Recommendations for the collection, analysis, and synthesis of further economic data to support informed decision-making regarding the Lower Churchill River Hydroelectric Project

Response to the LCHP Environmental Impact Statement (Registry number 07-05-26178)

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1 Background

1.1 Proponent and Project

Nalcor Energy ("Nalcor"), a Crown Corporation created by the Government of Newfoundland and Labrador, has proposed the construction of two hydroelectric generating facilities on the lower Churchill River in central Labrador. The Lower Churchill Hydroelectric Project (LCHP) would be comprised of one dam located at Muskrat Falls and a second at Gull Island. The 32 m high dam at Muskrat Falls would have a capacity of 824 MW and require a reservoir with an area of 101 km^2, inundating 41 km^2 of marsh and forest land. The larger Gull Island facility will include a 99 m high dam with a 213 km^2 reservoir, inundating 85 km^2 of land. At a projected capital cost of at least $6.5 billion (2008 $) over ten years, the two dams are expected to generate 16.7 TWH of electricity per year.

Specific components of the construction and operation of the Project include:

- Approximately 345 km of temporary[1] road and 30 km of permanent road;
- Temporary accommodations for up to 3,000 people at the two construction sites;
- Reservoir preparation (clearing a portion of the vegetation from both reservoirs);
- Building the dams and generation facilities; and
- Installing transmission lines in a right-of-way between the sites and to potential offshore markets including the island of Newfoundland.

The Project site is in central Labrador. Lying between the straits of Belle Isle (~52°N) and Cape Chidley (~61°N) on the eastern coast of North America, Labrador has an area of 288,000 km^2 (Roberts *et al.* 2006).[2] With a population under 30,000 and only 0.14% of land developed, Labrador is one of the last relatively undeveloped areas in subarctic Canada. About 60% of Labrador is forested, with the balance of landcover including peatlands, tundra, and rock barren (Figure 1). Geographically, Labrador consists of four regions which correspond with provincial electoral districts, but the regional economic development boards break the area into five zones. The proposed development is sited in zone three, the central region. The central region settlements include Happy Valley/Goose Bay, Sheshatshiu, and Northwest River.

The rationale for the Project is to:

- Address the future demand for hydroelectric generation in the Province;
- Provide an electric energy supply for sale to third parties; and
- Develop the Provinces' natural resource assets for the benefit of the Province and its people.

The first point will be addressed by the LCHP only ***if*** electricity is transmitted to the island of Newfoundland. Because the Proponent has split the Project into generation and transmission components, it is not clear that future electric needs will actually be met if the current

[1] "Temporary" in these cases means "to be removed after construction is complete".
[2] Also see www.gov.nl.ca/aboutnl/default.htm for additional information on Labrador.

hydroelectric generation proposal is approved.[3] The third point is somewhat inexplicable as it does not seem to make sense to simply develop resources for the sake of developing resources, especially if there are substantial financial, social, or environmental risks associated with the Project. Thus, we are left with the fundamental conclusion that the LCHP should be viewed primarily as a profit-oriented business proposition and that it should be evaluated as such during the Environmental Assessment (EA) process.

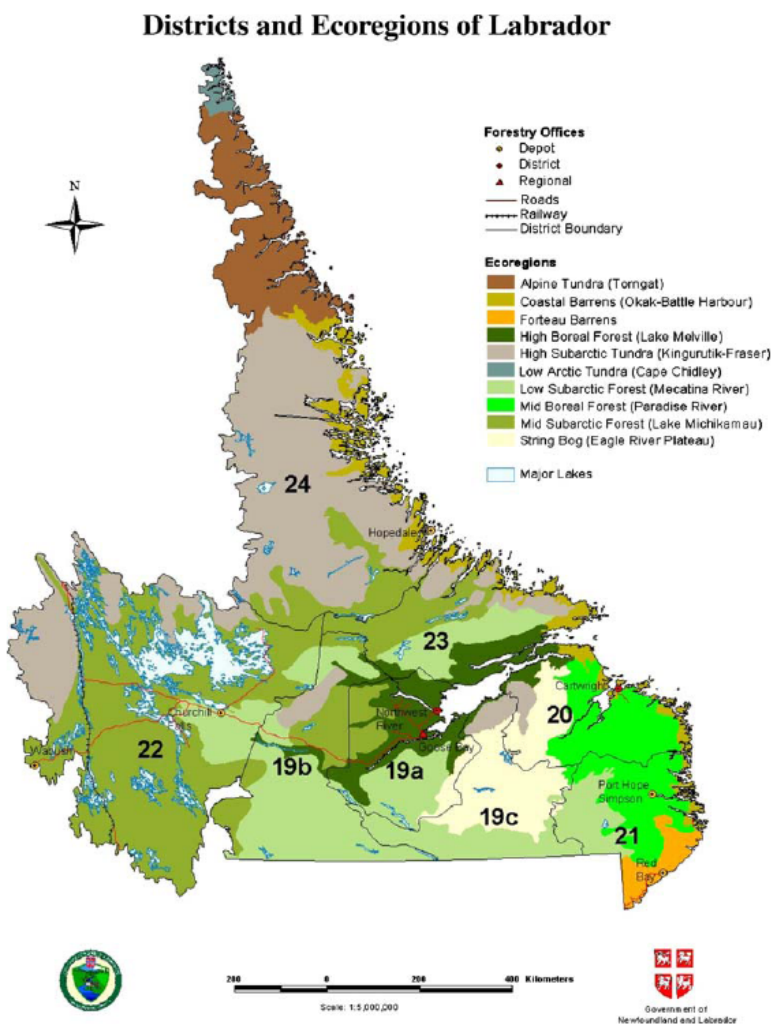

Figure 1 – Districts and ecoregions of Labrador (from Roberts *et al.* 2006)

3 The current EIS allows for transmission of electricity from the Muskrat Falls and Gull Island facilities to the Upper Churchill facility, where existing transmission corridors lead, via Quebec, to Ontario and U.S. markets. While the Proponent has registered a proposal for a transmission lines to the island of Newfoundland and stated its intent to install sub-sea transmission lines to the Maritimes and New England markets, this project faces several hurdles, including challenges surrounding running a transmission corridor through either Gros Morne National Park or the Main River watershed (a Canadian heritage river) and the very high expenses associated with running sub-sea lines from Labrador to the island and from the island to the mainland. Should the dams be approved and the transmission line proposal later rejected or withdrawn, it would be quite conceivable (even financially attractive) to simply use existing Quebec transmission corridors to export virtually all Lower Churchill electricity straight to export markets. In that case, only the second point of the rationale would hold. It is certainly the case that other options for supplying the island of Newfoundland with electricity. If, as the Proponent assumes, a carbon trading system is implemented in Canada, it should also be possible to sell carbon offsets from the LCHP and use the revenue to purchase offsets for Holyrood or other upgraded oil-fired generation facilities (conservation and renewable energy might contribute significantly to the island's power portfolio as well).

The Canadian Environmental Assessment Agency (CEAA) defines an environmental effect as "any change that the Project may cause in the environment…" and "any effect of any [environmental] change… on: health and socio-economic conditions; physical and cultural heritage; the current use of lands and resources…; and any structure, site or thing of historical, archaeological, paleontological, or architectural significance". Environmental effects are to be considered "whether any such change or effect occurs within or outside Canada". This large Project will cause a wide variety of environmental effects.

1.2 Environmental impacts of dams

Large dams[4] provide many benefits including flood control, electricity generation, and the reliable provision of agricultural water (Tullos *et al*. in press; World Commission on Dams 2000). Hydroelectric generation also has the potential to reduce greenhouse gas (GHG) emissions relative to fossil-fuel burning methods (Kammen & Pacca 2004; Pacca 2007). However, in recent years there has been a growing literature on the potentially adverse environmental and socioeconomic impacts of large dams. By impounding water and blocking a river channel, dams fundamentally alter stream flows, with resulting impacts to sediment and nutrient transport as well as water temperature (Rosenberg *et al*. 1997; Rosenberg *et al*. 1995). Reservoir construction affects riparian morphology and habitat (Bratrich *et al*. 2004; Lutterman 2007; Nilsson & Berggren 2000; St. Louis *et al*. 2000; Truffer *et al*. 2003), can result in considerable methane and other greenhouse gas discharges (Fearnside 2001; Galy-Lacaux *et al*. 1997; Pacca 2007) and the eventual creation of methylmercury due to decomposition of woody material (Mailman & Bodaly 2005; Mailman *et al*. 2006; Rosenberg *et al*. 1997; Rosenberg *et al*. 1995). Hydroelectric generation is often seasonally at odds with flow regimes, especially in boreal climates supplying winter-peaking markets. This means that generation needs are greater during winter, requiring the release larger volumes of water for generation when river flow is low, thereby exacerbating the effects of dams on aquatic species and their habitat (Poff *et al.* 1997).

The environmental changes induced by dam construction and operation can also have considerable social impacts (Tilt *et al.* in press), most dramatically when entire populations are displaced (Brown *et al.* in press). However, changes to river systems often result in the less dramatic impact of loss of access to different groups. Berkes (1988) describes several cases of unpredicted impacts to Cree hunters resulting from hydro development in James Bay. These included access to traditional hunting and fishing grounds, methylmercury contamination in fish, and the disastrous death of 10,000 caribou.

1.3 Economic cost-benefit analysis

Vining and Boardman (2007) point out that the key goal of economic policy analysis is to inform decision-makers and the public about the expected consequences – in terms of costs and benefits – of public investment decisions. The focus of the discipline of economics is on economic

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[4] The International Committee on Large Dams (ICOLD) defines a "large dam" as one that is 15 m or more high from the foundation. If a dam is between 5 and 15 m high and has a reservoir volume of > 3 million m^3, it is also classified as a large dam. According to ICOLD there are 45,000 large dams worldwide (World Commission on Dams 2000: 11).

efficiency. Even in cases when economic efficiency is not an explicit goal for a project, economic efficiency is important because inefficient decisions squander scarce financial capital that could be put to a better use elsewhere.

Efficiency is measured in terms of net economic well-being or utility. The primary tool for quantifying the net changes in efficiency due to various development or policy alternatives is economic cost-benefit analysis (CBA). CBA has a strong theoretical basis and best practices are generally well-known (EPA 2000, 2002; Hahn & Tetlock 2008; Heal *et al*. 2004; Kriström 2006; Pearce *et al*. 2006; Treasury Board of Canada 1992, 1998; Vining & Boardman 2007) even if the quantification of some costs and benefits is technically challenging.

There is general consensus among economists that CBA was first used in the U.S. to analyze of water-related projects (Pearce *et al*. 2006; van Kooten 1993). In France, Dupuit (1844) recommended the concept of marginal analysis as a basis to decide whether an infrastructure investment such as the construction of a bridge was worth pursuing. The US Flood Control Act of 1936 declared that control of flood waters was in the interests of the general welfare, and that the role of the government was to "improve or participate in the improvement of navigable waters … for flood control purposes if the benefits to whomsoever they accrue are in excess of the estimated costs." Particularly since the 1960s, agency use of CBA has expanded considerably. US Federal agencies in particular have increasingly used it to analyze a variety of types of projects and regulatory proposals (EPA 2000) and the Government of Canada requires the comparison of costs and benefits for regulatory decisions (Treasury Board Secretariat 2007). The Treasury Board *Cost-Benefit Analysis Guide* requires that "all regulatory departments and agencies are expected to show that the recommended option maximizes the net economic, environmental, and social benefits to Canadians."

Many authors provide guidelines for how to carry out CBA (EPA 2000; Hanley 2001; OMB 1992; Pearce *et al*. 2006; e.g., Treasury Board Secretariat 2007). One of the most widely accepted texts is by Boardman *et al*. (2001), which recommends basic guidance for conducting a CBA:

- Decide whose benefits and costs count;
- Select the portfolio of alternative projects;
- Catalogue, predict and monetize impacts;
- Discount or compound benefits and costs to find present values; and
- Address uncertainty and perform sensitivity analysis.

Economic efficiency is measured in terms of producer surplus (essentially firm profitability adjusted slightly for returns to management and risk) and consumer surplus. For market goods such as electricity, consumer surplus is the area below the demand curve but above market price. For non-market goods and services such as environmental quality, human health, community viability, and cultural vitality, consumer surplus is measured in terms of households' willingness to pay for improvements in those factors or willingness to accept compensation for degradations in those factors.

Economic efficiency is certainly not the only factor that decision-makers consider (Arrow *et al*. 1996; Pearce 1998). However, as Hahn and Dudley note, "even a reasonably good [economic] analysis does not assure that the ensuing decision will be sensible. But if the analysis is poor, it is certainly more likely that the decision makers will make poor decisions" (Hahn & Dudley 2007: 193). Harrington *et al*. (2009) recommend measures that would improve the overall quality and usefulness of economic analyses[5], advice which, if followed, would greatly enhance the credibility and quality of the LCHP Environmental Impact Statement:

- Give greater consideration to meaningful alternative policy options;
- The choice of baselines should reveal choices and trade-offs, not conceal them;
- Develop a checklist of good practices that all assessments should have, and provide an explanation for missing items;
- Be strategic about devoting resources to the estimation of benefits and costs of projects;
- Make key aspects of the analyses available to decision-makers earlier in the decision-making process;
- Include detailed descriptions of expected consequences as physical or natural units prior to monetization or discounting;
- Ensure greater transparency at all stages of the process;
- Reform current practices on non-monetized benefits including (a) providing expedited review for innovative analyses presumed to be high-quality and relevant to project assessment, (b) consider including some number or distribution of values in place of zero as the default value in analyses with non-market impacts, (c) impute the necessary benefits of a project, and (d) elicit the opinions of experts.

As economic valuation techniques have become more sophisticated and better integrated with contemporary ecological and geographic analyses (Brauman *et al*. 2007; Brouwer & Hofkes 2008; Brouwer *et al*. 2008; Fisher *et al*. 2008; Fisher *et al*. 2009; Heal *et al*. 2004; Kammen & Pacca 2004; Kotchen *et al*. 2006), it should now feasible to implement most, if not all, of Harrington *et al.*'s recommendations for the LCHP. While a comprehensive economic analysis will take time for the Proponent to design and implement, the costs should only be a very small proportion of the overall cost of the development. The potential savings from identifying/managing economic risk factors and from reduced transaction costs of governance (i.e., more community and citizen buy-in, increased information sharing, reduced risks of litigation, etc... – these are all benefits emphasized by transaction cost economists such as

[5] Harrington *et al*. present their recommendations framed in terms of economic analysis of regulatory reforms. We paraphrased their list slightly to put it an appropriate project-oriented framework. Note that the Treasury Board of Canada requires Federal agencies to consider economic efficiency during Regulatory Impact Analysis Statement (RIAS) formulation (subject to 'triage' guidelines to ensure proportionality of economic analysis and potential economic impacts). Thus a relatively small 'regulation change' (e.g., the use of a freshwater pond for mine tailings) can be subject to CBA while large mega-projects such as the LCHP are only subject to an environmental assessment. Given that the motivations for many mega-projects are virtually entirely revenue- or profit-driven (such as the LCHP), it seems to us, as economists examining the practice of EA, that there are some fundamental inconsistencies between Federal guidelines governing regulatory-driven change and project-driven change. Our view is that project appraisal under the Canadian environmental assessment process should be subject, at a minimum, to the same standards as Treasury Board requires for regulatory assessment simply because Treasury Board guidelines are more credible and transparent relative to environmental assessment guidelines that are dated and inherently inconsistent. Simply put, following minimum standards for environmental assessment provides the Proponents of mega-projects an easy 'end run' around Government of Canada standards that should be adhered to for any credible analysis, whether for a project, a policy, or a new regulation.

Williamson 1999) are potentially large. To rush a Project like the LCHP – which has been 30+ years in planning and development in various forms – without a proper economic analysis seems entirely inappropriate given the answers to many critical questions might help ascertain whether this Project is truly economically and environmentally sustainable.

Conducting CBA as part of the environmental assessment process is not without precedent. For example, the Wuskwatim Generation and Transmission Projects in Manitoba provided extensive information on Project business structure, Project costs, export market assumptions and models, economics, and financial risks to the Manitoba Clean Environment Commission during their Project review (Manitoba Clean Environment Commission 2004). While this review did not include non-market economic costs and benefits, the importance of the economic value of environmental effects of dams has been recognized for decades (Hundloe *et al.* 1990) and CBA has been used in other countries to assess projects, including dams, that alter hydrological regimes (Brauman *et al*. 2007; Brouwer & Hofkes 2008; Brouwer *et al*. 2008; Brown *et al*. in press; Crookes & de Wit 2002; Guo *et al*. 2000; Kotchen *et al*. 2006; Morimoto & Hope 2004; Wang *et al*. 2006).

