# Independent Evaluation
# of the
# NaiKun Wind Energy Project

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Dr. Thomas I. Gunton
Director of Resource and Environmental Planning Program

Chris T. Joseph
Senior Research Associate

School of Resource and Environmental Management
Simon Fraser University

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# Executive Summary

1. This report was commissioned by the Council of the Haida Nation (CHN) to provide an independent evaluation of the proposed NaiKun offshore wind energy project. The wind energy project would consist of an offshore wind farm of up to 110 turbines with a capacity of 396 megawatts, the HaidaLink underwater cable linking the wind farm to both the BC mainland and Haida Gwaii, and associated staging, operations, and maintenance infrastructure. The project is forecast to take three years to construct and would be in operations for at least 40 years. The proponent anticipates producing 1.3 terawatt-hours of electricity annually.

2. The proposed wind energy project has generated both hopes and fears among the Haida. On the hope side, wind energy represents an opportunity for sustainable economic development that can generate employment, income, and move the Haida closer to economic independence. On the fear side, there are concerns about potential environmental impacts and potential financial liability for the CHN. The purpose of this report is to assess these hopes and fears by examining both the economic and environmental impacts of the proposed wind energy project from the perspective of the Haida.

3. Wind farms are a proven and reliable technology. Growth in wind power is attributed largely to policy initiatives aimed at increasing renewable, green energy generation to reduce greenhouse gas emissions and climate change. Although the major proportion of wind power is onshore due to its lower cost, offshore wind farms are increasingly being developed. The world's first offshore wind farm was built in 1986 off the coast of Denmark near the community of Ebeltoft (the Vindeby farm). Currently, there are about 40 offshore wind farms across Europe and offshore China and Japan with a total capacity of over 3 GW, and significant expansion of offshore wind farms is planned.

4. NaiKun Wind Energy Inc. prepared an environmental impact statement and submitted the project for review to the BC and federal governments under the British Columbia *Environmental Assessment Act* and the *Canadian Environmental Assessment Act* review processes. The BC government announced that the project successfully completed the BC environmental impact assessment process in December 2009. The federal government announced that it had completed the federal review process in March 2011. Both the provincial and federal reviews concluded that, subject to the implementation of specified mitigation measures, the project is unlikely to have any significant adverse environmental effects.

5. The Haida significantly strengthened the project review process by provisions to expand the scope of the impact assessment to address key issues relevant to the Haida and by conducting their own impact assessment review. The Haida have also set a number of preconditions to protect their environmental and economic interests that must be met before the Haida approve the project.

6. The wind energy proposal has been subjected to a thorough and comprehensive impact assessment process comprised of three separate reviews (the BC review, the federal

review, and the Haida commissioned review by Rescan) that all concluded that, subject to the implementation of specified mitigation measures, the project is unlikely to cause significant adverse environmental effects**.** The completion of three separate reviews represents a very high level of scrutiny and provides a high level of confidence in the findings that there will be no significant adverse environmental effects.

7. The purpose of this report is to provide the Haida with further independent evaluation of the wind energy proposal. This assessment is based on a review of all documents on the project including: agreements between the Haida and NaiKun; documents prepared by NaiKun and its consultants; the environmental review prepared on behalf of the Haida (Rescan); the BC Environmental Assessment Office Wind Energy Project Assessment Report; the Federal Screening Report for NaiKun; and relevant scientific literature. We evaluated: the quality of the information used by the proponent in preparing their environmental impact statement; conclusions reached by the provincial government, the federal government, and Rescan on the environmental impacts of the project; the most recent scientific literature on offshore wind farms; and major uncertainties related to the impact assessment. Based on this review we assessed potential environmental and economic benefits and risks of the project from the perspective of the Haida.

8. Overall, we concur with the findings of the BC government, the federal government, and Rescan that, subject to the implementation of specified mitigation measures, the project is unlikely to have any significant adverse environmental effects. More specifically, the scientific evidence indicates that environmental concerns that the project will devastate clams, crabs, birds, whales, and other local species are unfounded. We note that there are some issues that deserve special attention in the development of mitigation measures. These areas involve: marine birds, ecosystem dynamics, invasive species, and cumulative impacts. We emphasize the importance of effectively implementing the proponent's plan to address these areas by preparing and following comprehensive mitigation strategies that include monitoring and adaptive management.

9. The project has the potential to generate economic benefits to the Haida in terms of employment opportunities and financial returns. Forecasts provided by the proponent (table ES-1) indicate that the project would provide between 30-50 direct jobs plus additional indirect and induced employment through multiplier affects during regular operations. Additional short-term employment opportunities during the construction phase are forecast to employ between 100-150 individuals in the region. Financial benefits to the Haida include: annual payment fees, dividends based on the Haida's share of ownership of the project and potential revenue from other financial instruments. The magnitude of economic and financial benefits depends on many variables including training programs, hiring protocols, ownership structure, and the project's financial performance. Financial performance in turn depends on terms of the BC Hydro power sale contract and costs of construction and operation.

**Table ES-1. Employment, GDP, and government revenue impacts per year during operations as estimated by proponent.**

| Indicator | Region | British Columbia | | | |
|---|---|---|---|---|---|
| | Direct | Direct | Indirect | Induced | Total BC |
| Employment (PY) | 30-50 | 65 | 337 | 95 | 498 |
| GDP (million $) | | 7.5 | 26 | 7 | 40 |
| Local and BC gov't revenues (million $) | | 24 | 2 | 1 | 27 |

10. We evaluated the economics of the NaiKun proposal to assess strengths and risks. Key economic strengths of the project from a business perspective are:

- consistency of the project with BC energy policy
- favourable wind conditions in the region for offshore wind energy generation
- independent evaluation and advice from leading offshore wind experts
- BC Hydro's sound financials as the potential purchaser of the project's electricity
- community and government support for the project
- potential increases in energy prices, and
- environmental benefits of wind energy.

Key economic risks of the project from a business perspective are:

- the high cost of the project relative to other energy supply options (NaiKun's proposal was not selected under BC Hydro's proposal call due to high cost)
- challenges in realizing revenue from environmental benefits ("green credits")
- lack of offshore wind energy experience and project development capacity of project developer (offset in part by contracts and potential partnerships with firms with offshore wind expertise), and
- lack of offshore wind energy experience in the North Coast region.

11. Conceptually there are several different types of strategies that the Haida can use to participate in the project. The benefits and risks of alternative strategies are summarized in Table ES-2 below. Benefit agreements are contracts between the Haida and the project developers that specify hiring, training, procurement, financial payments and other types of benefits that the project developers are required to provide as a condition of Haida approval. The effectiveness of benefit agreements is contingent on the agreements containing clear, quantitative commitments and penalties for non-compliance with the agreement. Although financial participation strategies can be part of a benefit agreement, they deserve special attention. We identify three types of financial participation strategies: royalties, traditional equity, and modified equity. Royalties are payments by the project developers to the Haida and can be based on annual lease fees or various payments based on the value or quantity of the resource extracted. Royalties are low risk because they involve no financial investment on the part of the Haida. Traditional equity involves an investment to secure a share of ownership for which the Haida can receive potential dividend payments. The benefits and risks of traditional equity depend on the financial performance of the project. The third type of financial participation strategy is a modified equity investment in which the Haida receive a share of ownership without risking any of their own financial resources. Equity can be given to the Haida in return for their approval of the project, or funds can be loaned to the project by a third party with no Haida financial risk to purchase an equity share. The benefits of a modified equity approach are receipt of potential dividends with no financial risk to the Haida. The best approaches based on a benefit to risk ratio are benefit agreements, royalties, and modified equity. The least attractive approach is traditional equity.

**Table ES-2. Benefits and risks of alternative participation strategies for the Haida.**

| Instrument | Benefit | Risk | Benefit/Risk Ratio |
|---|---|---|---|
| Environmental and Economic Development Benefit Agreements | High | Low | High |
| Royalty | High | Low | High |
| Traditional Equity | Medium | High | Low |
| Modified Equity | Medium | Low | Medium |

12. To assess the financial and economic benefits and risks to the Haida we reviewed the current agreements and proposed relationships between the Haida and NaiKun and developed an economic model of the wind energy project to test alternative economic scenarios. Key elements of the current agreements negotiated by the Haida include:

- annual fees to the Haida
- an equity share provided to the Haida for approving the project
- an option to purchase additional equity based on a series of conditions being met including obtaining loan guarantees, meeting project milestones, and other due diligence requirements
- a benefit agreement in the form of a Limited Partnership Agreement that provides employment, training, and procurement benefits
- A series of due diligent conditions that must be met before the Haida will approve the project

Based on our review and our assumption that future, more detailed agreements specifying targets and legal commitments will be negotiated consistent with the intent of the current agreements, we conclude that Haida have negotiated a sound framework agreement that could provide benefits for the Haida with minimum risk, should the project proceed.

13. We note that there have been specific questions raised regarding a potential equity investment of $300 million financed by a federal government loan guarantee. Details of this loan have not been concluded so we are unable to assess specific loan conditions. However, it is our understanding that the principle that guides discussion of this loan is that the liability for the loan will be held by the project and the federal government, not by the Haida. Based on this principle of the federal loan guarantee being a project-based loan, the Haida will receive the benefit of the investment while incurring no financial liability and therefore no risk to the Haida. We also note that the provision of any federal guarantee will be contingent on further federal due diligence assessment of project finances and feasibility. A decision to provide a federal loan therefore will provide an additional due diligence evaluation of the project.

14. In sum, the wind energy project has potential benefits for the Haida including: employment, financial returns, and environmental improvements generated by renewable, clean energy production. The project also has potential economic risks and challenges including: relatively high costs of production and lack of experience of the project proponent. Our conclusion is that:

- Based on the principles contained in the agreements negotiated by the Haida and preconditions set by the Haida for approval of the project, we conclude that the project is structured in a way that allows the Haida to realize potential economic benefits with minimal risk.

- Based on the extensive environmental reviews by Rescan, the federal government, and the provincial government, as well as our own review we conclude that contingent on the implementation of specified mitigation measures, the project is unlikely to have any significant adverse environmental risks.

15. There are several final qualifications to our findings and recommendations that should be noted.

- The capacity of the current project proponent to complete the project and the relatively high costs of the project (and consequent marginal financial returns) are constraints that impede project development and may require investigation of other options by the Haida to develop the potential wind energy source.
- It is likely that the nature of the project, including mitigation measures, corporate structure, business plan, and ownership of the project will continue to evolve to address these constraints. Consequently it is important that any changes be carefully monitored and that agreements and commitments are reassessed in light of changing circumstances. Any new agreements need to be based on the principles reflected in the current Haida agreements that maximize benefits and minimize risk to the Haida. Also, new, more detailed agreements will need to be negotiated that specify measurable, enforceable targets for social and economic benefits.
- The conclusion that the project is unlikely to have significant adverse environmental effects is contingent on the implementation of mitigation measures specified in the environmental assessment documents. It is therefore important that all specified mitigation measures be fully and effectively implemented and consideration be given to specifying compensation commitments in the event that any adverse impacts occur.
- The scientific literature on the impacts of offshore wind farms is evolving and needs to be carefully monitored to identify any new risks and mitigation measures to manage risks.

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## Acronyms

BC EAO – BC Environmental Assessment Office
BC EAA – BC *Environmental Assessment Act*
BTMU – Bank of Toyko Mitsubishi UFJ
CAPEX – capital costs
*CEAA – Canadian Environmental Assessment Act*
CHN – Council of the Haida Nation
EA – environmental assessment
EconIA – economic impact analysis
EIS – environmental impact statement
GenCo – NaiKun Wind Generating Incorporated
GHG – greenhouse gas
GW – gigawatt
HaiCo – Haida Enterprise Corporation
HNLP – Haida NaiKun Wind Operating Limited Partnership
IRR – internal rate of return
kV – kilovolt
MW – megawatt
NaiKun – NaiKun Wind Energy Incorporated
NPV – net present value
OPEX – operational costs
PY – person-years
TWh – terawatt hours
WTG – wind turbine generator

# 1. Introduction

## 1.2 Purpose and Objectives

The proposed wind energy project has generated both hopes and fears among the Haida. On the hope side, wind energy represents an opportunity for sustainable economic development that can generate employment, income, and move the Haida closer to economic independence. On the fear side, there are concerns about potential environmental impacts and potential financial liability for the CHN. The purpose of this report is to assess these hopes and fears by examining both the economic and environmental impacts of wind energy from the perspective of the Haida. The objectives of the review are to:

a. assess potential economic and environmental impacts of the project
b. assess potential costs and benefits of the project based on the impacts from the perspective of the Haida Nation
c. identify opportunities and risks of the project, and
d. make recommendations for mitigating risks and maximizing benefits.

To date, environmental assessment (EA) of the project's potential environmental, economic, social, cultural, and other impacts has included four separate reviews: the original review by the proponent reported in its environmental impact statement (EIS); a review of the EIS by Rescan (2009), an independent consultant retained by the Haida Nation; a review of the EIS by the BC Environmental Assessment Office (BC EAO) as per the requirements of the BC *Environmental Assessment Act* (BC *EAA*)(BC EAO 2009); and a review of the EIS by the federal government as per the requirements of the *Canadian Environmental Assessment Act* (*CEAA*)(CEA Agency et al. 2011). The proponent's EIS, published in May, 2009, stated that the project

> *is not expected to result in significant adverse biophysical, social, economic, heritage, or health effects. Potential benefits associated with the Project, including the provision of clean energy and economic development, have been identified* (NWEG 2009, 16).

Rescan, publishing its report in October, 2009, stated that:

> *development of NaiKun wind farm will greatly benefit the people, animals and natural environment of Haida Gwaii... when compared to... typical "major projects" the NaiKun Wind Development project clearly stands out in terms of the net benefits provided...Based on 30 years of experience in the environmental assessment field, it is clearly refreshing to work on a project that provides such a healthy net balance of positive results for people and the environment* (Rescan 2009, 5).

The BC EAO, in its November, 2009 report, concluded that "the proposed Project would not result in any significant adverse effects" (2009)[1]. The federal government's report, published in March, 2011, concluded that the project would not likely cause significant adverse effects (CEA Agency et al. 2011). In sum, all four reviews concluded that the project is unlikely to generate any significant adverse impacts as long as specified mitigation measures were implemented. The EA led to a series of commitments and assurances by NaiKun to address remaining issues and concerns.

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[1] No page number; see "Summary of the Assessment Report".

As part of its due diligence, the Council of the Haida Nation (CHN, hereafter Haida) has commissioned us to conduct another independent evaluation of the NaiKun project. In this report we examine the scientific foundation of the conclusions reached in the NaiKun EA and the environmental and economic benefits, costs, and risks of the project.

## 1.3 Project Description

The NaiKun proposal includes an offshore wind farm, the HaidaLink underwater cable linking the wind farm to both the BC mainland and Haida Gwaii, and associated staging, operations, and maintenance infrastructure (figures 1 and 2; table 1). The farm is planned for the shallow waters off the northeast coast of Haida Gwaii. The proponent plans to erect up to 110 wind turbine generators (WTGs) with a total capacity of 396 megawatts (MW) and annual production of 1.3 terawatt-hours (TWh) of electricity (NaiKun 2011).[2] The proponent plans a 100 km$^2$ grid of WTGs connected to an offshore converter station platform by an array of 33 kilovolt (kV) alternating current submarine power cables buried to a minimum depth of 1m in the ocean bottom. The offshore platform will be connected to Haida Gwaii via a 33 kV alternating current submarine cable and to the mainland via a high-voltage direct current submarine cable. An onshore converter station will be built on the mainland. From there, a 287 kV above-ground transmission line will connect the converter station to the BC electricity grid.

