Clean Energy | Association Of British Columbia

March 2nd 2012

DOCKET
11-RPS-01
DATE MAR 02 2012
RECD. MAR 06 2012

California Energy Commission
1516 Ninth Street
Sacramento, California
95814

Dear Sir/Madam:

Re: 11-RPS-01, Renewables Portfolio Standards:
A Response to Staff Workshop on BC Run-of-River Hydroelectric Projects Study

We thank you very much for the opportunity to attend the Webcast of the above-noted presentation on February 24, 2012 and the ensuing discussion regarding environmental aspects of run-of-river hydro projects in BC.

We are the Association that represents developers and technical and commercial supply chains for the renewable energy industry in British Columbia. As such, we offer CEC a first-hand perspective on the Areas of Consideration as identified by CEC staff in the February 24th Webcast briefing note. Our commentary below presents important considerations relating to each of the 21 Areas of Consideration during the development, construction, and operations of projects in BC.

We support environmental assessment, a process in BC that takes at least two years, and involves large teams of multi-disciplinary professionals and specialists to analyze potential impacts (including cumulative impacts) and recommend mitigation on a project-specific basis. After government review, the final mitigation measures become legal commitments to be carried out during the design, construction, and operation of the Project.

We welcome you to contact us should you require any additional information or clarifications. Please find attached our January 7th 2010 letter to CARB as an additional reference document. (NB: In July 2010 IPPBC changed its name to Clean Energy Association of British Columbia)

Sincerely,

Paul Kariya
Executive Director

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11-RPS-01, Renewable Portfolio Standards:
Responses by Clean Energy Association of BC
To CEC *Areas of Consideration*
Reference: Webcast February 24, 2012

1. Projects may impact fish, fish habitat, migration, and aquatic organisms

A fundamental premise that must be respected by all run-of-river proponents is that small hydro projects can neither be designed nor operated in a manner that will violate the federal *Fisheries Act*, which protects fish and fish habitat from "harmful alteration, disruption or destruction". Where fish *are* present, mitigation of specific impacts to fish is mandatory (ex. Screened intakes, development and implementation of species- and seasonally-dependent flow diversion and flow ramping criteria) and are imposed as required to ensure ecosystem health. Most small hydro facilities accommodate downstream passage of fish, and where appropriate, allow fish to migrate upstream past diversion weirs through installation of fish ladders

As "aquatic organisms" are vital to downstream fish, their habitat is important in the over-all assessment of "fish habitat" in a watershed (ex. while fishless, most streams present invertebrate habitat which ultimately provides food for downstream fish), and benthic ecosystem health is an important consideration in the establishment of Environmental Flow thresholds.

2. Projects may affect streamside (riparian) vegetation and surrounding habitat

BC Provincial and, where applicable, Canadian Federal legislation require the siting of projects in a manner that limits the disturbance or removal of riparian vegetation. In many cases some impacts are unavoidable (for example, for the intake area and the short section of penstock downstream of the intake, some road crossings, the powerhouse and tailrace area. The removal of riparian vegetation are mitigated through the use of detailed design and best management practices that limit, to the extent possible, the amount of riparian clearing for the project. These include the consideration of standard setbacks from streams as used by other industries where possible, Best Management Practices to limit both temporary and permanent impacts, and retaining understory vegetation at transmission line crossings. Note that small hydro projects can incorporate measures and mitigate past impacts to accelerate recovery from existing watershed impacts, such as unstable/eroding roads and historic logging practices.

3. Projects may affect streamside (riparian) vegetation and surrounding habitat

For all developments, a thorough environmental investigation following prescribed methodology (Hatfield, *et al*, 2007), and including detailed hydrological monitoring and flow modeling, is fundamental to the assessment of a suitable level of flow diversion available to a small hydro project. The amount of "instream flow release" (IFR) required to sustain ecosystem health is set based on the scientific studies that are carried out regarding fish habitat, fish use and populations, and the geomorphic context of the site. Only stream flows in excess of those required to ensure the continued viability of the aquatic ecosystem are available to be diverted for power generation – minimum IFR thresholds will commonly vary throughout the year depending on seasonal fish or fish habitat requirements. For example, under low natural stream flow conditions, 100% of flows may be required to maintain ecosystem health -- diversion for power production would be prohibited. Under high flow conditions more flow may be diverted, but only *after* environmental flow requirements are fulfilled. The precautionary implementation of IFR's provide a conservative approach to maintaining sufficient flows to sustain ecosystem health.

For clarity, It should be noted that IFR's set, for instance, at less than 10% of "mean annual discharge" (MAD) do not result in "diversion of more than 90% of river flow".