1.4 Format of submission

In the balance of the report, we identify seven key issues that we would recommend the Panel ask the Proponent to address before making recommendations regarding development of the Lower Churchill River Hydroelectric Development Project. They include:

1. The difficulty in assessing Project viability when dam development and transmission line development are not considered in a single package;
2. The use of an inconsistent and incomplete framework to organize and assess economic costs and benefits;
3. Inadequate accounting of Project financial costs and expected revenues;
4. Inappropriate setting of boundaries for assessing environmental effects;
5. Inadequate accounting of the economic costs of lost ecosystem services due to development of the Project;
6. Inadequate consideration of Project, market, and environmental uncertainty;
7. Conflation of economic impacts and economic benefits;

For each issue, we first elaborate on what we believe to be the shortcomings with the current EIS. Second, we highlight the information that we would consider essential for addressing these issues. Third, we suggest a series of actions and approaches that comprise current best practices in economic analysis and which would, if conducted in a careful and timely fashion, provide the Panel with crucial information on the true economic costs and benefits of the Project.

1.5 The "Bottom Line"

For this Project, our fundamental point is that it is impossible to assess the efficiency of the Lower Churchill Hydroelectric Project because primary information on Project revenues and costs has not been provided and the economic value of non-market externalities has not been accounted for. A comprehensive CBA (see Vining & Boardman 2007) is required.

The Proponent has claimed that the some of the information that would be needed for such an assessment is confidential. Our view is that whereas (a) the publicly-funded Project has potentially fundamental, and irreversible environmental, social, and economic impacts, and (b) the Project that has the potential to affect quality of life nationally – via its positive impacts on GHG emission reduction and negatively impacts on environmental and heritage resources, that full information needed to calculate the true costs and benefits of the Project need to be provided.

The current economic impact analysis is superficial and draws exclusively on a fundamentally flawed methodology (economic impact analysis) that confuses economic activities and benefits. It appears that this EIS follows the typical pattern of economic impact studies in that it was “commissioned to legitimize a political position rather than to search for economic truth [and that] this results in the mischievous procedures that produce large numbers that study sponsors seek to support a pre-determined position” (Crompton 2006: 67). As Vining and Boardman, two of Canada’s premier policy researchers highlight, economic impact analysis is used extensively used by government despite “fatal normative weaknesses” (Vining & Boardman 2007: 62). They further state that progress in economic analysis is actually impeded by the prominence of economic impact analysis in Canada and that economic impact analysis “is like Count Dracula – no matter how many times a wooden stake is driven through his heart you know he will be back for the sequel” (Vining & Boardman 2007: 76).

While CEAA guidelines do not technically require a CBA, we argue that it is financially and economically irresponsible to proceed with this Project until a full assessment of economic efficiency – including changes in consumer surplus arising from changes in non-market and public ecosystem services – is completed. There is a growing movement worldwide to include CBA in the EA process (Crookes & de Wit 2002; EPA 2000; Hanley 2001; Lindhejm *et al*. 2007; Pearce 1998; Pearce *et al*. 2006). CBA is an inherently more democratic process, as it uses citizens’ well-being as the basis of analyzing project benefits. Assessing a project using CBA makes the project’s net benefits easier to understand (Pearce 1998, Boardman *et al.*2001) for decision-makers and the public, as all benefits and costs are described in monetary terms.

We also find the treatment of environmental and economic uncertainty to be wholly inadequate and suggest that much more effort is needed to develop Project scenarios that realistically reflect uncertainty. Without a more in-depth treatment of uncertainty, the EIS will be superficial and of limited use for decision-making.

Calculating the costs of environmental effects requires GIS data that only the Proponent has at the moment. After that data is made publicly available, it will be possible to use economic value transfer functions to calculate key Project externalities not covered in the current version of the EIS. We suggest, based on modern environmental economics best practices and knowledge, that the costs could be distributed over a very wide geographic range and that they could be substantial (i.e., the loss of the river could well prove to be as valuable to Canadian society as any revenue from carbon offsets sold by the Proponent).[6]

[6] Aggregate national benefits of conserving high-profile species such as Atlantic salmon are in the hundreds of millions of dollars annually in Canada (Rudd 2009). For a largely free-flowing river like the lower Churchill, it is no inconceivable that the costs to society of seeing it fully dammed could run into several hundred million dollars annually.

2 Issues to be Addressed

2.1 Issue 1 – Project Splitting

2.1.1 Current EIS Shortcomings

The Proponent has split the hydroelectric development into two components, the current Project and a future transmission line Project. Based on recent news, it appears that the combined cost of developing the dams and installing underwater transmission lines to the island of Newfoundland and between the island and mainland could be in the $15 billion range. Without full information on the financial costs of dam and transmission line development, it is not possible to assess the economic efficiency for the Project.

2.1.2 Information Needs for Informed Decision-Making

The Proponent should provide cost estimates for the island-based transmission line option and for the alternative scenario of transmitting all LCHP electricity to North American markets via Quebec. These estimates should make key assumptions explicit and provide ranges of reasonable values where possible.

Even if the dam and transmission line Projects are not bundled for a single EIS (which would seem to be the logical approach for a profit-oriented Project that needs to get its product to a final market), it would also be useful for the Proponent to provide preliminary estimates on the area of various ecological land cover types impacted by the most likely transmission line options. This would allow for the preliminary calculation of the economic benefits of cumulative environmental effects of hydroelectric development on the Lower Churchill River.

2.1.3 Recommended Analytical Approaches

The information needed to better inform the Panel recommendation and Government decision is straightforward, consisting of standard financial data on transmission line cost and the physical size / land cover composition of the primary transmission line corridor (s) now and under various development scenarios.

2.2 Issue 2 – Incomplete Conceptual Framework for Assessing Causality

2.2.1 Current EIS Shortcomings

The current EIS follows the project-oriented approach typically used in the environmental assessment (EA) field, focusing on a mix of activities and impacts. Given CEAA guidelines permit this perspective, our critique here is not directed at the Proponent so much as towards the general EA framework used in Canada. The confusion caused by defining "environmental effects" so broadly as to include primary, secondary, and tertiary impacts on different societal assets seems, to us, to be the root of the problem here. Without having a consistent logic model and analytical framework for systematically considering the full spectrum of impacts on quality-of-life for impacted stakeholders (broadly defined to include the general public), it is inevitable that there will be confusion over 'activities', 'outputs', 'outcomes', and 'impacts'. This conflation and inadequacy has been noted in the environmental impact literature (Vanclay 2002) and makes the systematic assessment of Project efficiency difficult.

2.2.2 Information Needs for Informed Decision-Making

While we do not consider the lack of clarity in the EIS to be the fault of the Proponent, it would be useful for the Proponent to frame key the EIS in a coherent, results-based logic model.

2.2.3 Recommended Analytical Approaches

Our fundamental recommendation here is that the analysis be organized using the logic model used by the Treasury Board of Canada to ensure Government of Canada programs, policies, and initiatives provide value for Canadians (Treasury Board Secretariat 2001, 2002). This framework emphasizes the linkages between resource use, activities, outputs, direct and indirect outcomes, and their ultimate impacts on factors that matter to Canadians.

This approach can be embedded within a larger framework (Figure 2) comprised of the key 'capital assets' that define well-being for Canadians (Rudd 2004; Rudd in review-b). When impacts are conceptualized in terms of changes in people, technology, communities, culture, environment, and financial wealth (i.e., human, manufactured, social, cultural, natural, and financial capital), it helps clarify the linkages between activity and impacts on well-being caused be changes in the accumulation and depletion of various types of societal capital assets (Smith *et al*. 2001; United Nations 2001; World Bank 2001).

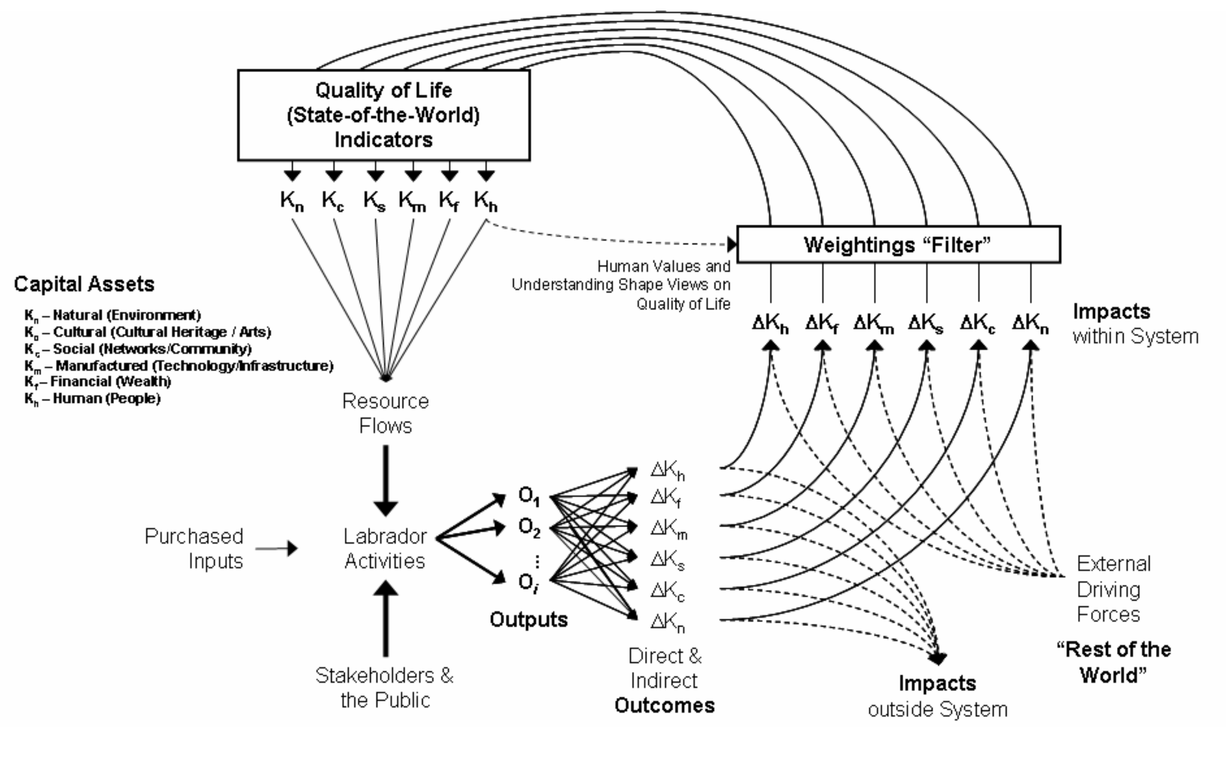

Figure 2 – Logic model for assessing societal well-being (adapted from Rudd in review-b)

Using this framework, changes in the abundance of natural capital (riparian land, free-flowing river system) due to dam development lead to change in environmental resource flows (ecosystem services). Changes in ecosystem service provision lead to changes in activities such as recreational use, food gathering, employment, business revenues, etc… and, ultimately, to changes in human well-being (Brauman *et al*. 2007; Daily 1997; Fisher *et al*. 2008; MEA 2003).

For example, changes in fish abundance, species balance and methylmercury contamination (characteristics of natural capital and ecosystem services), for example, will lead to different fishing participation rates (activities) that have different outputs (fish landing patterns), direct outcomes (home food consumption, recreational guiding revenue), indirect outcomes (e.g., changing the competitiveness of Labrador guides *vis à vis* other tourist destinations), and ultimate impacts (e.g., declines in human health due to mercury consumption, reductions in guide profitability, etc…).

Similarly, dam construction can be viewed as an activity that uses a variety of Labrador resources (water flow – natural capital; local manufactured and human capital; a very high level of financial capital; and a wide variety of purchased inputs from outside the system) to produce outputs (electricity for sale) that have direct outcomes (revenue) and indirect outcomes (e.g., changes in community and culture within Labrador, changes in tax revenues for the provincial government). When combined with external impacts (e.g., shifts in GHG emissions nationally) and the external driving forces that also impact the net impacts within Labrador (due, for example, to fluctuating market demand for electricity, foreign exchange rates, or shifting hydrological cycles due to climate change), the Project will have a diverse range of impacts on people, communities, culture, the environment, the technology and infrastructure in Labrador (i.e., not just dam facilities but roads, airports, hospitals, etc…), and the level of financial wealth of stakeholders and the public.

Two points that we revisit later are worth introducing here. First, net changes in financial wealth are the primary focus of economics and economic activity is only a means of generating true wealth. Economic activity is a necessary condition for generating wealth (i.e., you cannot generate wealth without economic activity) but it is not a sufficient condition (i.e., simply engaging in business activities does not guaranty that economic wealth will be generated). Care must be taken to avoid automatically associating business activity with economic wealth.

The second point concerns non-market economic valuation. The trade-offs between financial wealth, labour (a component of human capital), some components of natural capital (e.g,, timber, minerals) and technology are usually well-defined and articulated using established market prices. The trade-offs between financial wealth and other components of human capital (e.g., health), natural capital (e.g., biological diversity), social capital (e.g., social networks and resilience), and cultural capital (e.g., heritage sites) are real but are not usually directly articulated using market prices. A primary focus of the discipline of environmental economics is to quantify non-market costs and benefits by assessing the trade-offs that people are willing to make between different components of the assets that define well-being and to articulate those trade-offs in dollar terms.

If we can assess those trade-offs, then we can monetize the non-market benefits of changes affecting quality-of-life across multiple dimensions and assess the entire LCHP in terms of its net economic efficiency.

2.3 Issue 3 – Missing Project Financial Information

2.3.1 Current EIS Shortcomings

A Project of this magnitude necessitates a large investment of public money and while it is expected that the Project would generate considerable revenue over time, this is not addressed explicitly in the current EIS. In fact there is a relatively scant assessment of overall Project economics due, in the Proponent's view, to confidentiality concerns. Given the large financial commitment and the one-way nature of environmental damage (i.e., there is no plan for dam decommissioning in the future), a full accounting of Project costs and projected revenues is an essential part of the justification for the Project.

Volume IA of the EIS at page 2-2 states, under 2.4.1 (Demand for New Renewable Generation), that the demand for new renewable generation has been increasing across North America in recent years, driven largely by four factors:

- the increasing demand for electricity in general;
- the need to upgrade or replace aging infrastructure in the industry;
- rising costs of fossil fuels; and
- the need to address the contribution to climate change.

Revenue streams, of course, are subject to a certain amount of risk in any private enterprise. Power generation is no different. Assuming constantly increasing demand and steady prices for a product is not realistic. There is always the possibility of a significant change in demand via generation substitution. This could be due to a number of factors. For instance the cost of fossil fuel is not currently rising, but has been falling for some time. Section 2.4.2 states "the increasing demand for electricity is a national and international trend that is fuelled by population growth, growth in economic activity and technological advances." Many of these demand estimates have, however, been revised downward due to the recent change in "growth in economic activity" worldwide.

There are other areas where greater clarity would be useful. Volume IA of the EIS (at page 2-2) states: "The Project will be in an *optimal position to make a substantive contribution to meeting the targets* established by the federal regulatory framework. As a source of clean, renewable power, the Project *expects to benefit economically*" (emphasis added).

This is a perfect example of the need for CBA in this kind of planning process. These potential revenues, assumedly from carbon trading on the international market, need to be clarified and measured against all costs. What, in this instance, are the Proponent's assumptions about carbon revenues? Table 2-2 "Greenhouse Gas Emissions from the Electricity Sector (Annual Average 2004 to 2006)" assumes a \$15 t^{-1} price for carbon, citing the Technology Fund Contribution rate. It is considered standard practice to include a range of prices in this sort of analysis. In a meta-analysis of 103 separate emissions damage estimates from 28 published studies, Tol (2005) found a mean marginal damage cost of \$93 t^{-1}, but concluded that it is unlikely that marginal damages exceed \$50 t^{-1}. More recently, Ackerman and Stanton (2006) endorsed continued reliance on the UK Government Economic Service's 2002 estimate of £70 (\$131) t^{-1}. Despite variation in damage estimates, these studies illustrate there is a wealth of information available for assigning a cost to carbon emissions. And what are the precise mechanisms under which these revenues would be obtained? Furthermore, should a carbon tax be adopted, it is not inconceivable that net revenues would diminish despite the relatively low potential emissions as compared to a coal-fired equivalent.

Without a clear, thorough, and transparent accounting of all revenues and Project costs, the Canadian public cannot make an informed decision about the relative value of this Project.