**Figure 1. Project location and components (from NWEG 2009).**

The project is estimated to take three years to construct and cost $2 billion. About half of the capital cost is estimated to go to purchasing WTGs, 25% for transmission components, and 25% for other components and construction services. Operating costs are estimated at about $30 million annually. Insurance for the project is another large annual cost estimated to be in excess of $20 million. Insurance would cover injuries,

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[2] Materials given to authors during drafting by the proponent (NaiKun 2011) indicate that annual production will be 1.3 TWh, not 1.3 gigawatt-hours as listed in the EIS.

damages to equipment and components, and delays and interruptions affecting construction and operations.

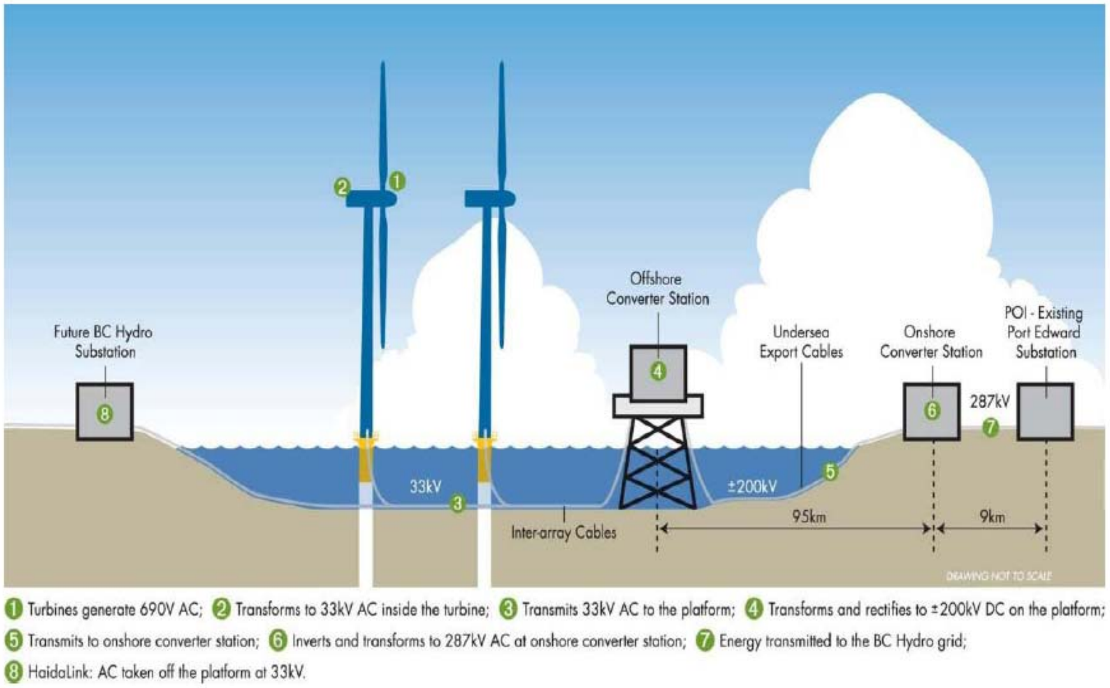

**Figure 2. Project components (from CEA Agency et al. 2011).**

**Table 1. Main components of project.**

| Component | Significant Characteristics |
|---|---|
| 110 WTGs | 396 MW capacity<br>1.3 TWh per year |
| Offshore converter station | At offshore site |
| Submarine power cables linking WTGs | 33 kV |
| HaidaLink power transmission corridor | 33 kV section to Haida Gwaii<br>400 kV section to BC mainland |
| Onshore converter station | On BC mainland |

Construction will entail fabrication of foundations (one for each WTG), further geotechnical studies, and the installation of foundations using pile driving. Construction of marine components will occur during favourable weather and sea conditions in the April to September time period. The proponent estimates that it will take about two days to install each foundation. WTGs are manufactured off-site, shipped to the site, and then each is erected. Cables between WTGs and between Haida Gwaii and the mainland will be laid into sea bottom sediment through jetting or affixing to rock. Marshalling areas near Prince Rupert on the mainland and on Haida Gwaii will be used to land and store project components, perform some of the final manufacturing, and store hazardous materials, waste and supplies.

Operations are planned for at least 40 years. WTGs operate without on-site operators through remote monitoring. The central control room will be located on Haida Gwaii. However, WTGs require routine preventive and corrective maintenance and so maintenance workers will be at the farm on an ongoing basis. Maintenance crews of 10 to 12 people will be airlifted to offshore support vessels for each weeklong shift. After 20 to

25 years WTGs will be rebuilt. If the project is working well, the proponent will rebuild/replace WTGs and other componentry as needed in order to continue running the wind farm beyond 40 years. The offshore converter station will require maintenance every two years. Submarine cables may be eroded out of bottom sediment or dislodged, and so the proponent plans regular inspections. The on-land converter station will require minimal maintenance. If the project must be decommissioned, then the proponent expects that decommissioning would take two years.

## 1.4 Study Methodology

For this study we began by identifying the key concerns of the Haida based on interviews with the Haida Nation Energy Committee and a review of documents summarizing Haida concerns and issues. The issues of concern include:

- impacts on the shoreline of Graham Island
- how the project might affect fishing and marine harvesting activities in the area of the project
- how the buried submarine transmission cables might affect crab fishing
- the potential effect of copper releases from WTGs on marine life
- the potential effect of WTG piles on marine communities including invertebrates, crabs, diving birds, other predators, due to the presence of colonization substrates and potential microclimates
- the potential effect of invasive species brought to the area by ships associated with the project
- how marine mammals might be affected by noise, pile driving, the physical barriers posed by the WTGs, and the timing of construction
- how marine birds might be affected, particularly by noise during project construction and operation, by anti-foulants if used, and by potential oil spills
- potential economic benefits and costs of the project.

To address these key concerns and issues we conducted a study with three components. First, we identified potential environmental impacts of the project based on the project EAs. In doing so, we examined new scientific literature on potential impats as well as the evidence contained in the NaiKun, federal, BC, and Rescan reports. Second, we assessed the risk of significant impacts associated with each of the above key concerns and issues and the ability of mitigation measures to address the risk. Third, we evaluated the economic benefits and risks of the project (figure 3).

To evaluate the scientific foundation of the EA we asked ourselves the following questions:

a) what are the findings is the proponent’s EIS, Rescan, BC EAO, and the federal government reviews regarding environmental impacts
b) are the findings in the EIS, Rescan, BC EAO, and the federal government reviews consistent, and supported by recent scientific literature
c) are there any major uncertainties or concerns that should be noted regarding environmental impacts?

To help answer the first question we examined the types of information used in the EIS (e.g., literature, field studies, modelling, etc.) and the quality of these information types  (e.g., use of peer-reviewed scientific literature, extent of literature reviews, redundancy in field surveys, whether models had been empirically verified, etc.). We reviewed Rescan's (2009) independent review of the EIS, the BC EAO's (2009) report, the federal government's EA screening report (CEA Agency et al. 2011), as well as additional materials produced by the proponent, the governments, and the Haida during the course of the EA. To answer the second question we examined the most recent science on the impact topics associated with the project. We searched the Web of Science[3] database for new scientific publications published after 2008 using keyword searches related to each topic. Where little literature had been reviewed on a subject in the EIS we extended our literature review to earlier years. We answered the third question based on the previous steps.

The second step was to make our own independent judgements on the risks that the project posed in terms of causing significant adverse effects. Formally defined, risk is the sum product of probabilities of alternative future events and the consequences of alternative future events. In practical terms, risk can be assessed by answering two questions: (1) is it theoretically possible that the project could cause a high magnitude outcome? and (2) is there a relatively high probability that the high magnitude outcome will occur?

To address these questions we considered:

a) the presence of risk factors in the present project case; and
b) conclusions in the latest literature regarding the probability that offshore wind farms cause significant impacts.

Standard risk factors include magnitude of potential impacts, the geographic extent of potential impacts, impacts' duration and frequency, reversibility of potential impacts, the ecological context in which potential impacts would occur, the probability of occurrence, and the effectiveness of mitigation measures. These are the factors that the BC EAO and federal government use in their EA processes to assess the significance of impacts.

An important consideration in assessing risk is the need to compare the risk of the proposed project to the risks associated with alternatives to the project. In the case of wind energy project, this means that potential risks should be compared to the risks of alternative means of generating electricity. From a local perspective, the risks of the project should be compared to the risks of alternative means of generating electricity on Haida Gwaii such as diesel power generation and the shipment of diesel fuel, which is a source of a significant proportion of Haida Gwaii's electricity. From a larger provincial and international perspective the risks should be compared to other energy supply options such as natural gas, coal, hydro, and demand-side management. As discussed later in this report, there is a consensus that wind farms generate fewer negative environmental impacts than many other means of electricity generation. While a detailed assessment of the risks of alternatives to the project was outside of the scope of this report and outside the scope of the federal and provincial impact assessment reports, this broader perspective should be considered in order to put the risks of the wind energy project in proper perspective.

The third component of our study entailed examining the business case for the project from the point of view of the Haida. All of this work relied upon publicly-

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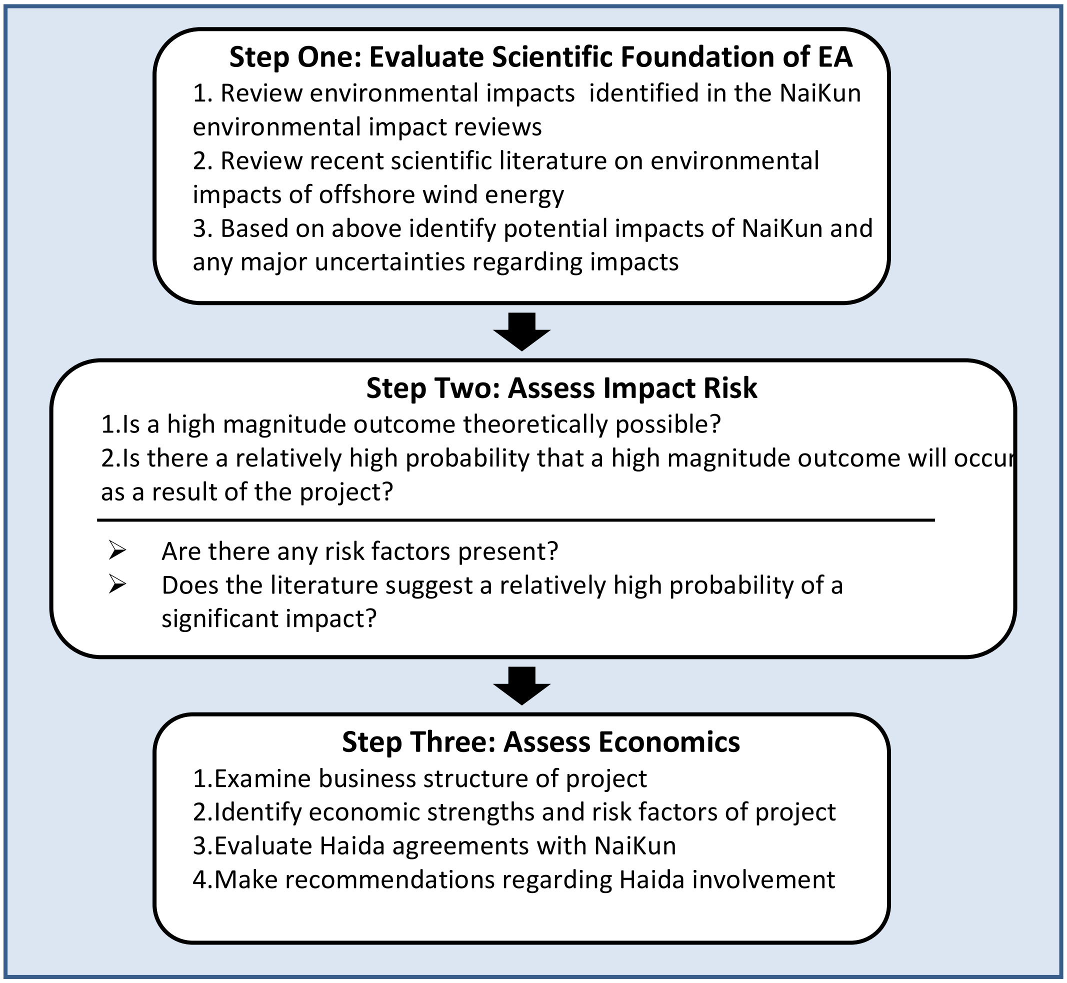
[3] http://wokinfo.com/products_tools/multidisciplinary/webofscience/

available documents generated through the EA process as well as confidential materials provided to us by the proponent and the Haida. To help assess the business case we built a spreadsheet-based economic model of the project to test alternative scenarios.



**Step One: Evaluate Scientific Foundation of EA**

1. Review environmental impacts identified in the NaiKun environmental impact reviews
2. Review recent scientific literature on environmental impacts of offshore wind energy
3. Based on above identify potential impacts of NaiKun and any major uncertainties regarding impacts

**Step Two: Assess Impact Risk**

1.Is a high magnitude outcome theoretically possible?
2.Is there a relatively high probability that a high magnitude outcome will occur as a result of the project?

- Are there any risk factors present?
- Does the literature suggest a relatively high probability of a significant impact?

**Step Three: Assess Economics**

1.Examine business structure of project
2.Identify economic strengths and risk factors of project
3.Evaluate Haida agreements with NaiKun
4.Make recommendations regarding Haida involvement

**Figure 3. Study Methodology**

## 1.5 History of Offshore Wind Energy[4]

Windmills used for electricity generation date back to the late 1800s when inventors in the USA and Scotland developed initial designs and employed them to power their homes. At roughly the same time in Denmark, Poul La Cour developed a wind turbine that incorporated aerodynamic design principles such as airfoil shapes. By the end of World War I, La Cour's wind turbine machines were in use across Denmark. After World War II wind energy development was being advanced in the USA as well as across Europe. In 1941 the world's first MW capacity wind generator was built in the USA with 75-foot blades. In 1957 the first 'modern' wind energy generator was erected in Germany, and in 1980 in New Hampshire, USA the world's first wind farm consisting of 20 turbines was erected. By the early 1990s wind power had begun to be appreciated as a viable source of energy.

To date most wind power development has been in Europe where there are now more than 25,000 wind farms in operation with more planned over the next decade. Significant expansions are also planned elsewhere in the world. In Canada, the first wind energy project was built in 1993 in the Yukon. Today Canada has over 4 gigawatts (GW) of wind capacity installed across the country (CanWEA Undated).

Growth in wind power around the world is attributed largely to policy initiatives aimed at increasing renewable energy generation and reducing the carbon footprint of electricity generation. As room for land-based wind farms has been used up and land-use conflicts have arisen, the wind power industry has been increasingly shifting to the offshore.

The world's first offshore wind farm was built in 1986 off the coast of Denmark near the community of Ebeltoft (the Vindeby farm). At time of writing there are about 40 offshore wind farms across Europe and offshore China and Japan with over 3 GW of capacity. The Thanet Offshore Wind Project in United Kingdom is the largest offshore wind farm in the world at 300 MW capacity, but numerous larger offshore wind farms are in construction or planning, some up to 1,000 MW in capacity. Currently there is no offshore wind generation in North America, though plans for offshore farms exist in BC (NaiKun at a planned capacity of 396 MW), Ontario, Delaware, Maryland, Massachusetts, New Jersey, New York, Rhode Island, and Texas.