4. Effects of river diversions on fish populations have not been well studied

The effects of river diversions on fish populations have been extensively studied in British Columbia, Canada, the United States, and throughout the world for decades. Decade-long studies have been completed on rivers in various jurisdictions that have quantified the effects of river regulation, and the results on ongoing research are continuously documented in peer-reviewed scientific journals such as River Research and Applications. Canada's Natural Sciences and Engineering Research Council of Canada supports the HydroNet Network, dedicated to promoting sustainable hydropower in Canada via a better understanding of the effects of hydroelectric operations on aquatic ecosystems. The current state of knowledge has allowed many advances in the design of hydroelectric facilities, including the development of run-of-river projects as a lower impact alternative to large storage projects, and the installation of Coanda Screens to prevent fish entrainment. Furthermore, historic research has allowed regulators to formulate comprehensive assessment and monitoring methodologies that quantify potential effects and define the mitigation and compensation necessary to avoid significant impacts. Mitigation to minimize impacts is included as commitments in the EA Certificate and/or the Water License for each run-of-river hydro project. Additionally, the entire EA review is conducted in consultation with First Nations and for consideration of all values associated with potential effects or cumulative effects. Fish and aquatic studies are also conducted during the operations phase of run-of-river projects to confirm impacts predictions. The effects of river diversions on fish populations have and will continue to be studied extensively in future. Irrespective of the level of study the federal Fisheries Act administered by Fisheries and Oceans Canada requires that any proposed impact on fish or fish habitat can only proceed if it is conditionally approved by DFO and compensated for to maintain no-net-loss.

5. *Fine sediment accumulation and sediment movement may cause downstream effects*

Steep stream channels, particularly those in areas dominated by coastal storms, have a naturally occurring sediment system that coveys both fine and coarse sediment through the system. The movement of this sediment is important for the stream function, and in natural systems, some disturbances are common such as landslides, wind thrown trees, and snow avalanches which bring sediment down to the stream. Run-of-river hydro projects developed in such environments must consider the movement of sediment as a key issue, both for environmental impacts and operational considerations. As most run-of-river hydro projects affect relatively small portions of the overall stream length in the watershed, and operational plans include the movement of sediment through the project area, the effects on sediment movement are not significant compared to the overall sediment movement in the watershed.

6. *Lack of high flows may affect channel maintenance*

A typical BC stream will commonly experience natural flows ranging from 5% to 500% of "mean annual discharge" (MAD) over the course a year, while a typical run-of-river hydro project is sized to divert a maximum of 75% to 150% of MAD. During flood events, flows passing the project diversion point are typically well in excess of MAD, and while diminished from natural levels, are sufficiently energetic to maintain natural scouring, sediment transport, and other geomorphic processes contributing to channel maintenance (particularly in the high gradient channels typically found in a project's "diversion reach"). As a run-of-river project does not have the ability to regulate the natural flow pattern within a watershed the flows for channel maintenance downstream of the project tailrace remain largely unaltered.

7. *Projects may impact recreation, aesthetic values and tourism*

The EAO process very often includes recreation and tourism as Valued Components for review by government agencies as part of the Environmental Certificate. Run-of-river projects are typically sited to minimize the potential impact on recreation and tourism, and government considers such impacts as part of their review. It is also important to note that run-of-river projects can also provide opportunities for enhanced tourism in an area. For example: one project maintains a road that is commonly used by snowmobilers in an area every winter; another project constructed a walking path next to the creek (with a bridge over the tailrace) for use by the local community; and another project near an outdoor school is looking to provide students with tours of the facility once constructed as a means to educate them about renewable energy. In areas where the projects are likely to be regularly viewed by the public, architectural techniques can be used to improve the appearance, such as natural wood siding or using logs to make the powerhouse look like a chalet. One project in a farming community used a barn-like structure to ensure the powerhouse blended with the other farms in the area.

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8. Projects may have low life-cycle greenhouse gas unit emissions as compared to other generation technologies

Information provided by the Clean Energy Association of BC (previously known as the Independent Power Producers of BC) outlined the overall carbon footprint of run-of-river projects compared to other forms of generation. A copy of this submission is attached as an Appendix to this letter.

