct orders of impacts.[111] **First order impacts** are the direct physical effects caused by constructing the dam and altering the river's flow. **Second order impacts** are the resulting changes in primary production and ecosystem structure,[112] and **third order impacts** are the long-term effects on invertebrates, fish, birds and mammals resulting from the integrated effect of all the first and second order changes. Not all impacts fit neatly into this hierarchy, but it is nevertheless a useful guide for understanding how dam impacts increase in scale or scope through a river system. The table above summarizes this framework.

While third order impacts are of most direct interest to human society, they cannot be properly predicted or understood without analyzing associated first and second order impacts. "If [a] stream's physical founda-

110 Dynesius and Nilsson, see note 100.

111 G. E. Petts, *Impounded Rivers: Perspectives for Ecological Management* (Wiley & Sons, Chichester, UK, 1984).

112 Primary productivity is the transformation of chemical or solar energy to biomass. Most primary production occurs through photosynthesis, whereby green plants convert solar energy, carbon dioxide, and water to glucose and eventually to plant tissue.

tion is pulled out from under the biota, even the most insightful biological … program will fail to preserve ecosystem integrity."[113] The following sections discuss these disruptions to ecosystem integrity.

5.1.2 Upstream impacts

The most important upstream impacts are those felt in and around the reservoir. However, they also include impacts on terrestrial and avian species inhabiting the catchment area.

5.1.2.1 First order upstream impacts

Habitat Modification. The most obvious upstream impact is the replacement of rapids, riffles and pools with flat-water reservoirs. Species requiring fast-moving water for all or part of their life cycles will inevitably lose habitat. While this effect is local in the case of small hydro facilities, large hydroelectric installations often involve storage reservoirs that convert many kilometres to flat water. When an entire river reach is converted to a chain of reservoirs, extirpation of such species is the inevitable result.[114]

Thermal regime. Temperature plays an essential role in many chemical and biological processes, and impoundments display very different temperature characteristics than do free-running streams. Large reservoirs act as buffers that temper seasonal and short-term temperature fluctuations, and also affect local and regional climate. They tend to become thermally stratified, as do large lakes, with a cold, dense bottom layer, a warm, well-mixed upper layer and an intermediate layer with a pronounced temperature gradient (up to 2°C per metre). As penstock intakes are generally well below the reservoir surface, the water released downstream through the turbines in many reservoirs tends to be much colder than under natural conditions.

Sediment. Reservoirs tend to accumulate sediment as the water slows and particles carried downstream from the catchment area settle out. Sediment accumulation is a major problem in tropical reservoirs, resulting in rapid loss of storage capability. At all latitudes, reservoirs reduce the nutrient load downstream by trapping organic detritus. As we shall see in Section 6.2, it is now realized that this sediment accumulation also feeds the processes that produce methane emissions, which contribute to global warming.

Water quality. Reservoir formation affects water quality in a number of ways, depending on the river's geography, the size of the dam and the water detention time. In a stratified reservoir, surface layers may be oxygen-saturated due to high growths of phytoplankton, whereas lack of sunlight and decomposition processes may result in anoxic conditions at the bottom. As with temperature, these conditions can also affect the downstream environment. Eutrophication may occur, depending on inflows of nutrients. Methylmercury may be produced by bacterial processes and bioaccumulate up the food chain.[115]

Erosion. Depending on the water management regime, water level fluctuations can cause shoreline erosion, which in turn can affect the colonization of the reservoir's banks by plants that provide habitat for many animal species.

5.1.2.2 Second order upstream impacts

Phytoplankton. Phytoplankton are relatively scarce in fast-running river systems, but impoundment often results in a boom in their population, due to a release of nutrients from flooded vegetation and soils and the trapping of nutrients flowing into the reservoir. This boom often leads to an increase in invertebrate and fisheries productivity, which may last up to five years after the dam is closed. However, this "trophic upsurge" is a temporary phenomenon, and is followed by a "trophic depression" due to the gradual flushing of the reservoir.[116]

113 Ligon *et al*., quoted in Bergkamp *et al.*, see note 98, p. 15.

114 Bergkamp *et al.*, see note 98.

115 There is a voluminous literature on methylmercury contamination resulting from Northern reservoir impoundment. See e.g.: D. M. Rosenberg *et al*., "Large-scale impacts of hydroelectric development," *Environmental Review*, Vol. 5 (1997), p. 28; D.M. Rosenberg, R.A. Bodaly, R.E. Hecky, and R.W. Newbury, "The environmental assessment of hydroelectric impoundments and diversions in Canada," (1987), in M.C. Healy, and R.R. Wallace, *Canadian Aquatic Resources*; R.A. Bodaly & D.M. Rosenberg, "Retrospective analysis of predictions and actual impacts for the Churchill-Nelson hydroelectric development, northern Manitoba," (1990), in C.E. Deslisle and M.A. Bouchard (eds.), *Managing the effects of hydroelectric development,* Collection environnement et géologie, Vol. 9, Société canadienne des biologistes de l'environnement.

116 Alfonso and McAllister, see note 106, p. 38.

Aquatic macrophytes. Higher water plants (floating or rooted) may colonize the shallow areas near the shores as well as river inlets, depending on the degree of water level fluctuation. They can slow flows and may assist in colonization by other species, including harmful species such as bilharzia-carrying snails, mosquitoes and hosts for flukes.

Riparian vegetation. Destruction of riparian vegetation by flooding is a major impact of reservoir creation. The drawdown regime is critical in determining what vegetation, if any, can colonize the new reservoir riparian zone. When fluctuations are great and out of sync with seasonal rhythms, the zone can remain virtually barren:

> Despite … mitigation efforts, adverse impacts from the building of the La Grande Complex remain. About half of the 9,600 km^2 of forested land which has been flooded is now in the drawdown zone, the strip between the reservoirs' high and low water lines. Water levels in these reservoirs fluctuate over ranges that vary from three to 15 metres. These fluctuations, and consequent erosion, mean that the shores of reservoir and diversion zones are essentially barren.[117]

Even in relatively stable reservoirs, the erosive action of waves coupled with the loss of sediment and seed inputs renders vegetation in riparian zones less diverse and healthy than those along free-flowing stretches.

5.1.2.3 Third order upstream impacts on invertebrates, fish, birds and mammals

Terrestrial ecosystems. The effect of lost terrestrial habitat varies greatly, depending on the area flooded and its importance in the larger ecosystem. It is most likely to be significant in the case of larger impoundments:

> The effects of inundation are especially severe when the reservoirs are situated close to mountains, in dry areas, or far north where the river valleys are usually the most productive landscape elements. All terrestrial animals disappear from the submerged areas. As many species prefer valley bottom habitats, *large-scale impoundments are likely to extinguish entire populations of species*. Many animals are caught and drowned during the filling of new reservoirs, and while there are many examples of salvage operations designed to rescue animals during such fillings, the populations decrease within a few years in proportion to the habitat area that is lost (Nilsson and Dynesius, 1994). *Flooding can result in both local and global extinctions of animal and plant species. Particularly hard hit are the species dependent upon riverine forests, and other riparian ecosystems, and those adapted to the fast flowing conditions of the main river course.*[118] (emphasis added)

Reservoir operating regimes that involve significant drawdown also greatly affect many species, including molluscs, fish and birds. The degree of impact depends on the extent of the drawdown, its frequency and its timing with respect to natural cycles. "In many dams the water regime and slopes do not favour colonisation by plants and this creates barren and sterile shorelines, equally unfavourable to a range of bird species."[119]

Aquatic ecosystems. As noted above, reservoir formation transforms the riverine biotic community into a lake-like community and can produce a spike in primary production that favours fish populations generally and certain species in particular. However, after this boom, productivity eventually falls to levels far below those experienced in the first years after reservoir filling.

Reproductive impacts on migratory fish can also be severe, as populations are cut off from their spawning grounds. As noted above, freshwater species in general and fish in particular have been subject to more extinctions, extirpations and loss of intra-species diversity than those of terrestrial or marine species.

Even dams referred to as "run-of-the-river" can significantly harm aquatic plants and the animal species that depend on them.[120] A recent study on ecosystem recovery on the St. Lawrence River found that the Moses-Saunders and Beauharnois dams were the cause of significant environmental harm, despite their very small impoundments.

117 Sean McCutcheon, *Mitigation Measures at the La Grande Complex: A Review*, Great Whale Environmental Assessment: Background Paper No. 8, Great Whale Public Review Support Office (Montréal, 1994), pp. 65-66.

118 Bergkamp *et al.*, see note 98.

119 *Ibid.*, p. 42.

120 Definitions of "run-of-the-river" vary considerably. According to some, a project is only run-of-the-river if inflow equals outflow on a real-time basis, i.e., if there is no storage or flow modification at all. Others also use the term to refer to projects with modest amounts of storage and flow modification. See Section 7.2, below.

> "The wide variability of water levels is the big problem," says Philippe Crabbé, the head of the study team. In winter, the unnaturally low lake levels let water freeze right to the bottom in some areas. And as ice moves downstream it "scours" the sediment, ripping out the aquatic plants that provide habitat and food for fish, crustaceans and other water creatures.
>
> It's a bad place to spawn and an unlikely spot for fish that do hatch to reach maturity, the study finds. "The poor habitat is certainly associated with the creation of the reservoir and dam operations, i.e. water fluctuations." Mr. Crabbé adds, "The biodiversity never had a chance to pick up there."[121]

Another important upstream impact is the methylation of organic mercury through bacterial processes and its resulting release into the food chain. While mercury levels in fish appear not to reach levels that harm the fish populations themselves, they can pose significant health risks to human populations that eat large amounts of fish, especially piscivorous species.[122] While limiting fish consumption can control health risks, this can have important indirect effects on Native societies, both in terms of public health (shifts from "country food" diets to those based on imported prepared food have been largely blamed for drastic increases in diabetes and heart disease among Northern aboriginal populations) and in terms of culture and identity.

5.1.3 Downstream impacts

5.1.3.1 First order downstream impacts

Flows. Changes in the flow regime are without doubt the greatest single driver of downstream ecosystem impacts. Some projects cut off flows entirely, in diverted streams in the bypassed reaches[123] and (for certain periods) in the main streambed as well, even in some so-called "run-of-the-river" projects.[124]

Natural river flows can vary greatly on a daily, seasonal and annual basis, and resident species are adapted to these fluctuations. It is now recognized that this variation is itself of great importance in sustaining a diverse ecosystem, even apart from the minimum flows required by certain species. As Poff *et al.* note:

> A large body of evidence has shown that the natural flow regime of virtually all rivers is inherently variable, and that this variability is critical to ecosystem function and native biodiversity. … [R]ivers with highly altered and regulated flows lose their ability to support natural processes and native species.[125]

To illustrate the variability of natural flows, Graph 5 (on page 42) shows the daily flows for three different years for the Coulonge River in Québec, which until 1994 was free-flowing. The inter-annual variation is as striking as is the inter-season variation.

Most hydroelectric dams are operated in a manner that produces a well-defined pattern of daily, weekly or seasonal variation. However, as these patterns are related to power needs rather than to the local hydrological cycle, there is little chance that local flora and fauna will be able to adapt to them. For example, Graph 6 shows the flow regime of the Colorado River, managed to meet daily peaks of electricity demand. Flows fall every night to 3,000-4,000 cfs, only to rise in the late afternoon to levels up to five times as high.

121 Tom Spears, "Fish pay price for Cornwall dam: Study blames hydro projects for St. Lawrence River damage," *Ottawa Citizen* (2 November 1998), referring to Philippe Crabbé *et al.*, *Ecosystem Recovery on the St. Lawrence* (U. of Ottawa, 1997).

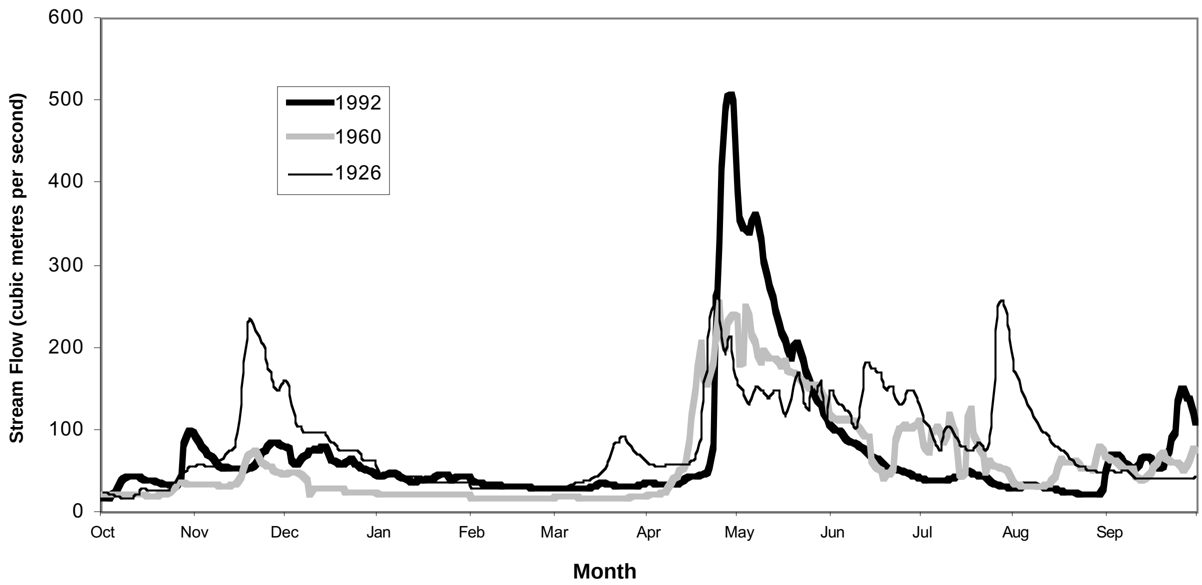
122 See, for example, T. Kue Young, Jeff Reading, Brenda Elias and John O'Neil, "Type 2 diabetes mellitus in Canada's First Nations: status of an epidemic in progress," *Canadian Medical Association Journal*, Vol. 163, No. 5 (2000); Charles Dumont, "Mercury and Health: the James Bay Cree Experience, *Proceedings of 1995 Canadian Mercury Network Workshop.*

123 A bypassed reach is formed when all or some of the river flow is diverted out of the river channel into a pipe or canal and then passed through turbines before being returned to the channel downstream of the dam.

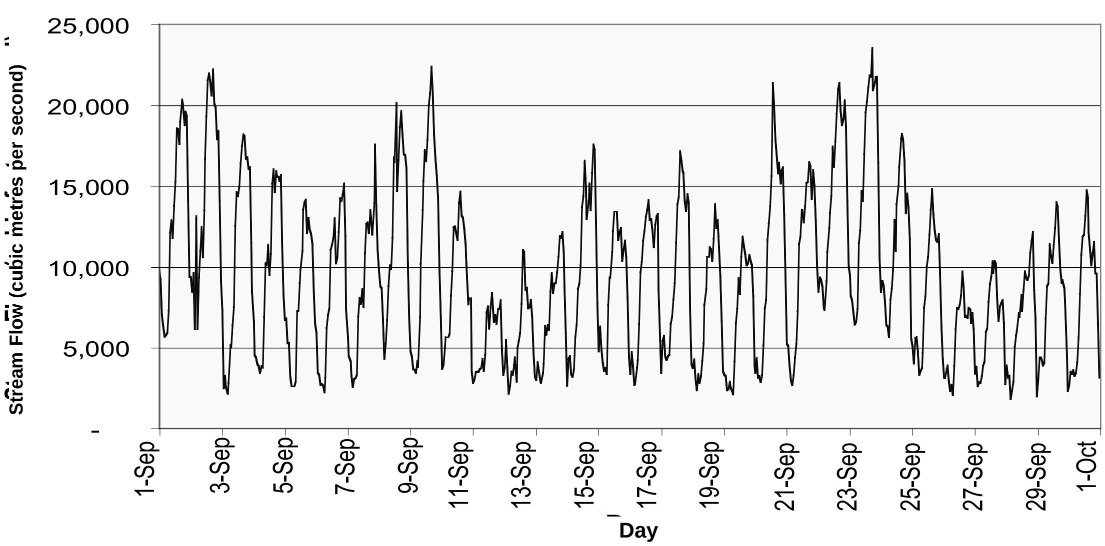
124 This point was emphasized by the Doyon Commission, a judicial commission of inquiry that was formed to investigate allegations of malfeasance in Hydro-Québec's awarding of power purchase contracts in the early 1990s, which concluded that the common assumption that so-called "run-of-the-river' projects have little or no impact on the river's flows or levels is incorrect." *Commission d'enquête sur la politique d'achat par Hydro-Québec d'électricité auprès de producteurs privés, Rapport final* (31 March 1997), p. 469.

125 N. LeRoy Poff *et al.*, "The Natural Flow Regime: A paradigm for river conservation and restoration," *BioScience*, Vol. 47 (December 1997), p. 780.

Graph 5: Daily Flows of the Coulonge River (Québec)



Graph 6: Daily Flows of the Colorado River



Daily Streamflow Variations in the Colorado River at Lee's Ferry in September.
(U.S. Bureau of Reclamation, Upper Colorado Region, 2000, reproduced in Bergkamp *et al.*)

The ecological consequences of such a regime have been described by Poff *et al.* as follows:

> *[T]he extreme daily variations below peaking power hydroelectric dams have no natural analogue in freshwater systems and represent, in an evolutionary sense, an extremely harsh environment of frequent, unpredictable flow disturbance.* Many aquatic populations living in these environments suffer high mortality from physiological stress, from wash-out during high flows, and from stranding during rapid dewatering. *Especially in shallow shoreline habitats, frequent atmospheric exposure for even brief periods can result in massive mortality of bottom-dwelling organisms and subsequent severe reductions in biological productivity.* Moreover, the rearing and refuge functions of shallow shoreline or backwater areas, where many small fish species and the young of large species are found, are severely impaired by frequent flow fluctuations. In these artificially fluctuating environments, specialized stream or river species are typically replaced by generalist species that tolerate frequent and large variations in flow. Furthermore, life cycles of many species are often disrupted and energy flow through the ecosystem is greatly modified. *Short-term flow modifications clearly lead to a reduction in both the natural diversity and abundance of many native fish and invertebrates.*[126] (emphasis added)

Even substantial minimum flows cannot adequately maintain biodiversity or ecosystem health:

> *Virtually all methods currently in widespread use for determining instream flow needs will possibly lead to inadequate protection of ecologically important flow variability, and ultimately to the loss of native riverine biodiversity and ecosystem integrity.* Current aquatic ecology theory and empirical observations suggest that a hydrological regime characterized by the full or nearly full range of natural variation is necessary to sustain the full native biodiversity and integrity of aquatic ecosystems.[127] (emphasis added)

In recognition of the importance of inter-annual variability, the state of the art in flow regimes is based on indexing flows to those of an unregulated stream in the same area.[128] In this way, the regulated flows are made to reflect local climatic conditions, putting them back in sync with other biological cycles. Only time will tell to what extent this approach will prove successful in mitigating flow-related ecological impacts.

Water quality. Water quality and temperature downstream of a dam depend on the quality of the water in the reservoir and the depth from which it is withdrawn. Cold water released from deep in a large reservoir can produce thermal effects as far as 400 km downstream, and can cause significant reductions in reproductive success.[129]

Chemical composition and oxygenation can also be modified. Water from the surface of a stratified reservoir will be well-oxygenated and warm, but depleted of nutrients. Water from the lower layers of such a reservoir will be cold and oxygen-depleted, but nutrient-rich. Water that is spilled instead of being turbined may be supersaturated in oxygen and nitrogen, which can cause fish fatalities from gas bubble disease. Turbining water from deeper layers can also result in increased atmospheric emissions of methane, as methane dissolved in the water column is released to the atmosphere before it can be oxidized to CO_2.[130]

Reduced sediment flows. By reducing sediment flows, dams affect the complex processes by which channels, floodplains, beaches, sandbars and deltas are formed. Scouring usually results for many miles below the dam, as sediment is removed but not replaced. Further downstream, both erosion and sediment deposition can be observed, depending on the precise combination of geography, morphology and flow modification. The downstream environment is deprived of nutrients due to the trapping of sediment in the reservoir. Even those nutrients that do pass may not be delivered at the time they are needed for example, in northern regions where spring runoff is saved for power generation in the winter. Hans Neu, a retired Canadian government oceanographer specializing in estuarine and coastal hydrodynamics, argues that reducing freshwater outflows during the spring and summer also reduces the haline circula-

126 *Ibid.*, p. 777, references omitted.

127 Brian D. Richter *et al.*, “How Much Water Does a River Need?” *Freshwater Biology,* Vol. 37 (1997), pp. 231-249. It is not clear if the authors considered the indexing described below as one of the methods “currently in widespread use.”

128 See, for example, FERC, Final Environmental Impact Statement, *Proposed Changes in Minimum Flow Requirements at the Potter Valley Project,* FERC Project No. 77-110, California Vol. 1 (2000).

129 Walker (1979), quoted in Bergkamp *et al.*, see note 98, p. 26.

130 World Commission on Dams, *Dam Reservoirs and Greenhouse Gases: Report on the Workshop Held on February 24-25, 2000,* Hydro-Québec (Montréal), p. 5.

tion, the current resulting from the difference in density between fresh water runoff and seawater that brings nutrient-rich seawater into the estuary. Transferring runoff from the biologically active period of the year to the biologically inactive, he writes, "is therefore analogous to stopping the rain during the growing season and irrigating during the winter, when no growth occurs."[131]

Scouring and pulse flows. While scouring resulting from reduced sediment flows creates these negative impacts, scouring from occasional flood flows is often essential to create habitat heterogeneity and temporal variability — two aspects that help maintain the richness and complexity of ecological communities.[132] Many dams eliminate these "scouring flows" — flows large enough to mobilize river substrate — which can lengthen river food chains, thereby making river ecosystems more robust. Natural flow variation gives riverine predators periodic access to their prey, while preventing them from overharvesting. Also, scouring flows often suppress invading alien riverine species because they are more vulnerable to these flows than are native species. Pulse flows can also be used to stimulate upstream and downstream migration of anadromous fish.[133]

5.1.3.2 Second order downstream impacts

The development of downstream riparian communities depends on the interaction of the flooding and sedimentation patterns created by the dam and its management:

> An important downstream manifestation of river impoundment is the loss of pulse-stimulated responses at the water-land interface of the riverine system. High discharges can retard the encroachment of true terrestrial species, but many riparian plants have evolved with, and become adapted to the natural flood regime. Species adapted to pulse-stimulated habitats are often adversely affected by flow-regulation. … [A]rtificial pulses generated by dam releases at the wrong time – in ecological terms – have been recognised as a cause of forest destruction.[134]

The stabilization of the riverbed as a result of dam operation can have a significant impact on aquatic macrophytes. Plants in regulated rivers experience less scour, suffer less stress from high flows and the rate of channel migration is reduced.[135] As a result, plants have greater opportunity to establish and develop in rivers below dams. Increased vegetation can, in turn, further stabilize once dynamic river channels. Thus, species that depend on dynamic river channels can suffer. For example, the black stilt on the Waitaki River in New Zealand require exposed gravel beds and sandbars for nesting and feeding.[136] Since dams were constructed upstream on both rivers, spring flood flows have been drastically curtailed and are no longer able to mobilize river substrate and create the preferred habitat. Moreover, the vegetation that has developed on the stable sand and gravel bars now provides cover for predators of black stilt eggs, young and adults. Black stilts have been forced to abandon nesting in all areas downstream of the dam.

5.1.3.3 Third order downstream impacts

The degree to which the first and second order impacts of any given hydro development affect invertebrates, fish, birds and mammals depends on the scale of the intervention and on the degree to which those species are adapted to take advantage of the particular features of the local ecosystem which have been lost. Impacts on river organisms, therefore, can be difficult to generalize. However, a voluminous literature demonstrates that dams can harm many species of fish that inhabit affected rivers and their estuaries, of birds and mammals that rely on watershed habitat, and even of seals, whales and other marine species that can be affected by altered estuarine flows.

As discussed previously, perhaps the best-known impact of dams on river organisms is on migratory fish. The rivers of the U.S. Pacific Northwest have received a level of notoriety commensurate with the scale of the dam-induced problem. More than 200 stocks of migratory salmonids have disappeared,[137] taking with them a strong fishing industry and a central part of the way of life of the region's aboriginal peoples.

131 Hans Neu, "Man-Made Storage of Water Resources A Liability to the Ocean Environment? Part I," *Marine Pollution Bulletin*, Vol. 13 (1982), p. 11.

132 Power *et al*., see note 103.

133 Michael Sale, Oak Ridge National Laboratories, pers. comm.

134 Power *et al*., see note 103, p. 31.

135 Bergkamp *et al.*, see note 98.

136 Ligon, Dietrich and Trush, see note 101.

137 Bergkamp *et al.*, see note 98. Loss of habitat and increased harvesting have also contributed to these species' decline.

A study of several Australian rivers shows how dams affect wetlands and organisms that depend on them for survival. The frequency of floods and areas inundated are one-third to one-tenth of the pre-dam levels in each of the rivers studied. In many cases, this loss of connection between rivers and their associated wetlands and estuaries changed aquatic systems to terrestrial ecosystems. As a result, in many wetlands and estuaries several bird species have declined or disappeared, such as the brolgas *(Grus rubicund,* a large water bird), glossy ibis *(Plegadis falcinel),* cormorant *(Phalacrocora sp.),* great egret *(Ardea al)* and the rufous night heron *(Nycticorax caledoni).*[138]

In northern British Columbia, the construction of the Bennett Dam on the Peace River caused a similarly transforming effect on the Peace-Athatbasca Delta. The delta has not flooded since construction of the dam in 1969, except in 1974 when a significant ice jam occurred. The rich fisheries declined. Waterfowl numbers declined dramatically as marshlands were invaded by willows and other trees. Quality grazing lands for wood bison declined after the annual deposition of rich sediments ceased, and muskrat, the staple of a local economy and diet, disappeared within a few years.[139]

River dolphin populations in South America, China and the Indian subcontinent have suffered significant declines in recent decades, and experts believe dams are a primary cause of their near-collapse.[140] River dolphins appear to require habitat where eddies form, whether due to sandbar formation, stream convergence or substantial accumulations of debris. Dams have reduced the complexity of habitat and reduced water levels in rivers on the Indian Subcontinent, causing significant impacts on dolphins. For example, the Indus dolphin *(Platanista minor)* now exists only in five small populations isolated by dams on the Indus River. Dams built in India along the Nepalese border have left Nepal with only a few small subpopulations of Ganges dolphins *(Platanista gangetica)* confined to the upstream portions of Ganges tributaries. A dam completed in 1961 on the Karnaphuli River in Bangladesh divided one of the remaining subpopulations of Ganges dolphins. Researchers believe that although a few individuals apparently remain upstream of the dam, the prognosis for their survival is poor.[141]

Hippos in Africa represent another river organism that dams have negatively impacted. Hippos forage at night, but during the day require pools of water sufficiently deep to protect them from the sun. Because hippos are territorial, only a certain number of hippos can occupy a given body of water. The river pool habitat found on the Zambezi River in Zimbabwe's Manna Pools National Park has been significantly reduced by the flow regulation effect of the Kariba Dam.[142] The river rarely floods enough to cover the once-expansive floodplains along the Zambezi, meaning the only permanent pools available to hippos are those along the river margin.

The large-scale hydro developments across Northern Canada have undoubtedly caused important third-order impacts, though due to the lack of baseline data and of independent scientific study of this remote area, well documented case studies are rare. This is particularly true in Québec, where:

> Hydro-Québec almost completely dominates the scientific and other research conducted in the region. The Crown corporation has commissioned hundreds of studies assessing impacts related to the megaprojects, but the results of most have not yet been released to the public. Very few of the studies have been subject to peer review; many are available only in the so-called "Grey literature" of consultants' reports and industry-sponsored papers.[143]

While definitive proof is still lacking, it is suspected that the freshwater plume under the sea ice created by the dramatically increased winter flows of the La

138 R.T. Kingsford, "Ecological impacts of dams, water diversions and river management on floodplain wetlands in Australia," *Austral Ecology,* Vol. 25, No. 2 (2000).

139 Commission on Geosciences, Environment and Resources, *Freshwater Ecosystems: Revitalizing Education Programs in Limnology* (National Academy Press, 1996).

140 R. Reeves and S. Leatherwood, "Dams and dolphins: can they coexist?" *Ambio,* Vol. 23, No. 3 (1994), pp. 172-175. In many instances, severe water quality problems have also contributed to the dolphins' decline.

141 R. Reeves, S. Leatherwood and R.S. Mohan, "Report from a seminar on the conservation of river dolphins of the Indian Subcontinent," 18-19 August 1992, New Delhi, India, as reported in Reeves and Leatherwood (1993).

142 World Commission on Dams draft Case Study on the Kariba Dam.

143 Canadian Arctic Resources Committee, Environmental Committee of Sanikiluaq and Rawson Academy of Aquatic Science, "Sustainable Development in the Hudson Bay / James Bay Bioregion," *Northern Perspectives*, Vol. 19, No. 3 (Autumn 1991).

Grande River[144] is adversely affecting the eelgrass beds along the James Bay coast. As these eelgrass beds provide a crucial food resource for waterfowl such as geese and especially brant during their northward migration in the spring, the success of their breeding season is believed to be linked to the abundance of these eelgrass beds.[145]

5.2 Biodiversity impacts

The natural world is characterized not only by large numbers of living individuals and communities, but also by the *diversity* of those communities. That diversity consists both of species diversity and of genetic diversity within a species. Thus, it is important to ask not only how a dam affects the populations of one or more key species, but also how it affects biodiversity in the watershed or region.