Table 2 presents global wind generation capacity on- and offshore and total electricity generation by country. In most countries, wind (and even more so offshore wind) plays a relatively minor role in electricity generation.

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[4] In addition to materials referenced in the text this section was written based upon materials at several websites:

- http://www.epo.org/topics/innovation-and-economy/european-inventor/inventions/2008/wind-energy.html
- http://www.guardian.co.uk/environment/2008/oct/17/wind-power-renewable-energy
- http://en.wikipedia.org/wiki/Offshore_wind_power
- http://www.offshorewindenergy.org/
- http://www.canwea.ca/index_e.php
- http://en.wikipedia.org/wiki/List_of_offshore_wind_farms

**Table 2. Global wind generation capacity.**

| Country | Total wind power capacity end of 2009[1] (MW) | Total offshore capacity end of 2009[1] (MW) | Proportion of wind capacity offshore | Total electricity production from wind, 2009[2] |
|---|---:|---:|---:|---:|
| USA | 35,159 | 0 | 0.0% | 1.9% |
| China | 26,010 | 23 | 0.1% | Unavailable |
| Germany | 25,777 | 72 | 0.3% | 6.5% |
| Spain | 19,149 | 10 | 0.1% | 14.4% |
| India | 10,925 | 0 | 0.0% | Unavailable |
| Italy | 4,850 | 0 | 0.0% | 2.1% |
| France | 4,521 | 0 | 0.0% | Unavailable |
| UK | 4,092 | 688 | 16.8% | 1.7% |
| Portugal | 3,535 | 0 | 0.0% | 15.0% |
| Denmark | 3,497 | 664 | 19.0% | 19.3% |
| Canada | 3,319 | 0 | 0.0% | 1.8% |
| **World** | **159,213** | **1956** | **1.2%** | **Unavailable** |

Sources: 1. WWEA (2010). 2. IEA (2010).

## 1.6 Economics of Offshore Wind

Offshore wind is generally considered an expensive source of electricity. In its most recent Annual Energy Outlook, the US Energy Information Administration estimates new offshore wind generation to cost \$243 per MWh compared to \$66 for conventional natural gas, \$86 for hydro, \$95 for conventional coal, \$97 for onshore wind, \$113 for biomass, \$114 for nuclear, \$136 for advanced coal with carbon capture and storage, and \$210 for solar (US EIA 2011). The US agency estimates that only solar thermal at \$312 is more expensive than offshore wind. Costs for offshore wind have increased significantly from 2006 to 2009 (Henderson et al. 2009).

However, a critical deficiency in many cost comparisons of alternative power sources is the exclusion of environmental costs. Environmental costs are costs not borne by suppliers of electricity or consumers of electricity, but by society as a whole. Two environmental costs of conventional coal-fired electricity generation, for example, are increased health care costs caused by smog formed from the nitrous oxide emissions of the generation plants, and climate change impacts caused by greenhouse gas emissions. In most cases, these health care costs and the costs associated with climate change are not paid for by the generation companies, or by ratepayers. When such environmental costs are included in the analysis, wind energy becomes competitive with other generation sources (figure 4)(see also European Commission 2003; Kammen and Pacca 2004; Sundqvist 2004). The challenge in making wind energy economically attractive therefore is to ensure that the environmental benefits of wind relative to other sources of energy are included in decision making.

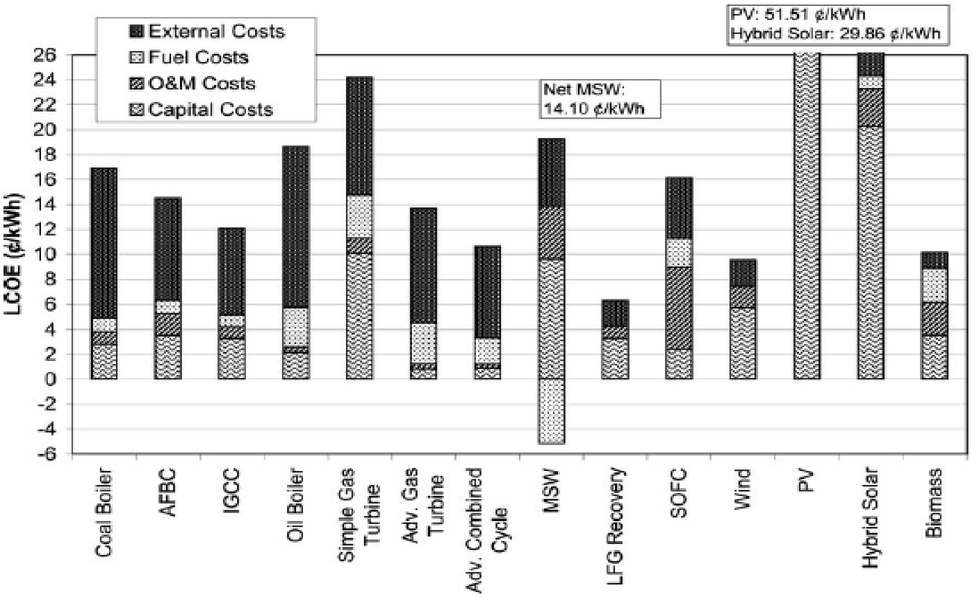

**Figure 4. Levelized costs for different electricity sources (Roth and Ambs 2004).**

AFBC = advanced fluidized bed combustion (coal). IGCC = integrated gasification combined cycle. MSW = mass burn municipal solid waste. LFG Recovery = landfill gas recovery. SOFC = solid oxide fuel cells. PV = utility scale flat plate photovoltaic (solar).

## 2. Marine Physical Environment

The Haida Gwaii wind energy proposal entails physical alterations at the wind farm and along the subsea transmission lines due to pile driving, emplacement of WTGs, and laying and burying of transmission cables. The emplacement of pilings and WTGs, as well as the planned mitigation measure of placing scouring protection devices, will alter the local seabed currents and lead to sediment erosion, or scouring, and sediment deposition. When scoured, sediment is transported away and underlying rock may become exposed. These disturbances have the potential to alter the physical environment at the project site as well as the surrounding seabed geomorphology. According to the proponent, the key issues associated with the marine physical environment are scouring effects on the seabed and ‘far-field littoral effects’ (NWEG 2009, 4-8).

The area’s physical character is the product of the dynamic interplay between waves, tidal currents, and seabed composition. The project area’s seabed is very dynamic because it is shallow and subject to strong currents and waves: the area is “a very active environment for foundation design and construction” (RPS Energy 2009, 24). The Geological Survey of Canada classified the shoreline on Graham Island as very sensitive to accelerated sea-level-rise impacts because of the area’s “macrotidal range, erodible sediments, frequent windstorms and surges, and an energetic wave climate” (RPS Energy 2009, 62).

To assess the potential for the project to cause significant adverse impacts on the marine physical environment the proponent conducted a literature review, gathered local data, and hired an international consultant with expertise in assessing the marine physical effects of offshore wind farms. This consultant (RPS Energy) adapted a model of physical effects of a planned Irish offshore wind farm (Codling Bank) to assess effects of the project on the local wind, wave, and tidal current regime. The consultant also used the monitoring results from an existing offshore wind farm (Scroby Sands, UK) to assess, by extension, the potential effects of the project on the shoreline of Graham Island. Based upon these investigations, and with various mitigation measures implemented, the proponent concluded that the effect of scouring will be localized around the emplaced structures and that entrained sediment will be thinly distributed over the local area. The proponent noted that due to the geographic distance between the proposed wind farm site and Graham Island, the currents and sediment dynamics that maintain the shoreline of Graham Island are separate from those that exist at the wind farm site. Consequently, they concluded that construction and operations of the wind farm will have no effect on the shorelines of Graham Island (NWEG 2009; RPS Energy 2009). Rescan, the BC EAO, and federal authorities also concluded that with planned mitigation measures the project should have no significant effect on the shorelines of Graham Island.

A challenge in assessing the impacts of the project on marine physical environment is lack of data related to marine physical effects from the local area. No other marine developments in the area exist to draw monitoring data from, and consequently much of the research done on the topic of effects of the project on the marine physical environment for the EA are predictive modelling studies based on other areas. This reduces the confidence level in the proponent's conclusions. Federal authorities reviewing the EIS expressed similar cautions.

The primary information source used by the proponent to predict the effect of the project on wind, waves, and tidal currents was a model developed by their consultant for the EA of an as-of-yet unbuilt offshore wind farm on Codling Bank off of Ireland (RPS Energy 2009).[5] The consultant justified using Codling Bank in Ireland on the grounds that it is similar in terms of bottom composition, water depths, wave regime, and tidal currents to Dogfish Banks of Haida Gwaii. The proponent provided no information on the accuracy of the model and the degree to which the model had been tested. Also the proponent did not review experiences of other offshore wind farms to buttress the findings of their model. Consequently, we concur with the reservations expressed in the Rescan, BC EAO, and federal reviews about the scientific robustness of the predicted impacts of the proposed project on wind, wave, and tidal currents. These issues were subject to subsequent review and analysis by the proponent in response to the Rescan comments and mitigation measures were developed. We agree with the Rescan, BC EAO, and federal reviews that the planned mitigation measures will address this uncertainty.

The primary information sources for the assessment of the effects of the project on the shoreline of Graham Island are better. One data source used by the proponent's consultant was Amos' (1995 in RPS Energy 2009) modelling of shoreline dynamics on Graham Island. Another source was a monitoring report from a UK offshore wind farm (Scroby Sands). According to the proponent, Scroby Sands is comparable to the project area because it is also shallow, exposed to storms, and has a mobile seabed. As this latter source was empirical evidence and not modelling predictions, we have greater confidence in the conclusions drawn from this component of the EIS. However, as with the Irish case study, the proponent did not provide sufficient justification for the choice of Scroby Sands over other potential comparisons. While monitoring data from Scroby Sands indicates little shoreline effect, what has occurred at other offshore wind farms? There

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[5] http://www.4coffshore.com/windfarms/codling-bank-ireland-ie02.html

may be no other comparable sites, but this is not indicated in the proponent's EIS. The proponent may have used Scroby Sands as a case study given the role of one of their partners – Offshore Design Engineering – in that wind farm, but additional comparisons would have been useful.

One other shortcoming of this part of the EA, as noted by Rescan, is that the proponent's review of the literature on the subject was incomplete, particularly with respect to the topics of the local wave regime and tidal currents. To address this we reviewed additional scientific evidence. We did not uncover any new information that conflicts with the conclusions of the proponent in our review of the literature and thus we have no reason to challenge the conclusion that the project will not cause significant adverse effects. However, consistent with other reviewers of the EIS, we note that there is uncertainty as to the effect that the project will have on the marine physical environment due to the deficiencies in the information upon which the proponent's consultant's conclusions rest. We also note uncertainties in the efficacy of mitigation measures including 'bypass' dredging at preventing significant impacts on the shorelines of Graham Island. We do note, though, that the proponent has made commitments to monitor sediment at the project site and to monitor changes on Graham Island. This monitoring should help identify any problems as the project is being constructed. As such, we conclude that risk of significant changes to the shorelines of Graham Island with associated aesthetic, cultural, and potentially economic (tourism) effects is low.

# 3. Effects on Marine Biota[6]

As detailed in the proponent's EIS, the project location is home to a diverse array of pelagic (open-ocean / water column) and benthic (seabed) fish, mobile invertebrates, and other benthic biota. The physical effects of the project discussed above in section 2 potentially affect this biota. This biota may also be affected by: noise and vibration during construction and operations; electromagnetic fields along submarine cable routes; copper dust contamination; and accidental spills.

The proponent's assessment of the impacts on marine biota is comprehensive and evidence-based. Volumes 5 and 6 of the EIS provide detailed descriptions of the project area, field studies undertaken by the proponent, reviews of pertinent literature, and explanations of the methods used to conduct the assessment. Notably, this part of the assessment benefitted from a variety of existing science reviews such as a 2007 synthesis of existing research conducted for the US Minerals Management Service (Michel et al. 2007). Compared to the study of the effect of the project on the marine physical environment (section 2), this part of the EIS has a much better scientific basis and thus we have much more confidence in the conclusions. However, as many of the impacts discussed in this section relate strongly to the physical impacts discussed in section 2, there is a need for on-going mitigating measures to address uncertainty.

## 3.1 Effects of Physical Changes

The physical changes that the project will introduce to the project area will have some effect on the local benthic habitat, though as noted, this is a naturally dynamic

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[6] To be consistent with the EIS and other reviews in the EA we discuss effects on marine mammals and birds separately in sections 4 and 5 below.

seafloor that is constantly changing. Emplacement of WTGs, the offshore converter station, scouring protection devices, and transmission cables causes sediment to be stirred up. The increased turbidity in the water column may affect local organisms, and settling of sediment may smother local benthos including eggs and larvae. The proponent concluded that sediment suspension and redistribution would be temporary during construction and localized in geography. To minimize turbidity and smothering the proponent committed to using dynamically-positioned vessels to reduce anchor effects and maintaining 1.5m clearance of propellers, among other mitigation measures. We expect that any residual impacts are of little consequence as research in Europe has shown that such a scale of change is within natural variation as sandbanks (the typical seabed favoured for WTG emplacement and the type of seabed where the NaiKun project is planned) are by definition highly dynamic environments (Wilson et al. 2010).

Once constructed and operational, the project will have a footprint on the seabed by way of the emplacement of pilings and scouring protection devices. The proponent estimated that the footprint is 0.1% of the available habitat in the wind farm area. This is comparable to the 0.15% footprint estimated for the Barrow Offshore Wind Farm, UK (Wilson et al. 2010). The proponent acknowledged this habitat loss but indicated that in selecting exact locations for structures they would avoid sensitive habitats such as sponge reefs and clam beds. The proponent has committed to habitat compensation to address habitat losses caused by the project.

While not stressed in the EA it should also be noted that emplacement of structures on the seabed can actually *expand* habitat in two ways. First, as mentioned above in section 2, emplacement will cause scouring. This scouring may change the seabed immediately around the WTGs from sand to cobble or boulders, providing habitat for many species such as barnacles, crabs, and reef fish (but taking habitat away from benthos that depend upon sand). The proponent plans to minimize scouring by placing scouring protection devices around the WTGs. The proponent estimates that the effect of the project will be to increase cobble/boulder habitat by only 2.5%. Given its greater physical complexity compared to sand, this created habitat may be beneficial to crabs and other species desirable to the Haida and/or other stakeholders.

More significantly, and as acknowledged by the proponent, new habitat is also provided by the emplaced structures themselves – the pilings and bases of WTGs, as well as the scouring protection devices, introduce new substrates (surfaces and structures) for biotic colonization. WTG foundations will have a diameter of about five metres. The proponent noted the both “positive and negative” ramifications of this introduced substrate (NWEG 2009, 7-2), based upon their studies including data from monitoring studies at offshore wind farms in Europe such as the Horns Rev farm in Denmark.

The artificial reefs created by emplaced structures in marine environments are often credited with creating local biological hotspots which are associated with enhanced species abundances and diversity (Thorpe 1999; OWE 2002; ETNWE 2003; Soerenson et al. 2003; ENTec 2007; Inger et al. 2009; Wilhelmsson 2009; Langhamer et al. 2010; Wilson et al. 2010). Typically, the structures attract shellfish and other benthic species that prefer hard substrates, which in turn attract reef fish and other organisms higher up the food chain. In doing so, species not typically found in the area, such as reef fish, may be introduced to the local site.