9. Penstocks, powerhouses, access roads and transmission lines may affect terrestrial environments and wildlife movement/mortality

Terrestrial and wildlife impacts are studied in detail as part of the environmental impact assessment for a small hydro development, and are reviewed as part of EA process. Siting of facilities during the design stage are typically employ "Best Management Practices" to minimize terrestrial impacts. Wherever possible, existing roads and other infrastructure are utilized so as to limit incremental impacts and construction costs. While concerns for impacts of linear developments on terrestrial habitat are not unfounded, the issue is not unique to BC run-of-river small hydro development

10. Construction activities emit air pollutants and greenhouse gases

The construction of any type of energy facility creates air pollutants and greenhouse gases. For renewable energy projects, such as run-of-river hydro projects and wind projects, these emissions are limited solely to the timeframe for construction with very minor emissions from vehicles during operations (mainly for maintenance crews). Conversely, natural gas and coal generation continually emit air pollutants and greenhouse gases during their operations (unless full sequestration is carried out, which is not economically feasible in almost all cases).

11. Construction activities may directly harm species and affect habitat

As with siting of the facilities, "Best Management Practices" (BMP) are typically employed to minimize terrestrial impacts during construction. Common practice involves development of a "Construction Environmental Management Plan" (CEMP) which specifically identifies potential construction impacts to wildlife and habitat and stipulates mitigation measures (ex. "*no tree removal during nesting season*", "*no earth movement activities during heavy rainfall event*"). The CEMP is enforced by Independent Environmental Monitor (IEM), who reports directly to government agencies and regulators. The CEMP is typically imposed as part of all construction contracts, and empowers the IEM to issue a "stop work" order in the event of an unauthorized departure from the plan.

12. Construction activities may cause erosion and spread invasive species

The potential for erosion and sedimentation during construction is handled as part of EA mitigation, permitting conditions, as well as BMP's. Control measures to minimize erosion, sedimentation and spread of invasive species are addressed in the comprehensive CEMP and by deployment of BMP's. Environmental Monitoring is carried out during construction by an IEM reporting to both Proponent and Government.

13. Cumulative impacts may arise and may not be sufficiently addressed,

- ***At the level of a river system if more than one tributary is diverted, and***
- ***Development of linear/ancillary facilities such as roads and transmission lines may result in future development of previously undisturbed areas***

The assessment of cumulative effects must recognize that natural systems have an inherent level of variability or activity, and in some cases this level of variability may be considerably more than the variability caused by the Project. For example, a study carried out for one project with a long air photo record showed that the past effects of glacial recession (snowfield melt, exposure of bare sediment that was then carried downstream) as well as historic logging practices (landslides, riparian logging, road crossings) resulted in considerable changes to the stream, and these changes were considerably more significant than the expected impacts of the proposed run-of-river hydro project.

In terms of future projects in previously undisturbed areas, the assessment of cumulative effects must consider the permanent impacts following the construction of a project, as well as other projects that may overlap in time and space. For past projects this is relatively easy, as they are in operation and the impacts are largely understood. Future projects may be foreseeable (where there is active work with First Nations, government agencies on permitting, and inventories for environmental assessment) and as such some understanding of these impacts is known. Speculative projects (where there is no active work on environmental assessment) may have only limited information for understanding potential impacts, but it is important to recognize they too will be required to carry out a cumulative effects analysis and receive environmental assessment before any work on site is carried out.

14. Projects may be increasingly proposed in sensitive wildlife and fish habitat

All projects must meet the necessary environmental requirements before proceeding to construction. Thus, if projects are proposed for areas with sensitive wildlife and fish habitat, these values are explicitly considered as part of the environmental assessment for the Project. For future projects that are in the same geographic area, this would be captured in a cumulative effects assessment (see Point 13, above).

15. Projects may provide benefits to First Nations Communities through partnerships, support for businesses, employment opportunities, training and capacity building

The materials, labour, and expertise for run-of-river projects are often sourced locally for a Project. For example, one project in coastal BC estimated that their project materials and supplies were purchased from over 350 local businesses and suppliers. The Clean Energy industry is proud to report that over 125 First Nations are part owner/operators in run-of-river projects or working with developers to look at commercial opportunities. The most encouraging aspect is that the skills and expertise that First Nations develop on a run-of-river project – whether it is training for environmental monitoring, learning how to operate heavy equipment, or mentoring to become project managers – can be used directly on other types of projects in the area once the run-of-river project is complete.

16. Environmental standards for run-of-river projects in British Columbia may be different than for other industrial projects, even if the impacts are comparable

There is no specific legislation that governs small hydro projects; the legislative framework is the same as all major industrial projects. Therefore, the environmental standards for run-of-river projects are comparable to other types of projects. The government and industry typically review best practices in other industries and determine how successful practices can be incorporated into run-of-river projects.