Freshwater covers only 0.8% of the planet's surface, but 2.4% of the world's species occur in freshwater, making the "species richness" of the freshwater environment 10% greater than the terrestrial environment and fully 15 times greater than the marine environment.[146] According to an important Canadian study, the rate of extinctions for freshwater fauna in North America is 1,000 times higher than the background rate of extinction[147] — five times higher than those for terrestrial fauna and three times higher than those for coastal marine mammals.[148] In fact, according to the study's authors Ricciardi and Rasmussen:

> Even more remarkable is that [North American] freshwater [extinction] rates fall within the range of estimates for tropical rainforest communities (1-8% loss per decade), which are thought to be being depleted faster than any other biome. This is compelling evidence that *North American freshwater biodiversity is diminishing as rapidly as that of some of the most stressed terrestrial ecosystems on the planet.*[149] (emphasis added)

They add that, although larger absolute numbers of species are involved in the tropics, "the elimination of even a few species in temperate habitats can promote further extinctions and disrupt ecosystem functioning." Alfonso and McAllister point out that the loss of *any* species in temperate areas may have a significant impact on the ecosystem.[150] Other studies estimate that a minimum of 20% and perhaps as many as 35% of freshwater fish species are extinct, endangered or vulnerable.[151] Recent studies show that species richness of freshwater molluscs in the U.S. has declined by 40% to 80% over the last 50 years, mainly because of habitat disruption caused by dams. Their decline will likely have significant impacts on riverine ecosystems, as they are a major food source for fish.[152]

Dams' impacts on fish go far beyond the well-known examples of disruption of migration for salmon and mortality from passage through turbines or over spillways. Reservoirs also tend to reduce biodiversity of fish species, even if total numbers are not affected:

> Fish diversity in reservoirs is usually not as extensive as in natural lakes, because natural lakes have more stable conditions under which the fishes evolve. … *As the reservoir fills, riffles, runs and pools of the river are lost beneath the rising waters leading to the extinction of habitat-sensitive riverine species with tightly defined niche requirements.*[153] (emphasis added)

144 Due to the diversion of the Eastmain and other rivers into the La Grande Basin, mean average flows of the La Grande River have doubled; because the project is used to meet Québec winter peak demand, winter flows are now some eight times greater than they were under natural conditions. Hydro-Québec is studying the possibility of partially diverting the Great Whale and Rupert Rivers into the La Grande Basin as well, which would increase mean annual flow by another 50%.

145 Alan Penn, pers. comm.

146 Bergkamp *et al.*, see note 98.

147 The background rate of extinction is the rate of extinction that would be expected to occur naturally without human intervention, either positive or negative.

148 Anthony Ricciardi and J. B. Rasmussen, "Extinction rates of North American freshwater fauna," *Conservation Biology,* Vol. 13 (October 1999), pp. 1220-1222.

149 *Ibid.*, references omitted.

150 Alfonso and McAllister, see note 106.

151 Stiassny (1996) cited in Bergkamp *et al.*, see note 98.

152 *Ibid.*, p. 36.

153 Bergkamp *et al.*, see note 98.

Loss of biodiversity refers not just to extinctions, but also to loss of diversity within a species:

> [S]pecies at the extreme limits of their range often have a proportion of alleles[154] that are rare in central populations. … Local genetic adaptation can result from millennia of natural selection …, but local variation can be lost instantaneously through extirpation [the disappearance of a species from a region] caused by habitat destruction or by genetic mixing.[155]

This type of effect is especially significant when a project is located in a transitional area between one type of ecosystem and another. A prime example is the Great Whale project, a 3,200 MW hydro project proposed by Hydro-Québec for which environmental assessment was carried out in the early 1990s.[156]

> Because the Grande Baleine (Great Whale) watershed is located within three ecoclimatic zones, some populations at the northern or southern limits of their ranges will have unique genomes. These populations, which may be uniquely adapted, are at risk. Communities of lentic and riparian species from numerous taxa will be eliminated from approximately 500 km of riverine habitat. Similarly, littoral species, communities and associated ecosystem services found in ca. 4600 km of existing littoral habitat will be eliminated. Locally adapted populations, individual species and communities will be eliminated. Also, ecosystem functions associated with these species and communities will be eliminated.[157]

5.3 Impacts on human societies

The effects of dams on human societies are vast and complex, impossible to summarize adequately in a brief overview such as this. These impacts occur at the level of individuals, families, communities, ethnic groups and indigenous nations; they can affect health, happiness, social cohesion and identity, as well as economic activities, both subsistence and commercial.

By far the most severe social impacts are those related to forced displacement. Huge numbers of people around the world have been flooded off their lands by dams. Studies commissioned by the World Commission on Dams indicate that more than 40 million people have been displaced by reservoirs in India.[158] In China, 10.2 million people were officially recognized as "reservoir resettlers" in the 1980s, but independent researchers believe that the true number of dam-evicted in China is much higher.[159] China's gargantuan Three Gorges Dam alone will displace as many as 1.8 million people.[160] These figures, furthermore, do not include the huge number displaced by dam-related infrastructure such as canals and powerlines.

While there are a few examples of well-planned and well-compensated resettlement programs, the overwhelming majority of studies of forced displacement for dams shows that people have suffered trauma and impoverishment. The World Bank — which, according to Patrick McCully, has paid for more forced evictions than any other international lending institution[161] — itself notes that:

> When people are forcibly moved, production systems may be dismantled, long-established residential settlements are disorganized, and kinship groups are scattered. Many jobs and assets are lost. Informal social networks that are part of daily sustenance systems — providing mutual help in childcare, food security, revenue transfers, labour exchange and other basic sources of socio-economic support — collapse because of territorial dispersion. Health care tends to deteriorate. Links between producers and their consumers are often severed, and local labour markets are disrupted. Local organizations and formal and informal associations disappear because of the sudden departure of their members, often in different directions. Traditional authority and management systems can

154 An allele is one of a group of genes that occur alternatively at a given locus.

155 Alfonso and McAllister, see note 106.

156 The project never went to public hearings as it was withdrawn after the cancellation of a large power purchase contract by the New York Power Authority rendered it unnecessary.

157 Alfonso and McAllister, see note 106.

158 Pranab Banerji *et al.*, *India Country Study*, World Commission on Dams (Cape Town, 2000), p. 225.

159 Jun Jing, *Displacement, Resettlement, Rehabilitation, Reparation and Development: China Report*, World Commission on Dams (Cape Town, 1999), p. 3.

160 Qi Ren, "Is Developmental Resettlement Possible?" in Dai Qing (ed.), *The River Dragon Has Come!* (ME Sharpe, Armonk, 1998), p. 54.

161 Patrick McCully, pers. comm.

> lose leaders. Symbolic markers, such as ancestral shrines and graves, are abandoned, breaking links with the past and with peoples' cultural identity. Not always visible or quantifiable, these processes are nonetheless real. The cumulative effect is that the social fabric and economy are torn apart.[162]

The already poor and marginalized have suffered most from dam-induced displacement. As a WCD-commissioned study on indigenous people and ethnic minorities written by anthropologist Marcus Colchester notes:

> As the World Bank acknowledges…those resettled as a result of dam projects are generally from the poorest and most vulnerable sections of society. Such vulnerability reflects not only their exclusion from the decision-making process and economic and political institutions that would enable them to exercise genuine control over their lives and livelihoods but also, in many instances, from racism and from discriminations of class, caste and ethnicity…[163]

In the words of Patrick McCully, "Areas with people who are well off and well connected do not make good reservoir sites."[164] This is true not only in India and China, but also in the United States and Canada. Colchester writes:

> In the USA, it was poor black sharecroppers who bore the brunt of the impacts of the massive dam building programme undertaken in the Tennessee Valley from 1933 to 1946, whilst native Americans have suffered disproportionately from the dams built by state and federal authorities in the arid West …
>
> … In North Dakota, a quarter of the Fort Berthold Reservation, shared by the Arikara, Mandan and Hidatsa peoples of the upper Missouri, for example, was flooded as a result of a staircase of dams (the Missouri River Development Project — MRDP), built during the 1950s and 1960s. The land lost included the best and most valuable and productive land on the reservation — the bottom lands along the river where most people lived. Five different Sioux reservations also lost land. Again, the impact was quite severe: the dams destroyed nearly 90 per cent of the tribes' timberland, 75 per cent of the wild game, and the best agricultural lands. Ultimately, the Missouri dams cost the indigenous nations of the Missouri Valley an estimated 142,000 hectares of their best land — including a number of burial and other sacred sites — as well as further impoverishment and severe cultural and emotional trauma. A guarantee, used to rationalise the plan in the first place, that some 87,000 hectares of Indian land would be irrigated was simply scrapped as the project neared completion.[165]

In Canada, variations of the same story have been repeated many times, whether it be the Cheslatta Carrier Nation of British Columbia (Alcan's Kemano project), the Pimicikamak Cree Nation in Manitoba (Lake Winnipeg Regulation project), the Innu of Québec (the Manic-Outardes and Sainte-Margarite projects among others), the Innu of Labrador (Churchill Falls project) or the James Bay Cree of Québec (the La Grande project).

Loss of access to resources is another important form of social impact. Indeed, for the World Commission on Dams, loss of access to resources is itself a type of displacement:

> In the narrow sense, displacement results in the physical displacement of people living in the reservoir or other project area. … However, the inundation of land and alteration of riverine ecosystems — whether upstream or downstream — also affects the resources available for land- and riverine-based productive activities. In the case of communities dependent on land and the natural resources base, this often results in the loss of access to traditional means of livelihood, including agricultural production, fishing, livestock grazing, fuelwood gathering and collection of forest products, to name a few. Not only does this disrupt local economies, it effectively displaces people — in a wider sense — from access to a series of natural resource and environmental inputs into their livelihoods. This form of livelihood displacement deprives people of their means of production and dislocates them from their existing socio-cultural milieu. The term 'affected' thus applies to people facing either type of displacement.[166]

162 Marcus Colchester, *Sharing Power: Dams, Indigenous Peoples and Ethnic Minorities*, World Commission on Dams (Cape Town, 2000), p. 21.

163 *Ibid.*, p. 19.

164 Patrick McCully, see note 101, p. 70.

165 Marcus Colchester, see note 162, p 27

166 World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (Cape Town, November 2000), p. 103.

The La Grande (James Bay) project in Northern Québec would not have been possible without the relocation of the Crees of Fort George, one of the largest subsistence-oriented native communities in northern Canada, to the new village of Chisasibi. The project also dramatically affected the Crees' access to resources:

> [In] Chisasibi…with a population of roughly 2,500…we are dealing with two distinct groups, of hunters whose skills are linked to the use of coastal and estuarine resources, and of in-landers who hunt and trap in the hinterland, the region of the reservoirs and forebays of the La Grande project. Each group has been affected in different ways by hydro-electric development. The coastal people are faced with ecological changes associated with the radically altered flow regimes resulting from basin development and inter-basin transfers….
>
> "[T]he changed thermal regime of the La Grande river has made access to the north shore a major issue for the north coasters. The river remains open and the coastal ice is dangerous and unpredictable. … Evidently, patterns of land resource use have changed as a result, and will no doubt change further. There are long-range implications for land tenure and territorial organization…
>
> We know as well that the community fishery has declined sharply in the lower La Grande river. In part this is attributable to mercury, since the La Grande river, especially above the first rapids, is heavily contaminated. Above these rapids the river has been closed for fishing completely. Below them, there is a mix of fish, some with low mercury concentrations typical of the coastal environment, but others with concentrations some 20-30 times levels recorded before the hydro-electric development took place….Many families…decide simply to avoid fish altogether.[167]

The loss of water rights is a major issue for Native Americans in the U.S. West. As Colchester explains:

> "Under the so-called 'Winters Doctrine', Indian reservations have a paramount right not simply to the water necessary to meet their present needs but their future needs as well. This right has been consistently abrogated, however, with Native Americans being denied access to the water that should flow through their reservations in favour of non-Indians. Virtually every drop of the water accruing from the Missouri River Development Project, for example, was consigned to non-Indian use. In many cases, Indians, who have often suffered great hardship as a result of the denial of their water rights, have had to agree to "voluntarily" relinquishing those rights in order to obtain access to the water they required to fulfil their own development plans, for instance through extending irrigation.[168]

While those who are directly evicted from their homes are the most obvious victims of dams, a substantial part of the social impacts of dams derives directly from their ecosystem impacts, and thus can be thought of as a "fourth order" impact, following the schema described above. In this sense, just as the characterization of third order impacts is as varied as the ecosystems in which dams are imposed, so these fourth order impacts depend upon the precise way in which communities depend on the region's ecosystem.

Indirect social impacts are thus borne by those whose livelihoods and more generally whose cultures are dependent on healthy riverine ecosystems. These include commercial fishermen and ecotourism operators, but the brunt of these impacts are again felt by the subsistence economies of indigenous and peasant communities. Native American communities in the Pacific Northwest have been particularly hard hit by the drastic decline in salmon runs due mainly to dams. According to Ted Strong of the Columbia River Inter-Tribal Fish Commission, for the Yakama, Umatilla, Warm Springs and Nez Perce people, salmon remain "the core of our traditional culture and religion."[169]

Even when ecological modifications benefit certain species, human communities may be adversely affected. For instance, while the impoundment of large reservoirs in the James Bay region of northern Québec has resulted in increased populations of certain piscivorous fish species, the integration of methylmercury into the food chain has made them unfit for human consumption. Not only has this made it impossible to

167 Alan Penn, Testimony before the National Energy Board (4 February 1990).

168 Colchester, see note 162, pp. 39-40.

169 *Ibid.*, p. 40.

exploit these fisheries commercially, but the affected Crees have had to severely limit their consumption of fish, with important direct and indirect effects on their culture and on their health.[170]

Other social impacts can be separated into those related to the planning phase, the construction phase and the operation phase of the dam.[171] In the planning phase, which may extend over a period of decades, economic activity can be paralyzed due to uncertainty, resulting in lack of investment and land speculation.[172] In Northern Québec, the Cree community of Nemaska was resettled to make room for a planned reservoir that will probably never be built.[173]

While the economic activity related to dam construction is often vaunted as one of the great benefits of hydropower development, job creation is mainly limited to the construction phase. The Revelstoke Canyon dam in British Columbia generated over 11,000 person-years of employment during construction, but only 42 permanent jobs once the dam was completed.[174] For small projects, there may actually be no direct post-construction employment.[175]

In fact, boom-and-bust development can in the long run be one of the more severe social impacts of large hydro development. Boom communities are often characterized by runaway inflation and social problems such as alcoholism and prostitution. If the migrant labour force remains after the dam is built, as is often the case in the developing world, it can result in the creation of huge slums without jobs or social services.[176]

The opening of hitherto remote territories by roads built to permit dam construction and operation represents another important impact vector, resulting in ecological impacts from habitat fragmentation, increased pressure on certain species as sport fishers and hunters obtain access to a previously impenetrable region, and effects on the communities themselves, thanks to increased contact with the mainstream culture. While such access is often presumed to be desired by remote communities, that is not always the case. For example, the Cree community of Whapmagoostui in Northern Québec was strongly opposed to the Great Whale hydro project, important because it would have included road access to the south. The Cree concerns were based on their knowledge of the social problems that have plagued the neighbouring community of Chisasibi since the construction of the 15,000 MW La Grande (James Bay) project in the 1970s, which involved building a permanent road to this formerly isolated community.

Worldwide, dams have negatively impacted the health, happiness and economic well-being of vast numbers of people. While the number of dam-affected people in North America is less than in many other regions of the world, the harm has still been significant, especially for Native Americans and Canadian First Nations.

170 See note 122.

171 Joseph Milewski, London Seminar on Social Impacts of Large Dams (January 2000).

172 See Bartolome *et al.*, *The Social Impact of Large Dams: Equity and Distributional Issues (draft)*, WCD Thematic Study (4 April 2000), p. 25.

173 The community of Nemaska was resettled due to expected flooding by Hydro-Québec's planned Nottaway-Broadback-Rupert project, which has since been abandoned.

174 H. Brody, *Assessing the Project: Social Impacts of Large Dams* (1999), quoted in Bartholome *et al.*, see note 172.

175 According to the Doyon Commission, "Permanent jobs [resulting from development of small hydro projects] are for all practical purposes nonexistent, except for tourist activities. The operation of a small hydro facility creates virtually no employment, and indeed it must be so for it to be profitable. Monitoring and control are often carried out remotely. The sole local activity is that security and maintenance, which is carried out on a part-time basis." *Commission d'enquête*, see note 124, p. 238 (our translation).

176 Ferradas (1999), quoted in Bartolome *et al.*, see note 172.

6. Greenhouse gases

Despite initial skepticism, over the last decade a broad consensus has developed that greenhouse gas emissions are having a significant warming effect on the global climate. It was initially assumed that, since hydropower does not involve the combustion of fossil fuels, it would not contribute in any way to global warming. Indeed, even today, despite a broad scientific consensus that reservoirs are significant emitters of CO_2 and methane, national greenhouse gas (GHG) inventories generally fail to take account of any GHG emissions from hydropower. On the contrary, concern over global warming is generally seen by the hydro industry as a substantial business opportunity: "The growing awareness about global warming is thus a plus for hydroelectricity."[177]

The question of greenhouse gas (GHG) emissions from reservoirs first caught the public eye in 1993 with the publication of a paper by John Rudd and other scientists at the Freshwater Institute, a research centre of the Canadian Department of Fisheries and Oceans.[178] Coming at the height of a bitter debate over Hydro-Québec's proposed Great Whale project, Rudd's paper made headlines for suggesting that large hydro projects might be as bad as fossil fuel-based electricity, with respect to climate change.[179]

While the figures in Rudd's paper were widely quoted, he made quite clear that they were only estimations, based on assumptions about the total amount of biomass available for degradation to CO_2 and methane (CH_4), the rate of degradation, and other factors. Within a few years, however, direct evidence of substantial greenhouse gas emissions from reservoirs began emerging from research teams working in Canada, Finland, Brazil and French Guyana. These efforts are complicated by the methodological difficulties involved in determining how much gas actually emerges from a large reservoir (which can vary greatly according to reservoir depth, the season and the weather), and by the very limited funding that has been made available for this type of research to date.

Nevertheless, important advances have been made and, while some aspects remain extremely controversial, a broad consensus has emerged. In early 2000, the World Commission on Dams convened a workshop that brought together the leading researchers in this field from around the world, including those directly associated with or employed by the hydro industry. Following the workshop, a consensus statement was issued, which indicated agreement on among others, the following points:

1. All reservoirs emit greenhouse gases and continue to do so for decades, at least,

2. GHG emissions result not only from flooded biomass, but also from carbon transported by the river from the catchment area, and

3. the multiplier commonly used to convert methane emissions to "equivalent CO_2" significantly underestimates the climate change impact of reservoirs over the first several decades.[180]

These issues will be discussed in the following sections. Other issues addressed by the consensus statement include:

- the appropriate framework for the comparison of reservoir GHG emissions with alternative energy sources. It was agreed that these should be on a life-cycle basis and based on net emissions, taking into account the baseline emissions in the watershed before hydro development,

- emissions of methane and CO_2 from water passing through the turbines, over the spillway and downstream of the dam. It found that these may be significant, and that they depend largely on the depth of the turbine intake, and

[177] International Energy Agency Hydropower Agreement, *Hydropower and the Environment: Present Context and Guidelines for Future Action, Vol. II: Main Report* (May 2000), p. 88. This report has often been mistakenly attributed to the IEA itself. In fact, it is issued by the IEA "Hydropower Agreement," a group of nine countries with large hydropower industries that work under the IEA umbrella. According to Hanns-J. Neef, Head of Energy Technology Collaboration Division for the IEA, "the report, for which Hydro-Québec was the task leader, does not represent the opinion of the IEA as an international organisation."

[178] J.W.M. Rudd, R. Harris, C.A. Kelly and R.E. Hecky, "Are hydroelectric reservoirs significant sources of greenhouse gases?" *Ambio*, Vol. 22 (1993), pp. 246-248.

[179] The controversy intensified when Rudd's employers, Canada's Department of Fisheries and Oceans, forbade him to travel to present the paper at a New York legislative hearing.

[180] World Commission on Dams, *Dam Reservoirs and Greenhouse Gases: Report on the Workshop Held on February 24-25, 2000*, see note 130.

- the range of factors influencing GHG emissions. It was agreed that these include the reservoir's depth, shape and size, operating regime and water residence time, as well as the size and nature of the watershed.

6.1 All reservoirs emit greenhouse gases

According to the consensus statement:

> *"Greenhouse gases are emitted for decades from all dam reservoirs in the boreal and tropic regions for which measurements have been made. This is in contrast to the widespread assumption (e.g. IPCC scenarios) that such emissions are negligible. …* [T]he rates of GHG emission measured so far justify consideration of these emissions in:
>
> > (a) evaluating individual future reservoir sites, such as hydroelectric dams (most particularly in tropical regions); and
> >
> > (b) in global inventories of anthropogenic changes in the sources and sinks for CO_2 and methane."[181] (emphasis added)

While scenarios of the Intergovernmental Panel on Climate Change (IPCC) do not currently take reservoir emissions into account, the IPCC recommended in 1996 that they be assessed.[182] The researchers thus lend support to this call for careful studies to ensure that these emissions are reflected in national inventories.

Based on a review of experimental emissions findings, Canadian researcher Éric Duchemin has estimated that adding the unreported reservoir GHG emissions in Canada to official emissions figures would increase energy sector emissions by some 17%, and total national emissions by 3%.[183] Taking these emissions into account diminishes the apparent advantage enjoyed by hydro-dependent regions, and increases the reductions necessary to meet Kyoto Protocol targets in countries with significant hydro generation.

6.2 Emissions are not limited to carbon in flooded biomass, but are also fed by carbon from the entire watershed

One of the key questions in assessing hydro-related GHG emissions is whether or not they diminish over time. Initially, based on the assumption that emissions were simply due to the degradation of flooded biomass, it appeared that they would inevitably diminish over the years, as that biomass was consumed. However, recent research makes this assumption untenable.

In their consensus statement, the researchers agreed that "GHG emissions cannot be directly explained by the volume of submerged biomass nor its carbon content." Rather, the sources of the carbon emitted from reservoirs also include dissolved organic carbon, particulate organic carbon and organic debris from the catchment area.[184] The current understanding is thus that emissions are based not only on the carbon in the flooded biomass, but also on the degradation of organic debris swept downriver from the catchment area, which is then trapped in the reservoir and slowly digested by bacteria.[185] The initial assumption that emissions would taper off over time would therefore appear to be unfounded.

This view was recently confirmed by a team led by Marc Lucotte of the Université du Québec à Montréal (UQAM), whose findings suggest that, apart from a CO_2 spike in some cases that diminishes within a few years after impoundment, greenhouse gases are emitted continuously from hydroelectric reservoirs. First, the UQAM researchers compared emissions from boreal reservoirs from 1 to 90 years old, and found

181 *Ibid.*, p. 4.

182 IPCC, *Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analysis, Working Group II* (Cambridge University Press, 1995), p. 603.

183 Éric Duchemin, *Hydroelectricity and greenhouse gas emissions: Emission evaluation and identification of the biogeochemical processes responsible for their production*, Ph.D. dissertation (University of Québec at Montréal, Montréal, Québec, Canada, 1999), p. 294.

184 WCD Workshop, see note 130.

185 É. Duchemin, M. Lucotte and R. Canuel, "Production and emission of methane from flooded lands in hydroelectric complexes in the boreal region," *Proceedings of the Fourth International Symposium on the geochemistry of the Earth's Surface* (University of Leeds, Ilkley, 1996).

similar emissions from all.[186] Secondly, they compared emissions from reservoirs and from neighbouring lakes. In the temperate region of Québec, they found that emissions from the Manicouagan, Cabonga and Gouin reservoirs were similar to those from neighbouring lakes.[187] While hydro developers might take some comfort from learning that these reservoirs are no worse than natural lakes in terms of GHG emissions, it is less comforting to realize that before flooding, these areas were for the most part not lakes but forests, which are significant GHG sinks. Insofar as permanent sinks are replaced with permanent sources, the net emissions are even greater than the gross emissions from the reservoirs themselves.[188]

6.3 The global warming potential of methane

The fact that methane emissions from reservoirs are essentially constant, as opposed to a one-time event related to the act of impoundment, has important implications. Most studies reduce methane to its "CO_2-equivalent" using the IPCC's 100-year Global Warming Potential (GWP) for methane. This value is currently estimated at 21, meaning that a ton of methane would affect the atmosphere 21 times as much as a ton of CO_2.[189]

In their consensus statement, the researchers convened by the WCD agreed that the currently widespread use of the 100-year GWP for methane significantly underestimates its climate impact over the first several decades. The 100-year GWP represents the comparative impacts of one-time ("pulse") emissions of a ton of methane and a ton of CO_2 after 100 years, taking into account the fact that methane is oxidized to CO_2 in the atmosphere over a relatively short period. If one compares the global warming effect of these pulse emissions after 20 years instead of 100, the ratio increases to 56 times.[190] In the first year, radiative forcing caused by a ton of methane in the atmosphere exceeds that of a ton of CO_2 by a factor of 91.[191]

If methane emissions were indeed a one-time event (even if spread out over several decades), resulting from the degradation of the soils, plants and other biomass submerged when the reservoir was impounded, this "pulse" approach might well be appropriate. However, to the extent that emissions are continuous, an entirely different methodology is required.[192]

Stuart Gaffin of the Atmosphere Program of Environmental Defense has developed a model for assessing the climate change impact of continuous emissions of methane compared to CO_2, based on determining the CO_2 emissions profile necessary to duplicate the radiative forcing of a given methane emissions profile.[193] As noted above, in the first year of emissions, one ton of methane is climatically equivalent to 91 tons of CO_2. According to Gaffin's model, the ratio declines exponentially to a level of about 30:1 after 30 years, only to rebound to about 40:1 later in the century, as shown by the middle curve in Graph 7 (on page 54).[194]

186 Université du Québec à Montréal, Chaire de recherche en environnement HQ-CRSNG-UQAM, *Étude sur la production et l'émission de gaz à effet de serre par les réservoirs hydroélectriques d'Hydro-Québec et des lacs naturels - Volet 2,* study commissioned by Hydro-Québec (December 1999), p. 36.

187 *Ibid.*, pp. 19-28. Emissions from natural lakes in the boreal region, however, were below the limits of detection, and thus substantially lower than those from the La Grande reservoirs.

188 As noted above, the WCD consensus statement also recommended that analysis of the GHG impacts of reservoirs and their alternatives be based on net emissions rather than gross emissions. WCD Workshop, see note 130.

189 This value has been adjusted several times in the last few years.

190 WCD Workshop, see note 130.

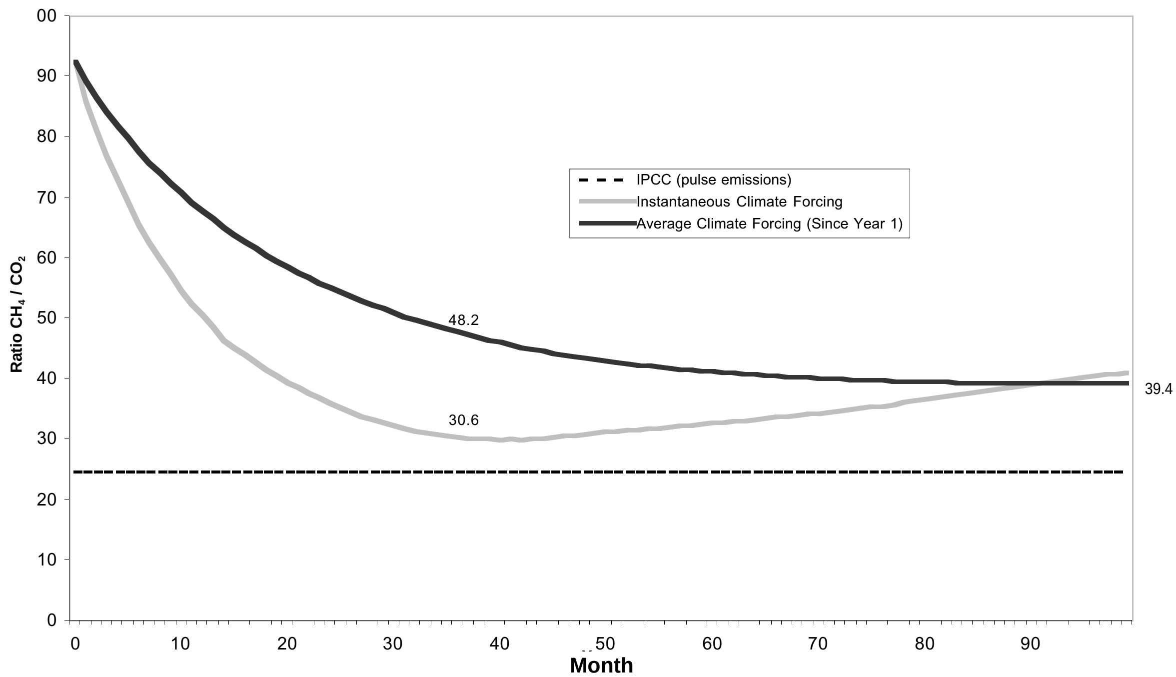
191 Stuart R. Gaffin, *Comparing CH_4 Emissions from Hydropower to CO_2 from Fossil Fuel Plants, Submission to the World Commission on Dams* (1999), p. 12.