If fishing is restricted around emplaced structures, as often occurs to protect both the structures and fishers' gear, then this local area effectively becomes a protected area (or fishing exclusion zone). Some research concludes that protected areas increase regional fish populations (OWE 2002; ETNWE 2003; Soerenson et al. 2003; Halcrow Group 2006; Langhamer et al. 2010; Wilson et al. 2010), while other research concludes that they may simply attract fish from elsewhere and shift regional fish distributions instead of boosting total fish populations (Manago and Williamson 1998; Patin 1999; Inger et al. 2009; Langhamer et al. 2010; Wilson et al. 2010). If fish populations are increased this will enhance fishing opportunities adjacent to the wind farm, a topic we take up further in section 8.

Regardless of these uncertainties, an important conclusion of artificial reef research is that reefs can be designed to achieve specific objectives such as enhanced commercial harvesting of fish (Langhamer et al. 2010). In a recent study of the effects of artificial reefs on benthic ecosystems provided by offshore wind and wave energy installations off of Sweden's coast, Wilhelmsson (2009) found that filtrating organisms such as mussels and barnacles were attracted to the foundations and that the 'structural complexity' of foundations was very influential in determining the effect on benthic ecosystems. The degree of the 'artificial reef effect' appears to be determined predominantly by the physical complexity of the structure(s) installed (Inger et al. 2009; Wilson and Elliott 2009; Wilson et al. 2010). The implication is that reef designers – in this case NaiKun – could establish habitat favourable to desirable species such as Dungeness crab. As discussed in detail by Wilson and Elliott (2009), developers can engineer a community at the bases of WTGs through choice of materials. Different species prefer different habitats and so developers can choose scouring protection devices and even WTG bases in concert with what is desired.

Developers and regulators should be cognizant that current artificial reef science is young, despite many decades of experience gathered through the study of offshore oil and gas development (METOC 2000; Inger et al. 2009; Wilson and Elliott 2009; Wilson et al. 2010), and this means that there is uncertainty about the impacts. Wilhelmsson (2009) found that enhanced structural complexity in scour protection devices may adversely affect some species by inducing predation, and research elsewhere also indicates that artificial reefs may change the species mix of the area for better, or for worse, through the enhancement of both desirable and undesirable species abundances, the change of ecosystem dynamics to the benefit or detriment of desirable species, and the attraction of detrimental exotic or invasive species (Thorpe 1999; Ball 2002; Inger et al. 2009; Maar et al. 2009; Langhamer et al. 2010; Wilson et al. 2010).

We note that the proponent plans to minimize any changes in ecosystem dynamics by not attempting to engineer subsurface habitat. This strategy of minimization of change appears prudent given the uncertain side-effects of artificial reefs. We also note the commitments that the proponent has made towards monitoring various species such as sand lance, flatfish, and prey fish. This monitoring will help the proponent adapt the project to prevent adverse ecological reactions caused by the project, though if problems are noticed after the project is constructed there may be little that can be done (other than decommissioning).

Overall, we conclude that the science underlying the impacts of emplacement of offshore wind farms on physical processes to be advanced enough to provide high confidence in the predictions made in the NaiKun EA, with the exception of effects on ecosystem dynamics such as predator-prey relationships and the effect of species attracted to the project area by the new habitat created by the project. This gap in the EA is important given the lengthy history around the world of human-induced changes to ecosystems with negative effects, and the presence of a valued crab fishery at the project site which could be affected by ecosystem changes induced by the project. With the limited study of the project on potential ecological changes induced by the emplacement of physical structures at the project site and the limited science on the topic we are not able to fully assess the magnitude of risk posed by the project in this regard. Consequently, it is important that the proposed adaptive management mitigation measures to address this uncertainty be effectively implemented. With this caveat, the proponent established a strong basis for their findings through their extensive studies, literature reviews, and use of empirical monitoring data.

## 3.2 Noise and Vibration

Marine construction including pile driving and the laying of cables is typically a noisy process involving boats, underwater machinery, and helicopters. During operations there is less activity but there is still the noise and vibration of boat and helicopter traffic and WTGs. Marine traffic through the NaiKun project site is not uncommon at present, though the project will introduce higher levels of activity concentrated at the wind farm site and along the transmission cable routes. Vibration from the WTGs in operation will be a completely new phenomenon for the wind farm area.

Noise can be detrimental to marine biota in three ways. First, noise in the marine environment can mask environmental sounds and interfere with organisms’ hearing, signalling, orientation, and navigation (Wahlberg and Westerberg 2005; Inger et al. 2009; Langhamer et al. 2010; Wilson et al. 2010). Second, noise can cause injury and even mortality (Inger et al. 2009; Langhamer et al. 2010), such as when fish and other biota are within about 100m of pile-driving, drilling, and dredging (Nedwell et al. 2003; ENTec 2007). Consequently, noise can cause organisms to avoid impacted areas with the effect of reducing suitable habitat (Wilson et al. 2010).

However, while marine biota in general reacts to noise, it doesn’t seem to be negatively affected by low levels of noise. Fish have been found to avoid WTGs, but only when very close, i.e., within 4m (Andersson et al. 2007 in Wahlberg and Westerberg 2005; Inger et al. 2009). The offshore oil and gas development literature similarly finds that operational noises are unlikely to have much effect on marine biota (e.g., Kenchington 1997; AGRA 1998). As such it seems reasonable to conclude that low levels of noise from the project, such as operational noise, will have little if any effect on local biota.

These conclusions in the literature support the proponent’s conclusions presented in their EIS. Through noise modelling and their own literature review, including consideration of the conclusions of other studies of offshore wind farm noise, the proponent concluded that pile driving is the only activity associated with the project that could cause injury. The proponent’s modelling concluded that noise of levels beyond injury thresholds would be exceeded at distances within 17 to 40m of pile-driving, even with mitigation measures taken. The proponent concluded that mobile species and species without swim bladders should be minimally affected, but less mobile and immobile species and species with swim bladders may suffer impacts. For mobile species, displacement from pile driving noise should only be temporary. With respect to low level noise, such as from vessels and WTGs during operations, the proponent's conclusions that little harm is expected are consistent with the literature.

However, as acknowledged by the proponent and stressed by Fisheries and Oceans Canada, the BC EAO, and the literature (e.g., Richardson et al. 1995; METOC 2000; Nedwell et al. 2003; Popper 2003; USNAS 2003; Betke and Schultz-von Glahn 2004; Wahlberg and Westerberg 2005; Inger et al. 2009), there is much uncertainty in the effects of noise on marine biota. The proponent noted that the safety thresholds used for modelling distances from pile-driving that would cause harm are "based on best available science" but that they "have not been rigorously field-tested" (NWEG 2009, 7-34). The bulk of the research on underwater noise has been on the effects of noise to marine mammals and fish; little research has been conducted on invertebrates such as crabs. The proponent demonstrated that safety thresholds for fish were based in a variety of studies but noted that there is insufficient science to establish safety thresholds for invertebrates. Similarly the proponent pointed out that no safety thresholds existed for continuous noise – i.e., operational noise – and no thresholds are established for behavioural reactions. The mitigation measures planned seem to be reasonable means to address the impacts of the noise of pile-driving on marine biota. Given the relatively poor understanding that scientists have of the effect of underwater noise on marine biota, mitigation measures such as prevention (i.e., noise reduction at source) and monitoring are prudent.

Another potential impact can result from vibration generated by WTGs in operation. The proponent concluded that the effects were likely minor but uncertain and so they committed to a monitoring program of sand lance. The proponent noted that there is a lack of scientific literature on the subject, and as well there is a lack of ambient vibration data for the project area. The proponent suggested that vibration effects of terrestrial wind farms could be used as a surrogate source of data, but it is unclear how relevant this data would be to the marine environment. We did not find any new literature on vibration to enhance the discussion of this subject.

In conclusion, we have medium confidence in the EA on the topics of noise and vibration. There are gaps in the science of underwater noise and vibration that create uncertainty regarding potential impacts. However, the sizeable body of existing science on the topic suggests that the project will cause relatively few impacts from noise and vibration when mitigation measures are taken. It is also important to emphasize that the most concerning of these noise impacts are temporary: they will cease after construction.

## 3.3 Electromagnetic Fields

Another concern is the possible effect of electromagnetic fields (EMFs) from power cables on marine biota, particularly on Dungeness crab movement and migration. Many species of marine animals use the Earth's magnetic field for navigation and sense electrical fluxes for hunting, such as migratory fish, elasmobranches (e.g., sharks and rays), and marine mammals. As detailed in the EIS, numerous animals that inhabit the project area have these capabilities.

The proponent considered two potential effects of EMFs: effects on organisms' ability to migrate, and impairment of prey detection. Based upon a review of the literature on the subject – including several reviews of the state of the science – and their modelling of the project's EMF effects, the proponent concluded that the project's EMFs would not cause significant adverse effects on marine biota in the project area. The proponent concluded that the project would cause only weak EMFs to be present and that burial of power cables to 1m would reduce EMF strength to insignificant levels. However, the proponent noted that elasmobranchs (such as sharks and dogfish) would be able to detect the EMFs, that no specific studies of local species' sensitivity to EMFs existed, and that little research has been conducted on the effects of EMFs on invertebrates. Consequently, to address stakeholder concerns (including those of the federal government) the proponent committed to further studies including monitoring of global research on the topic, monitoring of marine biota (e.g., of Dungeness crab movement and catch-per-unit-effort), burying cables to 2m depth where trawling occurs to reduce even further the impacts of EMFs on groundfish as well as prevent entanglement of fishing gear, and monitoring of cables after their laying to ensure they remain buried. This latter measure is important to prevent 'free spans' where scouring leaves transmission cables suspended which would both lead to greater EMF exposure as well as potential tangling of fishing gear. Where not possible due to hard sea bottom, the proponent committed to insulating the cables and/or emplacing cables within the rock bottom through horizontal directional drilling. These mitigation measures should prevent obstruction with fishing activities such as crab fishing and should mitigate the seemingly minor effects of EMFs on marine biota.

The proponent's conclusions as to the insignificance of the project's EMFs are generally consistent with our own review of the literature. Inger et al. (2009) noted that there is very little evidence of negative effects of EMFs on marine biota but that the topic is ripe for further scientific investigation. Langhamer et al. (2010) concluded that there is no strong evidence that undersea cables have any significant effect on marine biota, but they did acknowledge that the data is weak on this matter. Wilson et al. (2010) concluded that EMFs may cause both attraction and avoidance responses in fish, but these effects will be limited to the narrow corridor along cable transmission routes. Wilson et al. further noted that electromagnetic radiation may affect hunting performance or migration, but likely only for benthic or demersal species and that there is "little direct behavioural evidence" to back up these hypothetical observations (1396).

Obviously, a key message from the recent literature is that while there is no evidence of significant impacts of EMFs, uncertainty remains as to the effects of EMFs on marine biota. Given the uncertainty we support mitigation measures that minimize exposure and provide for monitoring and changes in practices if serious effects are found. The Dungeness crab monitoring program seems to be particularly important given that the crab is a benthic species and the value of the crab fishing industry in the area. Overall, we find that with the current uncertainties in EMF science we have medium confidence in the EA conclusions regarding EMF effects and mitigation measures. Further, though the uncertainties are worth probing through active adaptive management measures, the balance of evidence suggests that there is little risk of significant impacts from EMFs.

## 3.4 Copper

Another issue examined in the project reviews is the potential release of copper from WTGs into the marine environment. One study of the Horns Rev, Denmark offshore wind farm reported on in Volume 1 of the EIS found that each WTG released some copper dust but that the amount was small relative to ambient concentrations. In the case of the NaiKun project, the proponent assured that any dust that is generated through friction is contained in closed compartments of WTGs and will be cleaned out by vacuuming during regular maintenance. Overall, the proponent provided little discussion of the topic in their EIS, and the proponent relied upon one single study of Horns Rev for their conclusions. We did not find any other studies in our literature search on this issue. The scientific basis of this component of the EA is weak and thus our scientific confidence in this topic is low. However, the proposed mitigation measure of vacuuming would appear to address any concerns and thus we conclude that the risk of a significant impact from copper dust is low.

## 3.5 Spills

The proponent noted the potential for spills from vessels during construction or operations, as well as from vessels not associated with the project, such as fishing or tourist vessels that could collide with a WTG. The proponent concluded that the probability of spills is low for several reasons: (a) there is little vessel traffic in the shallow waters of the project area beyond fishing vessels and (what is assumed to be) rare recreational vessels[7], (b) lighting, marking, and navigational aids placed on the WTGs, and (c) the Transportation Safety Board of Canada incident data for the past 10 years show no 'notable' oil spills for Hecate Strait (NWEG 2009, 15-8). Based on our literature review, we conclude that collisions between WTGs and vessels are more likely to result in damage to WTGs than ships, and thus a spill from such a collision is unlikely (OWE 2002; ETNWE 2003). Nonetheless, the proponent concluded that any spills would be of "medium effect consequence" and that a hydrocarbon spill in particular would be of "high effect consequence" (NWEG 2009, section 15). We concur with the proponent's conclusions that the probability of spills is low but consequence of a spill could be significant. This is an important finding that underlines the significance of having a comprehensive spill response plan.

Spills are low probability events, but the possibility of a spill over the operating life of the project cannot be ruled out. The key issues with respect to spills are their potential scale, their chemical composition, and the vulnerability of the marine environment to sustaining the contamination, particularly fish and other marine species of importance to the Haida and other stakeholders.

The scale of potential spills from the wind energy project is unclear. Marine vessels associated with the project may have a wide range of chemicals on board including fuel, cleaning supplies, fire retardants, lubricants, cementing materials, and hydraulic fluids. The most voluminous toxic material identified in the EIS that poses a spill risk is the 75,000 L of diesel fuel that will be stored on the offshore converter station to run emergency generators.[8] There is also a spill risk generated by the fuel carried by vessels associated with the project (e.g., maintenance ships) and other vessels in the area. The Queen of the North ferry that sank in Wright Sound in 2006 was carrying "hundreds of thousands of litres of diesel and lubricating oils" (NWEG 2009, p8-52 and 9-40) and in various places in the EIS the proponent writes that large volumes of hydrocarbons may be present on ships associated with the project or otherwise in the project area and posing a spill risk (NWEG 2009, p8-58 and 9-55).

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[7] The proponent indicated that there are no statistics on recreational marine traffic in the region.

[8] Seventy five thousands litres is the volumetric equivalent of about 472 barrels of oil.

According to the EIS the most voluminous chemical that may be spilled is diesel fuel. The proponent indicated that diesel evaporates more readily than crude oil, implying that spillage of diesel would be of lesser environmental impact than crude oil spills.

The marine environment of Hecate Strait has a variety of qualities that affect the risk of spills. When chemicals are spilled into the marine environment they are rapidly acted upon by a number of physical, chemical, and biological "weathering" processes. Oil spills at the water's surface rapidly spread into slicks that eventually cover large areas of the sea surface (Patin 1999). Slicks immediately begin moving with the prevailing water flow regime and may break into many 'windrows' parallel to the wind direction. While dispersing in the water, hydrocarbons tend to dissolve, evaporate, emulsify, disperse within the water column, aggregate into lumps or balls, oxidize, enter the sediment, adhere to shorelines or other surfaces, or absorb into the ecosystem. The high-energy environment off of Haida Gwaii may serve to minimize spill damage. Hecate Strait is known for high winds and waves, and these meteorological conditions can be expected to disperse and decompose spills. This positive quality of the region, however, may be offset by the shoreline and ecological characteristics of Haida Gwaii and Hecate Strait.