17. Environmental Assessments may be required only for projects that are greater than 50 MW (although some applicants have and do opt in even when they do not trigger such a review)

Environmental Assessments (EA's) are required for all run-of-river projects in BC. For projects greater than 50MW (or a group of projects with a total greater than 50MW) the review is carried out by the Environmental Assessment Office. For projects less than 50MW, the review is carried out by Ministry of Forests, Lands, and Natural Resource Operations (FLNRO) and this process was recently clarified in the Development Plan Application Information Requirements by the Clean Energy Projects office of FLNRO.

18. Projects may lack information sharing between agencies

The government ensures there is information sharing among agencies during the EA review. For the EAO process, there is a Technical Working Group that contains members of all the agencies with a mandate to review some aspect of the project. This group meets and jointly reviews the project, using the information that contained in the Application. The non-EAO projects following the Development Plan Information Requirements also have Technical Working Groups similar to the EAO.

19. Environmental review may not provide for adequate public involvement

The government ensures public review through a process for every major project. The EAO has a mandated process for public involvement and the non-EAO projects are required to advertise and solicit feedback for the proposed project, including public open houses for most projects. It is also important to point out that many projects have public support in the communities where they are located, particularly in rural areas (Port Hardy, Stewart, and others).

20. Local agency involvement/approval may be limited

Consultation with local agencies and authorities is included in both the EAO Technical Working Group, and the FLNRO Development Plan processes. Project proponents generally engage local and regional communities during the course of preliminary project assessment and development stages to seek a better understanding of local issues.

21. British Columbia Strategic Land and Resource Plans and Land and Resource Management Plans for Crown land were originally meant for managing forests and may be less effective for run-of-river projects

Although many of the LRMP's were done before there was a broad interest in developing run-of-river projects in BC, the information contained in LRMP's can be used as baseline data for EA's at Project Level. For example, the LRMP information regarding adjacent wildlife habitat can be included as baseline data for further review and assessment as part of the review of a proposed, nearby project. It is also important to note that several LRMP's have expressly considered run-of-river projects and their development, namely the North Coast LRMP, the Central Coast LRMP, and the Sea-to-Sky LRMP.

IPPBC Independent Power Producers
association of British Columbia

January 7, 2010

Mr. Gary Collard
Air Pollution Specialist, Energy Section
California Air Resources Board
1001 - I Street
Sacramento, CA
USA 95812-2828

RE: Comments on *Technical Feasibility and Environmental Analysis* California Air Resources Board (ARB) – Draft for Public Comment

Dear Mr. Collard:

Thank you for the opportunity to comment on the preliminary draft of the concepts developed for California's Renewable Electricity Standard (RES). Similar to California, British Columbia has also taken a leadership role in combating climate change by introducing a carbon tax, legislating greenhouse gas reductions, adopting a low carbon fuel standard and supporting the development of a clean energy sector. IPPBC applauds California's 33% renewable electricity target from eligible renewable energy resources to be achieved by December 31, 2020.

Our purpose in writing is to ask ARB to consider for eligibility, under its definition of "renewable", high head non-storage run-of-river hydro located within the Western Energy Coordinating Council WECC member zone. These projects have minimal environmental impacts compared to other types of generation, and are developed under a rigourous environmental review and regulatory process.

The Independent Power Producers Association of BC (IPPBC), a 19 year old non-profit organization registered in British Columbia, supports its 320 members to produce clean renewable electricity for the British Columbia energy grid which also supplies power to US markets including California. While independent of government, public utilities and other organizations, IPPBC collaborates with provincial and federal government agencies, First Nations, local governments, BC Hydro, BC Transmission Corporation, Powerex, environmental organizations and others in developing a clean economy. IPPBC represents clean and renewable electricity producers who help British Columbia meet its domestic needs, and also has significant potential to meet the needs of members of the (WECC), including California.

IPPBC would like to see the ARB adopt a RES that embodies a principle that expands eligible sources of renewable electricity. All cost-effective, environmentally responsible, and GHG reducing renewable fuel type generation located within the WECC member zone should be included as eligible renewable resources. Specficially, the current eligible renewable resources definition should also be amended to include high head non-storage run-of-river hydro electric facilities larger than 30 MW capacity. Furthermore IPPBC asks ARB to undertake its own review and assessment of high head non-storage run-of-river hydro projects.

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Specific Comments and Feedback - RES Eligible Resources:

1. Eligible Resources
2. Excluded Technologies
3. Geographic Eligibility

1. Eligible Resources

Presently California's Renewable Portfolio Standard (RPS) and Assembly Bill No. 64 restrict "eligible renewable energy resource" to hydro projects of less than 30MWs. IPPBC believes this restriction is needlessly limiting and if retained in the proposed RES will prevent California from accessing clean electricity produced in the WECC area including BC. IPPBC requests the ARB and other California agencies to undertake their own due diligence as well as review reports provided by electricity utilities in California that speak to the clean and environmentally benign sources of energy in British Columbia. IPPBC suggests that science should guide a review of existing high-head, non-storage BC projects and their impacts as well as the environmental review process for their approvals. IPPBC would be pleased to assist with providing information and site tours of operating facilities to discuss the environmentally benign nature of these projects.