2.3.2 Information Needs for Informed Decision-Making

For any reasonable assessment of Project economics, the Proponent needs to include considerably more information on several components. Given that this investment is using public money and is subject to public review, a clear quantification of all costs and benefits should be provided. To begin with, despite the Project being essentially public, the Project rationale suggests a profit-making enterprise. Even if this is not the principal objective, a full accounting of projected revenue streams, including any risk thereto, should be included in Project documentation. For the Canadian public to be able to assess whether the Project is worthwhile even under that narrow rubric, it is incumbent upon the Proponent to provide such an analysis.

In terms of costs, the EIS does not provide a thorough accounting of costs that arise from the Project. These include non-market costs to ecosystem services, which we detail below. Reasonably, the costs should also include the construction of any transmission lines, in whose absence the Project cannot yield many of its projected benefits. By considering these as separate Projects, we believe the Proponent is not only masking capital costs, but also the economic costs of cumulative environmental effects.

2.3.3 Recommended Analytical Approaches

In terms of benefits, it is important to provide some analysis of potential changes in demand, from where the bulk of benefits arise. Deregulation allows consumers to choose their preferred method of generation. Work by Sundqvist (2003), and Bratrich *et al*. (2004) suggest that "green" certification for hydro schemes can be very important to consumers, who might be willing to pay more for clearly and thoroughly certified hydro generation. The LCHP Project would not qualify as "green" under either of the proposed schemes.

The fact that solar and wind generation were gaining in popularity until very recently (due to the decline in crude prices among other variables) suggests that consumers might be willing to switch to other generating modalities when possible. If the LCHP is to provide power to the New England or New York state markets, the Proponent should consider circumstances under which those markets might transition to a different generating mix[7]. For example, considering the costs for fossil fuel generation, Chakravorty *et al*. (1997) found that "if historical rates of cost reduction in the production of solar energy are maintained, more than 90 percent of the world's

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7 For instance, the State of New York recently announced its intention to install up to 100 MW of solar photovoltaic power to help meet the State's aggressive '45 by 15' renewable energy mandate (the goal of receiving 45% of its electricity through energy conservation and renewable power (DiSavino, S. NY wants to install 100 MW of solar power. Reuters, 15 May 2009). It is also important to note that built-in photovoltaic (BIPV) costs are falling rapidly and that new technologies (i.e., thin film plastic solar) will drastically reduce installation costs for BIPV applications, especially in markets where peak loads occur during summer, thereby reducing the installed cost of electricity generation capacity in local markets.

coal will never be used." This seems somewhat naïve these days, but it illustrates the possibilities of change given the probability of increasing demand for non-fossil fuel generation.

This propensity of consumers to switch between sources is the cross-price elasticity of demand for any given generation type. These elasticities have been calculated principally for fossil-fuel burning methods (Ko *et al*. 2001), but there is also some research on hydro (McDonnell 1991). This is in need of updating in part because it only considers cross-price elasticity with respect to coal, oil, and natural gas. Additionally, as US states move toward a renewable portfolio standard (RPS) as a component of a strategy to combat climate change, it is doubtful that large hydro will be a large component of these portfolios (Bird *et al*. 2009). The sensitivity of consumer demand across a different mix of generating options is an important component of planning for Project viability, and is not addressed at all in the EIS.

Socially responsible production methods can lead to market rewards for producers through mechanisms such as 'fair trade' labels (Caswell & Mojduszka 1996; Raynolds *et al*. 2007). Given the rapidly advancing technology for 'smart metering' (Haney *et al.* 2009), it is quite conceivable that electricity consumers in major markets will soon be able to specify which electricity they will use based on price and on other factors relating to non-market 'credence' attributes of production (e.g., the social and environmental costs of electricity production by various technologies) (Press & Arnould 2009). 'Green' labeling of electricity is likely to grow in importance over the years during which the Project would be constructed and, given rapid technological advance in the renewable energy sector, both pricing and production costs for competing electricity generation facilities.

2.4 Issue 4 – Whose Values Count?

2.4.1 Current EIS Shortcomings

Any major civil works project generates a stream of benefits and costs that are enjoyed or incurred by a variety of businesses, groups, or individuals. One part of establishing an accounting stance for conducting a CBA is to determine which sectors of the population are deemed relevant to that accounting. By selecting this stance, the agency conducting the CBA can either narrow or expand the scope of the costs and benefits that arise from the project, and thereby control the presented net present value (NPV[8]). This involves determining the scope of the market, a fundamental problem in applied economics (Varian 1992: 169).

Federal agencies often have guidance on this determination. OECD guidelines (Pearce *et al*. 2006) stipulate that the geographical boundary for CBA is usually the nation but can readily be extended if appropriate (as it may be for cases where GHG emissions change as a result of a project or policy). Political boundaries are not always the same as economic boundaries, as in the example of a Provincial agency whose projects can have impacts on 'downstream' users outside of their jurisdiction. Brent (1996: 4) suggests that for a social CBA, which would include any

[8] Net present value (NPV) is one of the calculations that results from a CBA. It is the total benefits of a project (summed over the life of the project and discounted for time) minus the total costs of a project, including all non-market costs (summed over the life of the project, discounted for time). As this calculation is net of costs, addresses all impacts over the life of the project, and deals with discount rates (the rate at which values in the future are compared against those in the present), it is a more thorough narrative than the economic impact analysis, which only addresses short-term expenditure impacts.

project under the purview of a federal government, "all benefits and costs are to be included, consisting of private and social, direct and indirect, tangible and intangible."

For this Project, the Executive Summary and each following document lays out the assessment area of different parts of the Project, effectively deciding whose benefits and costs count. For example, Volume III, section 2.3.1.1 states "the Assessment Area for Economy is the Upper Lake Melville Area." Volume IIA, section 2.2.1.2 states "The Assessment Area for the characterization of potential environmental effects on Air Quality resulting from Project activities is the Project Footprint (Volume IA, Chapter 4), plus an extended area out from the Project Area in each direction to approximately 5 km, as well as 500 m from the centreline of TLH (from Churchill Falls to Happy Valley-Goose Bay) and the transmission line access roads." For most of the effects described in the EIS, the area is essentially the Upper Lake Melville region, with a few instances of western Labrador. Spatial boundaries for various VECs are laid out, for example in Volume IIA, for various environmental effects. The assessment area for these effects never extends beyond the province. Volume III, p 2-8 states "The Assessment Area is the spatial area within which the significance of an environmental effect is determined. It is based on the geographic extent of the interactions with the Project, the availability of appropriate data, as well as the socio-economic and administrative boundaries described below."

By omitting what could be significant segments of the population that could be affected by the Project, the Proponent could be undervaluing either the Project's costs or benefits. Additionally, the Proponent is essentially stating that those segments of the population hold no values for Project costs or benefits. This represents a significant divergence from the intention of CBA. CBA is based on the notion that any measured costs or benefits should be "those of the affected individuals, not the values held by economists, moral philosophers, environmentalists, or others (Arrow *et al*. 1996: 222)." The term "cost" means any reduction in human well-being, and "benefit" means any gain in human well-being (Boardman *et al*. 2001; Pearce *et al*. 2006). This has more than philosophical implications. Analyzing project impacts from a welfare perspective rather than a scientific one results in a process that investigates how projects affect people's lives (Hanley 2001; Pearce 1998). The assumption, made throughout the EIS, that economic effects are only felt locally, is not justifiable. Conducting a thorough CBA would correct this deficiency.

While the assessment boundaries vary, there is an assumption throughout the documentation that effects will not be felt beyond the province. This is not justifiable as there is abundant empirical evidence that populations beyond the immediate project area often bear the costs of regional development projects or economic activities (Concu 2007; Hein *et al*. 2006; Pate & Loomis 1997; Pearce *et al*. 2006; Rudd 2009; Talberth *et al*. 2006), though the intensity of those effects can diminish with distance (Bateman *et al*. 2006; Hanley *et al*. 2003). Somewhat ironically, some of the primary economic research assessing distance decay effects is currently taking place in the U.S., where very serious consideration is being given to removing large hydroelectric dams on the Snake and Klamath Rivers in the western U.S., as well as numerous smaller dams throughout the country (Gowan *et al*. 2006; Loomis 1996; Pacca 2007). Pate and Loomis found that "restricting benefits [of dam removal] to just the political jurisdiction in which the site [Lower Snake River] is located would understate the benefits by at least $300 million" (Pate & Loomis 1997: 206)

2.4.2 Information Needs for Informed Decision-Making

Given our knowledge of the environmental values and preferences of Canadians (Rudd 2009, in review-a), it is highly likely that the Project will impose external costs on some segment(s) of the Canadian population due to changes in biological diversity, free-running river status, forest habitat loss, and the loss of heritage sites or cultural opportunities for Aboriginal people. Information is needed on the proper geographic scope of analysis for environmental effects of the Project. That is, we need to know if there is a gradient of declining impacts on Canadian as we move away from Labrador.

2.4.3 Recommended Analytical Approaches

There are two key issues to consider when determining who should and should not be counted in a CBA. The first issue is a property rights issue. That is, who has the formal or informal property rights over the component of natural, human, social, or cultural capital that is being impacted by development? For some things, the answer is straightforward (e.g., timber in the flood zone is owned by the Province), while for others the answer may be unsettled or disputed (e.g., Aboriginal claims over land and resources). Effects on the pre-existing structure of property rights are also critical to consider. For example, if a Project causes an increase in air and water pollution in a surrounding community, and property rights have been defined in such a way as to give the community a right to the existing level of air and water quality, then the added pollution represents a liability for the Project beneficiaries. For other types of public resources, the Government of Canada has the responsibility, on behalf of all Canadian citizens (and due to international treaty and leadership obligations), to act in the interest of Canadian society as a whole (e.g., protecting biological diversity). The impacted population might not even be aware of how a Project might affect them; John Dewey argued long ago that the primary role of policy analysts was to identify and account for the segments of the 'public' that were unaware of how processes in other regions impacted them (Dewey 1927).

If one has some form of rights to an ecosystem or cultural service, then a Proponent who causes damage should be prepared to compensate stakeholders and members of the public that are adversely impacted. It is obviously in a Proponent's self-interest to try to limit the geographic scope of the analysis of external costs so that their potential compensation obligations are minimized. If citizens do not, however, have any property rights but do not want to see a project go forward, it is up to the opponents of development to compensate the developer to not proceed with development. This “Coasian’ bargaining approach (Coase 1960) – through various negotiated side payments for example – must be considered if they are present. In the LCHP context, the proposed New Dawn Agreement with the Innu is a compensation package that arises from recognition of Innu rights in the Churchill River region. There are, however, no formal LCHP-specific side agreements with the Metis or Inuit. Volume III Section 2.8.8 also points out that individuals might lose access to six cabins along the Project footprint, but considers neither the property rights nor the cost to those individuals of losing access to their cabins, nor the value any greater community might place on that access. Similarly, local Labrador residents use the river below Muskrat Falls for smelt fishing. If changes in flow regime affect smelt populations, it is unclear as to who has rights to a relatively unimpaired hydrological cycle and whether that would / should be compensated for (the value of this fishery to local people could quite easily be calculated using time and travel expenses for fishing trips). It would be useful in the EIS for the Proponent to systematically outline the full range of potential interests potentially impacted by environmental effects, their *de jure* or *de facto* property rights, and the rationale for how those affected can be compensated or why they should not be compensated.

From an environmental economics perspective, the single most important question is whether citizens from outside the current EIS assessment area derive well-being from simply knowing that the lower Churchill River provides scale-independent ecosystem services. That is, are citizens outside of the Proponent-defined EIS boundaries impacted by the loss of a free-flowing river, its inundated riparian habitat and historical sites, and its ecological structure and function? Functionally the only way to assess non-market values is by stated preference survey methods (Pearce 1998) and empirically assess distance decay effects. In Canada, this has been done for marine aquatic species at risk (Rudd 2009) but not, to date, for freshwater ecosystem services.

2.5 Issue 5 – Missing External Costs

2.5.1 Current EIS Shortcomings

While the engineering costs are fairly well explained, the EIS ignores several categories of costs that are commonly addressed within a CBA. These include but are not limited to: lost or degraded ecosystem service values associated with the inundation of approximately 126 km^2 of currently intact riparian ecosystems; the loss of a free-running river; and the loss of historical sites important to Aboriginal and non-Aboriginal people in Labrador (and potentially beyond). Further, the cumulative non-market costs of the transmission line Project are likely to be substantial due to the large area of land that would be cleared in more populated areas and the impacts of sub-sea transmission lines on marine benthic organisms.

When external costs are not accounted for, private marginal costs of development (MC_1 in Figure 3) and full Project development could result in social costs (MC_2) that are much higher. The difference between private and social costs depends on the magnitude of the environmental effects and their geographic scope of influence.

With the LCHP, the current plan is to develop the dams to their maximum scale in order to capture the full power generating potential of the lower Churchill River.

Typically in the environmental assessment field one looks only at the costs of environmental effects, not at the costs and benefits. If external effects are accounted for adequately and we were to find, for instance, a relatively rapid increase in costs above some level of development, the typical response would be to have a scaled-back development with the level of development dictated by the shape of the cost curve (i.e., scale-back to just before the sharp escalation in Figure 3).

When the benefits of development are also considered, the situation changes (Figure 4). The economically efficient development is determined by the intersection of marginal cost and benefit (MB) curves. When the size of the Project is dictated by physical or engineering constraints, as is the case with the LCHP (i.e., one can't generate more electricity out of the river given the proposed dam configuration), one would hope that marginal benefits (i.e., electricity prices) would significantly exceed marginal costs so that the Project would generate strong profits (or resource rents as they are known in economics). If social costs are included in the analysis, it could be the case that there was actually an intersection of the MB and MC curves, implying that an economically optimal development would be smaller. Of course, a scaled-back development could cost substantially more to build and operate on a per MW basis, so the cost and benefit curves might simultaneously shift. Assessing the optimal (i.e., efficient) scale of development requires knowledge of revenue and both the private and social costs of the project.

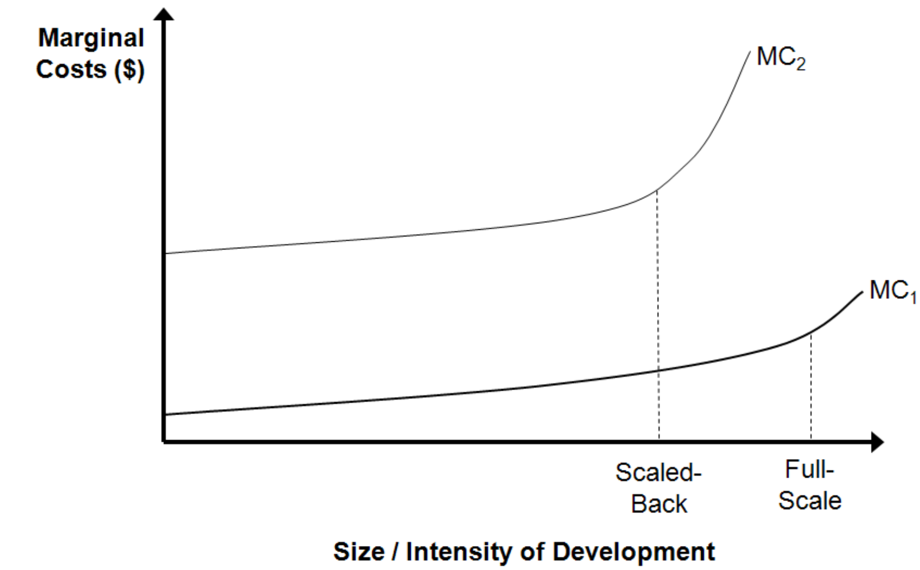

Figure 3 – Cost curves for various development scales

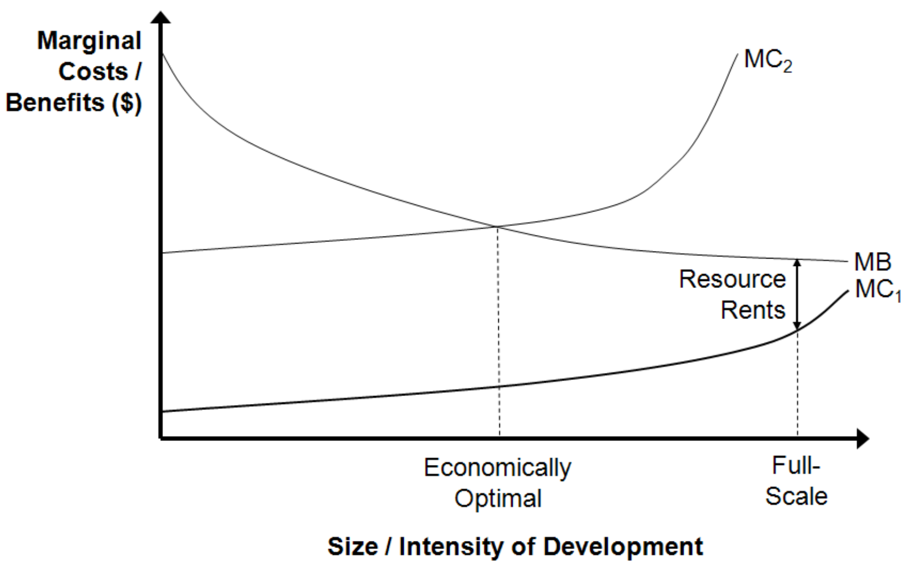

Figure 4 – Cost and benefit curves and the optimal scale of development

In the case of other costs to recreational users, the EIS presents information on current tourism revenues and potential for positive or negative effects arising from the dam construction. Volume III, at page 5-14, states "although boat access and navigability of the river will change as a result of the Project, they will not be decreased or reduced." Volume III at 5-19 states that a local canoe guide believes "it is likely that his clients would find the structures and reservoirs unattractive or uninteresting and that would likely provide a distraction from the wilderness experience his clients are seeking." The EIS goes on to state that the reservoir will in fact retain much of its natural appearance.