Modelling of oil spills between Haida Gwaii and the BC mainland coast finds that marine currents will disperse contaminants along the eastern shores of Haida Gwaii, the west coast of mainland BC, and the northern tip of Vancouver Island (Crawford et al. 2002; Cretney et al. 2002).[9] Crawford et al. (2002, 7) note that "for Queen Charlotte Sound and Hecate Strait, particularly in winter, prevailing winds and storm systems will undoubtedly transport spilled oil onto shores." This dispersal pattern elevates the damage caused by spills because it means spills will more than likely strike biologically-important shorelines.

Another risk factor is the physical characteristics of the area's shorelines in terms of sediment permeability and wave exposure (GESAMP 1993; Strong et al. 2002). Bornhold and Harper (2001 in Strong et al. 2002) estimate that substantial portions of the coastline within the Queen Charlotte Basin are highly permeable to oil and have low wave exposure. They estimated that 6,000 km, or 35%, of BC's North Coast has the highest oil residence class, meaning that spilled oil will enter shoreline sediment and remain there for a long period of time. Hydrocarbons that strike shorelines pose immediate threats to shoreline biota, but over time hydrocarbons embedded in shorelines can also chemically transform into more toxic forms that pose long-term chronic effects on shoreline biota (see Gunton et al. 2004). Further examination of shoreline residence of diesel compared to crude oil is warranted in order to better understand the potential impacts of a diesel spill on the region's marine environment.

A fourth risk factor is that the North Coast marine environment is important ecologically. The region's marine ecosystem is rich and highly productive and provides habitat for a diversity of fish, marine mammal, and seabird populations, as catalogued in the EIS. According to the Royal Society of Canada's report on potential offshore oil and gas development in BC, the region is one of the most important habitats for marine birds on the west coast of North America (Strong et al. 2002). As such, any spill in the project

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[9] The proponent cited modelling of oil spills in Hecate Strait by Living Oceans Society but did not present any information on this work. As such we are unable to determine if the two modelling exercises compare or conflict.

area will occur in one of the world's most ecologically important marine environments and has the potential to cause significant ecological damage.

A fifth risk factor is that the regional ecosystem is already stressed by fishing, forestry, marine vessel traffic, municipal and agriculture pollution, atmospheric fallout, introduced species, climate change, and other stressors. A number of species in the basin are already responding to cumulative effects (JWEL 2001; Strong et al. 2002; Bertram 2003; Sinclair 2003; RSC 2004). The proponents did not explore this and the previously-mentioned risk factors, perhaps because of their determination that the probability of spill is low.

An important consideration in assessing spill risk is that the project may actually reduce the risk of spills by reducing the need for diesel-fired electricity generation on Haida Gwaii. Electricity on Haida Gwaii is currently generated by two diesel-fired generators and one small hydroelectric dam. With the project, Haida Gwaii will be connected to the BC electrical grid, and so even if the wind farm isn't producing power Haida Gwaii will still be able to receive electricity over the HaidaLink. To the extent that the project contributes to the displacing of diesel generation and reducing the marine transport of diesel it will have a significant positive role in reducing the risk of spills.

In conclusion, we have medium confidence in the scientific foundation of the EA on spill risk, and conclude that there is little risk of a significant impact from a spill from the project. Spills of large volumes of toxins into the marine environment with significant effects are possible, but we expect these to be very low in probability. Further, if the project does contribute to displacing diesel generation on Haida Gwaii, the project may actually *reduce* the overall risk of a serious spill in the region's waters. We do caution that however low the risk of a spill, it is important to have a comprehensive spill management plan in case a spill occurs. The proponent has committed to developing a spill emergency plan, but details of this plan are not available. Given the history and nature of marine spills – poor recovery rates, failure of responsible parties to be prepared, and poor reclamation success – the development of a comprehensive spill management plan is essential.

## 3.6 Invasive Species

Another environmental issue that needs to be assessed in marine development is introduction of invasive species, which can cause significant, long-term impacts in marine ecosystems. Invasive species can be introduced by the release of ballast water from vessels collecting water in one locale and discharging it elsewhere. Ballast water exchange is believed to be behind the introduction of the European green crab into San Francisco Bay, a species that has migrated up the west coast of North America and into BC waters threatening indigenous ecosystems (Larson et al. 2003). Busy international ports such as Vancouver and Prince Rupert can be expected to have a wide variety of international marine flora and fauna (Cohen Undated).

Current shipping activity in Hecate Strait already creates a risk of invasive species introduction. It is unclear what impact a wind energy project will have on shipping activity in the region. Additional shipping activity associated with NaiKun may be offset to some degree by a reduction of shipping activity associated with the transport of diesel fuel for electricity. Overall, due to insufficient information, we are unable to ascribe a level of risk to invasive species introduction. We emphasize that it is essential that a comprehensive mitigation strategy for reducing the risk of invasive species introduction be developed and implemented if the wind energy project proceeds. Currently no comprehensive mitigation strategy has been provided by NaiKun other than a commitment to comply with federal ballast discharge regulations made in response to concerns about invasive species contained in the Rescan report.

## 4. Marine Mammals

At least 35 marine mammal species are found in the project area, and some of them – killer whales, fin whales, gray whales, humpback whales, and harbour porpoise – are classified as at risk of extinction under the federal *Species at Risk Act*. Just as we noted above in section 3, marine mammals like other marine biota may be affected by the project's physical presence, ecological changes, noise (i.e., in terms of masking effects, displacement, and injury and mortality), human activity (i.e., vessel and helicopter activity), EMFs, and spills. Much of the literature that we reference above is as pertinent to marine mammals as it is to other marine biota.

The proponent's EIS considered numerous impact hypotheses pertaining to pile-driving noise impacts, operational noise, spills, changes to marine habitat affecting feeding, risks of collisions with ships, cable entanglement, and EMFs. The proponent examined these topics through three lenses: displacement, barriers to movement, and injury and mortality (NWEG 2009, 8-11). To explore these topics in the EA the proponent reviewed existing studies of local and regional marine mammal ecology, field studies, literature reviews, and modelling exercises.

The proponent identified noise as a potential cause of marine mammal displacement, both during construction (i.e., from pile driving, vessels, and helicopters) and operations (i.e., from WTGs and maintenance activities). Our review of the recent literature similarly finds that such noise may cause marine mammals to avoid impacted areas (e.g., Carstensen et al. 2006; Thompson et al. 2010). The proponent concluded that displacement from the noise would only be temporary and that as the project area is not key habitat the significance of this displacement is low.

The proponent also noted that numerous species migrate through the area and operational noise could create a barrier inhibiting migration if marine mammals seek to avoid the sound. The proponent's literature review highlighted the evidence that suggests that marine mammals are often not impacted by low intensity sound, though they did note in Volume 7 of the EIS that there is limited data on how marine mammals react to offshore wind farm operational noise in particular. Given the limited data, there remains uncertainty on how marine mammals may be impacted. Regardless, the proponent's conclusion that operational noise will not be significantly adverse to marine mammals is consistent with the recent literature we reviewed (e.g., Tougaard et al. 2009; Wilson et al. 2010) as well as the offshore oil and gas development literature (e.g., Kenchington 1997; AGRA 1998).

The proponent noted that pile driving, ship collisions, and cable entanglement could cause direct injury and mortality to marine mammals. Based upon a literature review and noise modelling referenced to US safety thresholds, the proponent concluded that none of these activities will generate negative impacts provided that identified mitigation measures are taken such as soft-starts to pile driving and speed limits on vessels.

An issue that we have with this part of the EIS – also noted by Rescan (2009) – is that greater emphasis should have been placed on the degree of uncertainty that exists in terms of assessing the impacts of noise of offshore wind farm construction and operations on marine mammals. The proponent used literature on the effects of seismic noise on marine mammals to assess the effects of pile-driving noise. The proponent's EIS does acknowledge that this literature on seismic noise may not be applicable to understanding the effects of pile-driving noise on marine mammals, that "very little is known" about pile-driving noise impacts on marine mammals, and that modelling results are "inconclusive" (LGL Limited et al. 2009, 81). Nonetheless, the gaps in knowledge of underwater noise and marine mammals (e.g., Richardson et al. 1995; METOC 2000; Nedwell et al. 2003; Popper 2003; USNAS 2003; Betke and Schultz-von Glahn 2004; Wahlberg and Westerberg 2005; Inger et al. 2009; Bailey et al. 2010) should have been more clearly highlighted in the EIS.

A second issue with this part of the EIS is the lack of empirical verification of models used by the proponent to predict noise impacts. Bailey et al. (2010) point out that the sound propagation models that are commonly used in assessments of offshore wind farms (including the NaiKun EIS) to determine safe distances for marine life to pile driving activities have not been subject to adequate empirical verification. In their test of the model in UK waters, Bailey et al. (2010) found that the standard model wasn't effective at predicting noise levels near pile-driving, and that application of the model 'outside of the laboratory' is challenged by variations in sites' depths, sea bottom characteristics, blow force, and related factors. In the NaiKun EIS – in the section on marine mammals but also elsewhere – there is often little discussion of the empirical validity of the models that are employed. This lack of empirical data is an issue that affects all EAs of offshore wind farms. This data gap is starting to be filled as offshore wind farms become common in Europe. Monitoring data has started to come in from the Horns Rev and Nysted offshore wind farms in Denmark and no concerns appear to exist at the present time in terms of how these farms affect seals and harbour porpoises (the two marine mammal species found in the area of the Danish farms).

Another scientific issue in the NaiKun EIS is in regards to the effects of EMFs on marine mammals such as interference with hunting and avoidance effects. The proponent briefly indicated in Volume 1 (p8-11) of the EIS that EMFs should not be consequential for marine mammals and as such did not discuss the topic further. Given the uncertainty in the science around EMFs and marine biota (section 3 above) we believe it is appropriate to recognize this potential, albeit likely minor, impact.

A topic not raised in the EIS is the potential of the project to affect marine mammals by altering local ecosystems. The proponent noted that the project's footprint would lead to a minor (0.1% area) withdraw of benthic habitat, but did not consider the effect of introduced habitat (both from exposed sea bed but also the emplacement of new substrates leading to artificial reef effects) on marine mammals. Rescan (2009) noted also that the EIS did not consider how noise might affect marine mammal prey, and the consequent effects this may have on marine mammals.

In conclusion we have medium confidence in the EA conclusions regarding marine mammal impacts. While there are gaps in the EA in assessing ecological changes and spills, there is a substantial literature on marine mammals and noise and spills that provides a reasonable foundation for understanding impacts. Based on our review of the evidence, with the exception of ecological changes induced by the project, we also conclude that there is little risk to marine mammals posed by the project.

## 5. Marine Birds

The proponent noted that the project area is important bird habitat in terms of foraging, migration, and wintering, and that over 100 species of birds inhabit the area, including several birds that are considered 'species at risk' such as Pink-footed Shearwater, Peregrine Falcon, Marbled Murrelet, and Ancient Murrelet. The proponent writes that "no other similar marine ecosystem exists on such a scale elsewhere on the B.C. coast" in terms of forage quality (LGL Limited et al. 2009, viii).

The proponent observed that the project posed several potential threats to birds including:

- acoustic effects ranging from masking of communications by project noise to injury and death by pile driving noise
- potential collisions with rotors, nacelles, and towers
- the potential for the project to form a barrier to daily or seasonal movements
- disturbance and displacement from such things as vessel activity or the visual presence of the wind farm, and
- hydrocarbon spills.

Through literature reviews and five different types of field studies, the proponent (and the BC EAO and federal government) concluded that despite these concerns the project would not have significant effects on marine birds.

A key issue documented in the literature pertaining to wind energy development is the risk of bird collision with spinning turbine blades. As explained by the proponent in the EIS, birds migrate both during the day and night, and they can become attracted to offshore structures due to artificial reef effects, lighting, or activity. Determining collision risk (and thus population-level effects) is species-specific (Desholm 2009; Warren and Birnie 2009; Burger et al. 2011). Key factors shaping collision risk include:

- flight patterns (e.g., height at which birds fly/migrate, and whether projects are in flight/migration paths)
- birds' flying abilities
- migration behaviour (e.g., if migration occurs during times of bad visibility such as night)
- annual reproductive output
- size, and
- the nature of lighting and other attractants at wind farms (Allison et al. 2008; Desholm 2009; Wilson et al. 2010; Burger et al. 2011).

Through a lengthy literature review and consideration of local data the proponent concluded that collision risk did not likely present a significant adverse effect on bird populations. However, the proponent did acknowledge the uncertainty of this conclusion. The proponent responded to the uncertainty by proposing plans for 'adaptive management' monitoring and adjustment in practices. Though such activities should be useful they will likely be frustrated by technical challenges such as the difficulty of detecting collisions and recovering carcasses at sea (Allison et al. 2008; Inger et al. 2009; Wilson et al. 2010).

A second key issue with offshore wind farms and birds is whether or not farms cause birds to incur substantial energy costs in their avoiding of the farms during travel. When birds avoid wind farms they may have to travel further, thus using more energy that may cause increased mortality and lower rates of reproduction (Allison et al. 2008; Wilson et al. 2010). If birds avoid the project area then there is also a loss of habitat, though birds may just shift their habitat in response to development (Allison et al. 2008). The proponent's planned spacing of WTGs (800m by 1,200m) is intended to reduce this 'barrier effect' for birds, but this strategy is untested and may not work. Birds may still travel around the project area – a 100 km$^2$ area – instead of going through it as hoped. The proponent concluded that even if birds go around the farm and incur an energy cost and a cost in terms of lost habitat the negative effects would not be significant.

As we have indicated previously, the EA overall paid very little attention to artificial reef effects. Artificial reefs may affect birds positively, or negatively (Wilson et al. 2010). Section 4.1.6 of Volume 8 of the EIS provides a surficial examination of the potential for artificial reefs to affect birds and draws upon very little literature on the subject, especially compared to other impact topics elsewhere in the EIS. This may be the case due to a lack of literature on the topic. Our search turned up only one recent reference (Joschko et al. 2008) which found that a research station offshore Germany led in two years to substantial mussel colonization which could, they speculated, lead to large amounts of new biomass among a wind farm causing widespread ecological changes affecting birds and other biota. Nonetheless, the proponent's brief discussion of this topic provides an inadequate foundation from which to assess how marine birds may be affected by the artificial reefs that will form throughout the wind farm, and how birds (and the area's ecosystem generally) will be affected. We do note, though, that the proponent committed to monitoring bird attraction to WTGs due to mussel colonization.

As with many potential impacts of offshore wind energy development, the scientists studying the topics note that there is high uncertainty in their understanding of how marine birds are affected. Inger et al. (2009) note that even with on-land wind farms, there is high uncertainty:

> *despite having been studied for over 10 years, the impacts of terrestrial wind farms on avian populations remains unclear* (1146).

In discussing public debates about wind farm development in Scotland, Warren and Birnie (2009) note that

> *the effects of wind farms on birds is [an] area in which debate has run far ahead of the evidence base* (111).

Allison et al. (2008) note that

> *substantial uncertainty remains in our ability to predict the impact of wind energy projects on birds in the offshore environment* (35).

The proponent noted uncertainty in their predictions of collision risk, displacement, and artificial reef effects. The proponent also noted high uncertainty regarding noise impacts on birds, such as how pile-driving might affect birds in the near vicinity. The proponent found only one study that examined the effects of pile driving on birds, and noted that there are no existing underwater audiograms for birds, no noise safety thresholds for birds, that "investigations into the effects of impulsive or continuous noises on marine birds are extremely limited" (LGL Limited et al. 2009, 80), and that there is even little information on the effects of seismic noise on birds.