IPPBC notes that in the past, large hydro projects were constructed on the Peace and Columbia Rivers, as well as other areas. While providing substantial benefits in terms of flood control, these facilities have also served the electrical needs of ratepayers well in BC and elsewhere and offer tremendous power shaping capabilities for renewable energy for the future.

High head non-storage run-of-river hydro is not based on water reservoirs using large dams. These run–of-river hydro projects are much smaller in scale and rely on the high head (elevation drop) available especially in many BC river systems. Typically, these projects have the following characteristics:

- Rather than a large dam, there is a small weir that diverts water into the penstock, with minimal impoundment (less than 48hours of operation);
- Water flows down the penstock to the powerhouse, with the elevation difference between the weir and the intake driving the turbines;
- Some flow passes over the weir, as required by the Water Licence, to maintain the ecological function in the stream immediately below the weir;
- All water is returned to the stream after generation, as required by the Water Licence.

Projects that affect the habitat of salmon or other sensitive species are required to incorporate fish habitat mitigation programs, such that the net impacts (especially for a species like salmon) have been beneficial. In addition, many of the project sites and streams were affected by past forestry practices – collapsed culverts, slumped roads and landslides - and many of these problems were mitigated as part of the construction of the run-of-river project. The configuration of these projects leads to a inherently low carbon footprint that is enhanced by the opportunities for mitigation. (See: Appendix 1: Carbon footprints of different types of electricity generation technologies).

Non-storage run-of-river hydro – covering the range from 1MW systems to those in excess of 50 MWs, have been up and running in BC for over 15 years. After the construction phase, the environmental impact and footprint of typical run-of-river projects in BC is extremely modest. (See: Appendix 2: Comparison of environmental impacts by fuel/technology). Furthermore, the lifecycle payback ratio for run-of-river hydro is extremely positive (See: Appendix 3). Further, wherever possible, existing forestry roads andrights-of-ways for other utilities are utilized for penstock routes and transmission lines. Where multiple projects exist in an area, there are efforts to plan and build a single transmission line to reduce the overall footprint of the projects.

IPPBC is confident that if the ARB has the benefit of reviewing BC's high head non-storage run-of-river hydro projects and the environmental assessment process, the non-storage, and benign nature of these projects and the rigour of the process will be evident. Further, the abundance of opportunities in BC for these small hydro projects is such that only the most cost effective resources will be developed, as determined through competitive Calls for clean power from BC Hydro.

2. Excluded Technologies

As proposed, the RES regulation will not extend eligibility to large reservoir based hydroelectric generating facilities. However, BC's installed large dam hydroelectric facilities, and most importantly, the huge reservoirs created behind the dams, all of which are over 20 years old, represent significant opportunity as "storage capacity" to help shape and firm new clean and renewable energy generation.

This shaping of power by marrying existing large scale hydro (storage reservoirs) with new clean energy (wind, solar and small scale high head hydro), produces a very cost efficient and competitively priced firm electricity product for domestic and export needs.
IPPBC recommends that the proposed RES accommodate the use of existing large hydroelectricity as eligible for firming and shaping capacity for the clean energy sector in BC, including energy for export.

3. Geographic Eligibility

IPPBC supports the proposed RES eligibility for facilities in or out of state connected to the Western Electricity Coordinating Council (WECC) transmission system.

On March 24 2009, the Honourable Barry Penner, BC Minister of Environment wrote a letter to state legislators in California to address inaccurate information about environmental and regulatory standards and processes in British Columbia circulated by critics of the clean energy sector in the province. The typical high head non-storage run-of-river hydro projects in BC are required to obtain about 50 permits and approvals. The standard of environmental scrutiny and regulation is rigorous, with numerous scientific assessments carried out to study project sites prior to government approval for construction. In addition to, and as part of the regulatory processes on all resource development and land use matters, there is a requirement for dialogue involving IPP companies and local communities, First Nations, and the general public. IPPBC is also looking to improve the regulatory process by assisting governments, and engaging First Nations, key stakeholders, and others.