Both of these are changes to the current state of the river. Whether the net effects are positive or negative is an empirical question. To state that the reservoir will retain its natural appearance, or that navigation will not be affected is to make a very strong set of assumptions about individuals' preferences regarding those issues. The EIS takes a highly implausible and narrow perspective on environmental values by focusing primarily on the value of game animals and fish to local residents as the primary attributes of factors of value for humans, and making a series of very strong assumptions about what people value and what they don't value.

Volume III of the EIS considers Project impacts to subsistence use along the Lower Churchill River (Chapter 5), but does not consider the economic impacts from any potential changes. Environmental justice insights suggest that particular attention should be paid to external impacts imposed on Aboriginal peoples (Lambert *et al*. 2003). Talberth *et al.* (2006) investigate methods of quantifying losses to subsistence activity incurred by Inupiat Eskimos in Alaska, and found that due to potential changes in access and subsistence species behavior due to proposed dredging activity along the Chukchi Sea coast, costs to a local village could average approximately US$ 250,000 per year (2006 $).

2.5.2 Information Needs for Informed Decision-Making

Incorporating external costs has shown large hydroelectric projects to be less valuable than originally supposed (Han *et al.* 2008); other large infrastructure proposals with significant externalities are similarly less attractive economically when all external, unaccounted costs are tallied and included in economic analyses (Talberth *et al*. 2006), as best practices in economics dictate they should be (Arrow *et al*. 1996)[9]. Given that these costs are derived using best practices in environmental economics, it would be very useful to assemble data on the external costs of the LCHP for all Canadians.

Put succinctly, we simply do not know where the cost and benefit curves in Figures 3 and 4 are located. Thus we have no way to ascertain whether full-scale production is optimal after social costs are included in an economic analysis. This information is critical for informed decision-making of a Project that is justified on its economic benefits.

2.5.3 Recommended Analytical Approaches

All types of benefits and costs, both market and non-market, should be considered and quantified to the extent possible. Given advances in environmental valuation over the past decade, and its application towards the valuation of other types of public goods (Adamowicz *et al*. 2004; Boxall *et al*. 2003; Health Economics Research Group *et al*. 2008; Krupnick 2004; Noonan 2003; Ryan 2004; Throsby 2003), the potential for valuing environmental, social, and cultural impacts of the LCHP is high. It could be argued that if a Proponent is not in the habit of conducting this sort of economic analysis that it would be both costly and problematic to do so. A counter argument is that it would be costly and problematic *not* to do so.

[9] Kenneth Arrow, lead author on this article in *Science,* was the 1972 Nobel laureate in economics.

Fortunately, economists have at their disposal a wide range of tools for measuring non-market effects, including travel cost and random utility models, contingent valuation surveys, hedonic pricing models, benefits transfers, and replacement cost techniques. These are all widely accepted, peer-reviewed methods (Arrow *et al*. 1993; Champ *et al*. 2003; Heal *et al*. 2004). Environment Canada (1996) published a *Handbook of Environmental Economics* that helps lay out many of these methods and their application in decision-making.

We will focus on two primary methods of measuring willingness to pay that fit in the "stated preference" category: contingent valuation and choice experiment. There are several other categories, including revealed preference, avoided or replacement cost, and productivity. All of these methods are commonly used in empirical studies, and the principles behind these methods have gained wide acceptance among economists and policy makers.

Stated preference methods of measuring non-market values use surveys or interviews to ask people directly about their willingness to pay for some good or service (Champ *et al*. 2003). The surveys typically involve a choice about a hypothetical or proposed situation. A distinct advantage of stated preference methods is that they allow researchers and policy makers to target preferences for specific components of environmental changes, such as existence value. A disadvantage is that survey results can be affected by strategic responses - designed to influence the outcome of the research - rather than honest responses. Researchers have also found that some people are not willing to trade money for a loss in environmental quality (Rudd 2009; Spash 2002).

Two frequently used types of stated preference methods are contingent valuation and choice experiments.

Contingent Valuation

Contingent valuation (Arrow *et al*. 1993; Carson 2000; Hanemann 1994; Randall 1987) is a survey-based method for determining the values people hold for a specific, proposed change in environmental quality. In a contingent valuation survey, respondents are presented with a hypothetical or proposed environmental scenario such as a specific change (or set of changes) in an environmental program or policy.

Respondents' values are elicited through questions that address either willingness to pay or willingness to accept. Respondents are asked one of four questions:

- What would they or their household be willing to pay for the change in environmental quality?
- What would they or their household be willing to pay to avoid the change?
- What would they or their household be willing to accept as compensation for the change?
- What would they or their household be willing to accept to avoid the change?

The survey then proposes a payment method, such as a change in the amount of a water bill or a voluntary contribution into a fund. These payment methods are typically time-sensitive, so a well framed question will specify whether a single payment or a series of payments over time would be required. A contingent valuation question could be based on a proposal to ameliorate some of the potential first-order upstream environmental effects of the proposed dams, such as loss of existing riparian habitat. The particular valuation question could be "How much would your household be willing to pay to decrease the area of lost riparian forest upstream of the Gull Island Dam by 30%?"

CV is also used to elicit "nonuse" or "passive use" values that by definition have no discernible trail to market behavior (Carson *et al.* 2003). Perhaps the archetypal nonuse value is existence value, which is argued to arise from "simply knowing that some desirable thing or state of affairs exists" (Randall 1987). The consideration of existence value is included as part of total economic value in several guides and is regarded as a standard category of value (EPA 2000; Pearce *et al*. 2006). Another example of a nonuse value is option value. Specifically, individuals may hold an option value for an environmental good or service even though they currently do not make use of the good or service. Instead, they value the option of potential future use (Freeman 1993). None of these are considered or mentioned in the current EIS.

Choice Experiment

Choice experiments have several advantages relative to contingent valuation (Hanley *et al.*1998). Choice experiments provide more-detailed information about people's preferences over a range of outcomes, are less prone to biases caused by respondents answering questions strategically, and yield a greater amount of information than a contingent valuation survey for the same cost. A possible disadvantage of a choice experiment relative to contingent valuation is that because choice-experiment surveys are more detailed, it can be more difficult for people to respond or they may be less likely to respond (DeShazo & Fermo 2002; Swait & Adamowicz 2001). Pearce *et al*. (2006) depict CE as the principal stated preference valuation method when dealing with environmental goods for CBA.

A choice experiment addressing the non-market costs of the LCHP could investigate levels of provision of several of the attributes lost by construction, such as ashkui, riparian forest, length of free-running river, and heritage sites. The "product" being valued could be possible alternatives to the full operation of the Project that would have different levels of damage to these attributes. A final attribute would be either (a) increased costs, as reflected by a tax increase to compensate the Proponent for foregone profits due to lower levels of Project operation, or (b) reduced taxes for Canadians, as a result of increased financial self-sufficiency (and hence lower transfer payments) for NL and/or Aboriginal peoples. As highlighted previously, the choice of WTP or WTA in a stated preference survey depends on the nature of property rights and who should be compensated and who should do the compensating. Costs to individual households affect value and utility because a change in income is understood to produce a change in utility – the money paid for environmental benefits could be used to buy something else of value. The goal of a choice experiment is to assess how people simultaneously make trade-offs among the multiple environmental effects and money (i.e., natural capital, cultural capital, financial capital).

In a choice experiment survey, each respondent is presented a series of "choice tasks." Each choice task presents two or more options that are carefully designed to vary with respect to each of the attributes. One operation alternative, for instance, could have 25% of riparian forest maintained and allow 33% of ashkui sites to remain. This option might cost the respondent an additional $40 per year. Another alternative might allow for 50% of riparian forest maintained and a higher number of ashkui sites to remain, but cost $65 per year. People with different beliefs and preferences will tend to pick different options, allowing economists to calculate and statistically differentiate willingness to pay for each attribute. Appendix A shows a choice experiment which we drafted[10]; it would be available for refinement and research on the costs of lost ecosystem and cultural services to Canadians' due to LCHP development.

2.6 Issue 6 – Limited and Absent Ecosystem Services

2.6.1 Current EIS Shortcomings

Heal *et al*. (2004: 5) make an interesting point that "failure to include some measure of the value of ecosystem services in benefit-cost calculations will implicitly assign them a value of zero." Currently the EIS does not address the concept of ecosystem services at all, implicitly assigning all ecosystem services other that recreationally important wildlife and fish production zero value. However, it does highlight, throughout, impacts to these services from the construction and operation of the Project. Volume IIA describes effects to the natural environment including losses of riparian habitat. Volume III describes social, cultural, and economic effects including loss of ashkui, and the inundation of Innu and Settler heritage sites. However, at no point in the EIS are the economic values for these losses described or mentioned.

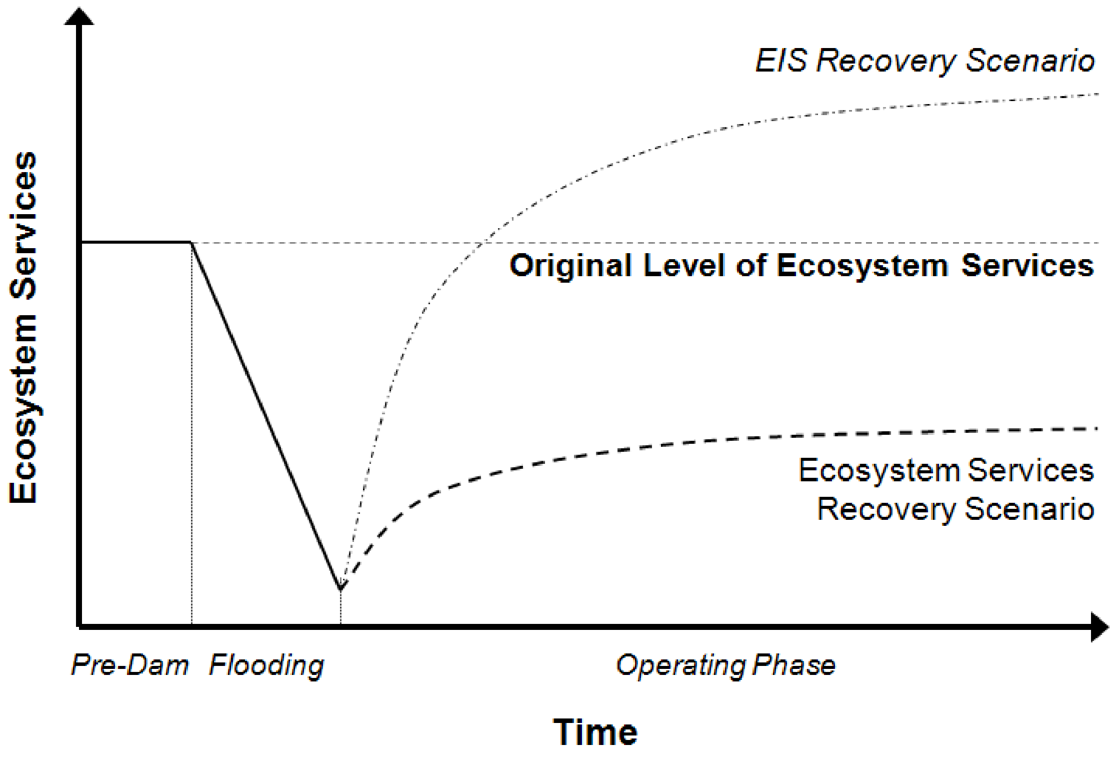

Figure 5 – Alternative perspectives on ecosystem service provision after LCHP development

[10] The Appendix includes a hard copy of an online choice experiment (www2.swgc.mun.ca/evplsurvey/dam/dam1logn.htm). If this survey was to be delivered to a sample across Canada, it would first need further focus group testing and scientific input on the survey attributes and their levels. It should be viewed, for now, only as an example of the type of survey that would be needed to assess the geographic scope of the environmental effects of the LCHP.

Further, the EIS makes the claim that damming the river will leave people better off than they were without the dams due to more recreational opportunities. This perspective is very narrow and is not at all credible. The Proponent goes so far as to claim that "The Project will result in the loss of 126 km^2 of terrestrial habitat, or approximately 12% of the area comprising the lower Churchill River valley. This habitat is not lost in absolute terms, but will be flooded." Essentially what the Proponent is claiming is that ecosystem service levels decline during dam construction but then bounce back to higher levels than ever during the operation phase (Figure 5).

There are about 20 generally accepted ecosystem services that should be considered, to the extent possible, in the valuation of river systems (de Groot *et al*. 2002), including:

- Gas regulation
- Climate regulation
- Disturbance regulation
- Water supply and regulation
- Sediment supply and regulation
- Erosion control
- Soil formation
- Nutrient cycling
- Waste treatment
- Biological control
- Refugia
- Food production
- Raw materials
- Genetic resources
- Nature appreciation
- Sport fishing
- Water sports
- Scenic view

The range of ecosystem functions they provide includes: regulation of chemical composition of the atmosphere; regulation of temperatures, precipitation at local levels; regulation of episodic and large environmental fluctuations on ecosystem functioning; supply and regulation of water flow; regulation of sediment supply to estuary and marine environment; retention of soil within an ecosystem; soil formation processes; storage, recycling, capture and processing of nutrients; recovery of nutrients, removal and breakdown of excess nutrients; regulation of animal and plant populations; habitat for resident and migratory populations; primary production for food; primary production for raw materials; unique biological materials and products; providing opportunities for the appreciation of natural features and wildlife; provision of opportunities for sport fishing; provision of opportunities for water sports; provision of scenic views; provision of opportunities for water based transport; and providing opportunities for non-commercial uses. For a current overview of hydrological ecosystem services, see Brauman *et al*. (2007).

When considered as a suite of ecosystem services, it is absolutely clear that any major dam will adversely impact many of the ecosystem services provided by river systems and that claiming otherwise is simply not credible.

Clearly there are economic values attributable to the ecosystem services and that they could be impacted by the creation and operation of the Lower Churchill dams. Reviewing the literature more broadly it is clear that wild nature has considerable value to humans (Balmford *et al*. 2002; Balmford *et al*. 2008; Bruner *et al*. 2008; Naidoo & Adamowicz 2005). Not to include even a consideration of these values, which in one case (Han *et al*. 2008) drove the benefit-cost ratio of a hydro project to below 1.0, seems irresponsible and is indicative of the superficial nature of the economic component of this EIS. As stated in many of these papers, including these values in the planning process for a hydro project allows decision-makers and the public to thoroughly consider the nature of any predicted impacts and to trade-offs that society is prepared to take.

2.6.2 Information Needs for Informed Decision-Making

In order to obtain ecosystem service values, it is essential to conduct either an original valuation exercise (see section above) or a benefit transfer. While benefit transfers are common practice in many areas, they are best suited to valuation situations where there are sufficiently transferable values. In order to get the most useful data on ecosystem service values lost through the Project, we recommend that the Proponent conduct/sponsor research that uses a choice experiment approach (outlined above) to assess several key ecosystem service values that could be impacted by the Project.

Both survey and benefit transfer approaches require information about how one land cover and/or habitat type is changed as a result of Project development. That is because ecosystem service values are linked to spatially explicit land cover types and their habitats[11]. Changes in land cover lead to changes in ecosystem services.

2.6.3 Recommended Approach and Best Practices

To assess changes in economic value from one development scenario to another, including the ‘no development’ scenario, the Proponent should fully quantify the ecotype and habitat transitions of the currently proposed Project and its alternatives. This would allow for the quantification of a more complete suite of ecosystem services relative to the current analysis, which focuses narrowly on local game species.