In sum, there is insufficient evidence to draw firm conclusions regarding potential effects of the project on marine birds. Consequently, we stress that the implementation of the adaptive management strategy to assess and manage the impact on marine birds committed to by the proponent is essential. Also given that mitigation may be very difficult if impacts are determined after the project is built and operating, further investigation of these issues is warranted prior to project approval.

## 6. GHG Emissions

Though the EIS did not do so, the project can also be assessed in terms of greenhouse gas (GHG) emissions. The project will entail lifecycle GHG emissions from the manufacturing of concrete foundations and the fossil fuels burned in construction and operations in vessels and helicopters, among other sources (Snyder and Kaiser 2009; Warren and Birnie 2009). As pointed out by Rescan (2009), the project may lead to a reduction of GHGs because it may directly or indirectly displace fossil fuel-based electricity production in North America. The proponent estimates that the project will eliminate 26,000 tonnes of GHG emissions annually if diesel generation is displaced on Haida Gwaii, on top of a reduction of 450,000 tonnes of GHG emissions if the project displaces fossil-fuel based emissions elsewhere in North America (NaiKun 2011). The specific impact of the project on GHG emissions depends on what alternative supply the project ultimately displaces on Haida Gwaii, and the impact of the project on supply and demand in the provincial and North American energy markets. It is reasonable to assume that the project will ultimately directly or indirectly displace to some degree alternative fossil fuel-based electricity production in North America. Therefore, while the specific GHG emissions reductions are difficult to estimate accurately due to the complexity of energy markets, the project will result in a reduction of GHG emissions.

## 7. Cumulative Impacts

The EA examined the project in terms of cumulative effects. Cumulative effects are “changes to the environment that are caused by an action in combination with other past, present and future human actions” (Hegmann et al. 1999, 3). Cumulative effects are incremental changes that “may be significant even though the effects of each action, when independently assessed, are considered insignificant” (Hegmann et al. 1999, 1). The proponent’s EA examines cumulative effects associated with each impact assessment topic (i.e., sections 5 through 13 in Volume 1 of the EIS, as well as section 16 in Volume 1) and presents a summary review of cumulative effects (section 14 of Volume 1). The cumulative effects assessment is largely qualitative and relies in part on several studies such as Michel et al. (2007). The EA focuses primarily on cumulative environmental impacts, though cumulative socio-economic effects are also considered.

A key finding of the proponent’s assessment is that it is difficult to determine with certainty what the cumulative effects of the project might be. The proponent noted that:

> *[i]t is difficult to predict measurable cumulative effects on some environmental or socio-economic components that are potentially affected by the Project, not only because there is a lack of information generally on trends and responses of environmental or socio-economic components to cumulative effects of human activity, but because there is a lack of*

> *information specific to the effects of wind farms in the Pacific Northwest on these environmental or socio-economic components* (16-19),

that

> *it is not possible to quantitatively assess the potential contribution of the Project to cumulative effects arising from accidents and malfunctions* (16-20),

and that

> *[t]he level of detail of assessment of cumulative effects was constrained by the limited availability of information to describe past, present, and future projects and activities* (16-83).

Consistent with these statements, the proponent's cumulative effects summary tables (p16-26, 16-38, 16-45, 16-51, 16-57, 16-60, 16-62, 16-67, 16-71 of Volume 1 of the EIS) list numerous 'unknowns'. Even so, the proponent concluded that the project did not likely pose significant adverse cumulative effects. The federal government, in their screening review of the EIS, concluded that

> *while none of the residual effects are predicted to be significant with respect to the health and sustainability of the environmental or socio-economic components, some could potentially contribute at low levels to existing and potential future cumulative effects on the environmental or socio-economic components. Cumulative effects should therefore remain an important consideration, particularly with respect to planning initiatives for the area (CEA Agency et al. 2011, 93).*

We found through our review of the literature that cumulative effects are a particular concern of experts studying the environmental impacts of offshore wind energy development. The literature explains that the impacts on biota with relatively small levels of offshore wind energy development may be small, but with greater levels of development, and when the many other uses of marine areas are considered, the cumulative effects may be large and significant (e.g., ABP 2005; US DOI MMS 2007). A wide variety of marine development projects and proposals exist on or for the BC coast including fish farms, tidal energy, and increased shipping traffic (e.g., see Joseph and Gunton 2008). We also noted above in our discussion of spills (section 3) that there are several reports of the BC coastal ecosystem exhibiting signs of environmental stress for some species, i.e., of cumulative effects. Consequently, cumulative effects are an important issue that was not adequately assessed in the proponent's EA.

The proponent intends to address this uncertainty regarding cumulative effects by 'adaptive management' comprised of monitoring, research, and alteration of activities found to be impactful. We also note that the cumulative effects should be addressed to some extent in future EAs of other proposed projects. The proponent noted that:

> *it appears prudent, and consistent with the precautionary approach taken in this assessment, to enhance the knowledge base specific to the way a wind farm interacts with local conditions in north Hecate Strait, and in particular with respect to key resources, including fishing and fish habitat, tourism and recreation, marine birds, and marine mammals* (16-84).

We note, though, that the proponent's planned adaptive management framework lacks much experimentation – the only active experimentation that we are aware of is NaiKun's plans to examine crab mobility in Hecate Strait. In its originally-proposed and more powerful form, adaptive management includes not just monitoring of the effects of human activities on the environment and adjustment of a project if negative effects are found, but active probing of scientific gaps through targeted experimentation (Walters 1986). We recommend adding additional active experimentation to the proponent's planned adaptive management framework if the project were to proceed.

# 8. Economic Impacts

The proponent examined an array of economic effects of the project in the EIS including employment, financial impacts, and how various industries might be affected. A key component of the proponent's economic impact assessment was an economic impact analysis (EconIA) using the BC Input-Output Model (BCIOM), supplemented with data from literature, government statistics, and consultation with government, community, and industry representatives. The proponent's assessment attempted to distinguish impacts occurring within the Skeena-Queen Charlotte Regional District ('the region') and those occurring elsewhere in BC.

## 8.1 Economic Impact Analysis

During construction, the proponent estimated through EconIA that the project would provide 421 direct person-years (PY) of employment in BC, of which 381 PY would be provided in the region (table 3). The proponent estimated that the 421 PY of direct employment would translate into hiring between 100 and 150 persons in the region and about 10 in Vancouver in the project's corporate headquarters. The proponent noted that the direct jobs provided by project construction are the equivalent of 10% of the regional unemployed workforce. The proponent noted that most of these jobs will require specialized skills (e.g., welding, marine vessel piloting) and indicated that by promoting training programs in the region they hoped that the project will employ many of the currently unemployed people in the region. The proponent also estimated that the project would create 2,350 PY of indirect employment (i.e., employment across BC due to the project's purchase of goods and services used as inputs to the project), and 629 PY of induced employment (i.e., employment spurred by project employees spending their earnings) across BC through multiplier effects. The proponent concluded that most of the indirect and induced employment impacts would occur outside the region. Finally, the proponent estimated that construction would entail a total of $262 million in GDP impacts across BC during construction, or $87 million GDP per year when in peak construction (direct, indirect, and induced), and $42 million in tax revenue to the provincial government and local governments across BC.

**Table 3. Employment, GDP, and government revenue impacts during construction as estimated by proponent.**

| Indicator | Region | British Columbia | | | | |
|---|---|---|---|---|---|---|
| | Direct | Direct | Indirect | Induced | Total BC | Average Annual (over 3 yr construction period) |
| Employment (PY) | 381 | 421 | 2,350 | 629 | 3,400 | 1,113 |
| GDP (million $) | | 38 | 180 | 45 | 262 | 87 |
| Local and BC gov't revenues (million $) | | 22 | 12 | 8 | 42 | 14 |

Source: Table 11-38 in Volume 11 of EIS.

For the operating phase, estimated to occur over the years 2015 to 2044, the proponent estimated that the project would provide 65 direct jobs, 337 indirect jobs, and 95 induced jobs per year (table 4). They estimated that the project would lead to $40 million in GDP impacts per year, and $27 million in provincial and local tax revenue annually across BC.

**Table 4. Employment, GDP, and government revenue impacts per year during operations as estimated by proponent.**

| Indicator | Region | British Columbia | | | |
|---|---|---|---|---|---|
| | Direct | Direct | Indirect | Induced | Total BC |
| Employment (PY) | 30-50 | 65 | 337 | 95 | 498 |
| GDP (million $) | | 7.5 | 26 | 7 | 40 |
| Local and BC gov't revenues (million $) | | 24 | 2 | 1 | 27 |

Source: Table 11-39 in Volume 11 of EIS.

### *Critique of Proponent's Economic Impact Analysis*

The proponent's EconIA contains several limitations that are common to this method of economic impact assessment (e.g., Davis 1990; Gunton 1992; Alavalapati et al. 1998; Armstrong and Taylor 2000; Vining and Boardman 2007).

The first limitation is that the NaiKun EconIA does not indicate whether or not the project provides a net benefit to the region. The EconIA conducted by the proponent simply estimates the gross impacts of the project without deducting project costs. The assessment of whether the investment in NaiKun is justified in terms of generating a net benefit requires a cost-benefit analysis, a method specifically designed to examine net impacts. To date, no cost-benefit analysis of NaiKun has been done and consequently there is no estimate of the net benefits of the project provided in the proponent's EconIA.

A second related limitation is that the tax impacts in the proponent's EconIA estimate gross tax revenues accruing to government without deducting the lost tax revenues that would have been generated by forgone projects or the incremental costs to government of providing services such as health, education and infrastructure to the project and its employees. An accurate estimate of fiscal impacts on government requires deducting these costs from gross tax revenue. The gross tax revenue estimates in the proponent's EconIA therefore do not provide an accurate estimate of the fiscal impacts on government.

A third limitation is that the proponent's EconIA provides insufficient documentation to allow us to assess the accuracy of the estimates and assumptions. The multipliers used to estimate indirect employment (5.6 for construction and 5.2 for operations), for example, are unusually high. The range of indirect regional multipliers for goods-producing sectors in BC is 1.1 to 1.4 (BC 2004) and the range of indirect provincial multipliers is 1.5 to 2.8 (BC 2004).

Fourth, the employment estimates in the proponent's EconIA do not provide sufficient detail to fully assess the local versus non-local geographic distribution of forecast employment and how many of the local jobs will be filled by local residents versus in-migrants. Projects such as NaiKun are normally justified on the grounds that they generate regional development that benefits local residents. Given the relatively high unemployment in Haida Gwaii, generating employment is an important consideration. To its credit, the proponent's EconIA estimates the local versus non-local distribution of direct operating employment. However, the EconIA does not estimate the local and non-local distribution for induced and indirect employment estimates. The EconIA acknowledges the issue of hiring local versus non-local residents and the need to train many of the local residents, but provides insufficient analysis to draw any firm conclusions on how many local residents may be hired. The NaiKun project is capable of providing employment to local residents, but it is essential to develop a benefit agreement that includes comprehensive and legally-binding numerical commitments to training and hiring of local residents to maximize the regional development benefits. Otherwise, many jobs may be taken by skilled in-migrants. We note that the Haida have signed a benefit agreement with the proponent to address these concerns and that future more detailed requirements will likely be negotiated that specify specific hiring targets if the project proceeds. Consequently, it would appear that these issues are being addressed by the Haida.

## 8.2 Impacts on Other Industries

The proponent noted that there are several oil and gas leases held in the project area but that there are no indications that an offshore oil and gas industry will develop in the near future. The major lease-holders – Shell and Chevron – have stated that the project may impede future offshore oil and gas exploration. However, further analysis is required to assess specific impacts on the oil and gas sector. Also, given that the Haida Nation opposes offshore oil and gas development, any impediments on the oil and gas sector would not be viewed negatively by the Haida.

The proponent noted that the project might be construed by some as having a negative visual impact that may impair the ‘unspoiled wilderness’ perception. The project may also attract interest from locals and tourists due to people’s attraction to renewable energy and the sense that the project signifies ‘progressive, environmentally-friendly’ energy development. The proponent conducted surveys of local community representatives and held open houses to canvas opinions on the effect of the project on tourism and found that “there were no strong opinions either way as to whether the wind farm might enhance or detract from Haida Gwaii’s current tourism appeal” (Hemmera 2009, 84). No survey or open house data was provided in the EIS to document this conclusion. The proponent also conducted a ‘viewshed analysis’ and viewpoint modelling to explore the topic. We note that the proponent did not conduct a literature review of the subject to further explore the potential for the project to create visual impacts on tourism, despite the considerable literature on the subject. To address this gap we conducted our own literature review and found that offshore wind farms seem to have minimal negative impacts on tourism (Ball 2002; OWE 2002; ETNWE 2003; Anemos 2004; Warren and Birnie 2009). Several studies have even found positive effects (OWE 2002; Anemos 2004; ABP 2005; AMEC 2006; FERC 2006; Warren and Birnie 2009). We found only one study that found a negative relationship between tourism and offshore wind (Lilley et al. 2010).

Wind turbines can cause electromagnetic interference by reflecting radio and radar signals and can also interfere with television, VHF radio, microwave (including cellular phone networks), and emergency communications. The proponent noted that the project might interfere with several types of communication technologies including point-to-point systems, multichannel multipoint distribution (MMDS), over-the-air reception (radio and TV), and maritime stations and radio navigational aids. To conduct their assessment of the potential effects of the project on communication technology the proponent examined Canadian technical and guidance documents and consulted authorities and users. Overall the proponent concluded that the project should pose no significant adverse effects on communications, though they did note that it is difficult to predict effects with certainty. We note that there is a literature on the subject of offshore wind farms and communication technologies (e.g., METOC 2000; Ball 2002; OWE 2002; WEDCAIWG 2002; Howard and Brown 2004; Maritime and Coastguard Agency 2004; World Energy Council 2007; BWEA Undated) that also finds that interference is unlikely.

Marine navigation is another industry that might potentially conflict with the project. To conduct this portion of their EA the proponent relied upon a literature review (including review of experiences in other jurisdictions with offshore wind farms) and consultations with experts and stakeholders. The proponent noted that "there are no precedents in British Columbia for assessing the effects of offshore wind projects on navigation" (13-87) but nonetheless came to the conclusion that there would be little risk to navigation posed by the project. As the wind farm area is in shallow water, the only traffic is crab fishing vessels.[10] The proponent noted that there is little evidence of collision risk from European offshore wind farm experiences, and they noted that Transport Canada has not required any exclusions zones around the project during operations. Our literature review also found that the navigational hazard posed by offshore wind farms installations is low (Salter, 2001 in Ball 2002; CRES 2002; ETNWE 2003). Notably, one benefit listed in the literature regarding the effect of the offshore renewable energy development on marine navigation is that it can enhance marine safety as such projects are often in shallow waters and are generally required to be well-marked and/or lit. The exclusion zones that typically surround the energy projects and the marking and lighting serve to minimize shipping traffic and may reduce accident rates (Ball 2002; ETNWE 2003; Soerenson et al. 2003; Halcrow Group 2006).