The generation of power by high head non-storage run-of-river projects in British Columbia has been verified and qualifies for participation in the EcoLogo program, regardless of the size of the project. The EcoLogo program, founded by the Canadian government in 1988 (meets ISO 14024 standards for eco-labelling) is an international organization for standardization of eco-labeling. The EcoLogo program compares products with others in the same category, develops specific and scientific criteria that consider the life-cycle of a product and awards the EcoLogo certification to those products that are verified by a third party as complying with the criteria. IPPBC suggests that Eco-Logo Certification (or a similar process) can provide the ARB with confidence that clean energy projects, including high head non-storage run-of-river power generation in British Columbia, represent clean, renewable sources of energy and are suitable for California's RES as clean-energy projects.

Conclusion

IPPBC is concerned that as work proceeds on developing the RES, that it not be restricted by the existing RPS eligibility of hydro projects of not more than 30 MW. Limiting the size of hydro projects to 30MW or less will adversely impact a significant number of high head non-storage run-of-river projects in the WECC area, by precluding them from qualifying as an "eligible renewable energy resource". Such a limitation will adversely impact California because it will reduce the available supply of clean, cost competitive and renewable hydro sources of energy that might otherwise be available to supply the California market. Such limitation will also adversely impact the ability of electric utilities to meet their obligations to secure clean and renewable energy supplies as part of their renewable portfolios. Furthermore, this limitation appears to be inconsistent with the requirements set out in Governor Schwarzenegger's letter of increasing the supply pool of renewable projects; expanding the eligibility of projects within the WECC to include more out-of-state projects; and expanding the statutory definitions of renewable that are included in meeting the RPS to include larger hydropower projects.

IPPBC believes that ARB should consider modifying the definition of renewable energy to include high head non-storage run of river hydro projects from British Columbia based on objective scientific assessment of environmental footprint, rather than arbitrary thresholds or definitions. All generating projects in British Columbia undergo a rigorous environmental review and assessment process. IPPBC will be pleased to provide project examples and other information.

IPPBC encourages the ARB to consider the substantial potential and benefits of British Columbia's resources to provide abundant clean, green and renewable energy projects and power to serve both our domestic and export customers. IPPBC is confident that the clean and renewable energy available from British Columbia will help California and other members of the WECC achieve their renewable portfolio standards and their greenhouse emissions reduction targets, as well as satisfying Governor Schwarzenegger's requirements regarding the contents of any state legislation reaching him for approval. Enclosed are several fact sheets and copy of a DVD entitled *Generating Green Power and Jobs in B.C.* that IPPBC recently produced regarding IPP development in British Columbia.

We welcome the opportunity to meet and discuss these matters with you and would be happy to provide you with any additional information you may require. We can be reached at 604-568-4778.

Yours sincerely,

Paul Kariya, PhD
Executive Director

Cc: Ms. Mary Nichols, Chair
Mr. James Goldstene
Mr. Robert Fletcher
Mr. Kevin Kennedy
Mr. David Mehl
Mr. Mike Tollstrup
The Honourable Sam Blakeslee
The Honourable Michael Duvall
The Honourable Felipe Fuentes
The Honourable Danny Gilmore
The Honourable Paul Krevorkian
The Honourable Nancy Skinner

List of Appendices

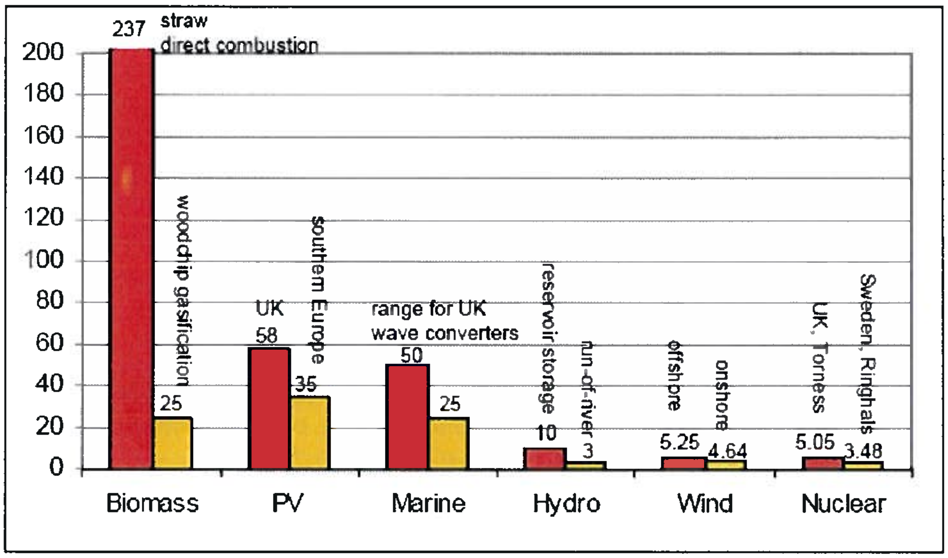
1. Carbon Footprints of Different Electricity Generation Technologies
2. Comparison of Scored Environmental Impacts by Fuel/Technology
3. Comparison – Power Plant Life Cycle Payback Ratio