The Millennium Ecosystem Assessment (MEA), generally regarded as standard guidance on this issue, is a comprehensive report on the status of ecosystems worldwide that was commissioned by United Nations Secretary General Kofi Annan in 2000. The MEA outlined four categories of ecosystem services: provisioning (e.g., food, fresh water); regulating (e.g., regulation of climate and erosion); cultural (e.g., spiritual values, recreation), and supporting (e.g., primary production, soil formation).

Ecosystem services are defined as the benefits that nature provides to humans (MEA 2005). Other classification schemes have been proposed (e.g., Daily 1997), but none, at that time, were

[11] We requested the GIS layers that would be needed to calculate these transitions from Nalcor but have not yet received a response from the Proponent.

based on a process as inclusive and comprehensive as the MEA. Ecosystem services provide economic benefits to society, although humans are not always aware of these benefits.

Using some Churchill River-specific examples, local residents or tourists would benefit from provisioning services when they catch and eat smelt during the winter or pike during the fall. The estuarine system of Goose Bay and Lake Melville provides regulating services by absorbing the force of storms in coastal areas and regulate changes in air and water temperature; air temperatures in coastal areas are less variable than inland temperatures. Additional regulating services provided by the river and estuary include the transportation of raw sewage away from the communities of Happy Valley-Goose Bay and Sheshatshiu. The Churchill River provides many cultural services, outlined in Volume III, such as all the spiritual values held by Innu people, and the value of historical sites along the river. Recreation is also included in the cultural services category.

While, as we describe above, the valuation of ecosystem functions has been addressed for some time by environmental economics, the ecosystem service framework diverges from tradition by providing both a specifically anthropocentric perspective on ecosystem function and by aligning the description of that function more with a growing body of literature in ecology (Balavanera *et al.* 2006). While this difference may seem subtle it is potentially quite powerful. The incorporation of an unabashedly human focus on ecological analysis fits well within CBA, so for that purpose it is very helpful. In fact for any management decision that could have ecological and socioeconomic effects at various scales, ecosystem service valuation could be critical (Farber *et al*. 2002; Farber *et al*. 2006).

In this section we will provide a review of relevant freshwater ecosystem service valuation research, and a more specific focus on ecosystem service research relevant to hydroelectric generation. Freshwater ecosystems include rivers and streams, wetlands, and lakes, all of which provide an extensive array of services to humans. The value of freshwater ecosystems is seen as quite high in many sectors, to the point that several large international conservation NGOs have published guides to their economic valuation (e.g., Emerton 2005; Schuyt & Brander 2004).

The values held for these various attributes vary worldwide, and there is some variation with respect to which types of values are the highest. Brander *et al*. (2006), in a large meta-analysis of wetlands valuation studies, found a median value of US $2,800 ha^{-1} yr^{-1}. Pointing out that this is also a very conservative estimate, the World Wildlife Fund (Schuyt & Brander 2004) estimated that the total value of wetlands in North America as of 2000 was approximately US $676 million.

In terms of ecosystem service types, Brander *et al*. (2006) found that biodiversity ranked the highest, with a value of US$ 17,000 ha^{-1} yr^{-1}. Brauman *et al*. (2007) suggest that provisioning services might be most highly valued as people are generally very aware of the economic value of such resources as timber or fish that require functioning ecosystems. de Groot *et al*. (2006) present a list of component values arising from wetlands ecosystem services. In their work, the cultural values far exceed any of the other categories, with “aesthetic information” topping the list at nearly US $900 ha^{-1} yr^{-1}. The next most valuable service is “amenity/recreation” ranked at just over US $500 ha^{-1} yr^{-1}. These values are global averages. Brouwer *et al*. (1999) found that riverine wetlands had the highest value in terms of freshwater systems, with flood control having the highest value, at US $96.20 household^{-1} yr^{-1}.

Birol *et al*. (2006) conducted a choice experiment to ascertain values for ecosystem services at the Cheimaditida wetlands in Greece. They presented four attributes: biodiversity, open water surface area, research and education, and re-training of locals. These were presented under two scenarios, high and low, and a status quo no change scenario. Consumer surplus was calculated at $158.31[12] per person to improve management of all the four attributes at a high level, described as follows: "biodiversity is managed at a high level; open water surface area is high; research and educational opportunities are high, and 150 local farmers are re-trained (p. 154)." Of all the attributes, biodiversity ranked the highest in value, with increases from status quo to the medium or medium to high averaging $20.15 per person.

Brauman *et al*. (2007) provide a framework for understanding hydrologic ecosystem services, and Sternberg (2008) provides a history of the rise and relative fall of hydro as a preferred form of generation. Perhaps recognizing the trend of this body of literature, Volume IA of the EIS lists both the negative and the positive impacts of the proposed dams and describes the electricity generated as "greener" than that generated by a comparable capacity coal-fired plant. While that comparison might be valid, there is a considerable literature that deals with the meaning of the term "green" when applied to hydroelectric generation.

Brown *et al*. (in press) propose a tool they call the Integrated Dam Assessment Model (IDAM). This tool uses three categories of impacts: biophysical, socioeconomic, and geopolitical. Each category is broken into nine variables, providing 27 variables in total, each with an objective and subjective measurement scale. These are linked into a visual representation that can be used to quickly judge the nature of overall impact composition. The visual tool is presented in two panels, a cost side and a benefit side. All 27 variables are represented in each side. The biophysical indicators include "water retention time," and "C02 equivalent to coal." The socioeconomic category includes "displacement," and "cultural change." The geopolitical category ranges from "downstream riparian population" to "socio-economic impacts for non-constituents (2)." These categories taken together form a multi-criteria CBA that normalizes all measurements to a single common metric: a combination of objective and subjective impacts. The authors provide two hypothetical case studies that illustrate how hydro projects with very different impacts can have remarkably different aggregate economic benefits (net present values), though the measurements are not in dollars or currency values at all.

Bratrich *et al.* (2004) propose a green hydropower certification methodology that takes several categories of criteria into account. Their management matrix has an ecological component (many of which are described in Truffer *et al*. 2003) and a management component. The ecological component includes hydrological character, connectivity, morphology, landscape, and biological communities. This is complemented by a management component which includes instream flow regimes, hydro-peaking, reservoir and bedload management, and power plant structures. Each of the ecological elements is mapped to the management elements in a five by five management matrix (p. 872) so that, for instance, the intersection of biological communities and reservoir

12 Values in the original were calculated in 2005 Euro. Conversions based on information found at http://www.xe.com/ict/ accessed April 28th, 2009.

management reads, in part, "schedules flushing outside critical seasons for the reproduction of important fish species." This set of criteria has been adopted by the Swiss Association for Environmentally Sound Electricity (VUE), "an independent organization which is supported by Swiss hydropower companies, electricity suppliers, environmental NGOs, and consumer NGOs (p. 868)." Raphals (2004) has explored the issue of green hydropower certification in the Canadian context.

There is a growing literature that specifically considers the nonmarket economic impacts of hydroelectric dam projects. Some early papers include Hanley and Nevin (1999) who investigated nonmarket costs arising from a proposed hydro scheme in the North Assynt Estate in northern Scotland. They conducted a Local Economic Impact Analysis (LEIA) and a Contingent Valuation (CV) survey. The CV survey asked respondents two questions. The first was to rank via a 5 point Likert type scale which of three types of renewable generation facility they would prefer in the area (hydro, biomass, or wind). This selection of preferred alternatives was based in part on detailed information about the environmental impacts of each mode. The second question was how much they would be willing to pay into a community fund set up to develop capital for the preferred project[13]. Out of the three modes, the windfarm was the preferred option, with hydro preferred to biomass. Of those in favor of the wind farm, WTP per year was £87. For the whole sample (including those not in favor of wind), WTP was £52.25. Among those in favor of the hydro project, yearly WTP was £77, and £54.93 for the whole sample.

Han *et al*. (2008) conducted a choice experiment to ascertain the value of natural resource damages arising from the construction of a large dam on the Tong River in Korea. They described four attributes "(1) Forest: the population of protected forests, (2) Fauna: the number of protected fauna species, (3) Flora: the number of protected flora species, and (4) Remains: protection levels of historical remains (258)." The authors used water rates as the payment vehicle for improvements in these attributes. Their survey presented three options to choose between: a status quo (predicted environmental effects with no mitigation) and two "environmental improvements." Willingness to pay for each attribute was provided by attribute. Marginal willingness to pay for the "Forest" was lowest, with per-household values ranging from 0.1129 (less than US$0.01) Korean Won per household[14]. The "Remains" attribute showed the highest mean WTP, at 254.43 (US$2.12) Korean Won per household. In an ecosystem services framework, this would suggest that the cultural services had the highest value in this project.

The authors then aggregated these per household values across the approximately seven million households in the relevant affected population. They found that total willingness-to-pay per year for the entire population of the study area was about 209.9 billion Korean Won (US $ 174.9 million). Including these aggregated values, Han *et al*. also recalculated the project's proposed benefit cost ratio. The original ratio was 1.02, but with the addition of these environmental values, the ratio was calculated at 0.85. At any point below unitary (where the benefit-cost ratio=1), a project cannot be recommended on a cost-benefit basis (Boardman *et al*. 2001).

[13] Or if they did not like either of them, how much compensation they would need to receive, via reduced electricity rates or increased jobs in the area, to mitigate their loss of environmental well-being.

[14] The authors conversions are 1US$=1199.06 Won.

Sundqvist (2003) conducted a choice experiment using non-residential (private and public enterprise) power consumers in Sweden to investigate their preferences over various green electricity options. In the wake of deregulation of Swedish electricity markets, it became important for providers to differentiate their products in order to attract consumers, and Sundqvist reports that consumers often displayed a preference for green generation. Like several authors, they pointed out that there were few standards for what constituted "green" generation, and little market research on what exactly consumers were demanding. They specifically investigated WTP for "specific environmental attributes and, thus, indirectly the mitigation measures than can be taken to limit the environmental impacts of hydroelectric production (p. 2)."

The author described three non-monetary attributes: downstream water level, erosion and vegetation, and fish. The first, water level, captures effects on downstream flora and fauna, as some minimum instream flow is required for the survival of certain species. Instream flow in the status case was a positive amount but described as possibly insufficient for the survival of all pre-dam organisms. Two higher levels of flow were also provided. Erosion and vegetation addressed reservoir level effects on beach-adjacent vegetation.

The status quo case and two less damaging release schedules were provided. Effects to fish life were captured by different operating and remediation protocols, with three levels of provision specified. The price attribute was a set of different rates per kWh. Sundqvist found that respondents were willing to incur a cost increase of 1.76 öre (around $0.15) per kWh for all fish species to be preserved or an increase of 1.41 öre per kWh for 50% reduction of erosion and beach-adjacent vegetation impacts. The authors do not extrapolate these values to a population beyond that of the sample, and it is not included in a benefit-cost framework.

Heal *et al*. (2004) suggest some guidance as to including the valuation of ecosystem services in policymaking:

- Policymakers should use economic valuation as a means of evaluating trade-offs; that is, an assessment of benefits and costs should be part of the information set available to policymakers in choosing among alternatives;
- If benefits and costs are evaluated, the benefits and costs associated with changes in ecosystem services should be included along with other impacts to ensure that ecosystem effects are adequately considered;
- Economic valuation of changes in ecosystem services should be based on the comprehensive definition embodied in the Total Economic Value (TEV) framework (Randall 1987) and both use and nonuse values should be included;
- The valuation exercise should be framed properly. In particular, it should value the *changes* in ecosystem good or services attributable to a project, program, or policy; and
- In the aggregation of benefits and/or costs over time, the consumption discount rate reflecting changes in scarcity over time should be used instead of the utility discount rate.

By using this and other available guidance, it should be relatively straightforward to determine the economic value of many missing environmental effects and incorporate them into a Project cost-benefit analysis.

Can anything be said regarding the potential magnitude of ecosystem services prior to research specific to the LCHP decision? Given the current results from economic benefit transfer meta-analyses (Brander *et al*. 2006; Brouwer *et al*. 1999; Johnston *et al*. 2005; Johnston *et al*. 2006; Liu & Stern 2008; Martin-Lopez *et al*. 2008; Navrud & Ready 2007; Woodward & Wui 2001), it seems that values for forest land might be in the range of up to \$2,000 ha^{-1} yr^{-1} (\$200,000 per km^2). But this is quite a stretch given the uncertainty over the links between dam development and ecosystem services and the multiple types of transitions (i.e., from one type of aquatic ecotype to another, from riparian ecotype to aquatic ecotype). At \$2,000 ha^{-1} yr^{-1} the loss of forest habitat, from an ecosystem services perspective, would be approximately \$3 million yr^{-1} based on inundation of 146^2 km of forest land..

Benefits transfer is complicated by the nature of ecosystem benefits: some are properly valued in area-based measurements only but others (e.g., existence values) are properly denominated in terms of \$ ha^{-1} $household^{-1}$ yr^{-1} (again highlighting the importance of getting the geographic scope of analysis right as the number of households impacted can have a huge impact on overall value).

An alternative way to ‘ballpark’ non-use values is to work from the other direction, calculating implicitly what society would need to be willing to pay to preserve ecosystem services (e.g., Rudd & O'Higgins in review). The Project is anticipated to lead to reductions of 16.9 t of carbon dioxide emissions annually (EIS Vol. 1, Part A, Sections 2.6-2.7). Assuming a value of \$15 t^{-1}, this is worth \$253.5 million. Canada has slightly over 12 million households, so the approximate value of carbon reduction would be in the \$20-25 $household^{-1}$ yr^{-1} range. This is in the same range that Rudd (2009) found for Canadian values for biological diversity; he found significant and positive household willingness to pay for investments that helped conserve high- and low-profile aquatic species at risk in Atlantic Canada. Other meta-analyses have also found values for the conservation of aquatic animals and habitats to be in this range (Johnston *et al*. 2005; Loomis *et al*. 2000; Loomis & White 1996). Still other research has found that WTP for free-running rivers (aside from values associated with recreational or agricultural benefits) to be very substantial. The aggregate value for just the restoration of the free-flowing nature of the Lower Snake River was U.S. \$420.13 million (Loomis 1999).

That is, it is quite feasible that the non-market values arising from preservation of the lower Churchill River would meet or exceed the financial value of carbon offsets from the development. The magnitude of the external costs can only be narrowed once ecotype transition matrices are calculated and economic costs (or cost distributions) are assigned to the appropriate changes in ecotype and habitat (e.g., Guo *et al*. 2000; Li *et al*. 2006; Rudd & O'Higgins in review; Wang *et al*. 2006).

2.7 Issue 7 – Treatment of Uncertainty

2.7.1 Current EIS Shortcomings

Many environmental impact assessments inadequately consider environmental, social, and economic uncertainty, both internationally (Brismar 2004) and in Canada (Berkes 1988; Bérubé 2007). Brismar, in a review of six large dam projects internationally, noted that “little effort was made to carefully explain the potential impact pathways involved; root causes were often referred to in general terms only, and potential pathways leading up to an anticipated higher order effect or following upon an expected lower order effect were often inadequately addressed or ignored" (p. 59). We believe the LCHP fits into this category as well.

The Proponent claims that their Study Teams were "able to make accurate, albeit conservative, predictions regarding the interactions of the Project with the biophysical and socio-economic environment." Given the tremendous environmental, social, and economic uncertainty in the world, and the explicit recognition of this uncertainty by the vast majority of scientists, it seems incredulous that the Proponent could claim to make accurate and conservative predictions.

There are numerous problems with such an 'equilibrium' perspective. First, it can be extremely difficult to understand the 'ecological production functions' that causally link development decisions, ecosystem service provision, and the impacts of development across scales from households to society as a whole. Coupled ecological-human systems can be complex, with subtle interactions between system components, non-linear feedbacks, and threshold effects (Carpenter *et al*. 2006a; Liu *et al*. 2007; Morgan & Henrion 1990). Second, even when the ecological production functions are relatively well-understood, people can hold fundamentally different preferences and vary in their willingness to make trade-offs between coastal protection and other worthy public investment priorities (Pindyck 2007). Third, river ecosystems can provide ecosystem services that give rise to benefits for people at variable geographic scale. Fourth, there are tremendous market uncertainties arising from, at a minimum, foreign exchange fluctuations (impacting equipment purchases and potentially sales revenue), technological advance (particularly competition from solar power, which could achieve grid parity within the next few years), oil prices, and long-run economic growth. The financial crisis of 2008/2009 has fully demonstrated how much uncertainty there is in the financial world and in international energy markets. The key message is that the Proponent cannot make "accurate, albeit conservative, predictions". We live in a world of fundamental socio-ecological uncertainty (Arrow *et al*. 1995; Carpenter *et al*. 2006b; Ostrom 1999; Walters 1997).