192 Luiz Pinguelli Rosa and Marco Aurelio dos Santos, *Certainty and Uncertainty in the Science of Greenhouse Gas Emissions from Hydroelectric Reservoirs: A report on the state of the art for the World Commission on Dams, Final Report,* p. 36.

193 Gaffin, see note 191.

194 This rebound effect is due to the uptake of atmospheric carbon by carbon sinks. Just as the absolute radiative forcing of methane emissions declines over time (due to oxidation), the absolute forcing of CO_2 does as well (due to absorption by sinks), but on a much slower timeframe. Thus, the numerator of the CH_4:CO_2 forcing ratio declines rapidly, resulting in a quick drop in the early years; the denominator declines more slowly, resulting in a partial rebound starting around year 40. Stuart R. Gaffin, pers. comm.

Graph 7: Climate Change Impact (methane compared to CO_2)



The upper curve, on the other hand, represents the average (and hence cumulative) warming impact for an installation that emits a ton of methane per year, compared to one that emits a ton of CO_2 per year. This cumulative average reflects the warming caused by these emissions since the plant was built. Thus, for example, the climate forcing in year 35 due to the methane emitting plant is some 30 times greater than that of the CO_2 emitter, however, its *cumulative* impact is more than half again as great (48.2 times that of the CO_2 emitter), reflecting the warming that took place in the early years, when the forcing ratio was much higher. After 100 years, the cumulative global warming effect of a constant methane emitter is some 39.4 times greater than that of a constant emitter of an equivalent quantity of CO_2.

6.4 Emission ranges

As noted above, early estimates of reservoir GHG emissions were theoretical, based on estimates of the rate of decay of flooded biomass. In recent years, however, empirical studies on GHG emissions from a number of reservoirs in different parts of the world have begun to allow a quantitative assessment of these emissions.

Relying on studies of his own team as well as those of other groups, Duchemin found mean net emissions in the boreal region of up to 60g CO_2-equivalent per kWh, whereas in tropical reservoirs they range from 200 to 3,000g/kWh.[195]

These reservoir emission figures are based on the 100-year Global Warming Potential (GWP) for methane. Using a higher multiplier to reflect the fact that methane emissions are continuous over the long term, as discussed in the previous section, can only increase the climate impacts of reservoirs, especially tropical reservoirs, where methane emissions are much greater than in temperate and boreal regions.

Using the radiative forcing values for methane derived from Gaffin's model, Duchemin found that gross emissions increase by approximately 25% for deep tropical reservoirs, 50% for temperate and boreal reservoirs and 90% for shallow tropical reservoirs. The adjusted emissions for boreal reservoirs range up to 90g/kWh CO_2 equivalent for the Churchill Falls complex in

[195] Duchemin, see note 183, p. 311.

Labrador, and 75g/kWh for the massive La Grande project.[196] For tropical reservoirs, estimated emisssions range from around 250 g/kWh for Tucuruí to 5,700 g/kWh for Curuá-Una;[197] unit emissions from the Balbina project are vastly higher, as it produces very little energy.

In contrast, CO_2 emissions from state-of-the-art natural gas fired combined cycle plants are between 300 and 400g/kWh CO_2.[198] When the heat from such facilities is used to replace inefficient boilers and produce useful heat as well as electricity ("combined heat and power," also known as cogeneration), the net emissions can be as low as 135g/kWh CO_2 (or around 260g/kWh on a life-cycle basis).[199]

Thus, emissions from even the best tropical reservoirs are only slightly lower than those of a modern gas plant; tropical projects with shallow reservoirs such as Curuá-Una display emissions more than ten times as great. Boreal hydropower, on the other hand, does enjoy a certain advantage over combined-cycle gas plants. However, this advantage shrinks markedly when compared to cogeneration.

6.5 Methane's role in global warming

In an influential series of articles in the *Proceedings of the National Academy of Sciences,* James Hansen of NASA's Goddard Institute for Space Studies and his colleagues argue that the cooling effects of sulphates and organic aerosols released when coal and oil are burned have offset much of the radiative forcing due to CO_2 over the last hundred years. However, since aerosols are not long-lasting, their offsetting effect depends on current levels of emissions and not historic ones. Due to the declining growth rate of fossil fuel usage, the long-term warming caused by emissions over the last century has begun to overshadow the short-term aerosol cooling effect, allowing the underlying warming trend to emerge.[200] Therefore, they suggest that other greenhouse gases such as methane, N_2O and CFCs are considerably more important than CO_2, on a relative basis.[201]

The unavoidable conclusion is that a ton of CO_2 or methane emissions that is accompanied by pollutants such as SO_2 and organic aerosols is less harmful to the global climate than one that is not (state-of-the-art natural gas generation, fuel cells, hydropower).[202] This finding may be inconvenient for those who would make GHG emissions the sole indicator of environmental performance. However, insofar as environmental preferability involves integrating all known environmental and social impacts, one would nevertheless expect clean generation to emerge superior to polluting generation, even if the latter obtains a partial countervailing benefit against its GHG emissions.

Hansen's finding is, however, relevant to the characterization of GHG emissions from reservoirs. While it does not affect the results of a comparison between greenhouse gas emissions from reservoirs and from efficient natural gas plants (which produce little or no aerosols), statements comparing the global warming impacts of hydropower to those of traditional fossil fuels should be nuanced to take into account the protective effect of aerosols.

The second Hansen paper made headlines for its suggestion that climate catastrophe may be avoidable. Whereas, under the scenarios developed by the IPCC, even meeting the Kyoto objectives would have little effect on warming in the 21st century, Hansen argues that, given the mitigating effect of aerosols on CO_2-forced warming, most of the warming that has been observed to date has been caused not by CO_2 but by methane, CFCs and tropospheric ozone. Of these, he singles out methane as causing the largest net climate

196 These emissions estimates are several times greater than those recognized by the hydro industry. Hydro-Québec claims that the average emissions of its total system (which includes some fossil fuel power as well as hydro) are just 21g/kWh. Deloitte and Touche, Chartered Accountants, Electricity Sold by Hydro-Québec: Energy Supplies and Atmospheric Emissions (29 November 1999).

197 Duchemin, unpublished data.These tropical estimates do not include methane emitted from water passing through turbines or over spillways, which may increase emissions substantially. Other researchers have proposed substantially higher emissions for Tucuruí (see WCD, note 130, p. 77).

198 However, taking into account natural gas leakage during production and transmission increase this total by almost a third, on a life-cycle basis, to around 500g/kWh. P.L. Spath and M.K. Mann, "Life-Cycle Assessment of a Natural Gas Combined-Cycle Power Generation System," National Renewable Energy Laboratory (Golden, Colorado, 2000).

199 Philippe Dunsky, unpublished data.

200 J. Hansen *et al.*, "Climate forcings in the industrial era," *PNAS*, Vol. 95 (October 1998), p. 12,757.

201 J. Hansen *et al.*, "Global warming in the twenty-first century: An alternative scenario," *PNAS*, Vol. 97 (August 2000), pp. 9,875-9,880.

202 On the other hand, black carbon (soot), emitted primarily from burning coal, further contributes to warming.

forcing and thus offering the greatest management possibilities. In consequence he proposes a scenario based on a 30% reduction in methane emissions over the next 50 years as the earth's best chance to tame human-induced climate change.

Such a strategy cannot afford to ignore the high methane emissions that we now know are associated with dams, especially in the tropics. In a recent review of reservoir emissions studies performed worldwide, Canadian researchers estimate that CO_2 emissions from reservoirs are equal to 3.7% of all other anthropogenic CO_2 emissions — an amount that certainly would justify their inclusion in national GHG inventories. The contribution of reservoirs to worldwide anthropogenic methane, however, is even greater: an astounding 17.2%, which is more than the estimated contribution from rice paddies or from the burning of biomass worldwide.[203]

The unavoidable conclusion is that reservoirs are a significant source of anthropogenic methane emissions, which play a significant role in global warming. Reducing methane emissions by 30%, suggested by Hansen *et al*. as the most achievable scenario for avoiding a climate catastrophe, is thus probably incompatible with the large new hydropower developments foreseen by some as the solution to global warming. As we shall see in the next section, this finding is of considerable significance to the evolving debate over the Clean Development Mechanism of the Kyoto Protocol.

6.6 The Clean Development Mechanism of the Kyoto Protocol

The Kyoto Protocol, signed in December 1997, creates, for the first time, specific obligations on developed countries to substantially reduce their emissions of greenhouse gases. The Kyoto Protocol is an instrument of the Framework Convention on Climate Change (FCCC), signed in June 1992 at the Earth Summit in Rio de Janeiro. The FCCC has been ratified by more than 100 countries and came into force on 21 March 1994.

In December 1997, ministers and other high-level officials from 160 countries met in Kyoto, Japan, for the Third Conference of Parties (COP3) of the FCCC and agreed to the Kyoto Protocol, whereby industrialized countries must reduce their collective emissions of greenhouse gases by 5.2% by the period 2008 to 2012. The United States is committed to reducing emissions to 93% of their 1990 levels; Canada's commitment is to reduce them to 94% of the 1990 baseline.

The Kyoto Protocol will be legally binding once it is in force, which will occur when 55 of the 84 signatories have ratified it, including countries accounting for at least 55% of the total 1990 CO_2 emissions from developed and transitional countries.[204] This threshold creates a *de facto* veto for the United States, where ratification now appears unlikely. These political considerations create a pall of uncertainty which greatly complicates the already difficult issues related to Kyoto compliance.

One important feature of the Kyoto Protocol is the Clean Development Mechanism, or CDM. Once implemented, the CDM would allow credits resulting from emissions reductions in developing countries to be applied to emissions reduction commitments of developed and transition countries. In order to produce credits that can be used by these countries against their Kyoto commitments, emission reductions from CDM projects must be certified, based on "real, measurable and long-term benefits" related to the mitigation of climate change.

Furthermore, the project must be "additional" to any that would otherwise occur, and it must "contribute to achieving sustainable development." While this "sustainability" criterion has yet to be fleshed out, it is expected to require that a project not cause significant other environmental problems, and that it provide direct benefits to local communities.[205]

203 Vincent L. St. Louis, Carol A. Kelly, Éric Duchemin, John W. M. Rudd, and David M. Rosenberg, "Reservoir surfaces as sources of greenhouse gases to the atmosphere: a global estimate," *BioScience*, Vol. 50, No. 9 (September 2000).

204 To date, 22 nations have ratified the Protocol, accounting for a fraction of 1% of the target emissions. No developed or transition countries have yet ratified the Protocol.

205 Center for International Environmental Law, "Designing a Legal and Institutional Framework for the Clean Development Mechanism," *Linkages*, Vol. 4, No. 4 (October 1998), p. 26.

The hydropower industry, supported by the governments of the U.S. and Canada, is urging that hydro projects be deemed eligible for the CDM, hoping thereby to overcome the difficulty of obtaining private-sector financing for large-scale hydro projects in developing countries. Others, however, argue that because of the significant environmental impacts associated with large-scale hydropower, it should not be eligible under the CDM, even if it were judged to meet the other criteria.[206]

While it has long been assumed that developing new hydropower resources in developing countries would inevitably result in significant climate change benefits compared to the energy alternatives that would otherwise be developed, the findings described in this chapter cast serious doubt on this assumption. As we have seen, GHG emissions from tropical hydro developments are in the best cases only slightly lower than those of efficient thermal power, and in many cases are several times greater. While actual determination for an individual project would have to be based on detailed baseline studies, generally speaking, the methane emissions from tropical hydropower are such that it should no longer be thought of as a low-GHG resource. Thus, the logic of subsidizing and encouraging tropical hydropower developments via the Clean Development Mechanism is increasingly untenable.

[206] See, for example, World Resources Institute, *Financing Sustainable Development with the Clean Development Mechanism* (March 2000).

7. Factors affecting the impacts of hydropower

7.1 Effects of design and operating choices on impacts

More than any other generating technology, the environmental impacts of hydropower vary enormously depending on the characteristics of the individual facility. Based on the brief overview of the environmental and social impacts of hydropower provided in Chapter 5, one can begin to assess relationships between a project's site, its design, its operating regime and its impacts.

The fundamental characteristics of a hydro site depend on the river's topography and the natural flow regime (average annual flow and the typical seasonal pattern). Within these constraints, the developer has a great range of choices, all of which are inter-related and affect both the economics and the eventual environmental impacts of the facility. The choices to be made include:

- how to design the facility in order to maximize the head (the vertical distance the water can be made to fall before hitting the turbines),
- whether to impound a reservoir above the dam, in order to shift flows from one time period to another and to increase the head, and if so, of what size (storage capacity),
- the size and number of turbines to install (installed capacity),
- whether to direct other watercourses into the impoundment (or into the dammed river farther upstream), in order to increase flows and thus annual energy production,
- whether the dam is to be part of an integrated hydro complex involving several dams on the same river system,
- whether the turbined water is to be returned to the streambed immediately below the dam, or whether to increase the head by guiding it further downstream via a long penstock, bypassing part of the streambed (the "bypassed reach"),
- the temporal pattern of flows through the turbines, and
- the amount of water, if any, that will be allowed to flow down the bypassed reach (or over the diversion dikes upstream) in order to mitigate environmental harm.

These choices made by the developer will to a large extent determine the project's costs, the value of the power it generates and the extent of its environmental impacts.

7.2 Run-of-the-river hydro

The question of whether or not to create an impoundment is perhaps the most important choice facing a developer. If there is no impoundment at all, and hence no storage capacity, the water must be turbined as it arrives from the catchment area. Such a facility is referred to as "run-of-the-river."[207] Such a facility will cost less to develop than a storage facility, but its power benefits will also be lower (limited ability to produce during peak periods; need to spill during flood periods).

For run-of-the-river facilities, the choice of installed capacity (turbine size and number) determines how much water can be turbined at any given moment and, by extension, how much of the river's annual flow will be available for electricity generation. Most free-flowing rivers display significant seasonal flow variation. The larger the installed capacity, the greater the percentage of the peak flow that will be usable for generation.

Greater installed capacity will thus provide more power during the high-flow periods and more energy over the course of the year. However, it will run below its full capacity much of the time, or even be unable to produce at all.[208] If the developer chooses instead to install smaller or fewer turbines, the project's power output will be much more constant, and its capacity factor will be greater. However, water will be spilled whenever flows exceed their capacity. As turbines are among the most expensive elements of building a hydro station, developers pay great attention to optimizing installed capacity on an economic basis.

207 As noted earlier, this term is used in a number of different ways. Many facilities commonly described as run-of-the-river do have a certain amount of storage capacity.

208 Hydraulic turbines require a certain percentage of their maximum flow capacity to generate electricity.

7.3 Storage hydro

Adding a reservoir to provide storage capacity changes the picture dramatically. Whereas with a run-of-the-river system, generation rises and falls with the river's flow, once there is storage capacity, production can be timed to correspond to periods of peak demand.[209] Thus, even if the turbine is sized well below the river's natural peak flow, no water needs to be spilled (e.g., during the spring flood); it can be stored in the reservoir and turbined at a later time.

Storage hydro can thus be designed to turbine the river's entire annual flow without spillage, except insofar as environmental flows are required. When these are meant to ensure minimum flows in the downstream environment, these flows limit the operator's flexibility; however, when they are designed to provide minimum flows in the bypassed reach or downstream of a diversion dike, they directly reduce total power generation. In either case, it is in the owner's economic interest to keep them to a minimum, to the extent allowed by regulators.[210] Once these flows are determined, the developer will optimize the installed capacity.

It should also be noted that, in the event that other dams have been built (or are planned) upstream, the facility may obtain the benefits of flow regulation ("buffering" of flood and drought flows, shaping of flows to approximate demand shape) even if there is no storage capacity directly associated with it. If the facilities are part of an integrated complex, flows will be optimized taking both dams into account, even though the downstream facility is technically "run-of-the-river."[211] If, on the other hand, the upstream facility is separately owned and operated, the downstream operator will have no control over the flows that arrive at his facility (absent a negotiated water management agreement). Since the upstream operator is probably selling into the same market as the downstream operator, in many cases the flow regime will be favourable to the latter as well. However, if the upstream operator has a higher flow capability, the downstream operator may at times be forced to spill.

7.4 Design choices

As we have seen, the developer's design choices can dramatically affect the environmental and social impacts of a hydro project for a given site. Among those design choices that lead to higher impacts are:

- **river diversions –** loss of flow on a permanent basis from the diverted river can irreversibly alter the downstream ecosystem. The increased flow in the recipient river can also be disruptive;[212]

- **flooding –** all else being equal, there is little doubt that impacts increase with the territory flooded. However, all habitat is not equal, and detailed ecosystem studies are necessary in order to adequately assess the importance of the lost habitat. As for greenhouse gas emissions, they vary not only with the extent of the flooding, but also with the climatic region, the type of lands that are flooded and the operating regime. Methane emissions are highest in tropical areas; in northern regions, flooded peat bogs produce greater emissions than do forest soils. Shallow reservoirs and those with substantial drawdown zones generally produce greater emissions than do deep ones with stable banks. All else being equal, projects with rapidly fluctuating water levels probably produce a higher proportion of methane — and thus higher total GHG emissions — than do those with stable water levels. However, it is not possible at this time to predict with any degree of certainty the actual GHG emissions of a planned reservoir;

- **bypassed reaches –** unless very substantial environmental flows are provided for in the bypassed reach, the local ecological impacts may be catastrophic. The larger significance of these impacts depend on the extent of the bypassed reach and on the importance of the lost habitat for the larger ecosystem. Projects which are designed with substantial bypass – the Great Whale project would have dried up the last 40 km of the Great Whale River – are almost inevitably high-impact projects;[213]

209 In a monopoly context, this helps the utility to meet its obligation to provide service at all times. In a market context, it allows the generator to sell his output when prices are highest.

210 There is great variation in these requirements. See Section 7.6, below.

211 It might be more appropriate to call such a facility "run-of-the-reservoir." Examples of this type of facility are the LG-1 dam on Hydro-Québec's La Grande system, which is regulated by the large Robert-Bourassa and Caniapiscau reservoirs upstream, and the projected Lower Churchill project in Labrador. Since such a facility shares the benefits of the upstream reservoir, it should probably be deemed responsible for a share of the impacts as well.

212 An example is the Eastmain River in northern Québec, which lost 92% of its flows to the La Grande project. Thanks to this and other diversions, average annual flows in the lower La Grande have doubled from pre-project levels, as described in note 144.

213 Sophisticated flow management can go a long way toward mitigating these impacts. However, the reduction in energy production — and hence the increase in unit costs — can be substantial.

- **chain of reservoirs –** hydroelectric complexes in which the reservoir behind one dam stretches almost to the tailrace of the dam above it create system-wide fragmentation, with tributaries often severed from the mainstem and from one another. With most or all of the river converted to flatwater, no habitat remains for species that require rapids, riffles or pools for all or part of their lifecycle;

- **high dams –** for rivers that are home to migratory species of fish, high dams often pose impossible obstacles. Enormous quantities of money have been spent in the last 10 to 20 years to mitigate these impacts, but with only limited success.

It is important to realize that these design choices are suggested — but not dictated — by the physical and hydrological characteristics of site itself. Traditionally, hydro facilities are designed in order to optimize their economic and energy performance, with measures to mitigate their environmental impacts only added at a later stage. However, certain design choices create major, and largely unmitigable environmental impacts. In a monopoly/planning context, it is thus incumbent on the regulator to ensure that environmental criteria are given sufficient importance, requiring developers to choose lower-impact designs even if they result in increased unit costs.

Even in a market context, government and/or regulatory approvals will always be required for building hydro projects, as they involve the exclusive attribution of hydraulic force to a single developer as well as the right to construct on a public waterway. Thus, regardless of the structure of the electricity market, the right to build can be conditioned on project design that minimizes environmental impacts.

Furthermore, developers will have an economic incentive to design projects that can obtain certification as “low impact” power, as such certification will increase the value of the power produced by the facility (see Chapter 8).

7.5 Size

In recent years, the assumption that small hydro facilities are environmentally benign has been subject to considerable scrutiny. It is increasingly clear that small dams are responsible for substantial environmental harm. A vigorous movement has arisen in the United States to substantially modify the way dams are operated in order to mitigate their impacts, or, in some cases, to remove them.[214]

This movement has achieved a degree of success in relicensing proceedings before FERC,[215] and has provoked an emphatic response from the hydropower industry.[216]

Far from accepting the intuitive notion that small dams are less destructive than large ones, the hydropower industry argues the opposite:

> [O]ne large hydroelectric facility is generally less damaging to the environment than the cumulative impacts of smaller hydroelectric facilities yielding the same power and generating capacity. Because a small reservoir has a higher surface area to volume ratio than a large one, it actually takes about 7 times the surface area to generate one MW of electricity from small plants (smaller than 100 MW) than from large ones (1000 MW and larger).[217]

This argument is misleading in several ways. First, the comparison addresses reservoir size, which is proportional to storage capacity, not to energy production. Storage capacity undoubtedly confers important power benefits, allowing the operator to “regulate” generation to meet demand peaks. However, as we have seen, such regulation also comes at an environmental price, as downstream river flows are raised and lowered out of sync with natural cycles. Upstream of the dam, the reservoir’s shoreline can withdraw by hundreds of feet, again entirely out of sync with natural cycles. The resulting ecosystem harm is not factored into this simplistic comparison.

214 Bruce Babbitt, Secretary of the Interior in the Clinton administration, has become a vigorous advocate for dam removal. “In some places, the call for removing a dam is so easy to make, one wonders why it took so long.” “A River Runs Against It: America’s Evolving View of Dams,” *Open Spaces* (22 January 2001).

215 Most hydro facilities in the U.S. operate under 30- to 50-year licenses granted by FERC. Due to significant changes in the *Federal Power Act* in the 1980s, these relicensing proceedings have taken on considerable importance. As discussed below in Section 7.6, relicensing often leads to significant changes in flow regime to eliminate effects experienced during the term of the original license. Though rarely used, FERC also has authority to require owners to remove dams at their own expense.

216 An association called *Waterpower: The Clean Energy Coalition* has been created to lobby for legislation that would streamline the relicensing process. Its spokesperson is former FERC chair Elizabeth Moler. “New Coalition Calls On Congress to Improve Hydropower Licensing Process,” (13 October 2000). <http://www.water-power.com/>

217 Hydro-Québec, *Environment and Electricity Restructuring in North America*, Paper presented to the North American Commission for Environmental Cooperation (CEC) (June 2000), p. 6.

More importantly, many large facilities affect entire watershed ecosystems in ways that small facilities do not, resulting in ecological impacts that are not only quantitatively more severe than those of small projects, but qualitatively as well. The vast majority of the environmental impacts described in the literature referred to in Chapter 5, above, have been caused by large-scale hydro projects. Many of these impacts may well occur on a limited scale from small projects, particularly when there are multiple dams on a river. However, the gravest environmental and social impacts, such as relocation of communities and extirpation of native species are primarily associated with large hydro.

It is of course important to recognize the scale of the power benefits from a particular project in evaluating whether its impacts are acceptable. To the best of our knowledge, no satisfactory indicator has yet been developed to reflect the varied and complex impacts of hydropower, making impossible any straightforward comparison of a given project's power benefits to its environmental costs.

Such judgement calls are never value-free, but rather depend on cultural, political and societal values. Given the very unequal distribution of dams' costs and benefits, emphasized by the World Commission on Dams, international technocrats, utility planners and "oustees" are unlikely to agree on what is "acceptable."

As we have noted, planning processes designed to make these judgment calls through a transparent and technically sophisticated process, in which those who would bear the brunt of the impacts play a significant role in the decision-making process, have largely disappeared thanks to competitive restructuring of the electricity sector.[218] Developing mechanisms that can function within a competitive electricity market to ensure that inappropriate hydro projects are not built remains one of the great challenges of electricity restructuring. We will return to this question in Chapter 11.

7.6 Operating regime

The regime under which a hydro facility is operated can also substantially affect its environmental impacts, though perhaps to a lesser extent than design choices. The operating regime refers primarily to the question of flows — the volumes of water that are passed through the turbines or over the spillway, or that are released from diversion dikes. The temporal pattern of these releases, in combination with the temporal pattern of inflows (due to seasonal and meteorological variability) determine the variation of water levels in the reservoir and of flow rates downstream. As we have seen above, these water level and flow variations are very significant determinants of the facility's effects on a wide variety of ecosystem components.

Generally speaking, the greater the drawdown and the more its frequency and timing are out of sync with natural rhythms, the greater the ecological impacts on the reservoir and its surroundings. Downstream, impacts are related to flows below or above those provided by the natural regime, and to flow variations unconnected to natural rhythms.

Defining a low-impact flow regime thus involves specifying not only minimum flows but also seasonal limits and ramp rates (the rate at which flows can be "ramped" up or down). More sophisticated flow regimes modulate the required flows depending on whether it is a wet or dry year, and provide for seasonal flood flows as well.[219]

While project siting and design are set once the facility is built, the operating regime can be changed at any time, making it the most important way to reduce the impacts of an existing project. Indeed, this is the reasoning underlying the World Commission on Dams' recommendation that, "All large dams have formalised operating agreements with time-bound licences." It also underlies the certification criteria of the Low Impact Hydropower Institute (see Chapter 8).[220]

In the U.S., most hydropower facilities are licensed by FERC. Under the original *Federal Power Act* (FPA), adopted in 1920, projects had to be "desirable and justified in the public interest," but there were few, if any, environmental constraints placed on the design or operation of hydro plants. In 1967, however, the Supreme Court expanded the meaning of this expression by indicating that:

> the determination [of whether or not a project is in the public interest] can be made only after an exploration of all issues relevant to the public interest, including future power demand and supply, alternate sources of power, the public interest

[218] FERC still has a mandate under the *Federal Power* Act to ensure that hydropower developments are in the public interest.

[219] An example of such a sophisticated flow regime is the one recently proposed for the Potter Valley Project in northern California. See note 128.

[220] World Commission on Dams, see note 164. Such time-limited licenses are standard in the U.S., but not in Canada.

> in preserving reaches of wild river and wilderness areas, the preservation of anadromous fish for commercial and recreational purposes, and the protection of wildlife.[221]

The *Electric Consumers Protection Act* (ECPA) of 1986 modified the FPA to make explicit the issues that FERC must consider before issuing a license. In particular, ECPA modified Section 4(e) of the Federal Power Act to read as follows:

> … in deciding whether to issue any license [for a hydroelectric project], the Commission, in addition to the power and development purposes for which licenses are issued, shall give *equal consideration to the purposes* of *energy conservation, the protection, mitigation of damage to, and enhancement of, fish and wildlife* (including related spawning grounds and habitat), *the protection of recreational opportunities, and the preservation of other aspects of environmental quality.* (emphasis added)

Because the current licensing standards are so much stricter than they were 50 years ago, relicensing hearings before FERC have become the prime forum for addressing the environmental impacts of existing hydro facilities. This has led to increasingly more restrictive flow regimes, as mentioned above.

It is difficult to generalize as to Canadian practice in this regard, as each province is largely responsible for its own licensing procedures.[222] Many projects have been approved, even in recent years, without any flow requirements at all. In other cases, simple minimum flows have been established, but without seasonal limits or ramp rates, much less the sophisticated features that have emerged from FERC relicensing proceedings over the past decade.

Generally speaking, Canadian environmental legislation is procedural rather than normative. That is, with certain exceptions, authorization of specific projects is subject to ministerial discretion rather than predetermined norms; laws and regulations are designed primarily to establish procedures that must be followed to ensure that that discretion is exercised judiciously, rather than to set up objective standards for acceptable impacts.[223]

A full review of provincial licensing requirements, practices and procedures is beyond the scope of this report. Nevertheless, there is growing need for such a review, as the internationalization of electricity markets is making environmental comparability between the U.S. and Canada increasingly important. We will address this question is greater detail in Chapter 8, on green power marketing.

7.7 Impact mitigation

Various measures have been developed and implemented in different regions to mitigate the environmental impacts of hydropower development, with varying degrees of success. Indeed, the effectiveness of these measures is often hard to assess, as post-construction monitoring often leaves much to be desired.

More and more, however, it is recognized that the most effective ways to mitigate these impacts is to avoid creating them in the first place. Thus, many of the most effective so-called mitigation measures are in reality lower-impact choices with regard to the siting, design or operating regime of the planned hydropower facility.

This conclusion emerges from a report issued recently by the IEA Hydropower Agreement.[224] While the general thrust of the report is unashamedly pro-hydro, it nevertheless finds that the most effective measures to mitigate the impacts of reservoir impoundment are to avoid them in the first place — by minimizing the areas to be flooded (design) and by reducing the water residence time (operating regime).

Similarly, the most effective steps identified by the report to avoid loss of biodiversity are also primarily based on siting and design, together with increased protection for areas not affected by the dam.

> The most effective steps to avoid loss of biological diversity are as follows:
>
> - choose a reservoir site that minimizes loss of exceptional ecosystems,
>
> - try to limit as much as possible the size of reservoir, per unit of energy produced…[225]

221 387 U.S. 428 (1967) at 450, quote in J. D. Echeverria, P. Barrow and R. Roos-Collins, *Rivers at Risk: the Concerned Citizen's Guide to Hydropower* (Island Press, 1989), p. 45.