Appendix 1

Carbon Footprints of Different Electricity Generation Technologies

In October 2006 the UK Parliamentary Office of Science and Technology Energy and Environment Report evaluated the "Carbon Footprint of Electricity Generation" and produced the following table:

Carbon footprint of low carbon electricity generation technologies (UK & Europe)



An accompanying slide on Hydro states:
Carbon footprint range:

Highest: 10 gCO$_{2eq}$/kWh (non-alpine reservoir storage)
Lowest: 3 gCO$_{2eq}$/kWh (non-alpine run-of-river)

Issues:

- Two main schemes: reservoir storage (large scale), run-of-river (small scale)
- Storage schemes have higher carbon footprint since a dam is constructed
- Run-of-river schemes have the smallest carbon footprint of all technologies
- Hydro has small CO_2 emissions, but some methane (CH_4) is also emitted

* I think that alpine run of river will be lower since high head means smaller headpond.
** Note the use of the label "reservoir storage".

The report states:

- All electricity generation technologies generate carbon dioxide (CO2) and other greenhouse gas emissions. To compare the impacts of these different technologies accurately, the total CO2 amounts emitted throughout a system's life must be calculated.

- "Run of river schemes have very small reservoirs (those) with weirs) or none at all so do not give rise to significant emissions during their operation. Carbon footprints for this type of hydro scheme are some of the lowest of all electricity generation technologies (<5gCO2eq/kWh)."

- "Hydroelectric storage schemes require dams. In run-of-river schemes, turbines are placed in the natural flow of a river. Once in operation, hydro schemes emit very little CO2, although some methane emissions do arise due to decomposition of flooded vegetation. Storage schemes have a higher footprint, (~10-30gCO2eq/kWh), than run-of-river schemes as they require large amounts of raw materials (steel and concrete) to construct the dam.9

- Electricity generated from wind energy has one of the lowest carbon footprints. As with other low carbon technologies, nearly all the emissions occur during the manufacturing and construction phases, arising from the production of steel for the tower, concrete for the foundations and epoxy/fibreglass for the rotor blades.10 These account for 98% of the total life cycle CO2 emissions. Emissions generated during operation of wind turbines arise from routine maintenance inspection trips. This includes use of lubricants and transport. Onshore wind turbines are accessed by vehicle, while offshore turbines are maintained using boats and helicopters. The manufacturing process for both onshore and offshore wind plant is very similar, so life cycle assessment shows that there is little difference between the carbon footprint of onshore (4.64gCO2eq/kWh) versus offshore (5.25gCO2eq/kWh) wind generation (Fig 2).11 The footprint of an offshore turbine is marginally greater because it requires larger foundations.

The use of biomass is generally classed as 'carbon neutral' because the CO2 released by burning is equivalent to the CO2 absorbed by the plants during their growth. However, other life cycle energy inputs affect this 'carbon neutral' balance, for example emissions arise from fertilizer production, harvesting, drying and transportation. Biomass fuels are much lower in energy and density than fossil fuels. This means that large quantities of biomass must be grown and harvested to produce enough feedstock for combustion in a power station. Transporting large amounts of feedstock increases life cycle CO2 emissions, so biomass electricity generation is most suited to small scale local generation facilities, or operating as combined heat and power (CHP) plants.7 The range of carbon footprints for biomass is related to the type of organic matter and the way it is burned (Fig 2). Combustion of low density miscanthus results in higher life cycle emissions (93gCO2eq/kWh), than gasification of higher density wood-chip (25gCO2eq/kWh).

Current gas powered electricity generation has a carbon footprint around half that of coal (~500gCO2eq/kWh), because gas has a lower carbon content than coal.

Coal burning power systems have the largest carbon footprint of all the electricity generation systems analysed here.

For more information on carbon footprints of energy generation read the UK Parliamentary Office of Science and Technology Energy and Environment Report Number 268, Carbon Footprint of Electricity Generation, October 2006.