As a result, the EIS contains some erroneous assumptions, which are not addressed via a sensitivity analysis. Volume IA, at 2.4.1.1 (p. 2-2) states: "The increasing demand for electricity is a national and international trend that is fuelled by population growth, growth in economic activity and technological advances. The demand is predicted to continue well into the future. The National Energy Board (NEB) is forecasting growth in energy demand in Canada from 2010 to 2020 of almost 14 percent, or 82 terawatt hours (TWH) over this 10 year period (NEB 2008, Internet site). The United States Department of Energy (USDE) is forecasting that electricity consumption in that country will grow to 4,972 TWH by 2030, approximately 30 percent over 2006 levels (USDE 2008a, Internet site). This growth in demand presents an opportunity for benefits to accrue from inter-provincial and international trade of power for regions with an excess of electricity supply."

The Canadian NEB's 2009 report has not been released at the time of this writing. The US Energy Information Authority (EIA) of the Department of Energy (DOE) releases yearly reports. We examined the 2009 report projecting energy demand to 2030. This report provides a 16 percentage-point spread due to uncertainty arising from several variables. In their estimates, "in the reference case, [US] electricity demand increases by 26 percent from 2007 to 2030." In the low economic growth assumption, demand increases by 19%, and in the high case, by 35%."

However, the EIS presents a figure with no variation. The EIA report mentions that under one scenario "environmental concerns and a scarcity of new large-scale sites limit the growth of conventional hydropower, and from 2007 to 2030, its share of total generation remains between 6 percent and 7 percent." Additionally, as New England is a summer-peaking market, and currently experiencing a growth in solar and wind generation, it is important to outline the possible variations in demand due to these shifts.

There are other possible sources of risk and uncertainty. One has to do with the actual operating life of the project. The EIS (Vol. IA at 1-12) states: "the life span of hydroelectric generation sites is 50 to 100 years or more." The EIS does not take into account the potential for decommissioning the Project at some point during its life. After 100 years, what happens? Or what if, for any reason, Nalcor should decommission the Project after less than that? There would be a significant cost involved in decommissioning, which is not mentioned in the EIS. Additionally, any potential for the Project not operating to its full 100-year lifespan would result in a different revenue stream for Nalcor, and this should be accounted for in the CBA.

2.7.2 Information Needs for Informed Decision-Making

It is critical to highlight sources of potential uncertainty throughout the development and operation of the Project. We recommend that the Proponent provide clearer explanations of sources of uncertainty for every impact throughout the EIS and develop appropriate models to assess the impacts of uncertainty and risk on environmental, economic, and social impacts of the Project.

2.7.3 Recommended Analytical Approaches

We suggest that a recent approach to risk analysis under uncertainty be adopted and that landscape ecology and ecosystem service valuation modeling be combined with Robust Decision-Making (RDM) methods (Bankes 1993; Groves & Lempert 2007; Lempert & Collins 2007; Lempert *et al*. 2006). This approach can be applied to identify robust dam development strategies that ensure both environmental and economic sustainability of the Project. RDM is one of a number of ensemble modeling approaches that draws samples across a wide range of plausible computer-generated scenarios and identifies strategies that perform well across a wide range of alternative futures.

Scenario analysis is recommended for environmental impact assessment (Duinker & Greig 2007) and used widely in the risk analysis field (Morgan & Henrion 1990). Recent advances in scenario modeling that focuses on ecosystem service provision and value have arisen from the huge Millennium Ecosystem Assessment effort (Carpenter *et al*. 2006a; Carpenter *et al*. 2006b; MEA 2005) and from new developments in risk assessment (Groves & Lempert 2007).

In highly uncertain situations analysts and decision-makers can downplay uncertainty in order to make analyses more tractable and narrowly-conceived plans may prove vulnerable to surprises (Lempert *et al.* 2002). The general process of RDM modeling for ecosystem service assessment should include a four step process: (1) model future land cover change for the LCHP system (which the Proponent has already done); (2) calculate the economic costs and benefits of changes in ecosystem services at various levels of aggregation; (3) develop scenario-generating models that sample ecological and economic performance outcomes from a wide range of plausible alternative futures (which vary according to key environmental and economic uncertainties); and (4) identify robust development options based on that scenario generation and sampling process. A particular advantage of the RDM approach as it might be applied to LCHP planning is that it can incorporate both quantitative data (conditional probability distribution functions) and qualitative data (e.g., expert opinions on conditional probabilities linking primary and higher order effects, Traditional Ecological Knowledge).

2.8 Issue 8 – Economic Impact Analysis

2.8.1 Current EIS Shortcomings

The current economic impact analysis is insufficiently narrow in its scope and lacks at least two major components: a clear explication of impact assessment methodology, including all assumptions and data, and a more thorough accounting of all costs and benefits, especially with regard to distribution and non-market effects. As it stands the analysis gives what appears to be a very one-sided view of the project's contributions to the regional economy, with a few suggestions of what some of the negative outcomes might be. The analysis does a reasonable job of describing the projected positive impacts of building and operating the dams. According to the EIS, this Project will yield several economic benefits to the province:

- Increased employment and income to Labrador during the construction and operations and maintenance phases;
- Generate 34,000 person-years of direct and indirect employment over the life of the Project;
- Increase Labrador's income by $924 million during the construction phase;
- Generate an expected $770 million of income for individuals directly employed by the Project during construction; and
- Contribute an expected $70 million to the Labrador economy through purchases of goods and services from Labrador-based businesses during the construction phase.

While this may be the case, we argue that this type of analysis is simply not sufficient for a project of this magnitude, which merits a full-blown CBA. It is very important to repeat that CBA is not the same as economic impact analysis. Economic impact analyses focus on short-run changes in economic activity and jobs due to Project or sector spending. As Peter Drucker notes, "Whoever argues impact on jobs rather than impact on the consumer is not an economist but a politician" (as highlighted by the Treasury Board of Canada 1998 - see Drucker, P. 1989. *The New Realities*). It is quite possible to generate tremendous amounts of economic activity, as measured by changes in GDP, with zero economic benefit. This is the case because it is possible for a firm with $100 million in business revenue, for example, to incur $105 million in the costs to supply its goods and services.

When the non-market costs of social or environmental damage are present and factored in, the situation can become even worse: projects that generate "positive" economic impacts but that are marginally profitable can easily swing to being "unprofitable" from a societal perspective if those negative externalities of business activities are properly priced. From a societal perspective, in that case, Canada would be better off as a whole to have not undertaken the project. Functionally, the citizens of the nation are subsidizing a project that decreases overall well-being. The classic example of this is the Exxon Valdez oil spill in the U.S. The massive oil spill actually increased Alaskan GDP because of all the economic activity associated with spill clean-up. The Exxon spill led to protracted court battles and spurred the development of modern environmental valuation techniques .

The economics perspective is that analytical focus should be, first and foremost, on economic efficiency and that economic impact analyses should be used secondarily to assess distributional effects of economic impacts (Vining & Boardman 2007). The impact analysis provided by the EIS does not do that secondary job very well.

Volume III of the EIS, under section 3.2.2 "Other Construction Projects," describes the benefits generated by several other large projects in the region, such as Voisey's Bay nickel mine and the Hibernia off-shore drilling platform. This section begins by stating that "major construction projects in Newfoundland have created socio-economic benefits for area residents and businesses and for the Province as a whole." Whitelaw et al. (2002), make it clear in their work on the economics of dam decommissioning, that the presentation of benefits alone is a dubious strategy, often intentionally misleading. "The first principle—first in order and first in priority—admonishes decision-makers to consider both the benefits and the costs (p. 725)."

The EIS states that the model used was developed by Strategic Concepts Inc. specifically for use in Newfoundland and Labrador, and figure 3-1 explains the concept behind the model. While the EIS lists forward and backward linkages and presents multipliers (Volume III, p. 3-18: "the implicit Project employment multiplier is 2.5") used to calculate outcomes, it does not cite either which method is actually used or where these values are drawn from. It does not provide clear assumptions or the data involved. Based on the publicly available results from other studies conducted by the consulting company engaged for this Project's economic impact assessment, we are assuming that an economic input-output (I-O) model was used.

2.8.2 Information Needs for Informed Decision-Making

Fundamentally what is required is information on the distributional impacts on business activity and employment. Crompton (2006: 67) emphasizes that "most economic impact studies are commissioned to legitimize a political position rather than to search for economic truth. Often, this results in the use of mischievous procedures that produce large numbers that study sponsors seek to support a predetermined position." This is precisely what we contend is happening in this EIS. Gale and Gale (2006) also note biases typical in industry-based social and economic assessments. While the EIS does mention potential negative impacts that could occur, such as "the need to relocate people; disruption of traditional economic activities; and boom-bust effects associated with rapid growth and equally rapid decline (Volume III, p. 3-4)," and "the potential for increased alcohol and drug use and the implications for criminal activity, the health of the individual and the family and the loss of the traditional way of life (p. 4-1)," it does not quantify those effects in its listing of impacts.

Given the unusually complex mix of traditional and market economies in Labrador, and the potential for conflicts due to widely varying cultural perspectives, one hopes that the accounting of all project costs and benefits will incorporate these issues. Whether or not this is true of the model used is not immediately clear, but as no clear mention is made of it, it seems safe to assume that it is not.

2.8.3 Recommended Analytical Approaches

One way of dealing with these distributional issues is through a Social Accounting Matrix (SAM). A SAM is a type of Input-Output (IO) model that tracks the monetary flows between industries and institutions. In Volume III, the EIS describes the use of the Strategic Concepts, Inc. model, which is an IO model, and uses coefficients to describe and predict results in various sectors of the economy. One principal difference between a standard IO model and a SAM is that a SAM tracks these results from a social perspective, not just an industrial one.

Kriström (2006) proposes a way to include the distributional effects that result from environmental policy changes in a SAM analysis. Lenzen and Schaeffer (2004), in a paper addressing the construction of a SAM for Brazil that synthesizes social and environmental effects by sector, provide a review of SAM applications since the early-1960s. Originally developed without any significant recognition of the costs and benefits of consuming natural capital, SAM analysis is now incorporating the distributional effects of environmental policies and projects on different groups. SAM analysis could be used in for cases such as the Lower Churchill, which impact different socio-economic populations in considerably different ways.

The EIS generally adopts a fairly general attitude toward what economic effects might be. Volume III at 3.0 describes the economy as the “set of activities relating to material production, distribution and consumption of goods and services in a particular region (3-1).” It proceeds to describe the nature of economic impacts thus: “The Project will directly affect the lives of many residents of the Province through, for example, employment and income, training and skills development, and business opportunities. Indirect influences include increased revenue to government and the subsequent benefits from the spending of that revenue on public goods and services (ibid).” Again, for the purposes of an I-O model, this is sufficient, but a CBA has to take a wider perspective. We strongly urge the broadening of the defined concepts of both costs and benefits. In order for the public and any other group to be able to address the actual contribution of the LCHP in terms of economic efficiency, the current narrow definitions are insufficient.

This is a large enough Project to justify a more sophisticated approach to analyzing regional economic impacts such as a computable general equilibrium (CGE) model (Brouwer & Hofkes 2008; Brouwer *et al*. 2008). This is due in part to the fact that there will be considerable difference in impacts between Labrador, where the Project is proposed, and the island of Newfoundland, from where the Project will be operated.

3 Conclusions

This Project is fundamentally a profit-driven venture and it is imperative that economic efficiency be assessed in order to make judgments on whether the Project is justifiable. A comprehensive CBA, although not technically required under CEAA guidelines, would be the tool that would provide the type of information that is really needed for the Panel to make an informed decision about Project. Information about revenues, costs, and key market assumptions are needed to make an informed decision. As we pointed out earlier, such an assessment is not without precedent as other utilities have made this type of information public during the environmental impact assessment process (Manitoba Clean Environment Commission 2004).

The CBA should include a full accounting of key non-market benefits arising from changes in ecosystem services (i.e., 'environmental effects') due to the Project. The CEAA guidelines are clear that environmental effects should be considered wherever they occur. Given the nature of the Project and the lower Churchill River - and given the vast literature on the non-market benefits of conserving free-running rivers, biological diversity and cultural heritage - it is highly probable that the external costs of development (i.e., the benefits of conservation) are positive, significant, and geographically widespread. By applying existing best practices in environmental valuation and benefits transfer, the Proponent should be able to provide an economic analysis that more accurately portrays the net benefit of this Project to Canada as a whole.

The current economic analysis in the EIS is particularly weak and there is a pressing need for a complete revision of that section. The primary focus of a revised analysis – preferably a comprehensive CBA – should be firstly on economic efficiency and secondly on distributional effects. A simple I-O model is, in our view, inappropriate for such a large Project over such an extended time frame. We recommend that a Computable General Equilibrium (CGE) model be developed to assess distributional impacts of dam construction and operation.

Finally, the treatment of uncertainty in this EIS is completely inappropriate. The Proponent's view that complex environmental, social, and economic inter-relationships have been (and can be) accurately (and "conservatively") analyzed is at odds with current knowledge in both the natural and social sciences. Despite the Proponent's claim that their Study Team "accessed the best and most up-to-date science from around the globe", even a cursory examination of the scientific literature shows that this is a hollow claim. In order to remedy the complete lack of attention paid to the diverse array of uncertainties surrounding dam development and operation, the Proponent should develop models that incorporate uncertainty between causal linkages in the socio-ecological system. We suggest taking a Robust-Decision Making approach although more traditional approaches (Monte Carlo expected value modeling) could also be used.

Our suggestions would undoubtedly have a financial cost and take some time to complete. However, given the magnitude of the Project and the lack of key information needed to assess both environmental and economic sustainability of the Project, we believe that a thorough analysis using current best practices from the environmental economics and risk analysis fields is the only way in which transparent and credible decisions can be made regarding the LCHP. The Proponent is asking the public to invest billions of dollars in a Project that has unknown costs (especially given the transmission route is not yet finalized), that won't generate any revenue for over a decade, and that is subject to tremendous market uncertainties. This requires more than a "Trust Us" promise from the Proponent.

Approval for the Project should be contingent on a real debate of the environmental, social, and economic costs and benefits of the Project. The initial EIS has done very little to support a transparent debate and, in our opinion, the Panel should now mandate the Proponent to be more forthcoming so that an informed debate can still happen in the future.

4 About the Authors

Dr. Murray Rudd holds a Canada Research Chair in Ecological Economics and is an Assistant Professor in the Division of Social Sciences at Sir Wilfred Grenfell College, Memorial University. He has undergraduate and Master's degrees in Agricultural Economics from UBC and a Ph.D. in Environmental Sciences (Rural Policy / Economics of Consumers and Households) from Wageningen University (Netherlands). Prior to joining Memorial in 2006, Dr. Rudd was with Fisheries and Oceans Canada (DFO), where he was a senior economist with Policy Branch, Maritimes Region. His research at DFO and Memorial University has focused on the environmental valuation and policy analysis frameworks, with a special emphasis on watershed, fisheries, and biodiversity issues. The results of his research have been published in international journals such as *Coastal Management*, *Ecological Economics*, *Endangered Species Research*, *Environmental Conservation*, and *Fish and Fisherie*s. Dr. Rudd is the elected economics representative of the Society for Conservation Biology's Social Science Working Group (SSWG) and Chair of SSWG's Policy Committee. He is a member of the Editorial Board of the Society's flagship international journal *Conservation Biology* and has acted as a reviewer numerous other journals (including *Canadian Journal of Agricultural Economics*, *Ecological Economics*, *Fisheries Research*, *Society and Natural Resources*, *Tourism in Marine Environments* over the last two years), government technical reports, and research grant application. Dr. Rudd is an Adjunct Professor with the School for Resource and Environmental Studies, Dalhousie University and has acted as a senior team member on government-funded environmental valuation projects for Gardner Pinfold Consulting Economists.

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7 APPENDIX A

Draft choice experiment survey instrument for assessing willingness to pay (WTP) for a reduction in the scale of the LCHP Project or willingness to accept (WTA) compensation (reduced household taxes) for allowing the Project to proceed and induce some damage to environmental and cultural resources. Note that only one of the two sets of questions regarding payment or compensation would be shown to each respondent. These screen shots are from a draft Internet-based survey available for review at:
http://www2.swgc.mun.ca/evplsurvey/dam/dam1logn.htm

Hydroelectric Power and the Environment

Welcome to the Survey

You are invited to participate in this survey of the Canadian public regarding hydroelectric development and the environmental impacts of large dams.

The goal of this survey is to help develop understanding about how the environmental impacts of large-scale hydroelectric development might affect the well-being of Canadians across the country.