222 Under the Canadian Constitution, natural resources are a provincial jurisdiction.

223 On this question of discretion, see the excerpt from a judgement of the Québec Court of Appeal on p. 72.

224 International Energy Agency Hydropower Agreement, see note 177.

225 *Ibid.*, p. 92.

In addition to impact avoidance, mitigation measures include the use of weirs, fish ladders, fish capture and transportation, planting and seeding of banks, and so on. Space does not permit a full review of the effectiveness of these types of measures. However, the net benefits of mitigation efforts tend to be small compared to the environmental impacts they seek to mitigate, and the costs of more effective measures are often prohibitive.

For example, a review of the mitigation efforts undertaken by Hydro-Québec's subsidiary the James Bay Energy Corporation at the massive La Grande project found that:

> None of [JBEC]'s experiments in correction were dramatically successful. Most were neutral, or made limited, local biological improvements — and did so at considerable expense. By any general measure of ecological health, there is little if any difference between the mitigated and the unmitigated project; that is, the residual (post-mitigation) impacts are for the most part, those that were predicted for the hydro project.[226]

The limits of effectively mitigating the major ecological impacts of hydropower were acknowledged by Hydro-Québec in its assessment of the Sainte-Marguerite project:

> If one compares [the table of residual impacts] with [the table showing predicted impacts before mitigation], it is seen that no impact is sufficiently mitigated to change its overall degree. … [This is explained in part because] the remedial measures are only applied to a part of the disturbed element … and thus do not change the global evaluation of the impact for the resource as a whole. Finally, *a hydroelectric project of [this] size involves permanent changes to the milieu that cannot be mitigated …* (emphasis added)[227]

These same conclusions were reached by the World Commission on Dams, which found that "efforts to avoid or minimise impacts through choice of alternative projects or alternative designs were more successful than efforts to manage the impacts once they were built into the design of the dam."[228] In its "cross-check" survey, it found that only 20% of mitigation measures worked effectively, and that 40% did not mitigate the impact at all.[229]

In many cases, the results of mitigation efforts are primarily cosmetic, as utilities naturally focus their efforts and their budgets on problems that can be easily seen, tending to ignore those that cannot:

> Efforts to establish attractive environments near busy areas — one of the developers' three main mitigation aims — were indeed effective. The former construction sites and the rivers with reduced flow look less damaged than they would if mitigation had not been undertaken.[230]

With few exceptions, however, good data does not exist as to the effectiveness of mitigation practices. A 1991 survey of environmental mitigation practices at 280 hydroelectric projects in the U.S. by the Department of Energy found performance monitoring to be so uncommon that it was unable to draw any conclusions at all as to their effectiveness.[231]

[226] McCutcheon, see note 117.

[227] Hydro-Québec, *Aménagement hydroélectrique Sainte-Marguerite-3, Rapport d'avant-projet* (1991), p. 13, quoted in *Ibid.*, pp. 66-67.

[228] World Commission on Dams, see note 166, p. 90. The Commission also states that, "The primary option for avoiding ecosystem impacts from large dams has been not to build the dams in the first place," p. 91.

[229] *Ibid.*, p. 91.

[230] McCutcheon, see note 117, p. 68.

[231] M. J. Sale *et al.*, *Environnemental Mitigtion at Hydroelectric Projects: Vol. 1, Current Practices for Instream Flow Needs, Dissolved Oxygen and Fish Passage*, DOE/ID-10360 (December 1991).

Part III

Addressing the Impacts of Hydropower in a Competitive Environment

PART III: ADDRESSING THE IMPACTS OF HYDROPOWER IN A COMPETITIVE ENVIRONMENT

As we saw in Part I, competitive restructuring of the electric industry has radically altered the context in which decisions about hydropower are made. We have also seen in Part II that hydropower often involves substantial impacts on ecosystems and societies, as well as contributing to global climate change.

At the end of Part I, we made reference to a broad range of tools that have been developed to ensure that externalities are not ignored in restructured electricity markets. In the following chapters, we will look at how these mechanisms have been applied — and how they should be applied — to hydropower.

The restructuring that has largely taken over the electric power industry in the U.S., parts of Canada and much of the rest of the industrialized world means that, in many regions, the choice of energy supply will eventually be made by the consumer, not by the electric utility. As a consequence, the choice of *future* energy supply will largely be made not by a regulatory planning process, but rather — like in other competitive industries — by private companies making at-risk investments, based on their own estimations of future consumer demand and preferences.

As we saw in Section 4.2, the arrival of competitive markets and subsequent market fragmentation allows environmentally-concerned consumers to “vote with their pocketbooks” by choosing to avoid certain energy sources or to support others. Certification, however, is essential to a vigorous green power market. A number of complementary and/or competing green power certification systems have been established in the U.S. and Canada. These systems and their different approaches to dealing with hydropower are discussed in detail in Chapter 8.

Green power certification lets customers identify “premium” green power, but how much of an improvement is it over “system power”? In order to make this comparison, consumers need substantive information regarding the environmental impacts of the other power products offered in the marketplace. As we saw in Section 4.3, this need cannot be met through a voluntary certification system, since generators that don’t expect to be certified would have no interest in reporting their emissions or other impacts. It is thus incumbent upon regulators and legislators to ensure that a system of mandatory impact disclosure is established.

This need for reliable information has fostered the movement to require environmental disclosure, or labelling, for power products. There are many options for configuring mandatory labels. In Chapter 9, we will look at the labelling requirements that have been imposed in various jurisdictions, and at their adequacy for allowing consumers to make informed choices as far as hydropower is concerned.

Finally, as we saw in Section 4.4, one mechanism that has been adopted in many jurisdictions to favour the acquisition of low-impact power on a societal, as opposed to an individual, level, is the renewables portfolio standard (RPS). An RPS obliges power marketers to ensure that a certain percentage of their power is obtained from particular types of low-impact power sources, or to buy equivalent amounts of tradeable permits.[233] The role of hydropower in the RPS applied or proposed in various jurisdictions is discussed in Chapter 10.

233 In some jurisdictions, a slightly modified RPS is applied to generators rather than to marketers.

8. Green power marketing

The existence of a retail power market in which individual consumers can choose their suppliers makes it possible for marketers to distinguish themselves from their competitors by selling "green," "low-impact" or "environmentally friendly" power.[234] To the extent that a significant number of consumers wish to use their purchasing power to favour environmentally desirable generation, marketers should be able to charge a certain premium for such power, in relation to the "system power" alternatives.

As with all "green marketing," however, reliable criteria are required to prevent unsubstantiated claims. This problem is even more acute for electricity than it is for most consumer products, since the consumer cannot directly examine the product. In fact, the situation is even worse, in that the kilowatthours consumed by a "green power" client are in every way indistinguishable from those consumed by his/her "system power" or "brown power" consuming neighbour.[235]

Even more than for most other consumer products, the evaluation of the relative environmental merits of competing electricity products requires a level of technical sophistication and effort far exceeding that available to ordinary consumers. Certification organizations thus play an essential role, which ultimately is based on their ability to make judgement calls that the consumer *would* make, if sufficiently well informed.

Furthermore, unlike most other consumer products, electricity does not consist of discrete units that can easily be tracked from production through marketing and distribution to consumption. A ream of recycled paper does not lose its "green-ness" no matter how many middlemen buy and sell it, as long as it is properly labelled. To choose a paper supplier means buying into a supply chain that can be traced back, should one wish to do so, from distributor to wholesaler to manufacturer.

When we consume electricity, however, we are drawing from a common pool in which the output of all generators currently on-line are inextricably mingled. Choosing a supplier is thus not a matter of choosing the manufacturer of the product one consumes, but rather of choosing the producer who will have the obligation to replenish the pool for the amounts one draws from it. Thus, in order for green power marketing to work at all, reliable tracking systems are needed, to ensure that the energy produced by certified sources is of sufficient quantity to supply the sales attributed to it.[236]

To a large extent, the mechanisms needed to allow such tracking to occur are already part of the settlement systems in each power pool. However, careful coordination between these institutions is essential if green power tracking is to function properly.

An alternative approach relies on "tagging" instead of tracking. Under a tagging system, a green power generator earns a "tag" (credit) for each kilowatthour he produces, and a green power marketer must obtain enough tags to cover its sales. Since there is no pretence that the power sold as green was actually generated by a low-impact facility, there is in principle no reason that tags could not be bought and sold regardless of location and time of generation, much as emission reduction credits can be traded across national or even continental borders.

Indeed, tags are already sold by a broad range of organizations. On one extreme, there are environmental organizations such as the Bonneville Environmental Foundation, which uses funds from the sale of green tags to support renewable energy and watershed restoration projects in the Pacific Northwest. Another type of enterprise is PureWind, created by PG&E National Energy Group to market tags resulting from the Madison merchant wind project in New York State. There are also companies, such as Sterling Planet, that sell green tags over the internet without reference to any particular generating facilities. There is concern, however, that irresponsible marketing of detached "environmental attributes" may ultimately result in considerable harm to consumer confidence in green power.

234 There has been much debate as to the appropriateness of using the term "green" for electricity generation. According to the U.S. National Association of Attorneys General, "green" is a term of general environmental benefit which has no generally accepted meaning and thus cannot be defined with any precision. For the purposes of this paper, the term "green power" is used to mean "environmentally and socially preferable generation."

235 It is generally assumed that the alternative to "green power" is system power, composed of a variety of different sources. However, there is nothing to prevent a marketer from offering particularly dirty power (e.g., high-sulphur coal burned in low-efficiency high-emissions plants) at a discount to system power.

236 Most tracking systems permit producers to average their output over a year, in effect allowing wind power retailers to serve their customers with system power when wind power is unavailable, as long as it is "repaid" later in the year.

There is also concern that the marketing of tags from existing generators would effectively flood the green power market, thus giving consumers the impression they were “doing good” even though their purchases had no real effect on the mix of power sources.[237]

8.1 Does the green power market really help the environment?

Green power marketing has led to highly charged debates. Its proponents believe it is a key element of environmental sustainability in the post-restructuring era. For example, an interfaith religious group known as Partners for Environmental Quality seeks to convince parishioners that the choice of an electricity supplier is a moral choice: “If you buy the cheapest power, you’re killing your kids,” proclaims Rev. Franklin Vilas, one of the group’s leaders.[238]

Others, however, are skeptical of the extent to which green power marketing will actually affect the generation mix. In a scathing 1998 analysis entitled “Green Buyers Beware,” Nancy Rader, writing for Public Citizen’s Critical Mass Energy Project, took a close look at green power marketing in California and found that it came up wanting.[239] Rader concluded that consumers’ choice to buy “green power” would have little, if any, positive impact on the environment. While some of her points can be ascribed to the nascent state of the California retail green energy market at the time of her study, many of her criticisms remain relevant.

In Rader’s survey of the “green power” products for sale in the California market in 1998, all but one consisted largely of electricity produced by facilities owned by utilities or under long-term contract to them. Insofar as the utility still serves captive customers under regulated rates,[240] the costs of these resources are already recovered through the rates charged to captive customers. Under these circumstances, any premium resulting from the electricity’s sale on the green power market would in fact constitute a windfall for the utility, which is already earning a regulated rate of return on its investment (over and above its costs).

The green power buyer may in fact consume “cleaner” energy, but the utility will have to replace that power to continue to serve its captive customers — in all likelihood with “dirtier” power (e.g., by increasing the usage of a thermal plant which was not running at full capacity). Thus, while the transaction may indeed “green” the mix of power consumed in the purchaser’s area, it will result in a corresponding “browning” of the power mix consumed in the utility’s service area; the net environmental benefit is nil.

It is thus hard to find any real benefit in such circumstances, other than perhaps helping to create the impression that consumers care about the environment. While this may indeed be of some importance to help create political and commercial momentum, it is a long way from the direct environmental benefit that green power consumers think they are buying.

This problem could be avoided by restricting the green power market to “merchant” generators, excluding those that are owned by or under contract to a utility,[241] but none of the green power certification systems presented in the following sections impose this condition.

A similar question arises with respect to the marketing of electricity from existing facilities, even if they are not part of a utility’s ratebase. Critics argue that, since these facilities are already producing power, the sale of their output as (high-priced) green power produces no real environmental benefit.

Green power proponents respond, first, that because of the cost advantage of higher-impact generators, low-impact producers need the “encouragement” to survive in the competitive marketplace. Furthermore, they argue, once the demand for green power exceeds existing supply, construction of new low-impact power plants will increase. Rader dismissed this argument, contending that marketers are not usually rewarded until they have taken risks, made investments and delivered more desirable products to consumers:

237 The Department of Energy Resources in Massachusetts has proposed that a tagging approach be used for its RPS, in which all power imported from Hydro-Québec could be used to meet the “existing resources” requirement.

238 Kirk Johnson, “Turning Monthly Light Bill into a Moral Choice,” *New York Times* (10 July 2000).

239 Nancy Rader, “Green Buyers Beware: A Critical Review of ‘Green Electricity’ Products,” Public Citizen’s Critical Mass Energy Project (October 1998).

240 Either because the utility is in a jurisdiction which has not opened its retail market, or because it continues to serve as supplier of last resort.

241 Rader, see note 239, p. 10.

> It is difficult to think of any other product for which consumers are asked to pay extra for a future improvement of that product (e.g., imagine: "pay more for this broccoli, and we promise that what we sell you two years from now will be organically grown").[242]

Nevertheless, in the years since Rader published her analysis, green power purchases have indeed led to the construction of new low-impact generation, albeit on a limited scale.[243]

The pros and cons of green power marketing continue to be vigorously debated among energy activists and the wider public. On the one hand, green power marketing has proven to be a magnet for media attention and thus has raised public awareness of the environmental harm caused by electricity generation. Further, it may well prove to be a significant source of financial support for promising new low-impact technologies. On the other hand, it has probably contributed to an exaggerated sense among the general public that the environmental problems related to electricity generation have already been dealt with. Indeed, avoiding consumption through conservation and energy efficiency investments is environmentally preferable to even the greenest electricity, and green power marketing does nothing to reduce waste or to improve energy efficiency.

In fact, while the green power market does reduce environmental harm, even the "greenest" power (together with the transmission lines needed to transport it) is not free of environmental costs. More important still, the green power market simply has no effect on the worst generators and their customers. Finally, relying on green power markets to reduce the environmental impacts of power generation in effect leaves the common good to voluntarism, with the result that a small part of the population bears the full cost of energy choices that benefit all. This is the inevitable result of transferring the cost of environmentally preferable generation from ratepayers as a whole to those that choose to pay for it.

That said, there is little doubt that a credible and well-structured green power market is far superior to a shabby and dysfunctional one. It is important, however, to avoid exaggerating the benefits of green power marketing, and to ensure that it does not supplant more broad-based policy initiatives.

8.2 Green power certification systems

In order for the green power market to gain credibility and prosper, there must be some kind of neutral arbiter of what power products can be sold as "green." A number of different systems have been established to make these distinctions. In this section, we will review several notable examples in the U.S. and Canada.

8.2.1 The Green-e certification program

The most widely used certification program in the U.S. is the "Green-e" program, administered by the Center for Resource Solutions of San Francisco. The right to use the Green-e logo is granted to retailers for "electricity products" that meet the program criteria:

- at least 50% of the electricity must come from "renewable" sources, defined to include wind, solar, geothermal, certain hydro facilities (see below) and biomass (including landfill gas),
- emissions from the fossil portion (if any) must be lower than an equivalent amount of system power,
- the product must not contain any nuclear power, other than that contained in the system power portion,
- a certain percentage (5% in the first year after market opening, increasing by 5% a year to a limit of 25%) of the product must consist of "new renewable" electricity, from facilities commissioned after 1997 (or 1998, in New England).

Hydroelectric facilities under 30 MW are currently eligible to meet the renewable requirement, but this criterion is being phased out, to be replaced by certification by the Low Impact Hydropower Institute, described in Section 8.3.1, below. Hydro facilities are not eligible for meeting any of the "new renewables" requirements.

242 *Ibid.*, p. 28.

243 By August 2000, green power marketing had resulted in some 46 MW of additional generating capacity in the U.S., as well as in 58 MW of planned additions. Utility green pricing programs, which mirror green marketing but are offered to monopoly utility customers, have resulted in a further 72 MW of real and 121 MW of planned green power capacity additions throughout the United States. Blair Sweezy and L. Bird, *Green Power Marketing in the United States: A Status Report (Fifth Edition)*, National Renewable Energy Laboratory (Golden, Colorado, August 2000).

8.2.2 EcoLogo

EcoLogo is a trademark of the Environmental Choice Program of Environment Canada (the environment department of the Canadian government). It is administered under contract by the Ontario-based TerraChoice Environmental Services Inc. and covers a broad range of products, from appliances to office products to electricity. Guidelines for each product category are developed by TerraChoice and then submitted to the Canadian Government for approval.[244] As they are technically governmental regulations, they must be published in draft form in the *Official Gazette* for public comment before their adoption by Cabinet.

In 1996, the Environmental Choice Program developed interim criteria for certification of "alternative source" (environmentally preferable) electricity generation.[245] Under these criteria, run-of-the-river hydro facilities of 20 MW or less installed capacity are eligible for certification, as are generating facilities using wind and solar technologies as well as those based on recovering sewage or landfill gas (methane).

In October 1998, TerraChoice launched a consultation process to review these alternative source electricity guidelines,[246] largely due to the renewed interest in green power resulting from the Ontario restructuring legislation.[247] It was decided to replace them with separate guidelines for "low-impact renewable energy" and for "low-impact non-renewable energy" (e.g., fuel cells and clean gas technologies). A proposed guideline for low-impact renewable energy was finalized in December 1999; work has not yet begun on a guideline for low-impact non-renewable energy.

The proposed EcoLogo guideline for low-impact renewable energy differs from the approach applied by Green-e in two important aspects. First, whereas Green-e certifies *electricity products* offered to consumers (which are almost inevitably composed of a mix of power from a variety of sources), EcoLogo certifies *electricity generators.* While marketers offering electricity products to the general public are expected to mention the EcoLogo certification of the generator whose product they are marketing, it is not the "package" *per se* that is certified, but its component parts. Thus, for example, under the Green-e approach, a power product composed of 51% wind power (and the rest of system power) would be certified, whereas one that contained only 49% would fail. Under the EcoLogo approach, both packages could use the EcoLogo, as long as they indicated the percentage of certified wind power the package contained.

The second important difference is that the proposed EcoLogo guideline establishes certification criteria for all types of renewable power. Green-e, in contrast, requires no generator certification in order for wind, solar or geothermal power to qualify for its "renewable" portion.

The EcoLogo criteria for these renewable sources are comprehensive, requiring:

- that the generation process as well as the disposal of any waste products must meet the requirements of all applicable laws, regulations and safety and performance standards,
- that appropriate consultation with communities and stakeholders has occurred, that their issues of concern have been reasonably addressed, that all reasonable mitigation of adverse impacts has been employed, that conflicting land use, biodiversity losses and scenic, recreational and cultural values have been reasonably "addressed" during project planning and development, and
- that there be no adverse impacts for endangered or threatened species.

Additional criteria are specified for each generating technology separately (wind, solar, biomass, hydro). For example, wind power can only be certified if it is shown that structures do not obstruct migratory routes and are not located in an area of high bird concentration or of endangered bird species. For solar power, it must be demonstrated that all solid waste (including disposal of equipment containing measurable levels of cadmium) be properly disposed of or recycled. Biomass and biogas must meet a series of requirements concerning air emissions, and biomass certification also depends on a number of source restrictions. EcoLogo's extensive hydropower certification criteria are examined in detail in Section 8.3.2, below.

244 TerraChoice generally sets its criteria such that about 20% of the products in the marketplace in a given product category can obtain certification.

245 Environmental Choice Program, Panel Review Process, Verification and Licensing Criteria PRC-018.

246 The author of this paper participated in these consultations.

247 The Ontario retail market opening was initially set for 2000; it is now expected to open sometime in 2001.

In establishing these stringent criteria, TerraChoice was cognizant that far less than 20% of existing electric generation in Canada would qualify. However, it found this departure from usual EcoLogo procedure to be necessary, because criteria that would have certified 20% of existing supply would not have been seen as credible in the new green power market. As we shall see below, these draft guidelines have not yet been adopted or even published for public comment by the Canadian government.

8.2.3 Scientific Certification Systems

Scientific Certification Systems (SCS) of Oakland, California, takes an approach very different from those of Green-e and EcoLogo. SCS describes itself as "a neutral, third-party testing and certification organization evaluating a wide variety of food safety and environmental claims."[248] It operates certification programs for forestry, organic foods and marine fisheries, and has been authorized by non-profit organizations such as the Marine Stewardship Council and the Forest Stewardship Council to certify companies as being in compliance with their criteria. At the same time, it also certifies products as "environmentally preferable," using its own protocols based on life-cycle assessment. Its approach to certification of environmentally preferable electricity has attracted considerable interest on the part of several utilities, though it remains largely unknown in the environmental community.

SCS offers two types of electricity certification: Environmentally Preferable Electricity *Portfolios* and Environmentally Preferable Electricity *Sources*. Portfolio certification seeks to determine the most environmentally preferable combination of cost-effective options, including upgrades to existing generation assets, improvements to transmission and distribution infrastructures, new alternative power generation sources, distributed generation technologies and demand-side conservation initiatives. It does so by comparing environmental performance and improvements against the average performance of the regional power pool.

SCS Environmentally Preferable Electricity *Source* certification, on the other hand, certifies the environmental performance of specific energy sources, compared to the average performance of the regional power production pool. It quantifies a project's impacts based on twenty indicators grouped into six categories (see page 76). For each one, the project is then compared to the system average (scaled to the equivalent energy production) for the regional grid where the generator is located. Individual generators that "beat" the system average on all indicators are deemed to be "environmentally preferable."

This "source" certification is thus in some ways analogous to the EcoLogo described above. However, unlike EcoLogo, which relies on specific guidelines for each generating technology, any generator, regardless of its type, is eligible for SCS certification. Indeed, any proposed action, from building a wind farm to installing high-efficiency industrial boilers to installing scrubbers on a coal plant, can, in theory, be compared as to their net effect on the total impacts from electric generation in the region.

According to SCS, this approach is "based on internationally standardized life-cycle impact assessment protocols to evaluate and certify the relative environmental merits and tradeoffs of various energy generation systems using a comprehensive, internationally standardized assessment methodology."[249]

In seeking to establish a strictly objective evaluation system, where "the numbers" speak for themselves and where no subjective or policy-oriented choices need be made, SCS has set itself a formidable task. The success of this ambitious project depends both on the accuracy and completeness with which the regional power system is characterized and on the sensitivity of the methodologies used to represent the real environmental impacts of each generating option. Given that all resources are, in effect, compared to each other, any systematic error in the assessment of any aspect of the regional generating system will affect the reliability of the entire system. The obvious difficulties in reducing the varied impacts of hydropower into simple quantitative indicators represent a crucial challenge in this regard. The SCS treatment of hydropower impacts will be addressed in detail in Section 8.3.3, below.

8.3 Certifying low-impact hydropower

Whether, or to what extent, hydropower should qualify for marketing as "green power" is a highly contentious question. The hydropower industry argues that it is one of the "greenest" of power sources, in that it makes it possible to avoid most of the air emis-

248 See http://www.scs1.com/.

249 Scientific Certification Systems, *A Study of Safe Harbor Hydroelectric Power Generation Based on Life-Cycle Stressor-Effects Assessment: Final Report* (September 1999), p. 1.

sions associated with fossil fuel generation. On this basis, some industry representatives go so far as to suggest that *all* hydropower should be certified for sale in the green power market.

However, as we have seen, hydropower is responsible for very significant environmental and social impacts, which vary greatly from project to project, depending not only on the site and the project design but also on the way the facility is operated. It goes without saying that hydro projects which are responsible for such impacts would not be regarded as environmentally benign by a fully informed consumer, and thus should not be certified as “green” by organizations whose mandate is to help those consumers make informed choices. How, then, should those organizations go about distinguishing high-impact from low-impact hydropower? In the next section, we will look in detail at some solutions that have been offered by different certifying organizations.

8.3.1 The Low Impact Hydropower Institute

The growing realization that small dams are not necessarily environmentally benign eventually had to come into conflict with the notion that all dams less than 30 MW should be considered “renewable” or “green.” A process was initiated in 1997 by American Rivers (a river protection organization) and Green Mountain Energy Resources (an energy marketer, since renamed GreenMountain.com) to establish a new approach to distinguish environmentally damaging hydro projects from those which are more benign. This process led to the founding of the Low Impact Hydropower Institute (LIHI).

American Rivers and Green Mountain convened a broadbased task force, including representatives from environmental groups, government bodies and the hydro industry, to develop a detailed program. Draft selection criteria were made public in the fall of 1998, and the Governing Board of the newly constituted Low Impact Hydropower Institute formally adopted the final selection criteria in November 1999. The first project was certified (on a preliminary basis) in February 2001.

To be certified by LIHI, a hydro project must meet detailed criteria with respect to eight distinct issues:

- river flows
- water quality
- fish passage and protection
- watershed protection
- threatened and endangered species protection
- cultural resource protection
- recreation
- not recommended for removal by a resource agency

The applicant must fill out a detailed questionnaire/flowchart, which sets out the precise conditions under which these criteria can be met.[250]

As we shall see below, many of these criteria rely on “Resource Agency Recommendations.” A “resource agency” is defined as “a state, federal or tribal agency whose mission includes protecting fish and wildlife, water quality and/or administering reservations held in the public trust.”[251] A “resource agency recommendation” is defined as the most environmentally stringent recommendation issued by a resource agency pursuant to a public legal or administrative proceeding.

It is important to note that the “resource agency” definition includes a broad range of federal and state agencies but specifically *excludes* FERC, the agency responsible for licensing most hydro projects.[252] While FERC takes resource agency recommendations into account in its licensing proceedings, its mission is not limited to resource protection. Thus, holding a valid FERC license does not in itself guarantee that a project will receive LIHI certification. Rather, certification requires compliance with the most restrictive recommendation issued by a resource agency, even if that recommendation was rejected by FERC.

In this sense, the LIHI criteria can be thought of as a compromise between those who would argue that the judgement of the governmental licensing authority is all that matters and those who argue that environmental judgements must be made independently, without relying on any governmental agency. Ultimately, this compromise rests on the credibility of state and federal resource agencies in the U.S. and on their procedural safeguards, such as the right to due process and the right of appeal.[253] Because the LIHI criteria are so firmly embedded in the American regulatory and procedural context, they cannot be transferred to other countries without considerable modification.

250 The full criteria can be found at: http://www.lowimpacthydro.org/package.html.

251 Low Impact Hydropower Institute, Certification Criteria, s. C-12.

252 Except with respect to cultural resource protection, as described below.

253 Not all stakeholders are willing to make this “leap of faith,” as noted below.

Canadian regulatory practice with respect to authorization of hydro projects differs greatly from that in the U.S. While the differences between provinces make generalization hazardous, it is safe to say that the procedural safeguards in U.S. law far exceed those available in Canada. For example, a landmark 1993 decision of the Québec Court of Appeal makes clear how faint are the procedural guarantees in Québec's Environmental Quality Act:

> [The] administrative decision-making process, in appearance very democratic, is ultimately nothing but a simple consultation process which, while complex, creates *no real judicial constraint for the administration* …
>
> [A] first reading of the Act gives the impression that ministerial discretion is carefully delimited and takes its place in a broad process of democratic participation where each person can present his point of view and where the Minister is obliged to take these views into account. *These are the appearances. The reality is entirely different. In fact, the Act withdraws in its provisions that which it seems to grant in its declarations of principle.* …
>
> *[T]he Act … gives the decision maker such broad discretion as to practically forbid any judicial review …*[254]

Given the degree of governmental discretion in project authorization under Canadian environmental legislation, any "Canadian version" of the LIHI criteria would have to rely on absolute standards rather than on agency recommendations.

8.3.1.1 Criteria

The following provides a brief summary of the LIHI criteria.

River flows. A facility can meet this criterion by being in compliance with a resource agency recommendation regarding flow conditions for fish and wildlife protection, mitigation and enhancement (including in-stream flows, ramping and peaking rate conditions, and seasonal and episodic instream flow variations) for both the reach below the tailrace and all bypassed reaches. In the absence of such a recommendation, the in-stream flows must at a minimum meet the Aquatic Base Flow (ABF) standard, or be sufficient to be qualified as "good" according to the Montana-Tennant method. This latter standard requires in-stream flows equivalent to 20% of the average annual flow during the winter months, and 40% during the summer.

Water quality. To meet this criterion, a facility must be in compliance with the requirements of the *Clean Water Act.* Furthermore, starting in 2002, it must periodically monitor water quality parameters that may be affected by the facility and make such results public.

Fish passage and protection. A facility can meet this criterion by being in compliance with a resource agency recommendation regarding upstream and downstream passage of migratory fish. If no such recommendation exists, the applicant must demonstrate that the facility has not contributed to the extirpation of any species and that the agency did not decline to require fish passage simply because doing so would not successfully mitigate a situation to which the facility contributed in whole or in part. Alternatively, the applicant must demonstrate fish passage survival rates of greater than 95% over 80% of the run.

Watershed protection. The facility must be in compliance with resource agency recommendations and FERC licence conditions regarding watershed protection, mitigation or enhancement. Furthermore, after 2002, it must establish a 200-foot conservation buffer zone around the entire impoundment or take compensating measures, such as designating a similar area of substantial ecological value for conservation purposes. The acceptable compensating measures and the date when they are required may be modified before 2002.