Another industry with the potential to be affected by the project is fishing. In particular, the wind farm is proposed for an area within the Area A crab fishery focused on Dungeness crab. The proponent concluded that the project is unlikely to have any significant adverse effect on the crab fishery because the wind farm will exclude only a very small portion of the fishing area from fishers (100m buffers around each WTG) and that historical crab landings vary enormously. The proponent estimated that the project would lead to a 3% or less reduction in landings from the project, a reduction that is well within the historical variation in landings. The federal government estimated a 4.7% reduction in landings and landed value (CEA Agency et al. 2011, 71). The proponent concluded that there is a very low probability that a fisher's gear could become tangled on a transmission cable within the wind farm area or along the transmission lines to Haida Gwaii or the mainland, primarily because the cables will be buried in the majority of places. The federal government noted uncertainty in terms of the long-term effect of the project on fishery species productivity, movement, and the long-term viability of fishing access within the project area (CEA Agency et al. 2011). The federal government concluded that fishing would be negatively affected by the project, but not enough to significantly and adversely affect commercial fishers. The BC EAO concluded that fishing would not be significantly adversely affected. Based upon our literature review

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[10] The proponent noted that there might also be recreational traffic in the area but noted that no statistics were available to determine the volume of this traffic.

we agree with these conclusions and support the various research and monitoring programs being initiated to help address current uncertainties.

In fact, there may be positive effects of the project on fishing opportunities. With the exception of one recent study that found no effect of the Barrows Offshore Wind Farm in England on catches of lobster and crab inside and outside the farm area (Wilson et al. 2010), most of the literature suggests that offshore wind farms can have a positive effect on fishing. Fishing may be enhanced in several ways. As discussed above, artificial reefs can enhance aquatic ecosystems which can boost fish stocks in the project area. Second, the effective creation of fishing exclusions zones around WTGs can also boost fish stocks (OWE 2002; ETNWE 2003; Soerenson et al. 2003; Halcrow Group 2006; Inger et al. 2009), though there is uncertainty over the magnitude of these positive effects (Manago and Williamson 1998; Patin 1999; Ball 2002; Scottish Natural Heritage 2004; ABP 2005; Inger et al. 2009; Langhamer et al. 2010), in part because of a lack of ample research on the topic. The NaiKun project may boost Dungeness crab fishing in the area, especially if efforts are made to install WTG foundations and scouring protection devices favourable to crab. Wilson et al. (2010) write:

> *one of the most common forms of scour protection is to deploy large boulders around the base of the tower. This mimics a rocky outcrop environment and therefore may increase lobster, crab and reef fish within the wind farm boundary. Given that the perceived impact on commercial fisheries is often one of the greatest objections against offshore wind farm developments, this has the potential for a win-win situation, as both the benthic population and commercial fishermen may benefit from the installation of the turbines* (1393)

Inger et al. (2009) even suggest that there might be new opportunities for aquaculture within the wind farm.

Another positive effect of the project on economic development on Haida Gwaii will result from the islands' connection to the mainland electrical grid. The proponent reported that Haida Gwaii's current electrical supply is "undependable" and "considered a deterrent to new and existing businesses locating or growing there" (NWEG 2009, 13-36). The proponent noted that residents of Haida Gwaii

> *have long been concerned with the relatively high cost of diesel generation... the negative environmental consequences of burning fossil fuels for generation* (13-48)

and that the islands'

> *electricity supply can be spotty and unreliable, and as such, has been a consistent deterrent to small industrial manufacturing operations to locate and grow their businesses there* (13-48).

The proponent concluded that

> *the economic development implications for Haida Gwaii of potential connectivity with the provincial electricity transmission grid could be substantial* (13-48).

Based upon our literature review we agree that the development of dependable power would likely be positive in terms of economic development (Yamaguchi and Kuczek 1984; Campbell and Pape 1999; Ecotec 2002; Helimax 2002; Hoffer 2002; ADAS 2003;

Washington 2003; BC EAO 2004; Aeolis 2005; AMEC 2006; Cornett 2006; ENTec 2007; BC Hydro Undated).

# 9. Financial Assessment

## 9.1 NaiKun Corporate Structure

The principal developer of the NaiKun project is NaiKun Wind Energy Inc. (NaiKun), which is a publicly traded company on the TSX Venture Exchange. NaiKun has secured an investigative use permit from the Province's Integrated Land Management Bureau and a permit to conduct research from the Haida Power Authority for the proposed wind farm. NaiKun has been responsible for designing the project, obtaining necessary environmental approvals and permits, and managing development of the wind farm.

The corporate structure of the proposed wind farm is the subject of ongoing negotiations. Several ownership structures have been discussed involving a combination of entities including NaiKun, the Haida, and other investors. One proposal is to use NaiKun Wind Generating Inc. (GenCo), an existing subsidiary of NaiKun, as the company that will own the wind farm. If the project gets an electricity purchase agreement from BC Hydro, and several other conditions are met, then GenCo's ownership structure could change, and two new companies would be created: the Haida NaiKun Wind Operating Limited Partnership (HNLP) and the Haida Enterprise Corporation (HaiCo).

Currently GenCo is 50% owned by ENMAX, a Calgary-based company involved in electricity generation (including wind farms) in Alberta, and 50% owned by NaiKun. However, if the project goes ahead, then NaiKun may sell down its interest through a MOU signed on August 13th, 2009 between the Haida and NaiKun giving the Haida the option to acquire an equity share of up to 40% in the wind farm. Under this model, the Haida plan to form the HaiCo through which they will acquire their equity stake in GenCo, potentially financed by a loan guarantee from the federal government. Additional equity may be held by other investors and utilities. The HNLP would be formed to operate the wind farm. Figure 5 shows the planned project ownership structure of GenCo under this model.

Other more recent options include creating non-profit trusts combined with a for-profit limited partnership again involving the Haida and other investors. Opportunities for government loan guarantees to lower the interest rates on debt capital are also being considered along with corporate structures designed to minimize tax liabilities. It is anticipated that the NaiKun corporate structure will continue to evolve through negotiations among the major parties.

As discussed previously in this report, NaiKun was successful in receiving a certificate of project approval under the BC *EAA* (December 2009) and *CEAA* (March 2011). NaiKun submitted its project as a proposal under the BC Hydro proposal call for energy projects in 2008 but was informed in March 2010 that the proposal was not selected due to its high costs relative to other submissions. Subsequently, NaiKun has continued to pursue discussions with BC Hydro on power purchase options for the NaiKun project. If a satisfactory power purchase agreement is concluded the project may proceed to the development stage.

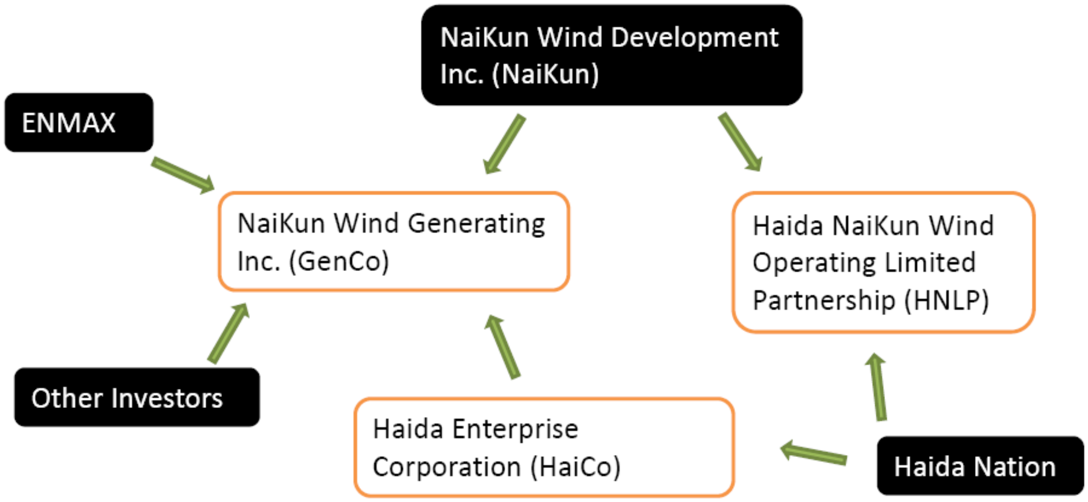

**Figure 5. Planned corporate structure for the NaiKun project.**

## 9.2 Business Case for the Project

According to NaiKun the business case for the project is favourable based on the following factors. First, the project will help BC meet its objectives as outlined in BC's Energy Plan. BC now imports up to 15% of its power from US, Alberta, and Saskatchewan – most of which is generated through fossil fuels. The BC Energy Plan (BC MEMPR 2007) calls for electricity self-sufficiency in BC by 2016, with at least 90% generated from 'clean and renewable sources'. This commitment was reinforced by the 2010 BC *Clean Energy Act*.

Second, local site characteristics including the quality of the wind resource, shallow water depths, geology, and onshore terrestrial ecology are all favourable for wind energy. The winds in the project area are well-suited for wind energy at around 10 meters per second and only insufficient for power generation 8% of the time. The generation capacity factor is estimated at 41%, a factor slightly better than typical offshore wind projects (40%).

Third, feasibility analysis of the project is based on planning work involving input from several 'expert' parties including: Offshore Design Engineering who engineered and operates the Scroby Sands farm offshore UK, a major supplier of wind farm equipment (Siemens), project financiers Bank of Toyko Mitsubishi UFJ (BTMU) who has experience financing large offshore wind farms in Europe and is among the top ten largest financial institutions in the world, and international insurance providers for major projects (Aon Reed Stenhouse). Risk assessment was also undertaken by the independent firm (IPA) that concluded that the project's business plan was sound.

Fourth, the proposed purchaser of the wind energy, BC Hydro, is financially sound and is backed by the provincial government.

Fifth, though offshore wind is a relatively high cost source of electricity generation, it is still less than diesel generation on Haida Gwaii, and this presents the project with an economic advantage. Currently, electricity is generated on Haida Gwaii through the operation of two diesel generators and one small hydroelectric dam. Diesel generation on Haida Gwaii costs BC Hydro an estimated $300 per MWh, which is higher than the NaiKin estimated costs which are in the range of $150 per MWh. Wind energy costs are also relatively stable because unlike fossil fuels (the source of much of North America's electricity) its costs are not impacted by changing commodity prices.

Sixth, the project has community and government support by virtue of its commitment to provide training, employment, and economic development opportunities for First Nations and North Coast residents.

Seventh, wind energy has a significant environmental benefit in terms of reduced GHG emissions that can be translated into additional revenue in the form of green credits that improve the economics of the project.

## 9.3 Risk Factors

A key risk factor for NaiKun is that it is a relatively expensive energy source. Although cost comparisons should be interpreted with caution due to differences in methodology and accuracy, figures in the NaiKun business plan suggest that NaiKun costs are in the range of $150 per MWh, almost 4 times higher than BC Hydro's average cost from current generating sources, double the average cost of projects submitted under Hydro's 2006 proposal call ($74), and in the range of 50% higher than Site C ($97), which is BC Hydro's major new undeveloped project (NaiKun Undated). The NaiKun project was not selected by BC Hydro because BC Hydro concluded that it was more expensive that the other projects submitted under its proposal call. Cost estimates for alternative new energy sources are likely to change as information is updated and as NaiKun's relative cost position may improve or deteriorate. Nonetheless, given the energy supply options, it will be challenging to negotiate a price with BC Hydro high enough to justify Naikun.

It is important to acknowledge that the high cost of offshore wind projects such as NaiKun is offset to some degree by the significant environmental benefits of wind energy (see section 1.6 in this report). With inclusion of environmental benefits, wind can be an economically attractive option. However, the constraint in BC is that the lower cost alternatives to NaiKun are largely hydro projects that also have significant environmental benefits in terms of reduced GHG emissions. Therefore, including the environmental benefits of the NaiKun project will not have a significant impact on NaiKun's cost competitiveness within BC. The only way the environmental benefits become a significant financial advantage is when NaiKun is compared to other fossil fuel projects in the export market, but realizing the environmental benefits in the form of "green credits" is also dependent on consumers willing to pay a premium over other sources of power and NaiKun receiving these green credits in its revenue stream. Securing these green credits in the export market will be challenging.

A second risk factor is that the NaiKun project would be one of the largest offshore wind farms in the world developed under the control of a company (NaiKun) that has no track record in developing and operating offshore wind farms. The company also has limited financial capacity to develop a large project. The company has attempted to overcome these limitations by contracting with offshore wind energy experts and companies for advice and likely would seek a major international investment partner with wind energy experience if the project it to go ahead.

Third, the experience with major projects undertaken by even experienced firms is not encouraging. Global evidence indicates that project developers have a history of underestimating costs and overestimating performance (Flyvbjerg et al. 2003; Lovallo and Kahneman 2003; Samset 2003). On average, actual rates of return on investment are in the range of one-half of forecasted rates of return (Gunton 2003). BC and Alberta have a history of cost overruns on major projects and (Gunton 2003; McColl et al. 2008) The recently approved Kearl oil sands mine, for example, has seen its capital costs (CAPEX) for its first phase rise 353%.[11] Offshore wind energy projects in particular have experienced significant cost escalation (Henderson et al. 2009). Therefore, given the inexperience of the project developer for NaiKun, the lack of experience operating offshore wind farms in BC, the recent escalation in offshore wind project costs, and the general tendency of investors to underestimate risk, there is a moderate to high probability that NaiKun will end up with higher energy generation costs than forecast.

Fourth, NaiKun is a large capital-intensive project with high fixed costs in terms of debt servicing. Once the investment is made, there will be little flexibility to adjust fixed debt servicing costs to reflect changing market circumstances because the costs are already incurred in the capital investment. There will also be little flexibility in compensating for higher CAPEX costs by lower operating costs because operating costs represent a relatively small proportion of total cost. CAPEX overruns will not be able to be passed on to consumers because of the fixed price power contract and the unwillingness to reopen or replace the contract by purchasers because of the availability of lower cost energy options. Consequently, any cost overruns will be borne by the investors in the project.

It is possible to mitigate these risks by contract design, due diligence, and price premiums for green energy. Nonetheless, there remain significant risk factors with NaiKun that could impact the economic viability of the project. While there appear to be significant environmental and regional development benefits of the project that help justify the project, translating these benefits into project revenues to compensate for the risk will be challenging. On a positive note, the operating costs for the project are relatively low. Therefore even if the project equity investors and lenders incurred a below market return or loss, the project could continue to operate and generate jobs, revenue, and environmental benefits. We also emphasize that the risks reviewed above are risks associated with the project and it is possible for the Haida to protect themselves against these risks by the structure of agreements that Haida negotiate. This issue will be discussed in more detail below.

## 9.4 Financial Analysis

To evaluate the economics and risks of the NaiKun project we constructed an economic model of the project that estimates the project's financial performance. The model is designed to examine project financial performance under different risk scenarios and to test the project's overall financial viability. An important qualification to keep in mind when interpreting the findings is that there is substantial uncertainty related to project parameters as discussed in the risk section of this report. For this reason we have tested different scenarios to test the resilience of the project to different parameter values.

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[11] CAPEX for Kearl's train 1 were originally estimated to be $2.3 billion (2005 CDN) but by 2010 were estimated at $8.1 billion (2010 CDN) (Imperial Oil 2005; 2009; 2010).

There is also uncertainty regarding what market rate of return (i.e., discount rate) is necessary to justify investment in a project like NaiKun. The average observed real before-tax rate-of-return on private sector investment over the long term is in the range of 10%. Private sector companies often use rates even higher than 10% in their feasibility studies to compensate for optimism bias. Given the uncertainty, we have calculated the real before-tax rate-of-return (the internal rate of return, or IRR) for alternative scenarios instead of calculating net present values based on specified discount rates. The reader can then decide whether the rate of return is adequate or not. The results of the modelling show that the rates of return for NaiKun vary from 0% to 8.2% (table 5). Even under the most favourable scenario, NaiKun still earns below the generally accepted 10% rate of return. (See Appendix 1 for detailed information on the assumptions underlying each scenario).