If you have any problems accessing the survey, please send an email and we will respond to your query as quickly as possible.

Next

Environmental Valuation and Policy Lab (EVPL), Sir Wilfred Grenfell College, Memorial University of Newfoundland

Hydroelectric Power and the Environment

Purpose of the Survey

Large dams are an important source of hydroelectric power in Canada. That power is used domestically within Canada and is also exported to the United States, helping to generate revenue for a variety of government agencies and supporting important public services for Canadians.

Hydroelectric power from large dams is 'environmentally friendly' from one perspective but 'environmentally harmful' from another perspective.

> First, hydroelectric power from large dams has the potential to help reduce greenhouse gas emissions, combat global climate change, and assist the Government of Canada in meeting its international obligations *if* it displaces electricity generated by 'dirty' coal- or oil-fired power generating plants.
>
> Second, large dams flood river valleys, inundating productive riparian (river-side) forest lands, submerging historical and archaelogical sites, and changing river flow regimes that, in turn, cause changes in fish abundance and distribution.

This survey explores Canadians' opinions about hydroelectric development and its local environmental impacts. We focus on the Lower Churchill Hydroelectric Development Project, a large project in Labrador that is currently undergoing environmental assessment reviews.

The results from this survey might be used by government agencies to better align strategic investments in electricity generation facilities with the values and priorities of Canadians.

Next

Hydroelectric Power and the Environment

About the Survey

Your participation in this survey is voluntary and you may decide to stop participating in the survey at any time.

All information collected in this survey will be aggregated for analysis. As a result, it will be impossible to identify any individual. Once all survey information is collected and the survey is closed, all access codes will be deleted from the database, making it impossible for anyone to link you and your responses. No personal information gathered in this survey will be shared with any other organization or government agency.

We do not collect information about your IP address or any other information from your computer. We are not using cookies with this survey.

If you have further concerns about data collection or confidentiality, please feel free to contact us by email prior to proceeding with the survey. In completing and submitting the survey, you agree that you understand that you have been asked to participate in a research study and agree to the use of your responses as outlined above.

The information that you provide is important! We truly appreciate the time and effort you take to complete this survey.

Next

Hydroelectric Power and the Environment

Survey Layout

There are four parts to the survey and in total it should take *about 20 minutes* to complete.

Part 1 consists of a series of 15 comparisons that ask your opinion about how various "big picture" factors impact the quality of life of Canadians. It should take less than 5 minutes to complete the comparisons.

Part 2 asks your opinions on the desirability of different methods for generating electricity. It consists of a series of 10 comparisons and should take less than 5 minutes.

In Part 3, we ask you to compare and choose your preferred option for hydroelectric development for the Lower Churchill River from options that vary in their environmental impacts and their ultimate financial impact on your household. It should take about 10-15 minutes.

Part 4 asks some questions about your general opinions and personal background. It should take less than 5 minutes.

This survey uses three types of questions:
- check marks (click on the box or button to choose that option)
- drop-down menus (click on the 'click here' box to show all your response options)
- response boxes (type in personal responses to further explain your views)

To navigate:
- click the 'Next' button to proceed.
- click on your browser's 'Back' button to return to the previous question.
- click the 'Submit' button on the last page to complete the survey.

Next

Environmental Valuation and Policy Lab (EVPL), Sir Wilfred Grenfell College, Memorial University of Newfoundland

Hydroelectric Power and the Environment

Part 1. Well-Being and Quality of Life - The "Big Picture"

In the following 15 questions, we ask you to consider four factors at a time that might impact the overall well-being and quality of life of Canadians. Please indicate which factor you would consider to be of greater importance and which you would consider of lesser importance for Canada to focus its attention and resources on.

Next

Hydroelectric Power and the Environment

Part 1. Well-Being and Quality of Life - The "Big Picture"

Many factors influence Canadians' well-being and quality of life. Governments can invest public resources in very different types of initiatives to enhance quality of life for Canadians now and in the future.

Considering only the four broad goals listed below at one time, which of the four do you consider the higher investment priority and which do you consider the lesser investment priority of the four?

Higher Priority	Goal for Canadian Society	Lesser Priority
	Advance Canadian technologies and improve international business competitiveness	
	Maintain and build public infrastructure in Canada	
	Build social cohesion and trust in Canadian society	
	Increase Canadian technical and financial support for international aid and development initiatives	

Next

Hydroelectric Power and the Environment

Part 1. Well-Being and Quality of Life - The "Big Picture"

Many factors influence Canadians' well-being and quality of life. Governments can invest public resources in very different types of initiatives to enhance quality of life for Canadians now and in the future.

Considering only the four broad goals listed below at one time, which of the four do you consider the higher investment priority and which do you consider the lesser investment priority of the four?

Higher Priority	Goal for Canadian Society	Lesser Priority
	Build social cohesion and trust in Canadian society	
	Improve our understanding of Canada's place in the world	
	Build networks for generating information and mobilizing knowledge, enhancing our capacity to cope with change	
	Increase protection for the rights of minorities in Canada	

Next

Hydroelectric Power and the Environment

Part 1. Well-Being and Quality of Life - The "Big Picture"

In the previous questions, you saw a total of 20 different factors that might be important to Canadian's quality of life and well-being.

Are there other important factors that you think Canadians should consider and goals we should strive to achieve? If you have comments, please use the space below to let us know your views.

Next

Hydroelectric Power and the Environment

Part 2. Electricity Production Options

In the following 10 questions, we ask you to again consider four factors at a time.

This time we ask your opinions regarding which which types of electricity generation methods are most and least preferred.

Next

Hydroelectric Power and the Environment

Part 2. Household Electricity Options

Electricity for household use can be produced using a variety of different technologies.

Considering only the four methods of generating electricity listed below at one time, which do you consider the most desirable generation option and which do you consider the least desirable of the four?

Most Desirable	Technology used to generate electricity	Least Desirable
	Oil-fired power plants	
	Small-scale hydroelectric developments (smaller, regional dams)	
	Solar power	
	Co-generation - electricity produced from waste heat of local or regional industies	

Next

Hydroelectric Power and the Environment

Part 2. Household Electricity Options

Electricity for household use can be produced using a variety of different technologies.

Considering only the four methods of generating electricity listed below at one time, which do you consider the most desirable generation option and which do you consider the least desirable of the four?

Most Desirable	Technology used to generate electricity	Least Desirable
	Co-generation - electricity produced from waste heat of local or regional industies	
	Windmills	
	Natural gas-fired power plants	
	Coal-fired power plants	

Next

Hydroelectric Power and the Environment

Part 2. Household Electricity Options

In the previous questions, you saw a total of 10 different technologies that could be used to generate electricity in Canada.

Are there ways of generating energy that you think Canadians should consider as part of our overall energy portfolio? Does it really matter at all to you where your household electricity comes from? If you have comments on these or other things related to electricity generation or supply, please use the space below to let us know your views.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

In Part 3 of this survey, we are going to show you a series of 14 questions in which you choose your preferred dam development option from amongst three alternatives.

The development options may vary in their local environmental impacts, their impacts on historical sites on the Lower Churchill, and on the ultimate cost to your household.

The options will be described using the following characteristics:

- The impact of the dam development on the length of free-running river.
- The impact of the dam development on the number of heritage sites in the valley.
- The way in which flooded historical sites are excavated and recorded prior to flooding.
- The impact of the dam development on the amount of forest habitat important for wildlife.
- The impact of the dam development on the number of ashkui sites left in the valley.
- The change in cost to your household resulting from various dam development options.

The following pages will present more information about how the dam development options vary.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

Lower Churchill River Hydroelectric Project

NALCOR Energy is a crown corporation created by the provincial government of Newfoundland and Labrador and is responsible for all hydroelectric power development in the province. For more information on NALCOR, click here.

NALCOR has proposed the construction of two hydroelectric generating facilities on the lower Churchill River in central Labrador (click here for map). One dam will be constructed at Muskrat Falls and another at Gull Island.

The 32 meter high dam at Muskrat Falls will have a capacity of 824 MW. It will require a reservoir with an area of 101 square kilometers, inundating 41 square km of land. The larger Gull Island facility will include a 99 meter high dam with a 213 square km reservoir, inundating 85 square km.

At a projected capital cost of CA$6.5 billion (2008$) over ten years, the two dams are expected to generate 16.7 TwH of electricity every year. That is equivalent to 2.8% of current annual electricity consumption in Canada.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

Free-Running River

A free-running river is one that is not blocked by dams or barrages or similar structures. Currently the Churchill River below the existing Churchill Falls dam is free-running all the way to Goose Bay (click here for map and click here for a video clip of part of the free-running river between Gull Island and Muskrat falls).

Dams would alter the nature and flow of the Lower Churchill by changing a portion of free-running river into reservoirs. Changes in river flow can cause a variety of other changes, including:

- ice formation (freeze-up and breakup times)
- nutrient and sediment flow
- habitat suitability for different kinds of fish
- navigability
- recreational opportunities (fishing may increase while whitewater canoeing declines)

In the questions that follow, assume that there are various alternative dam configurations that would vary in their impact on the length of free-running river left after development. Assume that all of the following options are possible:

- 0 km free-running river left (full development of Gull Island and Muskrat Falls dams
- 73 km (25%) of free-running river left
- 145 km (50%) of free-running river left
- 218 km (75%) of free-running river left
- 290 km (100%) of free-running river left (no development of any further dams)

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

Heritage Sites

Historic and archaeological resources include objects and structural remains from before 1960 that show evidence of manufacture, alteration, or use by humans, as well as burial, cultural, spiritual and other heritage sites and materials dating to the Pre-contact and Historic Periods.

To date, 46 archaeological sites have been identified in the Lower Churchill flood zone, including 26 sites with pre-contact components, six historic tilts (makeshift trapper's cabins), 14 historic campsites and other historic occupations, and two nineteenth century Hudson's Bay Company trading posts.

There are also two known sites of cultural and spiritual importance to the Innu people within the lower Churchill River valley. A rock knoll on the north side of Muskrat Falls (Manitu-utshu) is believed to be the dwelling place of the giant otter or seal-like being known as Uenitshikumishiteu in Innu mythology. The second site (Ushkanshipiss), on the south side of the Churchill River near Upper Brook, is where the last shaking tent ceremony (click here for more information on the shaking tent ceremony) took place in the fall of 1969.

The Lower Churchill dams could flood up to 42 of these sites. In the questions that follow, assume that there are various alternative dam configurations that would vary in their impact on the number of heritage sites left after development. Assume that all of the following options are possible:

- 0 heritage sites left (full development of Gull Island and Muskrat Falls dams
- 14 (33%) heritage sites left
- 26 (67%) heritage sites left
- 42 (100%) heritage sites left (no development of any further dams)

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

Excavation and Information Recovery from Flooded Heritage Sites

There are several ways to recover material culture and information from historical sites. The most thorough, according to the Labrador Historic Resources Act , is systematic data recovery (SDR). This is basically full excavation of the site.

Full excavation (SDR) has typically been considered the only solution to recovering information about historic and archaeological resources where flooding is unavoidable.

In the questions that follow, assume that those heritage sites that are flooded by dam development are either:

- fully excavated and documented
- not excavated and documented at all

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

Forest Habitat

The proposed dams could flood 146 square km (360,774 acres) of land, most of which is currently forested. Forest land contains many different types of animal habitat along the Churchill River.

Forest meadows and riparian (riverside) thickets provide habitat for muskrat, beaver, and birds such as the alder flycatcher. Spruce, mixed conifer, and hardwood forests all are used as nesting and breeding habitat by various bird species and feeding habitat for a variety of birds and mammals. Black spruce/moss forests often have edible plants such as Labrador tea and bakeapple and are used by songbirds such as Dark-eyed Junco and Ruby-crowned Kinglet for nesting and breeding. Moose, caribou, bears, and other mammals use all forest types for feeding and shelter to varying extents.

In the questions that follow, assume that there are various alternative dam configurations that would vary in their impact on the area of forested land left after development. Assume that all of the following options are possible:

- 0 square km of flood zone forest land left (full development of both dams
- 36.5 square km (25%) of forest land left
- 73.0 square km (50%) of forest land left
- 109.5 square km (75%) of forest land left
- 146.0 square km (100%) of forest land left (no development of any further dams)

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

Ashkui Sites

Ashkui refers to an area of open water surrounded by ice in the spring or fall (please click here for more information on ashkui).

Some ashkui may be open all year round due to the strong current there, while others only form at river junctions, lake outlets, or river and brook estuaries during fall freeze-up and spring break-up. The Innu people associate ashkui with migratory waterfowl, and as a result they established their spring camps near ashkui in order to take advantage of the species abundance there.

Ashkui have been referred to by Innu as nature's grocery store because they can be used for hunting, fishing and trapping in the late winter and early spring.

In the questions that follow, assume that there are various alternative dam configurations that would vary in their impact on the number of ashkui sites left on the Lower Churchill River after development. Assume that all of the following options are possible:

- 0 ashkui sites left (full development of both dams
- 2(33%) ashkui sites left
- 4(67%) ashkui sites left
- 6(100%) ashkui sites left (no development of any further dams)

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

Change in Your Household Income Tax

So far, we have described the potential environmental impacts of the Lower Churchill Hydroelectric Development Project. The Project has potential economic impacts as well.

In Canada, the Provinces and Territories have the authority to build dams for hydroelectric generation. Electricity from large dams can be used to supply needs within the region and to generate revenue for provincial governments when surplus electricity is exported to other parts of Canada or the United States.

In the case of Newfoundland and Labrador, revenues generated by the Lower Churchill dams would also be shared with the Innu people of Labrador (through the New Dawn Agreement, should it be approved by the Innu people).

If the Government of Canada were to judge that the local costs of dam development were too high, it might require the Project to be scaled back. As a result, there could be an obligation to compensate the Provincial government and/or the Innu people for lost profits.

The amount of the payment would depend on how much the Project was scaled back and would be open to negotiation but it would ultimately need to be funded by the citizens of Canada as a whole.

In the questions that follow, we assume that there are six possible levels of cost that your household could incur:

- $1.00 per year
- $2.50 per year
- $5.00 per year
- $10.00 per year
- $20.00 per year
- $40.00 per year

For the purposes of this survey, assume that the annual cost to your household would be collected by an increase in your household federal income tax.

Next

Hydroelectric Power and the Environment

Practice Question

The next page has a practice comparison so that you will be familiar with the format of questions to follow.

Each of the two scaled-back dam options vary according to the characteristics that were just outlined. These environmental targets might be achieved by building only one dam and/or changing the height or configuration of both the dams.

A majority of Canadians would need to be willing to help pay compensation should the full-scale development not go ahead. If there were a referendum on the issue, we would like to know how you would vote.

If you would not support either of the options to reduce local environmental impacts of the dams, you can check Option C, the option where the full dam development proceeds.

Please make your choice as if this were actually the choice you faced today. Remember that any increases in your household income tax mean that you would have less income available for other purchases.

You can click on all the underlined links to bring up definitions and background information as you need it.

Click the button below your preferred choice.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

If these were the impacts of the dam development options being considered and their associated financial impact on your household, which would you support?

	Option A (partial operation)	Option B (partial operation)	Option C (full operation)
Free-Running River Remaining	73 km (25%) left	218 km (75%) left	0 km left
Heritage Sites Remaining	14 sites remain (28 sites flooded)	28 sites remain (14 sites flooded)	No sites remain (42 sites flooded)
Excavation of Heritage Sites	No excavation of 28 flooded sites	Full excavation of 14 flooded sites	No excavation of 42 flooded sites
Forested Wildlife Habitat Remaining	36.5 sq km (25%) left	109.5 sq km (75%) left	0 sq km left
Ashkui Sites Remaining	2 sites (33%) left	4 sites (67%) left	0 sites left
Change in Household Income Tax	Your taxes rise by $40.00 per year	Your taxes rise by $2.50 per year	Your taxes remain unchanged

Click on one button to indicate which option you would support.

Next

Hydroelectric Power and the Environment

Part 3. Quality of Life Indicators and Investment Preferences

You may have found the example easy. If you support the idea of developing the Lower Churchill Hydroelectric Project, you likely chose Option C because you do not want to see the dams scaled back at all, especially if it costs your household extra money.

If you would be willing to support a scaling back of the dams in Labrador, Option B dominated Option A: the impacts for Option B were always smaller than the impacts of Option A and Option B came at a lower cost to your household.

You may find most of the comparisons that follow to be more challenging.

Remember, these comparisons are hypothetical and are generated by computer. Assume that all hypothetical combinations are possible and make your choices accordingly.

Please make your choices as if you really had to vote in a referendum on these choices today.