Threatened and endangered species protection. If there are any threatened or endangered species present in the facility area, and if a species recovery plan has been established, the applicant must demonstrate that the facility is in compliance with that plan. If the facility has received authority to "take" a listed species, it must be in compliance with the conditions of the authorization. Otherwise, the applicant must demonstrate that the facility does not negatively affect any listed species.

Cultural resource protection. In order to ensure that the facility does not inappropriately impact cultural resources, the applicant must demonstrate compliance with FERC license provisions concerning cultural resource protection, mitigation or enhancement. Facilities not regulated by FERC must be in compliance with a plan of this type approved by the relevant

[254] Québec Court of Appeal, Guy Bellefleur et Les Héritiers de Feu Jean-Robert Bellefleur c. Le Procureur Général du Québec (24 August 1993).

state or federal agency or Indian tribe; should no such plan exist, they must provide a letter from a senior officer of the agency or tribe stating that cultural resources are not negatively affected.

Recreation. The applicant must allow access to the reservoir and downstream reaches for recreational purposes, free of charge. It must also comply with any requirements for recreational access, accommodation (including recreational flow releases) and facilities conditions required by FERC or recommended by resource agencies responsible for recreation.

Facilities recommended for removal. No facility for which a resource agency has recommended dam removal is eligible for certification.

New facilities. The LIHI criteria only apply to facilities in service before August 1998. However, the Board may, at a later date, "develop separate, more stringent, criteria" to certify new dams. This is in keeping with the Institute's mission to "provide incentives to dam owners to change their operations to reduce environmental impacts,"[255] not to encourage new dam construction.

Facilities outside the U.S. No facilities outside the U.S. are eligible for LIHI certification, though the Board may at a later date revise the criteria to apply to hydropower facilities outside of the U.S. that could sell their power within the U.S.[256]

8.3.1.2 Governance

LIHI is directed by a Board of Governors, of which at least half the members are from environmental organizations and the remainder are from organizations such as resource agencies, First Nations and consumer advocacy organizations, or associations representing industries such as recreational boating or recreational or commercial fisheries. The Board must include broad regional representation as well as at least one "academic with industry interests" (i.e., a researcher in a related field).[257]

Representatives of the hydropower industry may not sit as Board members. However, a Hydropower Industry Advisory Panel has been constituted to advise the Board on industry concerns, including criteria, implementation, the certification process, technical issues, operations and management.[258] Similarly, a Renewables Advisory Panel advises the Board on concerns related to the program's impact on non-hydro renewables, reflecting the realization that the certification of massive amounts of hydropower could limit or even eliminate the benefits of green power markets for non-hydro renewables such as wind and solar power.[259] The chair of each advisory panel serves as a non-voting member of the Board.

8.3.1.3 Process

Certification by LIHI is the endpoint of a multi-stage process, all of which is open to public involvement. The steps of the process are as follows:

1. Applicant submits questionnaire and supporting information to Administrator

2. Administrator posts application on website for 60-day public comment period

3. Application and comments forwarded to independent Reviewer

4. Reviewer makes recommendation to Board

5. Board's preliminary decision is posted on website

6. Within 30 days, the applicant or a member of the public may appeal the decision

7. Appeals are reviewed by the independent Appeals Panel

8. Board approves Decision by Appeals Panel

The reviewer's job is to evaluate conformity of application with the criteria spelled out in the application questionnaire. He/she is also expected to conduct additional investigation as necessary, to resolve factual disputes and to evaluate veracity of claims before making a recommendation to Board.

255 Low Impact Hydropower Certification Program, Certification Package, p. 4.

256 *Ibid.*, p. 24.

257 *Ibid.*, p. 10.

258 The hydropower industry was also given an opportunity to provide input into the choice of reviewers and members of the appeals panel.

259 The author is a member of this panel.

In the event that an appeal of the Board's preliminary decision is requested by the applicant or by a member of the public, the file is transmitted to the appeals panel in order to evaluate the conformity of Reviewer's decision with the Institute's criteria.

8.3.1.4 Discussion

The LIHI criteria are detailed and procedurally (if not substantively) objective.[260] This is not to say, however, that they are uncontroversial. While many environmental groups have wholeheartedly embraced the LIHI process, others remain critical.

8.3.1.4.1 Criticisms

One of the most controversial aspects of the LIHI criteria is their reliance on resource agency recommendations, as described above. International Rivers Network (IRN) has pointed out that this reliance would prevent evolving issues pertaining to ecosystem and watershed management from being reflected in certification decisions unless they have already been adopted by the resource agencies.[261] IRN is particularly concerned that LIHI could certify a dam as low-impact even if community efforts were seeking its removal, as long as no resource agency had recommended decommissioning. That certification could in turn become a major obstacle to those decommissioning efforts, and could also undermine public credibility of the certification process.[262]

There are also concerns about the effects of the certification system on the public perception of hydropower. Even though LIHI's documents clearly state that *low impact* is not *no impact,* IRN believes that the certification of hydro facilities could well reinforce complacency rather than leading to more active public involvement in watershed and river management.

LIHI has been criticized by the hydropower industry as well. For example, a number of small hydropower associations attacked the watershed protection provisions, arguing that the obligation to provide equivalents to a 200-foot buffer zone around the facility (or equivalent compensating measures) are impossibly onerous for projects located in regions where real estate has become extremely expensive.[263]

Despite criticism from both sides, LIHI has won wide support for its criteria, due in large part to the transparent process described above. The commitment by Green-e and, more recently, Renew 2000, a new green power certification standard established jointly by utilities and environmental groups in the Pacific Northwest, to rely on LIHI certification for hydro projects represents a strong vote of confidence and virtually ensures its role in the U.S. green power market.

8.3.1.4.2 New projects

As noted above, LIHI has stated explicitly that new projects are not now eligible for certification. In limiting its application to existing projects, the institute has sought to provide incentives for operators to reduce the environmental impacts of existing facilities, without having to address all the "sunk" impacts resulting from the project's siting and design.[264]

Thus, the LIHI criteria focus largely on the downstream environment and only indirectly on reservoirs and their impacts. For instance, there is no mention of area flooded (either in absolute terms or in relation to power production), to greenhouse gas emissions (which vary greatly from one site to another, based on the location, the area and type of land flooded, the sediment load from the catchment area, and other factors), to the quality of habitat lost or to short- or long-term water level fluctuations. Similarly, the question of river diversions is not directly addressed in the LIHI criteria, except in the flow criterion. LIHI apparently judged that the extent to which waterways had

260 Since agency recommendations can vary widely, identical projects located in different states could obtain different certification decisions.

261 International Rivers Network, Comments on March 10, 1999 Draft Low Impact Hydropower Certification Program (Berkeley, California, 9 April 1999). These comments are reproduced in Appendix 3.

262 Juliette Majot, executive director of IRN, pers. comm.

263 According to the Connecticut Small Power Producers Association, a 2.5 MW project with a 335-acre impoundment would have to invest some $420,000 to purchase equivalent lands; the revenues from the project operations are around $50,000 per year.

264 LIHI is currently exloring the possibility of developing criteria for new hydropower facilities added to existing dams. Although the new criteria are under development, they will likely be designed to certify additions which create no new impacts and which result in net environmental improvements from the status quo. Lydia T. Grimm, Executive Director, LIHI, pers. comm. The issues surrounding new hydro resources in the context of renewables portfolio standards (RPS) are further explored in Section 10.1, below.

been diverted when the project was built was not relevant, as long as adequate flows are provided in bypassed reaches and as long as the other criteria (such as appropriate fish passage) are met. It is to be expected that siting and design issues such as these will be addressed if and when "separate, more stringent, criteria" are developed to certify new dams.

8.3.1.4.3 Foreign projects

Finally, the exclusion of projects outside of the United States follows inevitably from LIHI's reliance on the American institutional framework governing hydro projects. To the extent that LIHI certification becomes the standard for inclusion of hydropower in products sold in the U.S. "green power" market, the inevitable result would be to exclude Canadian hydro generators *a priori* from participation in that market, an exclusion that would almost inevitably be challenged, in court or elsewhere.

Two solutions seem possible. Either LIHI could develop new criteria for hydro projects in Canada and Mexico, or it could accord "recognition" to a similar certification process in these countries. If it develops its own criteria, they will almost certainly be "absolute" rather than process-related (like the ABF-Tennant option for in-stream flows). However, it may be seen as problematic for LIHI to be reviewing applications for facilities in other countries. Mutual recognition thus seems to be a more promising solution, though it would depend on the existence of similar bodies in Canada and Mexico that would apply criteria of comparable stringency.[265]

However, the complexities of trade law make such a straightforward outcome unlikely. As we shall see in Section 10.1 below, the Government of Canada has already threatened to lodge trade complaints about the treatment of Canadian hydropower under renewables portfolio standards in the U.S. It would be surprising if, once the dust settles, Canada would tolerate a situation where U.S. non-profit organizations would determine whether or not hydropower from its provincial utilities can be marketed in the U.S. as green power. Despite efforts by the North American Council for Environmental Cooperation (created under the environmental side-agreement to NAFTA) to promote harmony around this issue,[266] international trade litigation remains a very real possibility.

8.3.2 EcoLogo

As described earlier, the guidelines for certification of low-impact electricity under Environment Canada's EcoLogo program are currently under revision. While the guideline review committee was initially very interested in following the LIHI approach, it soon realized that, for the institutional and procedural reasons mentioned above, the LIHI guidelines could not be adapted to the Canadian context.[267] However, it took inspiration from LIHI in terms of the types of concerns that must be addressed before a hydro facility is certified as low impact.

Following these consultations, TerraChoice submitted draft guidelines to Environment Canada that, in addition to the general requirements described above, included the following provisions regarding hydropower:[268]

- the facility must be in compliance with all regulatory licenses regarding fisheries, water levels and flows, and must not operate under a conditional authorization allowing the harmful alteration, disruption or destruction of fish habitat,
- it must be run-of-the-river, with a maximum of 48-hours of storage capacity,
- any reduced flows must not be detrimental to indigenous aquatic and riparian species, and in-stream flows must be adequate to support such species at pre-project ranges,
- water quality must be similar to that in free-flowing or unaltered bodies of water or waterways in the area,

265 Political, social and regulatory differences between the U.S. and Canada would almost inevitably lead to certain differences in criteria. For instance, the river recreation community is far more influential in the U.S. than in Canada, and Native communities (First Nations) play a much greater role on the Canadian political scene, especially as concerns resource development.

266 This issue promises to be at the forefront of deliberations of the CEC's recently established Advisory Board on Electricity Restructuring and the Environment in North America.

267 As noted above in Section 7.6, most Canadian environmental legislation entrusts final decisions to ministerial discretion. While consultative hearings are held under some circumstances, they generally do not include the procedural guarantees which are central to LIHI's reliance on resource agency recommendations.

268 Draft Guideline ECP-79, Renewable Low-Impact Electricity (21 December 1999), reproduced in Appendix I.

- any temperature changes caused by the project must not be detrimental to indigenous aquatic species, and
- fish passages must be provided when necessary to allow pre-existing upstream and downstream migration patterns.

These provisions did not meet the approval of the Canadian Electrical Association (CEA composed of most Canadian utilities as well as other industry participants), nor of the Canadian Hydropower Association (CHA, composed of Canadian hydro utilities). The CEA effectively ceased its participation in the Guideline Review Committee on 14 September 1999, because "the criteria set unrealistic standards for eligibility… effectively excluding the vast bulk of electric power in Canada and thereby making the guideline of questionable value."[269]

Two months later, the CHA attacked the draft guidelines:

> Finally, we believe that the current approach of not providing the EcoLogo label to more than 20% of the production in any particular category will have undesirable consequences when applied to electricity generation. Ownership of electricity generation in Canada is concentrated in a small number of companies. In Québec, for instance, Hydro-Québec generates three fourths of all available generation in this province. … [U]nder these circumstances, the large Canadian companies would likely see no benefit in applying for an EcoLogo certification. *This would mean, in the eyes of the general public, that all the remainder of the production is not "green" or, even worse, that it has an unacceptable impact on the environment. The same perception would apply in U.S. markets, reinforcing the false perceptions against large hydro, with a negative impact on Canadian exports of electricity.*[270] (emphasis added)

The draft guidelines were submitted to Environment Canada in early 2000, but, at this writing, they still have not been published for comment in the *Official Gazette.* It would be surprising if this paralysis were unrelated to the opposition from Canadian hydro utilities, despite having obained language that opens the door for adding storage hydro at a later date (see "Notice of Intent," p. 103). In the meantime, TerraChoice continues to certify Canadian generators, based, it states, on the unapproved draft guideline. However, it is impossible to confirm this claim, as there is no public oversight of the EcoLogo certification process.

8.3.3 Scientific Certification Systems

As noted above, SCS has established an ambitious approach to environmental certification, based on life-cycle assessment of the entire regional grid. The success or failure of such a program depends largely on the extent to which it succeeds in representing the real impacts of each generating technology. While a full assessment of the SCS methodology is beyond the scope of this paper, it is important to look in detail at its treatment of the ecological impacts of hydropower.

The indicators used by SCS to evaluate energy systems are listed below. The environmental impacts of hydropower are represented primarily in the three italicized indicators. A brief analysis of the way each of these three indicators is applied is provided in Appendix I.[271]

Energy Resource Depletion
- Coal depletion (tons of oil equivalent, or toe)
- Biomass depletion (toe)
- Oil depletion (toe)
- Natural gas depletion (toe)
- Uranium depletion (toe)

Renewable Resource Depletion
- Water resource depletion (equiv. cubic metres)

Mineral Resource Depletion
- Mineral Resource Depletion (equiv. tons)

Ecosystem Disruption
- *Terrestrial and aquatic habitats (equiv. acres)*
- *Key species (if applicable) (% increased mortality)*

Emission Loadings
- *Greenhouse gas loadings (equiv. tons CO_2)*
- Acidification loading (equiv. tons SO_2)
- Ground level ozone loading (equiv. tons ozone)

269 Letter from Ken Adams of CEA to John Polak, President, TerraChoice Environmental Services (14 September 1999).

270 Letter from Pierre Fortin, Executive Director, Canadian Hydropower Association, to John Polak, President, TerraChoice Environmental Services, 17 November 1999. The letter incorrectly cited the LIHI program to argue that "the criteria for determining the lower impact hydraulic facilities under the EcoLogo guideline could thus be based upon the specific requirements of the licenses which must be obtained under the environmental legislation." As noted above, LIHI generally relies on resource agency recommendations, not on license requirements.

271 Hydro projects display non-zero values on other indicators, due for the most part to the fossil fuels used in their construction, but these values are generally insignificant. Projects that require substantial road construction, and air and land transport of workers and materials, such as those in Northern Québec, may be exceptions to this generalization.

Stratospheric ozone depletion loading (equiv. tons CFC-11)
PM-10 (equiv. tons PM-10)
Other hazardous chemical (air) loading (equiv. kg)
Eutrophication loading (equiv. tons P)
Total oxidizing chemical (TOC) loading (equiv. tons C)
Total suspended solids (equiv. tons C)
Hazardous aquatic loading (equiv. kg)
Thermal loading (degrees over ambient)

Residual Hazardous Wastes

Ash wastes (equiv. tons)
Radioactive waste (equiv. tons)

The conceptual attractions of life-cycle analysis are undeniable. However, it has yet to be demonstrated that this strictly quantitative approach can, in practice, be applied to hydropower in a way that accurately represents its actual environmental and social impacts. SCS acknowledges this weakness:

> Ideally, ecosystem disruption would be measured in terms of the depletion of the affected ecosystems. However, such assessment is not yet supported by current ecological field assessment techniques.[272]

Faced with its inability to measure ecosystem depletion, SCS measures this disruption "in terms of the physical alteration of habitats and, as warranted, identified key species."[273] However, given the great variety and subtlety of hydropower's impacts on the environment and on human societies, this approach can only be characterized as reductionist.

SCS limits its assessment of ecosystem impacts to impacts on terrestrial and aquatic habitats, and impacts on "key species." Habitat impacts are in turn reduced to a simple acres/GWh metric that implicitly attributes an equal value to every part of the earth's surface, without distinction as to ecological richness or complexity. Thus, the loss of an acre of "habitat" from the total dewatering of a rapids is deemed equivalent to the loss of an acre of grassland to an industrial development or to a power line corridor.[274] The profound effects that such dewatering may have on the riverine ecosystems are unmeasured and unreported, except insofar as effects are noted on "key species" (direct population impacts on a few species of greatest economic interest, such as commercial and sport fisheries). Flow-related impacts are also, for the most part, rendered invisible. The conundrum of how to systematically and quantitatively represent the complex impacts of hydropower on the intricate webs of life that inhabit riverine ecosystems is resolved by simply ignoring them. As for direct or indirect social impacts, whether on Native or non-Native communities, they are excluded from the SCS methodology altogether.[275]

In order to meet the challenge of accounting properly for the varied environmental and social impacts related to electricity generation, all impacts must be addressed, even those impacts that do not easily lend themselves to the selected analytical framework. Indeed, while the very notion of life-cycle analysis implies an attempt to include all direct and indirect impacts caused by each energy resource. A methodology that systematically understates hydropower's ecological impacts and greenhouse gas impacts and fails to take any note of its social impacts will inevitably make it look good when compared to generating technologies for which all impacts are fully accounted for. If some types of impacts are assessed less thoroughly than others, life-cycle analysis will simply become a mechanism for arbitrarily preferring one type of generation to another.

It seems clear that the SCS approach fails to fully account for hydropower's ecosystem impacts; indeed its methodological choices tend in many ways to minimize the perceived impacts. The SCS implementation of life-cycle analysis thus tends to underestimate the impacts of hydropower and hence to overestimate its benefits relative to other energy resources. It is therefore not surprising that SCS claims that its approach will highlight the "inherent environmental advantages of hydropower" and justify its value-added pricing.[276] Insofar as the SCS approach is to compare each resource to the entire system, this flaw tends to vitiate the entire program, not only its certification decisions for hydro projects.

272 SCS, *A Study of the Safe Harbor Hydroelectric Power Generation Based on Life-Cycle Stressor-Effects Assessment* (September 1999), p. 10.

273 *Ibid.*

274 To the extent that SCS considers the habitat "created" by flooding (aquatic habitat) or by dewatering (e.g., mudflats) to be of ecological value, the lost habitat can be compensated by a "credit" of up to 85%.

275 Stanley Rhodes, pers. comm.

276 Stanley Rhodes and Linda Brown, "Certified: green power," *International Water Power and Dam Construction*, Vol. 51 (January 1999), pp. 28-29.

It should also be noted, in this regard, that it is virtually impossible for coal, biomass, oil, natural gas or nuclear power resources to be identified as "environmentally preferable" under the SCS methodology, due to the choice of "energy resource depletion" indicators. Since a natural gas plant will inevitably have a greater effect on natural gas depletion than the average of a system which includes non-gas generators, such a plant will never be able to meet the criterion of beating the system average for *all* indicators. The same is true for oil, coal and nuclear power, but not for hydropower, since no equivalent "free-flowing river depletion" indicator is used.

A central aspect of the SCS methodology is the comparison between a particular project and the regional baseline, since the project will only be judged "low impact" if it is superior to the baseline in every impact category.[277] For such a comparison to be meaningful, the baseline itself must be based on a rigorous characterization of all generators on the grid. While this may be plausible for fossil fuel generators, it poses insurmountable problems when hydropower makes up a significant part of that region's power supply, as is the case in many parts of the U.S., and especially Canada.

Nevertheless, it is increasingly apparent that the hydro industry sees life-cycle assessment as its best chance to gain environmental acceptance.[278] SCS is already under contract to model the Pennsylvania-New Jersey-Maryland (PJM) electric system, and has carried out a feasibility study for the Canadian Electrical Association. Unless major modifications are made in its approach to characterizing the impacts of hydropower, the use of the SCS approach for modelling the North American electricity market could lead to significant distortions in resource choices.

8.3.4 Pembina Institute

The Pembina Institute, an independent, non-profit public interest group based in Alberta, has recently issued its own proposed green power guidelines for Canada.[279] For Pembina, Green Power should:

- be renewable over many centuries, and
- protect the environment significantly better than the current mix of available technology.

Pembina distinguishes between "gold" (the highest environmental performance), "olive" (better but not exceptional environmental performance) and "brown" (highly polluting power options). While supporting the shift from brown to olive technologies, Pembina believes that consumers should only be asked to pay a premium for "gold" sources, which should thus be the only ones eligible for green power certification.

Pembina's analysis is based on the principles of life-cycle assessment, applying a single analytical framework to all potential sources. Its approach is thus comparable in some ways to that of SCS. However, it integrates policy criteria for each generation technology, thus departing from SCS' strictly quantitative approach.

While SCS provides seven indicators concerning renewability, Pembina uses only one, reflecting its view that renewability is a *sine qua non* for certification. For air and water impacts, the two systems are broadly comparable. They differ greatly, however, in their treatment of the key categories for evaluating hydropower.

Pembina recognizes the wide variation in environmental impacts and benefits of hydropower, depending on the siting, design and operations:

> Projects that impound or divert the flow of a river, cause extensive flooding, or flood sensitive areas are not sources of Green Power. These systems often destroy stream-side habitat and aquatic populations and can have significant land impacts. At the other end of the scale are micro-hydro electric and run-of-the-river systems, both of which have minimal impacts on the environment.[280]

As we have seen above, SCS limits its assessment of ecological impacts to two quantitative indicators: acres of terrestrial and aquatic habitat lost (with "credit" for habitat creation) and percent increased mortality of "key species." Pembina, on the other hand, relies on three broad criteria:

- **direct impacts on watersheds:** to protect the watershed, a project must not cause any significant diversion or impoundment; head pond storage not to exceed six hours of average flow for any month in a 10-year average water flow regime;

277 The regional baseline also plays an essential role in SCS' Portfolio Certification, mentioned above.

278 Hydro-Québec, *Environment and Electricity Restructuring in North America*, see note 217, p. 15; IEA Hydropower Agreement, see note 177.

279 Marlo Raynolds and Andrew Pape, *The Pembina Institute Green Power, Guidelines for Canada* (July 2000).

280 *Ibid.*, p. 13.

- **direct impacts on landscape:** no flooding above the seasonal high-water line (based on 10-year average);
- **potential impact on flora and fauna:** no significant impacts on aquatic or terrestrial organisms. Where impacts do occur, mitigation must be provided.[281]

While these criteria are not as fully elaborated as those of the other systems we have looked at, they should allow for qualitative assessment of the full range of ecosystem impacts described in Chapter 5. However, the Pembina approach remains largely theoretical, as it has not yet been put into practice.

8.3.5 Comparison

The systems we have examined above all seek, at least in part, to make it possible for the consumer to distinguish "high impact" from "low impact" hydropower projects. However, they each pose the question differently, and in different contexts.

LIHI asks whether certain minimum criteria that it considers sufficient to qualify a project as "low impact" have been met. In most cases, it accepts certain types of administrative recommendations as adequate. In keeping with its underlying mission to provide incentives for hydro owners to modify the way they operate their facilities in order to reduce their environmental impacts and *not* to create incentives for the construction of new dams, only existing facilities are currently eligible for certification.

The draft EcoLogo guidelines are more restrictive in certain ways than are the LIHI criteria. However, unlike the latter, they are essentially silent as to what evidence is sufficient to demonstrate that they have been met. Rather than laying out a flowchart to determine whether or not a given project qualifies, they simply articulate the criteria that a project must meet. While the burden of proof is on the applicant, there is no public oversight of the application process (as there is with LIHI). This approach gives considerable responsibility to the consultant charged to evaluate an application, and could compromise the program's credibility, should it certify projects that prove to be controversial.

The SCS approach does not specify any criteria that must be met for a project to be judged "environmentally preferable," other than being superior to the regional power grid on the basis of a particular set of indicators. The analysis is done on a consulting basis, with limited peer review but without public input or oversight. As we have seen, severe methodological problems in each of the indicators affecting hydropower calls into question the credibility of this certification.

As for the Pembina Institute guidelines, they represent a promising development in the potential application of life-cycle analysis to hydropower. Until they are put into practice, however, they remain largely theoretical.

Table 2 on page 80 summarizes the position of the four systems on a variety of issues.

281 *Ibid.*, p. 14.

Table 2: Requirements for Low Impact Certification of Hydropower

Issue	EcoLogo	LIHI	SCS	Pembina
Endangered or threatened species	no adverse impacts	in compliance with recovery plan, with "taking" authority for any adverse impacts	no specific requirement; may be reflected in "key species" indicator	no adverse impacts
Compliance with license requirements	in compliance with all license requirements regarding fisheries, water levels and flows	in compliance with all license requirements	(no requirement)	(no requirement)
Habitat disruption	must not operate under a conditional authorization allowing the harmful alteration, disruption or destruction of fish habitat	not directly addressed; indirectly reflected in flow and watershed protection requirements	net loss of habitat per unit of energy generated less than estimated regional average	no flooding above 10-year high water mark; no net significant impacts on aquatic or terrestrial organisms within watershed
Storage	run-of-the-river, with a maximum of 48-hours storage capacity	(no requirement)	(no requirement)	no significant diversion or impoundment; run-of-the-river, maximum 6 hours storage capacity
Flows	any reduced flows must not be detrimental to indigenous aquatic and riparian species; in-stream flows must be adequate to support such species at pre-project ranges	must comply with most restrictive resource agency recommendation, or meet ABF standard or "good" on Montant-Tennant scale; must demonstrate that any extirpations not due in whole or in part to facility.	(no requirement)	(no requirement, but storage requirement implies minimal flow modification)
Water quality	similar to that in free-flowing or unaltered bodies of water or waterways in the area	in compliance with Clean Water Act certification for facility; if downstream reach not in conformity with CWA standards, must not be found to be cause of violation; after 2002, periodic monitoring required	lower than regional grid average with respect to eutrophication, turbidity and hazardous contaminants	no change from normal levels for dissolved gases, temperature, pH, toxics or turbidity
Temperature changes	not detrimental to indigenous aquatic species	(no requirement, other than water quality criteria above)	(no requirement)	no temperature changes

Issue	EcoLogo	LIHI	SCS	Pembina
Fish passages	must be provided when necessary to allow pre-existing upstream and downstream migration patterns	in compliance with resource agency prescriptions; fish passage survival rates of at least 95% over 80% of run (simplified)	no specific requirement; impacts to key species per unit energy generated less than regional average	effective fish passages must be provided when necessary to avoid impacts
Consultation	appropriate consultation with communities and stakeholders has occurred, issues of concern have been addressed and, where applicable, reasonable mitigation measures have been employed; prior or conflicting land use, biodiversity losses and scenic, recreational and cultural values have been addressed during project planning and development	public input into certification process	peer review of study; no public consultation	public stakeholder review regarding certain aspects
Watershed protection	(no requirement)	200-foot conservation buffer zone or equivalent in other habitat or in cash contribution to fund	(no requirement)	(no requirement)
Decommissioning	(no requirement)	not recommended for removal by a resource agency	(no requirement)	(no requirement)
Cultural resources protection	must have been addressed during project planning and development	in compliance with any mitigation requirements in license; letter from tribe or agency official attesting to no negative effect	(no requirement)	(no requirement)
New vs. existing	50% of the certified electricity in a retail power product must come from facilities built since 1991	must have been in service before August 1998	(no requirement)	(no requirement)
Location	(no requirement)	must be located in the United States	(no requirement)	(no requirement)
Greenhouse gas emissions	(no requirement)	(no requirement)	lower than grid average	life-cycle emissions less than 100g CO_2 equiv/kWh
Noise and visual impacts	(no requirement)	(no requirement)	(no requirement)	low enough not to impact area residents and others

9. Labelling and rating systems

9.1 Environmental disclosure (labelling)

9.1.1 Existing regimes

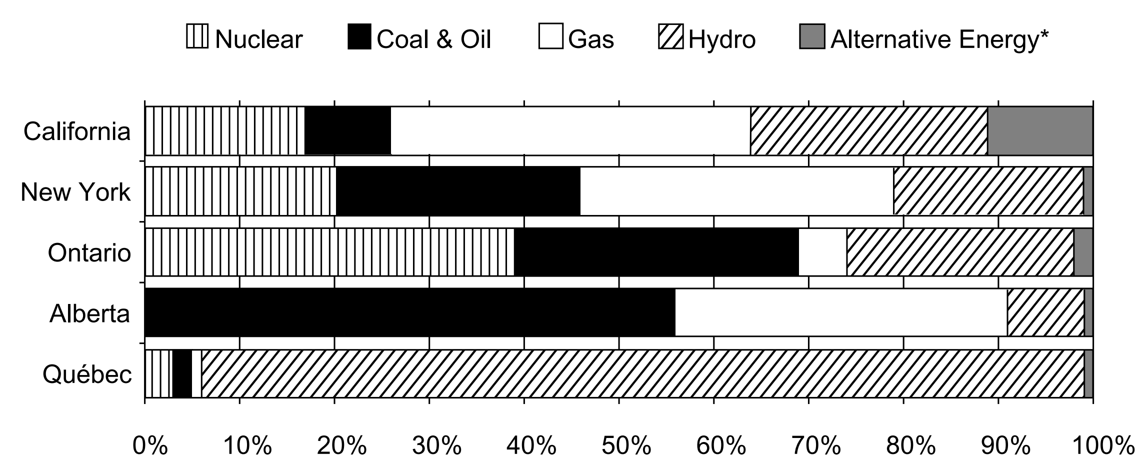
As noted earlier, green power markets ultimately rely on full disclosure of the environmental characteristics of the other power sources on the system. Since generators with no expectation of being recognized as "green" have no incentive to make public their environmental profiles, such disclosure can only occur if it is obligatory. Due to the complex nature of the electric system, an obligatory environmental disclosure system also requires a relatively sophisticated tracking protocol to ensure that the quantities of kilowatthours bought correspond to kilowatthours sold.Consumer discrimination among different power products begins with knowing the environmental characteristics of the electricity provided by their default supplier. Because of the nature of electricity, which flows across an AC network governed only by the laws of physics, it is usually impossible to distinguish which generator on a high-voltage grid is serving which consumer. Thus, it is assumed that each kilowatthour consumed from the grid is in fact a "mix" representing the various power sources supplying the grid at that moment, unless the consumer has taken specific actions to supply the power he or she consumes.