Appendix 2

Comparison of Scored Environmental Impacts by Fuel/Technology

Comparison of Scored Environmental Impacts by Fuel/Technology

APPENDIX 2

	Contaminant Emissions	CO2	Radioactivity	Land Use	Water Impacts	Waste Impacts	Resource Availability	Total Impact (Weighted)
Hydro (run of river)	0	1	0	0	0	0	1	21
Hydro (impoundment)	0	1	0	4	5.5	0	1	30.5
	0	1	0	8.5	5.5	0	2	36
Wind	1	1	0	4.5	0	0	0	34.5
Biomass	2	1	0	1	4	1	1	47
Photovoltaic	2	1	0	1	0	0	0	41
Nuclear	1	1	6	1	4.5	1	5.3	47.8
Natural gas (single cycle)	2	3	0	1	2	0	8	91
Natural gas (combined cycle)	2	2	0	1	2	0	8	71
Natural gas (cogeneration)	2	2	0	1	2	0	8	71
Gasification (without CO2 removal)	4	6	10	1	2	0	2	175
Gasification (with 90% CO2 removal)	4	2	10	1	2	0	2	95
Coal	5	7	10	1	3.5	10	2	216.5
Oil	5	10	1	1	5	3	5	265

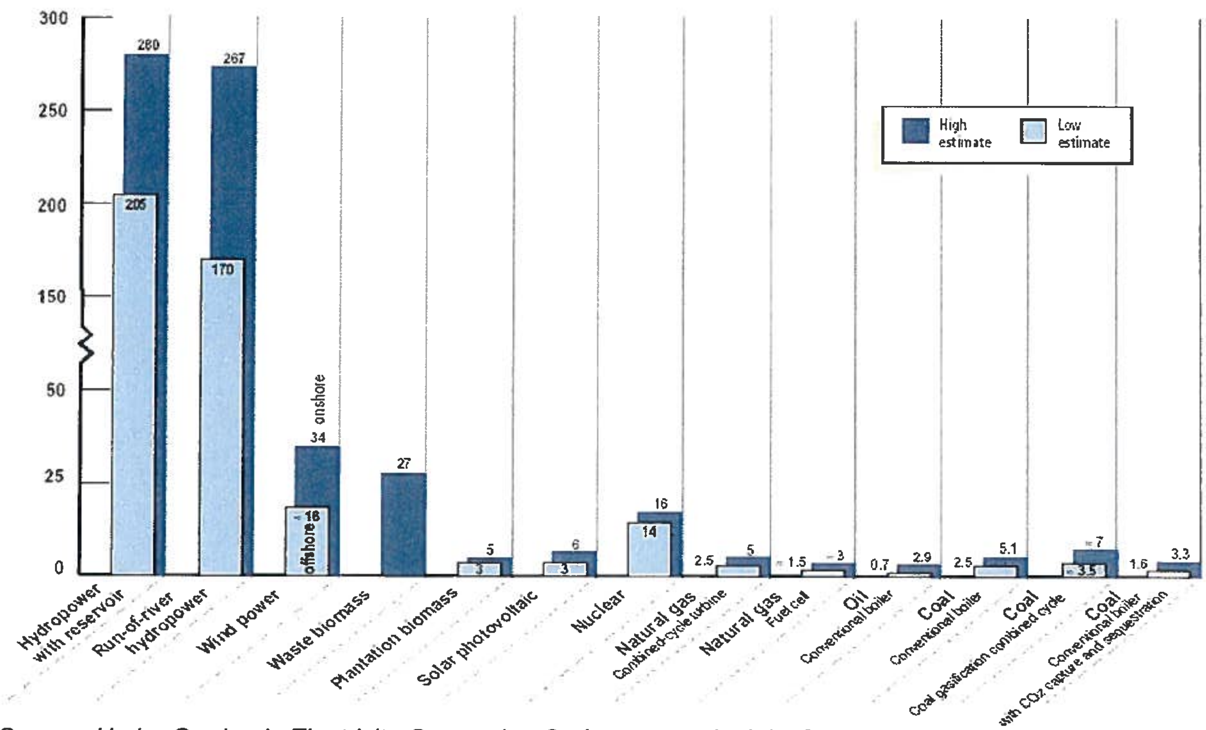
Note: The Total Weighted Impact is calculated by applying a weight of 10 to contaminant emissions, 20 to greenhouse gases, and 1 to all other categories.

Source: SENES Consulting and Ontario Power Authority, 2006

Appendix 3

Power plant Lifecycle Energy Payback Ratio

Power plant Lifecycle Energy Payback Ratio = Energy Produced divided by Energy required to build, maintain & fuel it.
According to Hydro Quebec's Electricity Generation Options report in July, 2005 hydropower project have the lowest Power Plant Lifecycle Energy Payback Ratio of 13 types of power generation. The graph below shows the PPLEP Ratios.



Source: Hydro Quebec's Electricity Generation Options report in July, 2005