Next

Hydroelectric Power and the Environment

Part 3. Quality of Life Indicators and Investment Preferences

We now have 14 comparisons for you. Please take your time and consider all the options carefully.

Assume that the two scaled-back development options presented are the only ones available to you. Choose the best option from between these two and Option C, where the full development proceeds and there is no cost to your household.

Assume that there are no impacts on greenhouse gas emissions for any of the options. That is, any electricity generated by the project would simply provide new electricity to the market - it would not displace any existing electricity generated by coal-fired plants.

Treat each new comparison as being unrelated to all previous comparisons you have already seen.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

If these were the impacts of the dam development options being considered and their associated financial impact on your household, which would you support?

	Option A (partial operation)	Option B (partial operation)	Option C (full operation)
Free-Running River Remaining	145 km (50%) left	73 km (25%) left	0 km left
Heritage Sites Remaining	14 sites remain (28 sites flooded)	28 sites remain (14 sites flooded)	No sites remain (42 sites flooded)
Excavation of Heritage Sites	No excavation of 14 flooded sites	Full excavation of 14 flooded sites	No excavation of 42 flooded sites
Forested Wildlife Habitat Remaining	73.0 sq km (50%) left	109.5 sq km (75%) left	0 sq km left
Ashkui Sites Remaining	2 sites (33%) left	4 sites (67%) left	0 sites left
Change in Household Income Tax	Your taxes rise by $20.00 per year	Your taxes rise by $15.00 per year	Your taxes remain unchanged

Click on one button to indicate which option you would support.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

If these were the impacts of the dam development options being considered and their associated financial impact on your household, which would you support?

	Option A (partial operation)	Option B (partial operation)	Option C (full operation)
Free-Running River Remaining	145 km (50%) left	218 km (75%) left	0 km left
Heritage Sites Remaining	14 sites remain (28 sites flooded)	28 sites remain (14 sites flooded)	No sites remain (42 sites flooded)
Excavation of Heritage Sites	Full excavation of 28 flooded sites	No excavation of 14 flooded sites	No excavation of 42 flooded sites
Forested Wildlife Habitat Remaining	73.0 sq km (50%) left	36.5 sq km (25%) left	0 sq km left
Ashkui Sites Remaining	4 sites (67%) left	2 sites (33%) left	0 sites left
Change in Household Income Tax	Your taxes rise by $10.00 per year	Your taxes rise by $2.50 per year	Your taxes remain unchanged

Click on one button to indicate which option you would support.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

If these were the impacts of the dam development options being considered and their associated financial impact on your household, which would you support?

	Option A (partial operation)	Option B (partial operation)	Option C (full operation)
Free-Running River Remaining	145 km (50%) left	218 km (75%) left	0 km left
Heritage Sites Remaining	28 sites remain (14 sites flooded)	14 sites remain (28 sites flooded)	No sites remain (42 sites flooded)
Excavation of Heritage Sites	No excavation of 14 flooded sites	Full excavation of 28 flooded sites	No excavation of 42 flooded sites
Forested Wildlife Habitat Remaining	109.5 sq km (75%) left	36.5 sq km (25%) left	0 sq km left
Ashkui Sites Remaining	2 sites (33%) left	4 sites (67%) left	0 sites left
Change in Household Income Tax	Your taxes rise by $5.00 per year	Your taxes rise by $10.00 per year	Your taxes remain unchanged

Click on one button to indicate which option you would support.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

If these were the impacts of the dam development options being considered and their associated financial impact on your household, which would you support?

	Option A (partial operation)	Option B (partial operation)	Option C (full operation)
Free-Running River Remaining	218 km (75%) left	73 km (25%) left	0 km left
Heritage Sites Remaining	28 sites remain (14 sites flooded)	14 sites remain (28 sites flooded)	No sites remain (42 sites flooded)
Excavation of Heritage Sites	Full excavation of 14 flooded sites	No excavation of 28 flooded sites	No excavation of 42 flooded sites
Forested Wildlife Habitat Remaining	109.5 sq km (75%) left	36.5 sq km (25%) left	0 sq km left
Ashkui Sites Remaining	4 sites (67%) left	2 sites (33%) left	0 sites left
Change in Household Income Tax	Your taxes rise by $2.50 per year	Your taxes rise by $15.00 per year	Your taxes remain unchanged

Click on one button to indicate which option you would support.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

If these were the impacts of the dam development options being considered and their associated financial impact on your household, which would you support?

	Option A (partial operation)	Option B (partial operation)	Option C (full operation)
Free-Running River Remaining	145 km (50%) left	218 km (75%) left	0 km left
Heritage Sites Remaining	14 sites remain (28 sites flooded)	28 sites remain (14 sites flooded)	No sites remain (42 sites flooded)
Excavation of Heritage Sites	No excavation of 28 flooded sites	Full excavation of 14 flooded sites	No excavation of 42 flooded sites
Forested Wildlife Habitat Remaining	36.5 sq km (25%) left	109.5 sq km (75%) left	0 sq km left
Ashkui Sites Remaining	4 sites (67%) left	2 sites (33%) left	0 sites left
Change in Household Income Tax	Your taxes rise by $5.00 per year	Your taxes rise by $20.00 per year	Your taxes remain unchanged

Click on one button to indicate which option you would support.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

If these were the impacts of the dam development options being considered and their associated financial impact on your household, which would you support?

	Option A (partial operation)	Option B (partial operation)	Option C (full operation)
Free-Running River Remaining	73 km (25%) left	218 km (75%) left	0 km left
Heritage Sites Remaining	14 sites remain (28 sites flooded)	28 sites remain (14 sites flooded)	No sites remain (42 sites flooded)
Excavation of Heritage Sites	Full excavation of 28 flooded sites	No excavation of 14 flooded sites	No excavation of 42 flooded sites
Forested Wildlife Habitat Remaining	109.5 sq km (75%) left	73.0 sq km (50%) left	0 sq km left
Ashkui Sites Remaining	2 sites (33%) left	4 sites (67%) left	0 sites left
Change in Household Income Tax	Your taxes rise by $2.50 per year	Your taxes rise by $5.00 per year	Your taxes remain unchanged

Click on one button to indicate which option you would support.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

If these were the impacts of the dam development options being considered and their associated financial impact on your household, which would you support?

	Option A (partial operation)	Option B (partial operation)	Option C (full operation)
Free-Running River Remaining	218 km (75%) left	145 km (50%) left	0 km left
Heritage Sites Remaining	14 sites remain (28 sites flooded)	28 sites remain (14 sites flooded)	No sites remain (42 sites flooded)
Excavation of Heritage Sites	Full excavation of 28 flooded sites	No excavation of 14 flooded sites	No excavation of 42 flooded sites
Forested Wildlife Habitat Remaining	73.0 sq km (50%) left	109.5 sq km (75%) left	0 sq km left
Ashkui Sites Remaining	4 sites (67%) left	2 sites (33%) left	0 sites left
Change in Household Income Tax	Your taxes rise by $15.00 per year	Your taxes rise by $10.00 per year	Your taxes remain unchanged

Click on one button to indicate which option you would support.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

If these were the impacts of the dam development options being considered and their associated financial impact on your household, which would you support?

	Option A (partial operation)	Option B (partial operation)	Option C (full operation)
Free-Running River Remaining	218 km (75%) left	73 km (25%) left	0 km left
Heritage Sites Remaining	28 sites remain (14 sites flooded)	14 sites remain (28 sites flooded)	No sites remain (42 sites flooded)
Excavation of Heritage Sites	Full excavation of 14 flooded sites	No excavation of 28 flooded sites	No excavation of 42 flooded sites
Forested Wildlife Habitat Remaining	73.0 sq km (50%) left	109.5 sq km (75%) left	0 sq km left
Ashkui Sites Remaining	2 sites (33%) left	4 sites (67%) left	0 sites left
Change in Household Income Tax	Your taxes rise by $40.00 per year	Your taxes rise by $20.00 per year	Your taxes remain unchanged

Click on one button to indicate which option you would support.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

If these were the impacts of the dam development options being considered and their associated financial impact on your household, which would you support?

	Option A (partial operation)	Option B (partial operation)	Option C (full operation)
Free-Running River Remaining	218 km (75%) left	145 km (50%) left	0 km left
Heritage Sites Remaining	14 sites remain (28 sites flooded)	28 sites remain (14 sites flooded)	No sites remain (42 sites flooded)
Excavation of Heritage Sites	No excavation of 28 flooded sites	Full excavation of 14 flooded sites	No excavation of 42 flooded sites
Forested Wildlife Habitat Remaining	109.5 sq km (75%) left	73.0 sq km (50%) left	0 sq km left
Ashkui Sites Remaining	4 sites (67%) left	2 sites (33%) left	0 sites left
Change in Household Income Tax	Your taxes rise by $40.00 per year	Your taxes rise by $2.50 per year	Your taxes remain unchanged

Click on one button to indicate which option you would support.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

If these were the impacts of the dam development options being considered and their associated financial impact on your household, which would you support?

	Option A (partial operation)	Option B (partial operation)	Option C (full operation)
Free-Running River Remaining	73 km (25%) left	218 km (75%) left	0 km left
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Click on one button to indicate which option you would support.

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Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

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Change in Household Income Tax	Your taxes rise by $5.00 per year	Your taxes rise by $40.00 per year	Your taxes remain unchanged

Click on one button to indicate which option you would support.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

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	Option A (partial operation)	Option B (partial operation)	Option C (full operation)
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Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

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Change in Household Income Tax	Your taxes rise by $15.00 per year	Your taxes rise by $5.00 per year	Your taxes remain unchanged

Click on one button to indicate which option you would support.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

You have now finished the comparisons. Thanks very much for your careful consideration.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

Change in Your Household Income Tax

So far, we have described the potential environmental impacts of the Lower Churchill Hydroelectric Development Project. The Project has potential economic impacts as well.

In Canada, the Provinces and Territories have the authority to build dams for hydroelectric generation. Electricity from large dams can be used to supply needs within the region and to generate revenue for provincial governments when surplus electricity is exported to other parts of Canada or the United States.

In the case of Newfoundland and Labrador, revenues generated by the Lower Churchill dams would also be shared with the Innu people of Labrador (through the New Dawn Agreement, should it be approved by the Innu people).

If the Government of Canada were to support the project, it could mean that there would be fewer transfer payments to Newfoundland and Labrador and lower financial obligations to the Innu people. As a result, proceeding with some level of development could save the federal government money and reduce income taxes for Canadians across the country.

The amount of tax savings would depend on how whether one or two dams were build, the configuration (height) of the dams, and negotiations between governments over splitting economic benefits from the project.

In the questions that follow, we assume that there are six possible levels of tax savings for your household:

- $1.00 per year
- $2.50 per year
- $5.00 per year
- $10.00 per year
- $20.00 per year
- $40.00 per year

For the purposes of this survey, assume that the annual savings for your household would be paid to you by a decrease in your household federal income tax.

Next

Hydroelectric Power and the Environment

Practice Question

The next page has a practice comparison so that you will be familiar with the format of questions to follow.

Each of the two dam options vary according to the characteristics that were just outlined. These local impacts of the project on the local environment and heritage sites might vary depending on the height or configuration of the dam(s).

A majority of Canadians would need to be willing to accept these local impacts should the Project go ahead. If there were a referendum on the issue, we would like to know how you would vote.

If you would not support either of the options to proceed with the project, you can check Option C, the option where no development proceeds.

Please make your choice as if this were actually the choice you faced today. Remember that any decreases in your household income tax mean that you would have more income available for other purchases.

You can click on all the underlined links to bring up definitions and background information as you need it.

Click the button below your preferred choice.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

If these were the impacts of the dam development options being considered and their associated financial impact on your household, which would you support?

	Option A (partial operation)	Option B (partial operation)	Option C (no dams)
Free-Running River Remaining	218 km (75%) left	73 km (25%) left	290 km (100%) left
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Change in Household Income Tax	Your taxes fall by $40.00 per year	Your taxes fall by $2.50 per year	Your taxes remain unchanged

Click on one button to indicate which option you would support.

Next

Hydroelectric Power and the Environment

Part 3. Quality of Life Indicators and Investment Preferences

You may have found the example easy. If you opposed the idea of developing the Lower Churchill Hydroelectric Project, you likely chose Option C because you do not want to see the dams developed at all, even if it saves your household money.

If you would be willing to support some level of dam development in Labrador, Option A dominated Option B: the local impacts for Option A were always lower than the impacts of Option B yet Option A provided a larger tax cut to your household.

You may find most of the comparisons that follow to be more challenging.

Remember, these comparisons are hypothetical and are generated by computer. Assume that all hypothetical combinations are possible and make your choices accordingly.

Please make your choices as if you really had to vote in a referendum on these choices today.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

We now have 14 comparisons for you. Please take your time and consider all the options carefully.

Assume that the two development options presented are the only ones available to you. Choose the best option from between these two and Option C, where there is no development of the Lower Churchill River and there is no tax saving for your household.

Assume that there are no impacts on greenhouse gas emissions for any of the options. That is, any electricity generated by the project would simply provide new electricity to the market - it would not displace any existing electricity generated by coal-fired plants.

Treat each new comparison as being unrelated to all previous comparisons you have already seen.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

If these were the impacts of the dam development options being considered and their associated financial impact on your household, which would you support?

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Click on one button to indicate which option you would support.

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Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

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Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

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Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

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Hydroelectric Power and the Environment

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Hydroelectric Power and the Environment

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Hydroelectric Power and the Environment

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Change in Household Income Tax	Your taxes fall by $2.50 per year	Your taxes fall by $5.00 per year	Your taxes remain unchanged

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Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

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Click on one button to indicate which option you would support.

Next

Hydroelectric Power and the Environment

Part 3. Hydroelectric Generation Options for the Lower Churchill River

You have now finished the comparisons. Thanks very much for your careful consideration.

Next

Hydroelectric Power and the Environment

Part 3. Followup Questions

To complete Part 3, we now have a few short followup questions for you.

Next

Hydroelectric Power and the Environment

Part 3. Followup Questions

What was the single most important factor to you when you made choices about the Lower Churchill River dam options you were shown?

- Length of free-running river remaining
- Number of heritage sites remaining
- The degree of excavation and recording of flooded heritage sites
- The amount of forest habitat remaining
- The number of Ashkui sites preserved
- The change in my household taxes

Are there other factors that were not included in the survey but that would be important to you when you make choices about which dam development option you would vote for? If so, or you have other comments, please use the space below.

Next

Hydroelectric Power and the Environment

Part 3. Followup Questions

What was the single least important factor to you when you made choices about the dam development options you were shown?

- Length of free-running river remaining
- Number of heritage sites remaining
- The degree of excavation and recording of flooded heritage sites
- The amount of forest habitat remaining
- The number of Ashkui sites preserved
- The change in my household taxes

Next

Hydroelectric Power and the Environment

Part 4. Background about You

In this final section of the survey, we ask about your personal background and some general opinions.

Next

Hydroelectric Power and the Environment

Part 3. Background about You

Please tell us how important each of these is as a guiding principle in YOUR life.

	Importance as a Guiding Principle (1 = not at all; 7 = extreme)						
	1	2	3	4	5	6	7
Respecting the earth, harmony with other species							
Wealth, material possessions, money							
Equality, equal opportunity for all							
A varied life, filled with challenge, novelty and change							
Protecting the environment, preserving nature							
Social justice, correcting injustice, care for the weak							
Unity with nature, fitting into nature							
Honoring parents and elders, showing respect							
A world at peace, free of war and conflict							
Curious, interested in everything, exploring							
Influence, having an impact on people and events							
Family security, safety for loved ones							
Self-discipline, self-restraint, resistance to temptation							
An exciting life, stimulating experiences							
Authority, the right to lead or command							

We use a 7-point scale, where 7 means that the statement is extremely important as a guiding principle to you and 1 means that the statement is not at all guiding principle to you.

Next

Hydroelectric Power and the Environment

Part 3. Background about You

What is your age category?

--- click here ---

What is your gender?

--- click here ---

What is your marital status?

--- click here ---

What language do you speak most often at home?

--- click here ---

What is the highest level of education that you have obtained?

--- click here ---

Next

Hydroelectric Power and the Environment

Part 3. Background about You

What was your total household annual income (in Canadian dollars) for 2007?

--- click here ---

In which province do you live?

--- click here ---

What is the postal code of your residential address? (enter 6-digit postal code)

Next

Hydroelectric Power and the Environment

Comments About the Survey

Do you have any other comments about this survey or about hydroelectric development in Canada? If so, please use the space below.

Next

Hydroelectric Power and the Environment

You've now finished the survey - thanks very much for your help!

If you are interested in following the results from this survey, please bookmark the site (EVPL) and check back occasionally - we will be posting summary results and reports for this research project as they become available.

Submit