While that composition will vary from moment to moment, and especially between peak and off-peak periods, it is common to average all generation over a year in determining the composition of "system power." Graph 8 describes the makeup of system power in several regions.

In response to pressures from the environmental community, a number of jurisdictions have adopted regulations requiring more detailed labelling of system power and of power products offered by marketers. Despite regional variations, labelling requirements in most North American jurisdictions that have adopted them are quite similar. The New York State label displayed Graph 9 is typical.[282]

While these labelling regimes are generally quite informative with respect to air emissions, they generally provide no detail whatsoever as to the type of hydropower projects that are included. Although environmentalists have sought ways to make electricity labels more informative with respect to their hydropower component, the difficulty of assessing hydro impacts on a generic basis makes the implementation of this goal problematic.

Graph 8: System Power Mixes in Five North American Regions



*biomass, wind, solar and geothermal

282 State of New York, Public Service Commission, Opinion No. 98-19, Case 94-E-0952, *Opinion and Order Adopting Environmental Disclosure Requirements and Establishing a Tracking Mechanism* (15 December 1998).

Graph 9: Label Format Adopted by New York State Public Service Commission

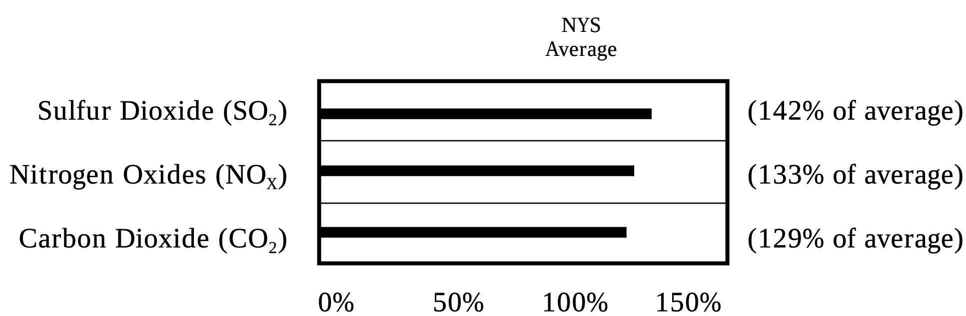
Fuel Sources and Air Emissions to Generate Your Electricity
(Period shown: 1/1/98 through 12/31/98)

FUEL SOURCES

Biomass	Less than 1%
Coal	35%
Gas	33%
Hydro	11%
Nuclear	16%
Oil	4%
Solar	0%
Solid Waste	1%
Wind	Less than 1%
Total	100%

(Actual total may vary slightly from 100% due to rounding)

AIR EMISSIONS RELATIVE TO THE
NEW YORK STATE AVERAGE



Note: Sulfur dioxide and nitrogen oxides are key pollutants that contribute to acid rain and smog, and carbon dioxide contributes to global climate change. Depending on fuel source, size, and location, the generation of electricity may also result in other public health, environmental and socio-economic impacts not disclosed above.

In adopting the label in Graph 9, the New York State Public Service Commission (PSC) disposed of this problem in the following words:

> The proposal … to have the label distinguish between types of hydropower, such as large/small, is not adopted. … *Given that historically some large hydro projects have not been controversial, while some smaller projects have been blocked due to environmental concerns, the distinction sought by the proponents that assumes that large hydro projects are environmentally worse than small projects does not necessarily hold true. No practical, meaningful, brief and simple distinction that captures overall environmental quality of any particular generating unit or units has been identified*. Similarly, we are not adopting the … proposal to include on the label descriptions of possible environmental consequences of hydro and nuclear power … We note that the label's disclaimer indicates that there may be "other public health, environmental and socioeconomic impacts not disclosed above", that *the fuel types "hydro" and "nuclear" are generally indicative of their environmental characteristics,* and that inclusion of descriptions of every conceivable impact of all fuel types would be so voluminous as to make the disclosure label useless.[283] (emphasis added)

The Commission failed to explain how it reconciled the notion that the "fuel type" hydro is generally indicative of its environmental characteristics, with the large differences in environmental impacts within both the large and small hydro categories.

The absurdity of using a label conceived for thermal power systems to communicate the impacts of hydropower are even more apparent in the label developed by Hydro-Québec on its own initiative, shown in Graph 10.[284] While this label indicates that most of Hydro-Québec's energy supplies are from hydropower, no environmental impacts related to this generation are even mentioned. The only environmental impacts detailed are air emissions (CO_2, SO_X and NO_X), apparently related to the 1.67% of the HQ power supply that is of thermal origin. It is unclear whether CO_2 emissions from the 3,391 square kilometres of reservoirs in the HQ system are taken into account, but there is no mention of either methane emissions from the reservoirs or of the ecological and social impacts they have caused.

Thus, the Hydro-Québec label does not even pretend to describe the environmental impacts associated with the hydraulic resources that make up over 90% of its power supply, but only the air emissions. A single-minded focus on air emissions may be defensible in labels for utilities in regions where the primary source of electricity generation is fossil fuels. However, for one of the largest electric companies on the continent to pass over in silence its most significant environmental impacts is most certainly not an acceptable approach to environmental disclosure.

Several years ago, Richard Cowart, then chair of the Vermont Public Service Commission, coined the phrase "ostrich economics" to describe how traditional (pre-IRP) resource planning used uncertainty about the precise value of environmental costs as an excuse to disregard them entirely:

Ostrich Math [re] Environmental Costs:

$$\begin{aligned} &E.C. > 0 \\ &E.C. < \infty \\ \therefore\ &E.C. = 0 \end{aligned}$$ [285]

Disregarding all environmental and social costs other than air emissions is just another variant of ostrich economics. Unfortunately, this approach to environmental disclosure threatens to become the norm in North America.

9.1.2 Improving electricity labelling to better reflect the impacts of hydropower

Devising labelling standards that adequately reflect the diverse nature of hydropower is far from simple. One possible solution would be to link the labelling process to "low-impact" certification, described in the previous section, by indicating on the label the percentage of supply that comes from certified low-impact hydro sources. This would of course dramatically augment the incentives for owners to seek certification and to make the changes necessary to obtain it. However, the

283 *Ibid.*, p. 11.

284 "Hydro-Québec Electricity Facts: Energy Supplies and Air Emissions," appendix 3 to *Hydro-Québec, Environment and Electricity Restructuring in North America*, Paper presented to the North American Commission for Environmental Cooperation (CEC) (June 2000).

285 Richard H. Cowart, *Integrated Resource Planning: The Contribution of Natural Gas*, presentation at the 4th Natural Gas Industry Forum (22 October 1992).

Graph 10: Hydro-Québec Label

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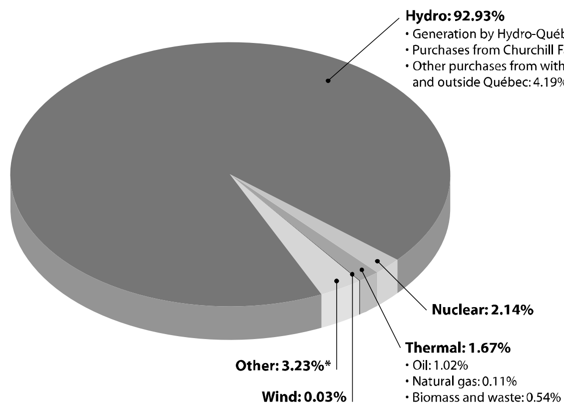
Hydro-Québec's Electricity Facts: Energy Supplies and Air Emissions

HYDRO-QUÉBEC SOURCES OF ENERGY SUPPLY

Breakdown based on energy generated, purchased and exchanged by Hydro-Québec: 12-month period ended September 30, 1999.



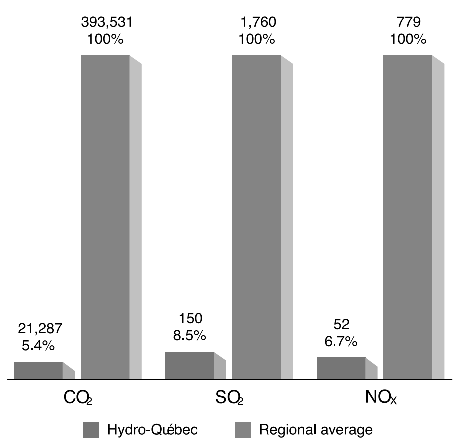
* Energy purchased by Hydro-Québec whose source cannot be determined with certainty.

AIR EMISSIONS

- CO_2 (carbon dioxide): major contributor to global warming.
- SO_2 (sulfur dioxide): major precursor of acid rain and fine particle.
- NO_x (nitrogen oxides): major precursor of ground-level ozone and acid rain.

COMPARISON OF HYDRO-QUÉBEC'S AIR EMISSIONS AGAINST THE REGIONAL AVERAGE*

Emission factors: metric tonnes/TWh



* Regional average for electricity utilities in the six New England States, New York State, Ontario and New Brunswick (1997)

In the opinion of Deloitte & Touche LLP, this information presents fairly, in all material aspects, Hydro-Québec's energy supply sources for the period of October 1998 to September 1999 and the air emissions of the reported constituents resulting from the electricity production and electricity purchases for the same period, in accordance with the criteria set out in the introductory paragraph of the auditor's report on the other side of the label.

Deloitte Touche
Tohmatsu
International

hydro industry would undoubtedly oppose any such proposal, arguing that it is unfair to imply that a project is "high-impact" simply because its owner chose not to apply for low-impact certification.

Another difficulty in this approach is that it would require the obligatory labelling regime to recognize a voluntary certification process. This would be problematic even in Canada, where there is a quasi-governmental certification process (EcoLogo); it is much more problematic in the U.S., where certification is entirely the domain of independent (and at times competing) non-profit and for-profit organizations.

To avoid the blanket characterization of non-participating facilities, the labelling authority would need to be able to fully characterize *each* generator on the grid. Such characterizations would have to be objective, unambiguous and relatively simple to assess.[286]

It would certainly be possible to provide information as to the size-class of the hydro energy in the mix (e.g., by indicating the percentage under 10 MW, between 10 and 100 MW, between 100 and 1000 MW, and over 1000 MW), but to the best of our knowledge no jurisdiction has taken this simple step. Furthermore, as we have seen, while size distinctions may provide some indication of the level of impacts, they fail to reflect the fact that some small dams have impacts far out of proportion to their size, and that the impacts of some larger dams may in fact be acceptable in relation to their power output.

Another simple, objective index of hydro projects is their storage capability. As we have seen, the environmental impacts of a hydro facility generally increase with its storage capability, due both to reservoir impoundment and to flow modifications downstream. While storage remains a crude measure that fails to take into account the many variables related to project design and operating regime, a label that broke down the hydro component by storage capability would be vastly more informative than the undifferentiated measure of hydropower currently in use.[287]

Despite its obvious advantages over the *status quo*, classifying hydro by size or storage would still provide consumers with only a vague and indirect appreciation of the actual impacts of the hydropower component of a particular power product. In order to improve on this approach, it would be necessary to develop an index that integrates the varied impacts of hydro developments on a single scale. Such an index would inevitably be imperfect, in that it would have to reconcile two mutually exclusive objectives: to accurately describe the environmental and social impacts of the hydro project and to be unambiguously determined on the basis of easily available information. The political challenge would be of a similar magnitude to the technical one: such an index would be useless if it was not widely endorsed in both environmental and hydro industry communities.

The index would inevitably have to be based on *indicators* of impacts rather than on the impacts themselves. Determining a project's actual impacts on fisheries and other wildlife, on families, communities and economies, leads directly into the phenomenal levels of complexity described earlier in this study. Vast amounts of effort are required to precisely characterize these impacts, which nevertheless remain controversial; it is inconceivable that this effort be required for every existing hydro station simply to allow proper labelling.

At the same time, there are many obvious indicators that undoubtedly *affect* impacts, though not on a precise mathematical basis. There is little question that impacts increase with the area flooded, as they also increase with the extent to which flows are modified from natural cycles. Similarly, chains of reservoirs inevitably affect river ecosystems more than do single dams, and projects involving river diversions have greater impacts, all else being equal, than those that do not.

As obvious as these beginning steps are, the process of developing a comprehensive index is fraught with difficulty. How to account for social impacts on individuals, communities and aboriginal nations? To what extent should scores be treated as "absolute," and to what extent should they be scaled to account for energy benefits (annual kilowatthours, installed capacity,

286 While thermal operators may consider emissions reporting requirements burdensome, they are methodologically straightforward.

287 The New England Power Pool characterizes all hydro facilities as either "daily cycle" (run of the river) or "weekly/seasonal," based on the relationship between installed capacity and storage volume (*NEPOOL Market Rules and Procedures,* Section 11, Installed Capability Market, Appendix 11-D, Rating and Auditing NEPOOL Resources). While a measure based on how a reservoir is actually operated would be a more useful indicator of impacts, it would require much more complex rules to allow for objective and unambiguous characterizations.

availability at peak periods)? And how should various components of the index be weighted?

Developing such an index would be a major undertaking, in which success is by no means assured. If broad consensus could be achieved, however, it would make possible a simple and straightforward ranking of hydro projects from an environmental perspective, which would be essential for an intellectually coherent labelling regime.

9.2 The Power Scorecard

A recent initiative that deserves mention in this context is the Power Scorecard, developed recently by the Pace Energy Project (part of the Pace University School of Law Center for Environmental Legal Studies). The Power Scorecard provides a straightforward methodology for comparing environmental impacts of all generating technologies.

The Power Scorecard rates generators and retail power products on the basis of eight criteria, using a scale from 0 to 10. (Scores can also be extended beyond the upper limit in the event of adverse environmental impacts significantly greater than the norm, or beyond the lower limit in the event that mitigation measures result in a positive environmental benefit.) The criteria are CO_2, SO_X, NO_X, airborne mercury, water use, water quality, on-site land use, and off-site land use.

For quantitative impacts such as CO_2 or SO_X emissions, the Power Score is based on an explicit schedule. For example, SO_X emissions are rated on a scale ranging from 0 points for the (near-zero) emissions of a high efficiency natural gas plant to 10 points for those of a high sulphur coal plant without flue gas desulphurization equipment (46.5 lbs SO_X per MWh). Power Scorecard has established default values for all eight criteria for 30 distinct generation types, which are used when plant-specific information cannot be obtained.

For hydropower, Power Scorecard assigns a value of zero for each of the four air quality criteria.[288] For water and land impacts, however, it assigns values based on whether the facility has been certified by LIHI (4), whether it has been reviewed by FERC since the 1986 legislative modifications (8), or not (10). Additionally, if a facility has been recommended for removal because of severe ecological or dam safety issues, it is given a value of 20.

Once the generators are rated, the rating for a power product is simply a weighted average of its suppliers. Power Scorecard also indicates for each power product the percent of its supplies that come from new, environmentally preferable renewable sources. These include solar, wind, geothermal and biomass, but exclude hydropower.[289] New environmentally preferable capacity is characterized as “new” for the first ten years after commissioning.

Power Scorecard has the advantage of being simultaneously a mechanism for characterizing generators (like EcoLogo) and power products (like Green-e). Like SCS, it requires characterizing all generators in the system, but it does so based on a transparent scoring system, albeit one without pretensions to scientific precision.

The Power Scorecard is identified as a work in progress. Its framework for rating hydropower is overly simplistic: it takes no account of the greenhouse gas emissions from reservoirs, and the point-values for the other categories appear to be largely arbitrary. Furthermore, because these ratings are inextricably linked to the U.S. regulatory framework, they are of no use in other countries. Nevertheless, the Power Scorecard’s straightforward, modular structure would make possible the use of more sophisticated rating systems as they are developed.

[288] As we have seen in Chapter 6, it is incorrect to give hydropower a score of zero for greenhouse gas emissions.

[289] Landfill gas may qualify under certain conditions.

10. Renewables Portfolio Standard

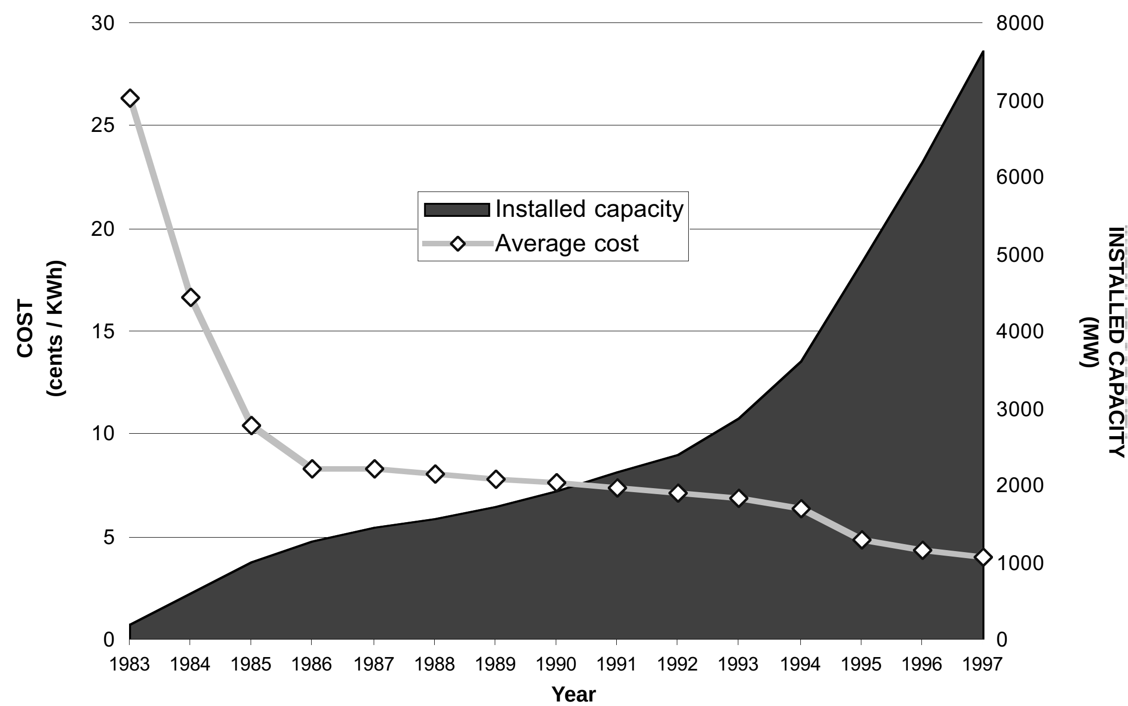
Among the key market mechanisms for fostering development of green power technologies within the competitive marketplace is the "renewables portfolio standard" (RPS). An RPS requires that a certain percentage of power sold or generated in a given jurisdiction be derived from environmentally preferable energy resources. Under a typical RPS, renewable generators earn credits based on their annual output. Retailers are obliged to obtain a sufficient number of credits (set as a percentage of annual sales); penalties are assessed against any retailer that fails to comply.[290]

The underlying purpose of the RPS is to create a market for environmentally preferable technologies which are not yet competitive from a purely economic perspective. The cost curves of new technologies often decline precipitously, due both to technological maturity and to economies of scale. Graph 11, for example, portrays the historic and projected evolution of the cost of wind power from 1983 to 1997.[291]

In order to ensure that the main objective of the RPS — significant market penetration by new, green power technologies — is achieved, it has been argued that eligible resources should be limited to those that share the following characteristics:

1. current costs must be above the market,
2. the technology must still be immature, with significant potential for improvement and cost reductions, and
3. its environmental benefits should be comparable to those of other resources included in the RPS.

Graph 11: Wind Power Costs and Unit Costs



[290] In some jurisdictions, the RPS obligation is placed on generators rather than on retailers. To avoid the semantic problems described below, this concept is sometimes known as a "generation portfolio standard" (GPS). However, as most of the literature still uses the term RPS, we shall do so as well.

[291] Philippe Dunsky, "La nouvelle conjoncture énergétique et le role des technologies distribuées," Presentation to the International Research Institute (May 1997), p 12.

States or other jurisdictions designing an RPS must decide which resources to include based on the goals they seek to accomplish through the policy. These goals may include improving the diversity of the resource mix serving the jurisdiction, environmental benefits and technology advancement. Policy makers may exclude certain types of resources if they do not provide these benefits are not judged sufficient or if the resource does not require additional policy support to provide them.

Based on these criteria, hydropower would be ineligible for inclusion in an RPS. Widely regarded as one of the most mature of generating technologies, hydropower does not need the RPS to be competitive in today's power markets. The National Hydropower Association contests this, arguing that hydro is not mature because it could gain market share through the development of nearly 30,000 MW of undeveloped hydropower potential, and because:

> …calling hydro 'mature' also fails to recognize the new development that could occur with advances in turbine technology and biological sciences that help minimize project impacts to fisheries.[292]

However, in a recent study carried out for the National Association of Regulatory Utility Commissioners (NARUC) and the U.S. Department of Energy, Nancy Rader and Scott Hempling reaffirmed that hydropower is technologically fully mature with respect to conversion efficiencies and costs. They point out that, while other renewable resources also have environmental impacts, none so uniquely affect a limited public resource such as waterways, and describe a number of practical difficulties associated with including hydropower in an RPS:

> Because it has been so extensively developed, hydropower is more likely than other resources to create practical problems when policy makers seek to make existing resources eligible under the RPS. … In particular, the problem would arise when a state wishes to provide an economic boost to at-risk hydro plants serving the state, but have difficulty doing so because of a large available supply of economically stable hydro resources in the region. Policy drafters would need to take care to target those at-risk hydro plants while not inadvertently helping economically stable ones.[293]

In their view, the special characteristics of hydropower in many circumstances provide a strong rationale for excluding it from eligibility under the RPS, or for restricting its eligibility:

> If hydro is included, drafters of the law must take particular care to ensure that the definition of eligible resources is sufficiently strict to prevent the unanticipated entry of a significant quantity of hydropower into the RPS market, which could prevent the development of other renewable energy resources.[294]

Nevertheless, the hydro industry has lobbied hard for inclusion in RPS legislation, based largely on the argument that hydropower is by definition eligible for inclusion in a "renewables portfolio standard." These arguments are reviewed in Section 10.1.

Since the standard establishes a reserved market for certain types of generation (anywhere from 3% to 20% or more of the total electricity market), the decision to include or exclude hydropower has very real consequences. A number of jurisdictions have included hydropower as an eligible resource (in some cases with size restrictions) on the same footing as wind or solar power. Others have developed a two-tiered system, offering separate degrees of protection for specific technologies, with hydro often being placed in the "second-class" category. Still other RPSs exclude hydropower altogether from the list of eligible resources. Box 1 summarizes the requirements of a number of existing and proposed RPS program designs.

292 National Hydropower Association, "Hydropower: Indisputably Renewable." <www.hydro.org/ga018.htm>

293 Nancy Rader and Scott Hempling, *The Renewables Portfolio Standard: A Practical Guide* (NARUC, 2001), p. 38.

294 *Ibid.*, p. 40.

Box 5: Existing and Proposed RPS

To date, RPS programs have been implemented in 10 American states, and are under consideration in many others. These programs vary by portfolio size and resource eligibility, among other key characteristics. The following table summarizes the general and hydro-specific attributes of programs currently under way.[295]

State	General Provisions	Hydro Eligibility
Massachusetts	Baseline proportion for all sales.[296] 1% above baseline by 2003; +0.5%/yr until 2009; +1%/yr thereafter	Baseline: yes[297] Additional: no
Maine	30% of sales in 2000[298]	Yes, if <100 MW
Connecticut	Class I or II[299]: 5.5% in 2000; 6% in 2005; 7% in 2009 Class I only: 0.5% in 2000; 1% by 2002; 3% by 2006; 6% by 2009	Class I: yes Class II: yes
New Jersey	Class I or II[300]: 2.5% in 2000 Class I only: 0.5% more by 2001; 1% by 2006; +0.5%/yr. until 4% by 2012	Class I: no Class II: yes
Iowa	~2.5% of sales	No
Arizona	0.5% of sales in 1999, rising to 1% in 2002	No
Minnesota	~4.3% of sales by 2002, plus possible 400 MW more of wind by 2002[301]	No
Nevada	0.2% in 2001 rising to 1% in 2009	No
Wisconsin	0.5% by 2001, increasing to 2.2% by 2011	Yes, if <60 MW
Texas	400 MW of new renewables by 2003; 2000 MW by 2009	Yes
FEDERAL	A number of bills before Congress – with widely differing attributes – would institute a nationwide RPS. Renewable targets range from 4% to 20% of total U.S. power consumption. While most bills contain specific provisions barring hydropower as an eligible resource, there are some exceptions.	

10.1 "Renewability"

The position of the hydropower industry is that hydropower is by definition renewable, and thus should be treated as an eligible resource in all renewables portfolio standards.[302] For example, Hydro-Québec's U.S. subsidiary, HQ Energy Services (U.S.) ("HQUS") argues that:

> The accepted lexical meaning of the word "renewable" should prevail to avoid confusion among consumers. The National Association of Attorneys General uses this reference to define "renewable" as any energy source that is naturally replenishable and replenished on some reasonable time scale. … All hydroelectric plants, regardless of their size, can produce electricity without compromising the ability of future generations to meet their own needs.[303]

295 From table produced by Union of Concerned Scientists, updated in February 2000. Available for download at: http://www.ucsusa.org/index.html.

296 Ambiguous in the statute.

297 The baseline fraction is defined by the statute to include "naturally flowing water and hydroelectric." See Section 10.2, below.

298 Existing installed capacity within the state of Maine is more than sufficient to meet this requirement.

299 In Connecticut, "Class I" refers to solar, wind, hydro, sustainable biomass, landfill gas and fuel cells. "Class II" refers to hydro, municipal solid waste and other biomass.

300 In New Jersey, "Class I" refers to solar, wind, sustainable biomass, landfill gas, fuel cells, geothermal, wave and tidal energy. "Class II" refers to municipal solid waste and hydro that meets high environmental standards.

301 Not part of RPS.

302 National Hydropower Association, see note 292, and "Electricity Industry Restructuring and Hydropower." <www.hydro.org/ga011.htm>

303 *Comments of HQ Energy Services (U.S.),* State of New Jersey, Board of Public Utilities, In the matter of the *Draft Interim Renewables Portfolio Standard, pursuant to the Electric Discount and Energy Competition Act* (19 July 1999), p. 4.

While there is obviously no fuel required to operate a hydro plant, to the extent that irreplaceable resources were lost in developing the site or that its operations create significant stresses on important ecosystem functions, such a facility clearly has non-renewable aspects as well. The inventory of the status of large rivers in the northern third of the earth cited earlier shows that large rivers are themselves endangered.[304] The renewability of hydropower was also called into question by the Doyon Commission in Québec:

> While water may be a renewable resource, the permanent character of hydro projects must be emphasized: the river and its environment are irremediably altered by the construction of hydropower facilities. There is rarely a way back, as dams are hardly ever dismantled to return the site to its natural state. Thus, *while water might be a renewable resource, it is dangerous to presume that a hydropower development is renewable as well.*[305] (emphasis added)

More important is the realization that "renewability" is but one aspect of environmental preferability. All else being equal, it is of course far better to meet energy needs through renewable resources — but all is rarely equal. A new energy technology that was, strictly speaking, renewable but that caused severe human health problems would hardly deserve the benefits reserved for the most environmentally benign energy resources.[306]

The National Association of Attorneys General (NAAG), invoked by HQUS in the passage quoted above in fact recognizes that renewability is only one part of environmental preferability:

> It is … deceptive to claim, directly or by implication, that a renewable energy source has no significant negative environmental impacts by sole virtue of the fact that it is renewable. …
>
> *Comment. In defining "renewable" for the purpose of these Guidelines, the Attorneys General have opted for the common meaning of the word, focusing on replenishability on a reasonably short time scale, and applying it to energy sources, rather than technologies. Under this definition, there is no basis for distinguishing between large-scale and small-scale hydro. However,* **renewable resources can still have a significant environmental impact, so "renewable" is not equatable with "green," "clean" or similar terms, and care must be taken to avoid overstating the environmental import of renewability.** *(bold added, italics in original)*[307]

The NAAG went on to offer as an example of deceptive advertising the use of the phrase "Good for the Earth, Because It's 100% Renewable!" to sell electricity generated in part by large dams. NAAG concludes that "the claim is deceptive because the company improperly asserted that its energy product had no significant environmental impacts by sole virtue of the fact that it is renewable."[308]

Following the energy crises of the 1970s, the term "renewable" began to be casually used as a synonym for all that is environmentally preferable in electricity generation. This usage has since been adopted in statutes and in regulatory orders, in the form of "renewables portfolio standards" and other instruments. In most cases, it is clear that the intent was not to rely exclusively on technical renewability to the exclusion of all other environmental considerations, regardless of their significance.[309] The important questions thus turn on the multi-dimensional question of environmental preferability, of which renewability is just a part.

This view can be seen, for example, in the legislative language creating an RPS in New Jersey, which defines "Class II" renewable energy as that produced at a

304 Dynesius and Nilsson, see note 100. They found that 77% of the total water discharged by the 139 largest river systems in the northern third of the world "is strong or moderately affected by fragmentation of the river channels by dams and by water regulation resulting from reservoir operation, interbasin diversion and irrigation."

305 *Commission d'enquête sur la politique d'achat par Hydro-Québec d'électricité auprès de producteurs privés*, see note 124, p. 468 (our translation).

306 A hypothetical example of such a technology would be one that used satellites to collect solar energy and microwaves to transmit the energy to Earth, but which led to increased cancer incidence in the region surrounding the collector. The Canadian Space Agency is indeed working on developing this type of technology, but it insists that there will be no risk to human health. R. Bryan Erd, Manager, Canadian Space Power Initiative, pers. comm.

307 National Association of Attorneys General, *Environmental Marketing Guidelines for Electricity* (December 1999), p. 15.

308 Ibid., p. 16.

309 The term "renewables portfolio standard" was initially proposed in Nancy A. Rader and R. B. Norgaard, "Efficiency and Sustainability in Restructured Electricity Markets: The Renewables Portfolio Standard," *Electricity Journal* (July 1996). While the term "renewable" was not defined, Rader confirms that the intent was never to guarantee benefits to every conceivable renewable energy resource, pers. comm.

resource recovery or hydro facility "provided … that the Commissioner of Environmental Protection has determined that such facility meets the highest environmental standards and minimizes any impacts to the environment and local communities."[310]

Hydro-Québec, however, considers the primary goal of an RPS to be "to enhance air quality at the lowest possible cost for consumers, by displacing the use of fossil fuel fired generation," and it has singled out this New Jersey provision as a barrier to trade.[311] These arguments have been taken up by the Government of Canada in a series of letters written by former Canadian Ambassador Raymond Chrétien to the sponsor of one of the most influential restructuring bills currently before the U.S. Congress, to the Administration and to other key legislators. In the letter, Chrétien wrote:

> Our review of the "Electricity Competition and Reliability Act" (H.R. 2944) and other restructuring legislation indicates that certain proposals, if enacted, could have a negative impact of this strong trade [in electricity between Canada and the U.S.] and *would be inconsistent with the NAFTA and other trade agreements*. … We believe that legislation should encourage competition in a non-discriminatory manner fully consistent with international trade rules."[312] (emphasis added)

In a document attached to the letter, the embassy explains:

> The implicit exclusion of Canadian-origin sources [from an RPS] is inconsistent with the NAFTA energy chapter. The requirement "to achieve a given level or percentage of domestic content" is inconsistent with the NAFTA investment chapter and the WTO agreement on trade-related investment measures. *Furthermore, through proposed legislative definitions of renewable sources, electricity would be accorded different treatment depending on its manner of production, a measure which would affect conditions of competition and which would be inconsistent with NAFTA and WTO national treatment obligations*.[313] (emphasis added)

Since discriminating among goods based on their "manner of production" has already been found inconsistent with trade agreements, a trade action on this basis could threaten all RPS legislation, not just with respect to hydropower.

According to the Canadian embassy, no such trade actions with respect to RPS legislation have yet been initiated. However, the embassy has not excluded the possibility of launching such actions if it finds that the RPS and reciprocity provisions of federal and state legislation are inconsistent with these trade agreements.

10.2 Existing resources

As seen in the preceding table, many RPS programs establish separate percentages for existing and for new resources. The underlying policy goal is of course to promote the development of new resources of the types covered by the standard, based in turn on the perception that their benefits in displacing other types of generation far outweigh any environmental impacts they might cause, and that they have not yet reached a level of technical and commercial maturity to allow them to compete successfully in the marketplace.

However, the "existing resources" portion of an RPS does not directly incent new development; rather, it provides a dedicated market for the sale of power generated by existing facilities. The main effect is thus to increase the market price for that power. For example, wind facilities that are not under long-term contract would benefit from such a guaranteed market, which indeed might be critical to their survival, if market prices are not adequate to cover their relatively high operating and maintenance costs.

The RPS can thus be seen in part as a tool to bridge the gap until the green power market is fully developed, in that it creates demand (and hence a market)

310 State of New Jersey, *Electric Discount and Energy Competition Act*. The Act also requires that retail competition be permitted in the region where the power is generated, considered by Hydro-Québec to constitute illegal discrimination against out-of-state producers.

311 Hydro-Québec, see note 217, p. 8.

312 Raymond Chrétien, Canadian Ambassador to the U.S., letter to Rep. Joe Barton, 22 October 1999. Barton is chairman of the Commerce Subcommittee on Energy and Power of the U.S. House of Representatives and sponsor of the *Electricity Competition and Reliability Act*, H.R. 2944.

313 Canadian Embassy, *Canadian Government Concerns Respecting Reciprocity Requirements and Renewable Energy Provisions* (undated).

for environmentally preferable power before the retail green power market is mature enough to do so.[314] Both the "existing resources" and "new resources" parts of the RPS are important in this sense.

However, it is important to note that even a vigorous green power market would not replace the need for an RPS. As we have seen earlier, the green power market is ultimately problematic in that it in effect requires "do-gooders" to shoulder the full cost of generation choices that benefit all. In requiring all power consumers to meet a portion of their needs through environmentally preferable power, the RPS ensures that this burden is shared, at least in part, by society as a whole.

As noted by Rader and Hempling, inclusion of hydro as a qualifying existing resource can interfere with this effect, if large amounts of hydropower are available in a regional market. For example, there has been considerable debate over what resources should be eligible for the RPS adopted as part of the restructuring legislation in Massachusetts. According to the legislation, hydropower is excluded from the "new" part of the RPS, but power that is "naturally flowing water and hydroelectric" is eligible for inclusion as an existing resource. This unusual formulation has not surprisingly given way to heated debates as to its meaning. In a white paper prepared for the State's Division of Energy Resources (DOER), consultants used logical gymnastics to conclude that "and" means "or" and thus that the intent of the Act was to make all hydropower eligible for the RPS:

> By linking the terms *naturally flowing* and hydroelectric with *"and"*, the most obvious intent would be that an eligible facility may be either naturally flowing *or* hydroelectric, which based on the above interpretations, would be no different than had the Act simply said *hydroelectric*. An alterative interpretation would require that a facility be *both naturally flowing and hydroelectric*, i.e., that naturally flowing would be a qualifier or limitation on eligible hydroelectric. *We find the former interpretation more compelling*. Had the Act intended to limit water power eligibility, we expect that the intent would have been much clearer, as it was for limitations on biomass eligibility.[315] (emphasis added)

Hydro-Québec, an active participant in the consultation carried out by DOER, is supportive of this definition,[316] which would make all of its hydro capacity eligible for sale in Massachusetts under the RPS, without regard to the characteristics of the individual facility.[317] Other participants in the consultation such as the American Wind Energy Association, the Union of Concerned Scientists and others not surprisingly disagreed. At this writing, DOER has endorsed the consultants' interpretation, but no final determination has been made.[318]

10.3 Conclusion

While there is a broad societal consensus that favours maximizing the development of new and currently marginal technologies such as wind and solar, there is no such consensus for hydropower. We have seen earlier that many of the environmental costs of hydropower are "sunk" from the moment when the facility is built. Thus, unlike a thermal plant, shutting down a hydro facility does little to reduce the impacts created by its construction, unless the dam is decommissioned. Rather, the construction of each new hydro facility contributes to the cumulative harm to the world's riverine ecosystems to a greater or lesser extent, depending on the project's siting, design and operating regime.

There may well be occasions where a new hydro facility would represent the least social cost solution to energy needs; that is where the expected impacts, once appropriately mitigated at the siting, design, and operational levels, are small compared to the power benefits. However, such judgements can only be made on a case-by-case basis. The use of the RPS as an across-the-board measure to promote and stimulate hydro development therefore has no place in modern energy policy.

314 Edward A. Holt and Robert C. Grace, *Massachusetts Renewables Portfolio Standard, White Paper #11: The Relationship between RPS and the Market for Green Power* (9 November 1999).

315 Robert C. Grace *et al.*, *Massachusetts Renewables Portfolio Standard, White Paper #5: Eligibility* (18 January 2000), p. 30.

316 "[T]he recognition of hydroelectric facilities of all size[s] as qualifying for this definition … is of primary importance for HQ." Hydro-Québec, see note 217, p. 13.

317 As a matter of corporate policy, Hydro-Québec declines to attribute sales to individual generating facilities, asserting instead that all sales are system power.

318 Massachusetts Division of Energy Resources (DOER), *Preliminary RPS Design Proposal, Version 3* (14 November 2000), p. 3.

11. Hydropower and the future of planning

As we have seen in Part I, competitive electricity markets generally rely on individual companies to make decisions about building new generation based on their own perception of commercial risk. The theory, of course, is that, once prices are determined by supply and demand, the "invisible hand of the market" will ensure that the optimal level of generation is built. To the extent that environmental externalities are internalized through appropriate fiscal or market-based mechanisms, the invisible hand will also ensure that environmental damage is kept to the optimal ("economically efficient") level.[319]

The events still unfolding in California — where, in the words of one wag, "the invisible hand was caught in the cookie jar" — have cast doubt on the market's ability to keep the lights on and to keep prices at reasonable levels. According to economic theory, markets lead to economically efficient results only when they are free of barriers to competition such as market power and externalities. The challenge in California is primarily one of market power, but the substantial externalities associated with the massive environmental impacts caused by electricity generation and transmission must also be internalized if competitive electricity markets are to function properly.

Most of the market-based mechanisms that have been developed in the restructuring process are designed to internalize the externalities of fossil-fuel based generation (air emissions). They consequently ignore the environmental costs associated with hydropower, most of which are not integrated into producers' costs. In many cases, these ecological costs go unstudied, unquantified, unmonetized and uninternalized in the market price of the resulting power. While environmental mitigation measures or compensation payments may internalize some of these costs, the rest are simply absorbed by riverine ecosystems and by the peoples who depend on them.[320]

Therefore, despite the widespread belief that market-based mechanisms mitigate the environmental consequences of electricity restructuring, they largely fail to do so insofar as hydropower is concerned. Thanks largely to the lack of interest in hydropower on the part of the architects of competitive electricity markets, (and in part to the focussed, behind-the-scenes lobbying of the hydro industry), these mechanisms contribute primarily to augmenting hydropower's market advantage rather than mitigating it.

Competitive markets thus remain incapable of ensuring that the construction of new hydropower facilities is limited to those that are in the public interest, taking into account their economic, environmental and social costs. On the contrary, leaving these decisions to the market virtually ensures that projects will be built whose costs to society exceed their benefits.[321]

For all these reasons, non-market interventions such as planning are still required. Indeed, this was precisely the conclusion of the World Commission on Dams, which, following a three-year process involving consultations with dam proponents and opponents around the world, concluded:

> [T]he main challenge for water and energy resource developers in the 21st century will be to improve options assessment and the performance of existing assets. This will require *open, accountable and comprehensive planning and decision-making procedures* for assessing and selecting from the available options.[322] (emphasis added)

It added:

> The preferred development plan is selected through a *participatory multi-criteria assessment that gives the same significance to social and environmental aspects* as to technical, economic and financial aspects and covers the full range of policy, programme, and project options. Within this process, investigations and studies are commissioned on individual options to inform decision making as required; for example, demand-side management studies or feasibility studies.[323] (emphasis added)

Thus, for the WCD, a comprehensive and inclusive planning process is essential to making appropriate decisions about dams. While it did not refer to it explicitly, the process it proposes closely resembles

319 The internalization of externalities is explained on page 3.

320 The increasingly stringent mitigation requirements imposed by the FERC in recent years has had the effect of reducing, but not eliminating, these externalities for some dams.

321 The propensity of government-owned utilities to favour the construction of new facilities for short-term political benefit only adds to this effect.

322 World Commission on Dams, see note 166, p. 167.

323 *Ibid.*, p. 262.

integrated resource planning (IRP), the planning process developed in the U.S. in the 1980s and early 90s which was discussed in Chapter 1.

In integrating externalities into the decision-making process and in involving the concerned public directly, IRP represented an attempt to ensure that the utilities' choices in fact represented the best interests of society as a whole. Precisely because hydropower projects represent such a complex mix of economic, environmental and social factors, integrated planning processes for the first time made it possible to compare them on an objective basis with other supply- and demand-side alternatives to meeting energy needs.

Desite its dramatic failure to resolve the debate over new supply in California in the early 1990s, IRP has in fact worked reasonably well in some jurisdictions. In fact, its potential for addressing the hard questions posed by hydro projects had only begun to be exploited when it was hit by the restructuring juggernaut.

Although much of the pioneering work on IRP was done in the Pacific Northwest, practitioners there were more concerned with mitigating the environmental impacts of existing dams than with building new ones. Hence, it was not until Canadian jurisdictions began to adopt IRP that this process began to be applied to proposals to build new hydropower dams.

It was British Columbia that first applied integrated planning methodologies to decision making about new hydro projects. Under the leadership of economist Mark Jaccard in the early 1990s, the British Columbia Utilities Commission issued integrated resource planning guidelines and ordered B.C. Hydro to use them to develop a long-term resource plan.[324]

B.C. Hydro did indeed carry out an integrated planning exercise, which eventually resulted in the publication of a long-term plan.[325] It balked, however, at the extent to which the Commission insisted that the public be involved. When the Commission ordered it to establish a collaborative committee to participate in the planning process, B.C. Hydro challenged in court not only the order, but also the Commission's power to require the utility to submit a long-term plan for approval. The B.C. Court of Appeal decided in favour of the utility, finding that the statute creating the Commission did not authorise it to require integrated resource planning, much less to demand that the public be involved in it.[326] As a result, while B.C. Hydro continues to update its integrated electricity plan,[327] it does so without public involvement or regulatory oversight.

As we have seen in Chapter 4, although vigorous *retail* competition would indeed make true IRP impossible (since decisions about energy choices are made by consumers, not by utilities or their regulators), the existence of competitive *wholesale* markets does not reduce the relevance of an IRP-type planning process. To the extent that a utility with an obligation to serve has access to a vigorous wholesale market, it may well choose to buy power to meet its customers' needs, rather than generating it. However, regulators can still require that the utility choose those resources with the least social cost — taking into account their environmental and social costs as well as financial ones.

Thus, as long as the utility has a fixed service territory with an obligation to serve, as is still the case in those Canadian provinces with significant hydro resources, it can continue to apply integrated planning processes. Even when retail access is permitted, a default provider can still carry out integrated planning, albeit with some limitations.[328]

In some jurisdictions, however, utilities have been in such a hurry to abandon integrated planning processes that they have managed to eliminate them even when retail competition is just a vague future possibility, if that. Utilities have traditionally been hostile to public oversight and regulatory control, accepting it as a necessary evil that softens public resentment over controversial projects and that allows them to avoid sole responsibility when things go wrong. Given the limited degree of public involvement in the complexities of energy regulation, it should come as no surprise that an oversimplified notion of competition has provided an excuse to jettison these structures altogether. The case of Québec, the region in North America with the

324 B.C. Utilities Commission, *Integrated Resource Planning Guidelines.* See also P. Raphals, *Energy in British Colombia: Integrated Resource Planning and Regulation,* prepared for the Québec Natural Resources Department (1995).

325 B.C. Hydro, *1995 Integrated Electricity Plan.*

326 B.C. Hydro and Power Authority v. B. C. Utilities Commission *et al.,* Court of Appeal for British Columbia (23 February 1996).

327 B.C. Hydro, *1998 Integrated Electricity Plan Update*; B.C. Hydro, *2000 Integrated Electricity Plan Update.*

328 Insofar as it is in competition with other suppliers, selecting resources that are substantially more expensive than power available elsewhere may cause the default provider to lose market share. Long-term above-market commitments could theoretically threaten its financial stability; however, in practice, many means are available to limit these risks.

greatest potential for and interest in building new dams, is an eloquent example of this phenomenon.

As we have seen at the end of Part I, a chain of events starting with the collapse of the Great Whale project led to the adoption of legislation that would require Hydro-Québec to carry out integrated resource planning under the oversight of a new regulatory agency. This legislation was largely inspired by the B.C. experience, in that it would *require* the kind of integrated resource planning process that the courts had found the B.C. legislation not to allow. This planning requirement was first frustrated and eventually repealed, thanks to Hydro-Québec's implacable opposition to regulatory involvement in its generation activities. The result is that the thousands of megawatts of new hydro projects that Hydro-Québec intends to build to serve the U.S. market will not be subject to any public review process empowered to weigh their expected commercial benefits against their financial risks and environmental and social cost. While only a few years ago it was said that the era of big dams was over, it appears rather that, from Hydro-Québec's perspective, it is the era of public involvement in planning that is over.

Restructuring of the North American electric industry has thus led to the disappearance of public involvement in most decisions about building new hydro facilities.[329] In so doing, it has rendered inoperative the tools developed in the preceding decade to balance economic, environmental and social concerns in planning and authorizing such projects.

These tools, of course, need to be adapted to work in a competitive environment. Much work remains to be done to reconcile competitive market structures with the need for planning — both to avoid price volatility resulting from drastic shifts in the supply-demand balance, and to ensure that resources with high environmental costs are developed only if they are in the public interest.

Conclusion

As we have seen, restructuring has led to the implementation of a number of mechanisms designed to ensure that it does not aggravate the environmental harm caused by electric generation. By oversight more than by design, these mechanisms fail to adequately represent the environmental and social impacts of hydropower. As a result, these mechanisms inevitably tilt the decision-making field in such a way as to favour hydropower in relation to other energy resources, thereby increasing the total environmental burden caused by providing energy services to the public.

This failure is largely the result of the way these mechanisms are implemented. Considerable improvement is therefore possible, but only if a real effort is made to ensure that restructuring does not promote inappropriate hydro development.

At the same time, we have seen that restructuring affects not only the operation and disposition of existing hydro facilities, but also the context in which decisions about new developments are made. While the operating regimes of some facilities may be improved by owners seeking green marketing certification, worsening of operating regimes following divestiture and consequent deregulation may well be a more significant result.

The disappearance of integrated resource planning and indeed of virtually all public involvement in decision making in those few areas in which substantial new hydro projects are likely is without doubt the single most significant consequence of restructuring, insofar as hydropower is concerned.

If the costs and benefits of hydropower are to be properly accounted for in the future, decision-makers and stakeholders will have to take greater care both in evaluating the implications of proposed market structures for the environment in all its aspects, and in designing an appropriate combination of market mechanisms and regulatory controls to internalize the externalities of hydropower. Doing so will require some degree of long-term planning, irrespective of market restructuring, as well as careful and sophisticated consideration of hydropower's distinct characteristics in designing mitigative mechanisms. While these problems are not insurmountable, much work remains.

[329] Neither the government of Canada nor any provincial government has yet to officially comment on the WCD report, nor has Hydro-Québec, which played an active role in the Commission's proceedings. The Commission concluded its report by inviting governments and stakeholders to endorse the Commission's recommendations and to report on how their policies and actions have changed as a result. WCD, *Dams and Development*, see note 166, p. 312. The reports are posted on-line at: http://www.dams.org/report/reaction.htm.

APPENDIX 1 – ECOLOGO GUIDELINES

Discussion Draft ECP-79

Renewable Low-Impact Electricity

Pursuant to paragraph 8(1)(*b*) of the Canadian Environmental Protection Act, 79 guideline on **renewable low-impact electricity** under the auspices of the Environmental Choice[M] Program (ECP).

The Environmental Choice Program is designed to support a continuing effort to improve and/or maintain environmental quality by reducing energy and materials consumption and by minimizing the impacts of pollution generated by the production, use and disposal of goods and services available to Canadians.

Based on a review of currently available life cycle information of the production, use and disposal stages, the product category requirements will produce an environmental benefit through:

(a) the displacement of non-renewable fuels by renewable, more sustainable fuel sources;

(b) the reduction of air emissions that contribute to global warming, smog, acid rain and airborne particulate pollution;

(c) the reduction of solid wastes arising from both the mining and extraction of non-renewable fuel sources, and the disposal of toxic metal emissions and nuclear wastes; and

(d) the reduction of impacts on aquatic, riparian and terrestrial ecosystems from electricity generating activities.

Life cycle review is an ongoing process. As information and technology change, the product category requirements will be reviewed and possibly amended.

Environment Canada anticipates that generators and marketers of renewable low-impact electricity which conform to this guideline will apply to the Environmental Choice Program for verification and subsequent authority to label the qualifying products with the Environmental Choice EcoLogo[M].

Interpretation

1. In the following guideline:

"alternative-use electricity" means electricity generated from the installation of a supplemental process and/or equipment to alter and/or add to the processes of an existing operation in order to generate electricity. The existing operation must not have been originally designed or intended for electricity generation, nor have had any processes in place at the time of commissioning that would have facilitated electricity generation. Although biogas-fueled electricity is a form of alternative-use electricity, it is defined as a separate category by this guideline;

"biogas" means gaseous products (primarily methane and carbon dioxide) produced by the anaerobic decomposition of organic wastes. Facilities producing biogas include *inter alia* landfill sites and sewage treatment plants;

"biogas-fueled electricity" means electricity generated from a system in which biogases are captured for combustion and conversion to electricity.

"biomass" means:

(a) the wood-wastes and agricultural wastes that are solid residues arising from the harvesting and processing of agricultural crops or forestry products that might otherwise be sent to landfill and/or incinerated,

(b) dedicated energy crops, and

(c) liquid fuels derived from biomass as defined in items (a) and (b), including *inter alia* ethanol, biodiesel, and methanol.

Biomass does not include materials for which other diversion methods are a viable alternative (e.g., soil amending, farm land applications, horticulture applications), nor the treated by-products of manufacturing processes (e.g., treated chipwood or plywood, painted woods, pressure treated lumber);

"biomass-fueled electricity" means electricity generated through the combustion of biomass as it is defined by the ECP;

"bypassed reach" means that area in the waterway between the initial point where water has been diverted through turbines or other mechanical means for water-powered electricity generation and the tailrace;

"CITES" means the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES Secretariat, 15, chemin des Anémones, CH-1219 Châtelaine-Genève, Suisse. Tel. (+4122) 979 9139/40, fax (+4122) 797 3417);

"CO" means carbon monoxide, and should be measured using the testing frequency, conditions and methods specified in Appendix 1 of this guideline;

"concentrating solar thermal technology" means a system that concentrates the heat of the sun through collectors, and uses the collected heat to drive a generating system to produce electricity;

"dedicated energy crops" means those non-food crops grown specifically for their fuel value, and in the case of this guideline, for electricity generation. These sources include *inter alia* short-rotation woody crops (such as poplar trees) and herbaceous energy crops (such as switch grass);

"diversion" means the construction of works to divert water into a canal, tunnel, penstock or similar conduit to supply water for electricity generation purposes;

"fish habitat" means spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes;

"fish passage" means both the upstream and downstream migration of fish, and can be ensured with the use of natural and/or human-made methods. Human-made methods include *inter alia* fishways, fish ladders, fish locks, fish elevators, powerhouse collection galleries, diversion screens, and by-pass facilities;

"generator" means an entity that produces electricity;

"head pond" means a body of water or a waterway that has been expanded in area or elevation through the construction of water-control structures in order to increase the available head and/or to store water for use during periods of low flow or periods of high demand for electricity. Head ponds also include changes caused by the diversion of a portion of a river through a canal or penstock. For the purposes of this guideline, head ponds are those bodies of water or waterways that are human-made;

"instream flow" means the water volume flowing in a waterway;

"marketer" means an entity that receives electricity from a generator(s), possibly combines electricity from various sources, and markets and/or sells the electricity. Note that in some cases, marketers may also be generators;

"MW" means megawatt or 106 watts, and (removed "is") a unit of electrical power;

"MWh" means megawatt-hour, and is a unit of electricity equal to one megawatt of power produced, consumed or flowing for a period of 1 hour;

"multi-sourced power product" means a combination of electrical power that is offered by marketers, and is comprised of electricity from more than one source and/or generator, where the sources and/or generators may or may not be certified under this guideline;

"net smog potential" means the calculated value that accounts for the emissions of both NO_X and VOCs as smog precursors. The NO_X emission rate is reduced by a smog production potential factor in those cases where VOCs are being destroyed during combustion processes in electricity generation. Required calculations are outlined in Appendix 2;

"NO_x" means nitrogen oxides, and should be measured using the testing frequency, conditions and methods specified in Appendix 1 of this guideline;

"operational air emissions" means the quantity of air-borne emissions of a specified substance or compound that is released as a result of the generation of electricity;

"PM" means particulate matter, and should be measured using the frequency and methods specified in Appendix 1 of this guideline;

"photovoltaic (PV) technology" means a cell, module, panel, array and/or array field that directly converts (removed text) light energy from the sun into electricity;

"riparian" means the land and habitat found along the banks of streams, rivers and lakes;

"solar-powered electricity" means electricity generated by converting the sun's light energy and/or heat energy into electricity, and includes *inter alia* photovoltaic technologies and concentrating solar thermal technologies;

"sound environmental management practices" means those practices and goals used to manage forest and/or agricultural products within a *sound environmental management system*, as defined in the definitions section of this guideline, that have the objectives of maintaining environmental values of the surrounding ecosystem. At a minimum, these practices must address:

(a) species selection;

(b) soil structure, temperature and fertility;

(c) soil composition rates, compaction and conservation;

(d) erosion control;

(e) hauling distance from the harvesting site to the combustion/generation site;

(f) silvicultural practices and techniques;

(g) harvesting practices including techniques, rates and waste minimization;

(h) crop regeneration;

(i) road/trail construction and maintenance;

(j) protection of biodiversity, wildlife and rare, threatened and endangered species;

(k) water quality and quantity;

(l) watershed conservation; and

(m) prior land use.

"sound environmental management system" means a system used to manage forest and/or agricultural products that incorporates *sound environmental management practices*, as defined in the definitions section of this guideline. At a minimum, system elements must include:

(a) planning elements such as: identifying forest and/or agricultural resources; identifying environmental aspects; assessing environmental impacts; identifying environmental legislative and regulatory requirements; and defining and committing to environmental policies, objectives and targets;

(b) operational elements such as: defining roles and assigning responsibilities; providing adequate staff training; communicating environmental aspects and policies both internally and externally; implementing an environmental management program based on identified environmental aspects and impacts; documenting all policies, goals and procedures; periodically reviewing and revising, where necessary, the system; and establishing an environmental emergency preparedness and response plan; and

(c) monitoring and measurement elements such as: monitoring and measuring key aspects of the system; evaluating and mitigating negative environmental impacts; correcting non-conformances with the management system; and performing internal reviews;

"SO_x" means sulphur oxides, and should be measured using the testing frequency, conditions and methods specified in Appendix 1 of this guideline;

"tailrace" means the point at which water is released back into the waterway below a generating station after being passed through turbines or other mechanical means to produce water-powered electricity generation;

"TOMA" means tropospheric ozone management area. The United Nations Economic Commission for Europe has defined Canadian TOMAs in the 1991 *Geneva Protocol Concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes.* Using this definition for the purposes of this guideline, Canadian TOMAs are:

(a) Canadian TOMA No. 1: The Lower Fraser Valley in the Province of British Columbia. This is a 16,800-km^2 area in the southwestern corner of British Columbia averaging 80 km in width and extending 200 km up the Fraser River Valley from the mouth of the river in the Strait of Georgia to Boothroyd, British Columbia. Its southern boundary is the Canada/United States international boundary, and it includes the Greater Vancouver Regional District.

(b) Canadian TOMA No. 2: The Windsor-Québec Corridor in the Provinces of Ontario and Québec. This is a 157,000-km^2 area consisting of a strip of land 1,100 km long and averaging 140 km in width stretching from Windsor, Ontario to Québec City, Québec. This TOMA is located along the north shore of the Great Lakes and the St. Lawrence River in Ontario, and straddles the St. Lawrence River from the Ontario-Québec border to Québec City. It includes the urban centres of Windsor, London, Hamilton, Toronto, Ottawa, Montreal, Trois-Rivières and Québec City.

"Type I Facility" means a facility that began operations prior to January 01, 1991, and generates ECP-certified renewable low-impact electricity;

"Type II Facility" means a facility that began operations on or after January 01, 1991, and generates ECP-certified renewable low-impact electricity. Both incremental increases in electricity generated as a result of facility upgrades (including *inter alia* efficiency improvements) and as a result of facility expansions (including *inter alia* new turbines or arrays) will be eligible for Type II consideration;

"user" means *inter alia* an individual, household, commercial or industrial establishment or institutional facility that purchases electricity from either a generator(s) or marketer(s);

"VOCs" means volatile organic compounds, and should be measured using the testing frequency, conditions and methods specified in Appendix 1 of this guideline;

"water-powered electricity" means electricity generated from a system or technology that uses a mechanical method to capture and convert the potential energy of water into electricity; and

"water quality" means dissolved oxygen, pH, total phosphorus, turbidity, transparency and chlorophyll, and any other item that is critical for or unique to the operating area.

"wind-powered electricity" means electricity generated from a wind turbine that converts the kinetic energy of the wind into electricity;

"wind turbine" means a system that uses air foils or blades attached to a drive shaft in order to capture the kinetic energy of the wind. The wind pushes against the blades/foils and spins a drive shaft. The drive shaft, either directly or indirectly through a series of gears, moves the generator to produce electricity; and

"wood-wastes and agricultural wastes" means a form of biomass, and includes *inter alia*:

(a) mill residues (e.g., waste by-products associated with the processing of forest materials such as bark, sawdust, solid trim, shavings, veneer clippings, clarifier sludge, pulping liquors),

(b) logging residues (e.g., residual materials left in the forest following harvesting such as slash, sortyard debris, thinning, stumps, roots),

(c) crop residues (e.g., materials not needed for soil reincorporation such as straw, chaff, corn cobs, bean residues, and dried stalks of harvested grain), and

(d) untreated construction wastes.

Category Definition

2. This category specifically includes:

(a) alternative-use electricity,

(b) biogas-fueled electricity,

(c) biomass-fueled electricity,

(d) solar-powered electricity,

(e) water-powered electricity, and

(f) wind-powered electricity.

For proponents of those technologies which are not considered or addressed within this guideline, but meet the intent of the guideline, the ECP may initiate guideline revision.

General Requirements

3. To be authorized to carry the EcoLogo, the renewable low-impact electricity must:

   (a) meet or exceed all applicable governmental, industrial safety and performance standards; and

   (b) be generated in such a manner that all steps of the process, including the disposal of waste products arising therefrom, will meet the requirements of all applicable governmental acts, by laws and regulations including, for facilities located in Canada, the *Fisheries Act and the Canadian Environmental Protection Act* (CEPA).

Notice

Any reference to a standard means to the latest edition of that standard.

The Environmental Choice Program reserves the right to accept appropriate equivalent test data for the test methods specified in this guideline.

Notice of Intent

It is the intention of the Environmental Choice Program to establish an operational air emissions level for PCDDs (polychlorinated dibenzo-*p*-dioxins) and PCDFs (polychlorinated dibenzofurans) for this guideline at some future date.

Additional criteria may be developed at some future date that address water-powered electricity with storage capabilities exceeding that specified in subsection 9(e). To better define these impacts, consideration will be given to the results of further work that is also based on a broad foundation of empirical and scientific data.

Product Specific Requirements

4. To be authorized to carry the EcoLogo, the renewable low-impact electricity must:

   (a) be accompanied by evidence that appropriate consultation with communities and stakeholders has occurred, issues of concern have been reasonably addressed, and, where applicable, reasonable mitigation of negative impacts has been addressed;

   (b) be accompanied by evidence that prior or conflicting land use, biodiversity losses and scenic, recreational and cultural values have been addressed during project planning and development;

   (c) be generated in a manner that is reliable, non-temporary and practical (e.g., not in research and development stages, not for pilot-scale demonstration purposes only);

   (d) in order to allow for conditions such as start-up, combustion stabilization and low combustion zone temperatures, be generated in a manner such that supplementary non-renewable fuels are used in no more than 1.65% of fuel heat input;

   (e) be generated in a manner such that no adverse impacts are created for any species recognized as endangered or threatened; and

   (f) meet the definitions applicable to the generation technology employed.

5. To be authorized to carry the EcoLogo, **alternative-use electricity** be generated in such a manner that all applicable certification criteria and definitions in this guideline are met. The environmental impacts from the existing operation and the alternative-use process will be reviewed and allocated on a case-by-case basis. If the potential impacts from the existing operation are not fully considered or addressed within this guideline, but meet the intent of the guideline, the ECP may initiate guideline amendment.

6. To be authorized to carry the EcoLogo, **biogas-fueled electricity** must be generated in such a manner that:

   (a) the total of load points assessed for operational air emissions of carbon monoxide (CO), particulate matter (PM), net smog potential and sulphur oxides (SOX), as determined in Appendix 2, does not exceed 6;

   (b) the generation does not occur within a TOMA if the load points, as determined in Appendix 2, for operational air emissions are greater than 3; and

   (c) if biogases are captured from a landfill site, the site has a leachate management program in place.

7. To be authorized to carry the EcoLogo, **biomass-fueled electricity** must be generated in such a manner that:

   (a) the total of load points assessed for operational air emissions of carbon monoxide (CO), particulate matter (PM), net smog potential and sulphur oxides (SOX), as determined in Appendix 2, does not exceed 6;

   (b) the generation does not occur within a TOMA if the load points, as determined in Appendix 2, for operational air emissions are greater than 3;

   (c) if generated from wood-wastes and/or agricultural wastes, *and* if the generator and the waste source share common ownership:

      (i) use only wood-wastes and/or agricultural wastes that have been sourced from operations that have implemented a sound environmental management system and are adhering to sound environmental management practices,

      (ii) ensure the rate of harvest does not exceed levels that can be sustained, and

      (iii) not use wastes from species that are listed in the CITES Appendices; and

   (d) if generated from dedicated energy crops:

      (i) use only dedicated energy crops that have been sourced from operations that have implemented a sound environmental management system and are adhering to sound environmental management practices, and

      (ii) ensure the rate of harvest does not exceed levels that can be sustained.

8. To be authorized to carry the EcoLogo, **solar-powered electricity** must be generated in such a manner that all solid waste resulting from the generation of electricity, including the disposal of equipment or machinery used in the generation process itself, that contains measurable levels of cadmium is properly disposed of or recycled.

9. To be authorized to carry the EcoLogo, **water-powered electricity** must be generated in such a manner that the generating facility:

   (a) operates in compliance with all regulatory licenses pertaining to fisheries including, for facilities located in Canada, the *Fisheries Act;*

   (b) operates in compliance with all regulatory licenses regarding water levels and flows;

   (c) does not operate under any conditional authorization allowing the harmful alteration, disruption or destruction of fish habitat. For facilities located in Canada, this includes conditions authorized, under per Section 35(2) of the *Fisheries Act*, by the Minister of the Environment or under regulations made by the Governor in Council under the *Fisheries Act;*

   (d) within practical limits and subject to regulatory direction and approval, ensures that plant operations are coordinated with any other water-power facilities operating on the same waterway in order to mitigate impacts and protect indigenous species and habitat;

   (e) as a maximum, causes as much water to flow out of the head pond as is received in any 48 hour period;

(f) operates such that reduced water flows in the bypassed reach and reaches downstream of diversion dams and/or dykes are not detrimental to indigenous aquatic and riparian species;

(g) operates such that instream flows downstream of the tailrace are adequate to support downstream indigenous aquatic and riparian species at pre-project ranges;

(h) operates such that water quality in a head pond, a bypassed reach, reaches downstream of the tailrace and reaches downstream of any diversion dams and/or dykes is comparable to that in similar free-flowing or unaltered bodies of water or waterways in the area;

(i) operates such that any changes in water temperature caused by the facility in the head pond or in reaches downstream of the tailrace or downstream of any diversion dams and/or dykes are not detrimental to indigenous aquatic species;

(j) where a human-made structure is placed across a waterway where no natural barriers exist, provides fish passage when necessary to ensure pre-existing migration patterns for maintaining fish communities both upstream and downstream; and

(k) provides any measures (including *inter alia* trash racks, oversized intake structures designed to slow intake velocities, underwater strobe and sound, fish screens) necessary to minimize fish mortality that would occur through impingement and entrainment.

10. To be authorized to carry the EcoLogo, **wind-powered electricity** must be generated in such a manner that:

(a) facility structures do not harm concentrations of birds; and

(b) facility structures are not located in an area with a concentration of endangered bird species.

11. In order to sell ECP-certified electricity, marketers of (removed wording) **renewable low-impact electricity** must be appropriately licensed as a secondary licensee with the ECP. Furthermore, the licensed marketer must ensure that a minimum of 50% of the ECP-certified electricity comes from Type II Facilities, while the remaining percentage comes from Type I Facilities.

Verification

12. Ownership of all environmental benefits (including emission reductions) will be assigned and transferred first to marketers and then to the final users of electricity that receives ECP-certification. This certification will be retained in any sale and/or transfer of the electricity only if the ownership of all environmental benefits is assigned and transferred to the marketer and final user. ECP-certification will not be retained if this ownership is assigned and/or transferred to a party other than the marketer or final user, or is retained by the generator.

13. ECP certification status is only available to electricity from ECP-complying generation facilities that are in operation, not electricity from planned generation facilities. Through a verification and auditing process, reconciliation measures will be implemented to ensure that sales levels do not exceed production/supply levels, and that, all environmental benefits have been assigned and/or transferred appropriately.

14. To verify a claim that a product meets the criteria listed in the guideline, the Environmental Choice Program will require access, as is its normal practice, to relevant quality control and production records and the right of access to production facilities on an unannounced basis.

15. Compliance with section 3(b) shall be attested to by a signed statement of the Chief Executive Officer or the equivalent officer of the licensee. Compliance with sections 9(a) and 9(b) shall be attested to by a signed statement of the Chief Executive Officer or the equivalent officer of the licensee, and by a signed statement from an authorized representative of each applicable government body that has issued a license and/or operating permit for the facility.

The Environmental Choice Program shall be advised in writing immediately by the licensee of any noncompliance which may occur during the term of the license. On the occurrence of any noncompliance, the license may be suspended or terminated as stipulated in the license agreement. In the event of a dispute related to the suspension or termination of the license, the license agreement provides for arbitration.

Conditions for EcoLogo Use

16. The EcoLogo may appear in association with a product, provided that the product meets the requirements in this guideline.

17. Only those components of a multi-sourced power product that fully satisfy all pertinent ECP certification and licensing criteria are allowed to be identified as "ECP-certified" and to carry the EcoLogo.

18. A criteria statement must appear with the EcoLogo whenever the EcoLogo is used in association with the electricity. While the exact wording used in the criteria statement is left to the discretion of the licensee, the statement itself should provide clarification as to why the product was certified. The statement must not misrepresent the product nor the reason it received certification, and must contain at least the following information:

    (a) for generators, identification of the amount of ECP-certified electricity generated and/or marketed in quantitative units (e.g., kWh or MWh);

    (b) for marketers, identification of the amounts of ECP-certified electricity received from generators and/or supplied to users as either percentages of larger multi-sourced power products or in quantitative units (e.g., kWh or MWh); and

    (c) for users, identification of the amounts of ECP-certified electricity purchased/used as percentages of larger multi-sourced power products.

19. All licensees must comply with the Environmental Choice Program's *Guide to Proper Use of the EcoLogo[M]* regarding the format and usage of the EcoLogo.

20. Any accompanying advertising must conform with the relevant requirements stipulated in this guideline, the license agreement and the Environmental Choice Program's *Guide to Proper Use of the EcoLogo[M]*.

For additional copies of this guideline or for more information about the Environmental Choice Program, please contact TerraChoice Environmental Services Inc.; Tel: (613) 247-1900, Fax: (613) 247-2228; 2781 Lancaster Road, Suite 400, Ottawa, Ontario, K1B 1A7.

APPENDIX 2 – INDICATORS USED BY SCIENTIFIC CERTIFICATION SYSTEMS

In the approach developed by Scientific Certification Systems (SCS), the environmental impacts of hydropower are summarized primarily by two "ecosystem disruption" indicators (loss of habitat and increased mortality to key species) as well as by the "greenhouse gas loadings" indicator. The way these indicators are applied in the SCS hydropower studies concerning the 417.5-MW Safe Harbour Project in Pennsylvania,[330] and the 50-MW Lake Chelan hydropower project in the State of Washington.[331]

A2.1 Loss of terrestrial and aquatic habitats

For this as for all the other indicators, SCS compares environmental performance of an individual generator against the average performance of the regional power pool, scaled to correspond to the annual electricity production of the station under study.

SCS measures ecosystem disruption in acres of lost habitat, net of habitat "gains" — i.e., after deducting the area of "created" habitat from the one that was lost. This reliance on area lost or gained as a measure of impact on terrestrial and aquatic habitats is one of the more controversial aspects of the SCS methodology. In the words of one of the peer reviewers of the Lake Chelan study, this methodology "probably underestimates the effects of operation of the plant [as i]t does not include all of the effects of project operation on the biota of the lake and in the receiving waters."[332]

Thus, for example, in the case of the flooding of Lake Chelan, the acreage of created "lake" habitat ("discounted" by 15%) is credited against the lost acres of forest, cliff and grassland habitat, resulting in a net loss of habitat of just 188.2 acres.

The resulting net habitat depletion value (422 acres) is compared to the estimated average habitat depletion for the entire Western System Coordinating Council (WSCC), estimated by SCS to be 400 to 1,200 acres per equivalent output of 375 GWh/yr.[333] Using the midpoint value of 800 acres as a benchmark, SCS finds the Lake Chelan project to be "environmentally preferable."[334]

Similarly, for the Safe Harbor Hydroelectric Project in Pennsylvania, Thus, for example, the ecosystem disruption indicator for the Safe Harbor study includes the following elements:

- 615 acres, representing the inundated forest area that now forms part of the reservoir. No entry is made either for the conversion of riverine to "lake-like" habitat, or for the sedimentation of 43% of the reservoir bottom,[335]
- 255 acres for the loss of islands above the dam. The submerged islands are described as having "flood plain forest and flood plain graminoid dominated vegetation cover," but no mention is made of the species or ecosystems supported by this habitat,
- 39.6 acres for the dam, access road, substations and operator's village,
- 470 acres for the transmission lines directly imputable to the project,
- a 250-acre "credit" for the mudflats and slightly submerged areas of significant siltation created by the dam. This credit is based on "the assumption … that changes in the acreage of this resource are correlated with changes in carrying capacity for migratory bird populations."[336] There is no mention of any attempt to confirm this assumption.

The resulting net habitat depletion value (1130 acres) is compared to the estimated average habitat depletion

330 Scientific Certification Systems, *Safe Harbor Study,* see note 272.

331 Scientific Certification Systems, *A Study of the Lake Chelan Hydroelectric Project Based on Life-Cycle Stressor-Effects Assessment* (3 March 2000), available at http://www.chelanpud.org/relicense/. SCS has also carried out a study of the Harspranget Power Station in Norway, owned by Vattenfall, which, unlike both Safe Harbor and Lake Chelan, is a large storage hydro facility, but it has not made this report public.

332 Richard R. Whitney, *Review of "A Study of the Lake Chelan Hydroelectric Project Based on Life-Cycle Stressor-Effects Assessment" Scientific Certification Systems Report for Peer Review Dated September 21, 1999 (*16 November 1999), p. 3.

333 No source or methodology is provided for this estimate. According to SCS, it is not based on an analysis of the habitat depletion caused by the hundreds of hydro facilities in the western grid, but rather on an estimate of the habitat impacts of coal mining, Stanley Rhodes, pers. comm.

334 SCS, *Lake Chelan Study,* see note 331, p. 44.

335 Applied Ecological Services, "Safe Harbor Ecological Review," Appendix 2 of the Safe Harbor study, pp. 9-10.

336 *Ibid.*, p. 7.

SCS Certified

Environmentally Preferable Energy Source

In every category of comparison, the Safe Harbor hydro power plant has lower environmental impacts than average energy production in the regional PJM power pool.

for the regional grid. SCS estimates this regional average to be 500 to 2,500 acres per equivalent output of 1,100 GWh/yr, but, again, no source or methodology is provided for this estimate. Using the midpoint value of 1,500 acres (1.36 acres per GWh) as a benchmark, SCS finds the Safe Harbour project to be environmentally preferable.

It should also be noted that the SCS habitat disruption index takes no direct notice of the fluctuations of reservoir water levels or of downstream flows. For example, while Safe Harbor is operated continuously as a run-of-the-river plant during high-flow periods, during periods of low flow it is operated so as to concentrate energy and capacity into on-peak hours. During periods of extremely low flow, weekend inflows are retained for use during the weekday on-peak hours.[337] No mention is made in the study of the required level of conservation flows during these periods, or of the ecological impacts that may result from these flow variations.

A2.2 Key species

In addition to habitat loss, SCS evaluates harm to "key species" as part of its evaluation of ecosystem disruption.

For the Safe Harbor project, only one key species was identified, the American shad.

For the Lake Chelan project, SCS identified four key fish species (burbot, cutthroat trout, pygmy whitefish and bull trout), but stated that "there was no evidence to suggest that the Lake Chelan Project has contributed in any measurable way to the decline in the population of such species."[338] It also recognizes the presence of Bald Eagle habitat in the region, but states that there is no evidence that they are impacted by the project either in terms of foraging or nesting.

In fact, according to comments by fish biologist Richard R. Whitney, one of the two peer reviewers selected to review the Lake Chelan analysis, the SCS draft study found no "key species" at all to be affected by the Lake Chelan Project. Whitney suggested that the four species mentioned above be identified as key species, noting that "all of them are species that are no longer abundant and merit special attention with respect to their maintenance."[339] He noted that the bull trout is listed as "threatened" under the Endangered Species Act, and may still be present, adding that:

> While bull trout were at one time very abundant in Lake Chelan, they have not been seen for a number of years. … It is difficult to imagine that they have been completely extirpated.[340]

337 SCS, *Safe Harbor Study,* see note 272, p. 14.

338 SCS, *Lake Chelan Study,* see note 331, p. 33.

339 Richard R. Whitney, see note 332, p. 4.

340 *Ibid.*

In response to these comments, SCS added the mention of the four species, though it did not mention the threatened status of the bull trout. It reiterated that:

> Based on the data available to the authors at the time of this study, there was no evidence to indicate that the Project operations have negatively impacted resident fish species.[341] (italics in original)

SCS also notes that additional studies are currently underway as part of the FERC relicensing process, and states that the current study would be subject to revision "if any ongoing or future field-based studies of resident fish populations indicate reductions in such fish populations due to Lake Chelan Project operations."[342]

One could thus characterize the SCS approach to impacts on key species as "innocent" until proven guilty." — a far weaker standard than the one applied in environmental assessment processes. If the absence of data is adequate for a finding of no significant impact, then it is of course in the operator's interest to keep detailed studies to a minimum. While this may not be a major issue in intensively studied areas, it could certainly be problematic in the vast wilderness areas of northern Canada where the utilities are virtually the only source of data.

A2.3 Greenhouse gases

The SCS determination of greenhouse gas loadings is meant to include both emissions from fossil fuels (life cycle analysis) and from the flooded biomass in the reservoir. This latter figure is based on "[a]n estimate of the biomass in the flooded area behind the power station, based on surrounding vegetation and historic maps."[343] No methodology, data or detail is provided regarding this calculation, other than the results.

SCS reduces gross emissions by a factor that reflects the number of years that have passed since the reservoir was built, using decay curves based on the estimated atmospheric lifetime of these gases. No explanation is given for the emissions estimates, nor is any provided for the unusual methodology involved in treating the construction-related GHG emissions.[344]

Thus, for the Safe Harbor project, which was built some 70 years ago, the gross CO_2 emissions of 4,228 tons/yr[345] are multiplied by a factor of 38%; for methane, the gross emissions of 1 ton/yr are reduced by a factor of one thousand.[346] As a result, SCS estimates total GHG loadings for the Safe Harbor project at 1,689 tons CO_2-equivalent per 1,100 GWh, or about 1.4 grams per kWh — about one quarter of 1% of the estimated average emissions for the PJM regional grid.

The assumption underlying this methodology is that all CO_2 and methane emissions related to flooding took place at the moment the reservoir was filled:

> Hydroelectric power generation systems differ markedly from other electricity generating systems in that virtually all of the CO_2 and methane releases … are traced back to the initial construction and impoundment, and dissipate over time.[347]

As we have seen in Chapter 6, it is now known that greenhouse gas emissions continue over the life of the project.[348] Based on its incorrect assumption, SCS' methodology practically eliminates all consequences of methane emissions from all but the most recently constructed hydro projects. It therefore dramatically understates the greenhouse gas emissions of older projects.

341 SCS, "SCS Response to Peer Reviewer Comments," Appendix 4 to SCS, see note 331, p. 3.

342 *Ibid.*

343 SCS, *Safe Harbor Study,* see note 272, p. 34.

344 SCS amortizes these emissions over 100 years but at the same time treating each year's quantum as having decayed in the atmosphere since the date of construction.

345 Including 128 tons/yr from a second construction phase in 1982-86.

346 *Ibid.* No explanation is provided for the gross figures used.

347 *Ibid.*, p. 35.

348 As described above, this consensus is based on the understanding that emissions result not only from flooded biomass, but from suspended and dissolved organic compounds swept downriver from the catchment area. World Commission on Dams, *Dam Reservoirs and Greenhouse Gases: Report on the Workshop Held on February 24-25, 2000, Hydro-Québec, Montreal (Final Minutes),* p. 4.

APPENDIX 3 – IRN COMMENTS ON MARCH 10, 1999 DRAFT LOW IMPACT HYDROPOWER CERTIFICATION PROGRAM

PREPARED FOR: AMERICAN RIVERS AND GREEN MOUNTAIN ENERGY RESOURCES APRIL 9, 1999

I. Addressing Public Ignorance About Dams

Hydroelectric dams are damaging to the environment. Although the impacts vary from dam to dam, it is impossible to avoid all impacts. It is extremely important that the public be made well aware of this, or else a potential outgrowth of the Institute's work could be that the public begins to equate "low" impact with "no" impact.

This is particularly important now as a growing segment of the population is advocating for dam removal. Some of the dams river activists are targeting for removal may even meet the low impact criteria set forth in the current guidelines. It would be unfortunate were the Institute's work to run counter to this leading force in river management.

Additionally, in many developing countries people are putting their lives on the line to fight the construction of hydroelectric dams. If sufficient safeguards are not contained in this program, dam-building advocates may be able to utilize this initiative to further justify dam construction.

At present, the only reference in the proposal that gives any indication that dams in general have impacts is:

"They [consumers] understand that dams have negative environmental impacts, yet also understand that hydropower provides an alternative to technologies that generate greenhouse gases and other air pollution or result in nuclear waste."

This reference is not nearly sufficient to articulate to the public all the problems with dams. Moreover, the statement is not entirely accurate. Consumers do not necessarily know that dams have negative impacts. Many still see dams, massive dams like Glen Canyon or Grand Coulee, as not having negative impacts. In fact, it is largely the public's misconception about dams under this deregulated energy environment that has spawned your institute. Additionally, although not as problematic in this country, reservoirs behind hydroelectric facilities, especially those in tropical countries, contribute significantly to greenhouse gas emissions – some as much as coal-fired power plants.

Two other instances where the draft gives mixed messages about dams are:

(a) Use of the term "avoid" environmental impacts

In several places within the guidelines, especially within the description of the goals and objectives, the reader is led to believe that it is possible to "avoid" environmental impacts associated with dams. This is scientifically impossible, as all dams result in some level of environmental impact, and is misleading to consumers.

(b) Marketing

Within the program objectives it states, "... to create and maintain a market of low impact hydropower." Were this an industry proposal and an industry-run organization, this would seem very appropriate. But the Institute as proposed is to be governed principally by environmental organizations. It seems counter to the mission of environmental organizations, especially river conservation groups, to be advocating a market for the consumption of rivers through the promotion of, albeit, "low" impact hydroelectric facilities. This seems especially true in light of the growing dam decommissioning movement. This objective also promotes the consumption of energy, the use of which is fueling a society that is destroying environments, communities, and economies throughout the world. Again, this is counter to the objectives of the environmental movement, which would seem to be more inclined to promote greater energy conservation as opposed to energy consumption.

To best remedy this mixed message it is critical that the Institute:

i. incorporate a clear statement within the introduction that all dams have negative environmental impacts, and a short description of these impacts.

ii. make it very clear throughout the guidelines that the Institute is merely providing a rating service to distinguish the scale of impacts associated with particular hydroelectric facilities, and that the Institute in no way promotes dams or the consumption of hydroelectric power.

iii. promote public education about the true impacts of all dams, so that the public is fully aware of them when making energy supply choices. This would include an active outreach program within the Institute that ensures consumers of all certified facilities receive information about dams and their social and environment impacts.

iv. aggressively promote strategies to accelerate the reduction in the need for hydroelectric facilities and energy supply generally by advocating energy conservation. This also must be a standing outreach program that includes ensuring that consumers of all certified facilities receive information about energy conservation opportunities. Additionally, an application requirement must be designed to ensure that the applicant has, or will have, in place an energy conservation program for its customers. In renewing any facility's certification, applicants must demonstrate progress in achieving energy conservation among their customers.*

Combined, these changes would help to ensure that consumers are well aware of the impacts associated with their hydroelectric choices, and how they can help conserve rivers and the environment generally by playing an active role in energy conservation.

II. Scientific Rationale

In ensuring the program's credibility with consumers, the guidelines cite three attributes: (1) based on objective certification criteria; (2) administered in a fair and efficient manner; and (3) judged on applications that are open to public review and comment. A critical fourth attribute is missing, one pertaining to scientific rationale. As much of what the Institute proposes to do surrounds rendering opinions pertaining to scale of environmental impact, public credibility demands that such opinions be based on state-of-the-art scientific knowledge.

III. Additions to the Eight Certification Criteria

(a) Specific Community Concerns

The certification process should afford greater opportunities to reinforce community involvement and responsibility in watershed management decisions. Every effort should be made to ensure that non-statutory, community concerns receive as much attention as those requirements currently on the books.

With the exception of criteria (4), Water Quality, much of the low impact determination will be based on existing agency statutes and policies. This, however, is not sufficient to adequately ensure the facility is indeed operating as low impact in accordance with evolving community concerns about the facility. Therefore, the review process must give serious consideration to evolving issues pertaining to ecosystem and watershed management that are being discussed within the community, but have not necessarily found their way into resource agency statutes. This is particularly critical if there are emerging local proposals to have the facility decommissioned or removed. Additionally, depending on the economic well-being of a particular community, they may not have had the ability to develop the same level of detail within their local statutes as some others, but the community itself may be inclined to develop such standards were resources available to do so. Thus it is important for reviewers to have discretion to accommodate issues raised by the community, independently of whether or not these issues have been addressed by a resource agency.

Lastly, it is also critical to assess community/agency capacity to effectively monitor a facility following certification to ensure all prescribed and mandated requirements are met.

(b) River Ecosystem Functions

Also missing in the criteria is anything that specifically relates to river ecosystem functions. These criteria would ensure impacts to key processes such as nutrient flows, impacts to floodplains, river channel morphology and sediment flows are addressed.

IV. Public Participation

In addition to the public notification procedures outlined in the guidelines, several additional steps must be taken by the applicant to ensure all interested parties have the opportunity to comment.

(a) Written notices must be mailed first class to all river conservation organizations and rele-

** Note that the California Energy Commission estimates that energy conservation and efficiency efforts undertaken since 1982, including those undertaken by utilities, will result in saving 11,500 MW of installed capacity by 2011.*

vant agencies that one, are operating within a 100-mile radius of the facility, and two, are contained in the most current "River Conservation Directory" published by River Network. The notice must be postmarked no later than the starting date of the 60-day comment period.

(b) This notice should inform interested parties of where they may obtain a printed copy of the application, as not all interested parties may have access to internet resources.

(c) The notice should state that any organization or interested stockholder has 30 days to exercise their right to request a public hearing on the application.

(d) If during the comment period a public hearing is requested, a subsequent notice must be distributed as in item (4.a.) above, with the hearing date no less than 30 days from the postmark date on the notice.

(e) The applicant must host the public hearing, and detailed minutes along with a transcript of the hearing must then become part of the application.

V. Comments Pertaining to Proposed Criteria

(a) Fish Passage and Protection

The guidelines make allowances for dams that contain no fish passage so long as they demonstrate that, "there was a recent decision that fish passage is not necessary for a valid environmental reason, or that existing fish passage survival rates at the facility are greater than 95% over 80% of the run." Despite the clarification on this issue resulting from previous comments, it still appears that dams upstream of other dams that have already sufficiently impacted fish runs such that fish no longer reach the upstream facility would be exempt. Such an environmental consequence should not be rewarded with low impact certification. If historical records indicate fish runs in the vicinity of the facility, those runs must first be reestablished before the facility can potentially qualify as low impact.

(b) Water Quality

In addition to the prescribed Clean Water Act compliances cited, section 404 pertaining to changes in flows affecting floodplain wetlands should be included. Additionally, provisions pertaining to the discharge temperature and potential anoxic water quality condition should be incorporated.

(c) Threatened and Endangered Species

In terms of evaluating the facility's potential impact on threatened and endangered species, the definition of "facility area" should include the basin downstream to the estuary. Additionally, as prescribed in the guidelines for evaluating compliance with the fish passage criteria, historical information pertaining to the entire ecological condition that existed around the facility under natural conditions must also be consulted. This information must be used to determine what role the facility may have played in the decline of these natural conditions, and thus the actions to be taken by the applicant to reverse this process.

(d) Facilities Recommended for Removal

As stated in (3.a.) above, facilities considered for removal must not be confined to those facilities where a resource agency has made such a determination, but also include those facilities where there is a demonstrated community interest in attaining such a determination.

(e) Watershed Management

The criteria here is specific to the reservoir and surrounding buffer zone, not the watershed as a whole. This title "Watershed Management" is misleading, thus we recommend that it be changed to "Reservoir and Buffer Zone Management."

(f) Flows

The flow requirements should be dictated by the need to sustain ecosystem processes.

VI. New Hydropower Facilities and International Hydropower Facilities

Although the response to comments section in the March 10 package states that the Institute will not be addressing new facilities or facilities outside the United States, the guidelines themselves leave this up to the governing board to address at a later date. The guidelines should state that under no circumstance will the Institute certify any facility constructed after 1999, or any facility outside the United States.