The results confirm that while the project may be marginally viable assuming a higher than market energy price, there are substantial downside risks to the project that may drive the rate-of-return on investment below competitive market levels. Depending on the financial structure of the project, it could continue to operate even if returns fell below market levels and be able to continue to service debt, albeit with a below-market return on equity. If the contracted price with BC Hydro is closer to the market prices defined as BC Hydro's cost to the next best new alternatives (Site C and small hydro), NaiKun is uneconomic. Under these lower price scenarios, we would not expect the project to be built. Again we emphasize that the Haida can structure their involvement in NaiKun to protect themselves from risk.

**Table 5. Financial modelling results for the NaiKun project.**

| Scenario | IRR |
|---|---|
| Base Case | 7.1 |
| 40% capacity factor | 6.9 |
| 350 MW total capacity | 5.9 |
| $97 price from BC Hydro | 2.9 |
| $125 price from BC Hydro | 6.4 |
| Two year delay of operations | 6.5 |
| CAPEX up 20% | 5.7 |
| OPEX up 10% | 7.0 |
| CAPEX up 20% and OPEX up 10% | 5.6 |
| Green credits at $5/MWh | 7.5 |
| Green credits at $15/MWh | 8.2 |
| Worst case scenario | 0.0 |

## 9.5 Approaches for Haida Participation in NaiKun

Conceptually there are several approaches that the Haida can use to participate in NaiKun (table 6). One approach is negotiation of a benefit agreement that specifies environmental regulations, hiring requirements and other social, economic, and environmental benefits as a condition of approval. An important distinction in benefit agreement provisions is between 'best efforts commitments' versus enforceable, measurable commitments. Best effort commitments obligate the developer to make a

**Table 6. Participation and Ownership options for the Haida.**

| Instrument | Benefit | Risk | Benefit/Risk Ratio |
|---|---|---|---|
| Environmental and Economic Development Benefit Agreement | High | Low | High |
| Royalty | High | Low | High |
| Traditional Equity | Medium | High | Low |

| | | | |
|---|---|---|---|
| Modified Equity | Medium | Low | Medium |

reasonable effort to fulfil the commitment, while enforceable, measurable commitments obligate the developer to fulfil the commitment or face penalties. For example, committing to hire local residents by best efforts provides no guarantee that local residents will be hired. Conversely, agreeing to hire a specific number of local residents or face onerous penalties ensures that the specified number of local residents will be hired. Obviously, the effectiveness of benefit agreements is contingent on using measurable, enforceable provisions instead of best effort provisions. The benefits of these types of agreements are high and the risk is low. As discussed above, the Haida have negotiated a benefit agreement with NaiKun.

A second approach is to impose royalties to be paid to the Haida in return for use of Haida resources. Royalty payments can be based on a fixed payment and/or variable payments based project performance. Variable payments can be assessed as a percentage of total sales revenue (ad valorem royalty), a percentage of profit (net profit interest or income royalty) and/or a charge per unit of energy production (volumetric royalty). All of these types of financial instruments are used by provincial and federal governments to realize a financial return on publicly-owned resources. Overall, royalties are an effective means for realizing a financial return on natural resources without any investment risk by the royalty recipient. However, royalties need to be carefully designed to ensure that the recipient receives a fair return without jeopardizing the economic viability of the project. Each type of royalty system has certain advantages and disadvantages and they are often used in combinations to achieve desired objectives. For more discussion on the structure and benefits of different types of royalty regimes see Gunton (2004). In the case of NaiKun, the Haida have negotiated an annual royalty payment. There may be an opportunity to negotiate other forms of royalties but care must be taken to ensure that any proposed royalties do not undermine the economic viability of NaiKun.

Full or joint ownership is another means of ensuring that the Haida realize benefits from the NaiKun project. Various ownership options are currently being negotiated. The advantage of ownership is that it gives the Haida more direct control over project operations, generates financial returns on investment, provides comprehensive information on project performance, and helps build management capacity among the Haida. In the case of NaiKun, Haida equity involvement also increases the probability of the project going ahead by providing potentially low-cost equity capital that improves project economics. The principal disadvantage of equity investment by the Haida is that the project may not generate an adequate return and therefore the equity capital could be at risk. This risk could be reduced or eliminated by a “modified equity” approach discussed below.

Under a modified equity approach, equity shares are issued to the Haida as a condition of Haida approval of the project without the Haida undertaking any direct investment. This equity approach has been used by various governments in many resource development projects as a form of royalty payment for access to the resource. Second, the Haida could obtain their equity investment by a government guaranteed loan backed solely by the project with no additional liability obligations. Under this arrangement the Haida would realize any upside potential from project ownership without incurring any risk. Third, Haida equity investment could be structured as preferred shares that would lower the risk of the investment. Given the economics of the investment, any equity investment by the Haida that is not structured in a way to reduce or eliminate risk would generate a high risk with few benefits.

## 9.6 Haida Involvement in NaiKun

Haida involvement in NaiKun is subject to ongoing negotiations and may change overtime. The current proposal is contained in a benefits agreement (HNLP agreement) signed between NaiKun and the Haida. The Haida have specified that their involvement in the project is contingent on six conditions being met:

1. BC Hydro would have to offer a purchase agreement
2. environmental approvals would have to be issued by the Haida and the BC and federal governments and all environmental issues would have to be addressed to the satisfaction of the Haida
3. the Haida would have to obtain a federal guarantee on any loans to the Haida that are invested in the project
4. Haida investment financing agreements would have to be confirmed and executed
5. commitments must be attained from all project equity partners in writing from all investors
6. all potential project financing sources and terms would have to be confirmed in a formal financing plan from financial advisors.

If these conditions are met, the Haida have the option to get 50% ownership in the HNLP, receive an annual fee starting on the Project Commercial Operation Date, and 50% of annual HNLP net cash distributions in exchange for the project using Haida lands and waters. The HNLP will also provide the opportunity for Haida to be trained and employed in operations once initial operational tasks are handed off from the European partners in the project. In exchange for investing in the project through acquiring an equity stake in GenCo, the Haida (through HaiCo) will get rights to proportional seats on the GenCo board, and annual cash distributions of profits at a target rate of Return on Equity, pre-tax, at a premium to that of a “Low-Risk Benchmark Utility”.

In addition to the benefits described above, the project also provides the Haida with the opportunity to earn returns on green energy credits. Green credits are purchased by parties trying to offset GHG emissions. BC Hydro currently claims a right to all potential credits associated with power it purchases from private clean energy producers, but NaiKun believes there is an opportunity to revisit this arrangement. According to the terms of the current agreement between the Haida and NaiKun, the Haida will get 60% of green credit net revenue above $5/MWh up to $15/MWh and 50% of revenue above $15/MWh. The value of green credits in BC Hydro’s 2006 power call was $3 per MWh produced, but according to NaiKun some analysts think this value could rise to $15 per MWh produced. These prices would translate into a value of $4 to 20 million per year. However, if BC Hydro retains the rights to green credits, the current agreement provides the Haida with the option to receive shares in GenCo and specified cash payments over time rather than green credit revenue.

## 9.7 Evaluating Haida Participation

A key objective for Haida participation in NaiKun is to ensure that the Haida receive maximum economic benefits with minimum risk. We have assessed the current

Haida NaiKun Wind Operating Limited Partnership Agreement (HNLPA) in light of this objective. Specifically, the HNLPA provides the framework and principles for:

- hiring, training and procurement initiatives to ensure that Haida receive employment and other social and economic benefits
- environmental monitoring and mitigation to ensure environmental protection
- financial benefits in terms of an annual fee
- financial benefits in terms of potential dividend payments based on equity ownership in the project
- eliminating risk by using a modified equity approach in which equity is obtained without any direct Haida investment or any liability incurred by the Haida (liability is held by the project and/or the federal government in the form of a loan guarantee), and
- conditions being met prior to Haida exercising options to participate in the project.

Our conclusion is that Haida have negotiated a framework that achieves economic benefits with minimum risk. We note that the nature of the project and Haida participation in the project will continue to evolve with changing circumstances. We recommend that the Haida continue to apply the general guiding principles contained in the HNLPA to any new agreements and that they enhance existing agreements by specifying the details of project developer obligations to ensure that they are measurable and enforceable on issues such as local hiring and environmental mitigation and compensation.

# 10 Conclusions

Overall, our findings on the environmental impacts of the NaiKun project concur with the conclusions of the federal, BC, and Rescan EA that contingent on the implementation of recommended mitigation measures, the project is unlikely to have any significant adverse environmental impacts. See Appendix 2 for a listing of mitigation measures planned. More specifically, the scientific evidence indicates that environmental concerns that the project will devastate clams, crabs, birds, whales, and other local species are unfounded. In some cases, notably ecosystem dynamics, invasive species, marine birds, and cumulative effects, there remains some uncertainty regarding impacts that the proponent intends to address by mitigation measures. Given the uncertainty, the effective implementation of these mitigation and monitoring programs is essential. We also note that the project will likely have positive impacts in terms of reduction of GHG emissions.

We also conclude that the project has the potential to generate economic benefits in terms of employment opportunities and revenue for the Haida and other residents of the region. The magnitude of potential economic benefits depend on many variables including training programs, hiring protocols, ownership structure, and the project's financial performance. Financial performance in turn depends on power sale contracts, costs of construction and operation, and how the business risks of the project are managed. The principal financial challenges facing the project are its high costs relative to other energy sources (and consequent low returns) and the lack of experience and capacity of the proponent.

An objective of the Haida is to structure their approval and involvement in the project in a manner that maximizes the benefits and minimizes the risks. To protect the environment it is important to have ongoing monitoring and implementation of mitigation measures, including means to ensure compensation for any negative environmental effects. To ensure employment benefits it is important to have a legally-binding benefit agreement that specifies measurable and enforceable training and hiring targets and other social and economic benefits. On the financial side it is important to utilize a combination of financial instruments that protect the Haida from risks generated by cost overruns and/or revenue shortfalls.

Based on our review, we conclude that the proposed wind energy project has potential benefits for the Haida including: employment, financial returns, and environmental improvements generated by renewable, clean energy production. The project also has potential economic risks and challenges including: relatively high costs of production (and consequent marginal financial returns) and limited resources and lack of experience of the project proponent. Based on the principles contained in the agreements negotiated by the Haida and preconditions set by the Haida for approval of the project, we conclude that the project is structured in a way that allows the Haida to realize potential economic benefits with minimum risk. Based on the extensive environmental reviews by Rescan, the federal government, and the provincial government, as well as our own review we conclude that contingent on the implementation of specified mitigation measures, the project is unlikely to have any significant adverse environmental risks.

There are several qualifications to our findings and recommendations that should be noted.

- The capacity of the current project proponent to complete the project and the relatively high costs of the project (and consequent marginal financial returns) are constraints that impede project development and may require investigation of other options by the Haida to develop their wind energy resource.
- It is likely that the nature of the project, including mitigation measures, corporate structure, business plan, and ownership of the project will continue to evolve to address these constraints. Consequently it is important that any changes be carefully monitored and that agreements and commitments are reassessed in light of changing circumstances. Any new agreements need to be based on the principles reflected in the current Haida agreements that maximize benefits and minimize risk to the Haida. Also, new more detailed agreements will need to be negotiated that specify measurable, enforceable targets for social and economic benefits.
- The conclusion that the project is unlikely to have significant adverse environmental effects is contingent on the implementation of mitigation measures specified in the environmental assessment documents. It is therefore important that all specified mitigation measures be fully and effectively implemented and consideration be given to specifying compensation commitments in the event that adverse impacts occur.
- The scientific literature on the impacts of offshore wind farms is evolving and needs to be carefully monitored to identify any new risks and mitigation measures to manage risks.

With these qualifications in mind, we conclude that an offshore wind farm has the potential to generate benefits for the Haida.

# Appendix 1: Financial Model Assumptions

**Scenarios**

Base Case

- CAPEX of $2 billion incurred over initial three years of project in equal amounts of $667 million each
- OPEX of $30 million a year starting in first operational year
- insurance costs of $20 million a year starting in first operational year
- total capacity of 396 MW
- production capacity factor of 41%
- price of electricity paid by BC Hydro of $150
- Green credit value retained by BC Hydro

40% capacity factor

- CAPEX of $2 billion incurred over initial three years of project in equal amounts of $667 million each
- OPEX of $30 million a year starting in first operational year
- insurance costs of $20 million a year starting in first operational year
- total capacity of 396 MW
- production capacity factor of 40%
- price of electricity paid by BC Hydro of $150
- Green credit value retained by BC Hydro

350 MW total capacity

- CAPEX of $2 billion incurred over initial three years of project in equal amounts of $667 million each
- OPEX of $30 million a year starting in first operational year
- insurance costs of $20 million a year starting in first operational year
- total capacity of 350 MW
- production capacity factor of 41%
- price of electricity paid by BC Hydro of $150
- Green credit value retained by BC Hydro

$97 price from BC Hydro

- CAPEX of $2 billion incurred over initial three years of project in equal amounts of $667 million each
- OPEX of $30 million a year starting in first operational year
- insurance costs of $20 million a year starting in first operational year
- total capacity of 396 MW
- production capacity factor of 41%
- price of electricity paid by BC Hydro of $97 (price of Site C dam April 2010)
- Green credit value retained by BC Hydro

$125 price from BC Hydro

- CAPEX of $2 billion incurred over initial three years of project in equal amounts of $667 million each
- OPEX of $30 million a year starting in first operational year
- insurance costs of $20 million a year starting in first operational year
- total capacity of 396 MW
- production capacity factor of 41%
- price of electricity paid by BC Hydro of $125 (assumed Average Clean Power Call price)
- Green credit value retained by BC Hydro

Two year delay of operations

- CAPEX of $2 billion incurred over initial five years of project in equal amounts of $400 million each
- OPEX of $30 million a year starting in first operational year (2018)
- insurance costs of $20 million a year starting in first operational year
- total capacity of 396 MW
- production capacity factor of 41%
- price of electricity paid by BC Hydro of $150
- operations start two years late (2018 instead of 2016)
- Green credit value retained by BC Hydro

CAPEX up 20%

- CAPEX of $2.4 billion incurred over initial three years of project in equal amounts of $667 million each
- OPEX of $30 million a year starting in first operational year
- insurance costs of $20 million a year starting in first operational year
- total capacity of 396 MW
- production capacity factor of 41%
- price of electricity paid by BC Hydro of $150
- Green credit value retained by BC Hydro

OPEX up 10%

- CAPEX of $2 billion incurred over initial three years of project in equal amounts of $667 million each
- OPEX of $33 million a year starting in first operational year
- insurance costs of $20 million a year starting in first operational year
- total capacity of 396 MW
- production capacity factor of 41%
- price of electricity paid by BC Hydro of $150
- Green credit value retained by BC Hydro

CAPEX up 20% and OPEX up 10%

- CAPEX of $2.4 billion incurred over initial three years of project in equal amounts of $667 million each

- OPEX of $33 million a year starting in first operational year
- insurance costs of $20 million a year starting in first operational year
- total capacity of 396 MW
- production capacity factor of 41%
- price of electricity paid by BC Hydro of $150
- Green credit value retained by BC Hydro

Green Credits at $5/MWh

- CAPEX of $2 billion incurred over initial three years of project in equal amounts of $667 million each
- OPEX of $30 million a year starting in first operational year
- insurance costs of $20 million a year starting in first operational year
- total capacity of 396 MW
- production capacity factor of 41%
- price of electricity paid by BC Hydro of $150
- Green credits earned at $5/MWh

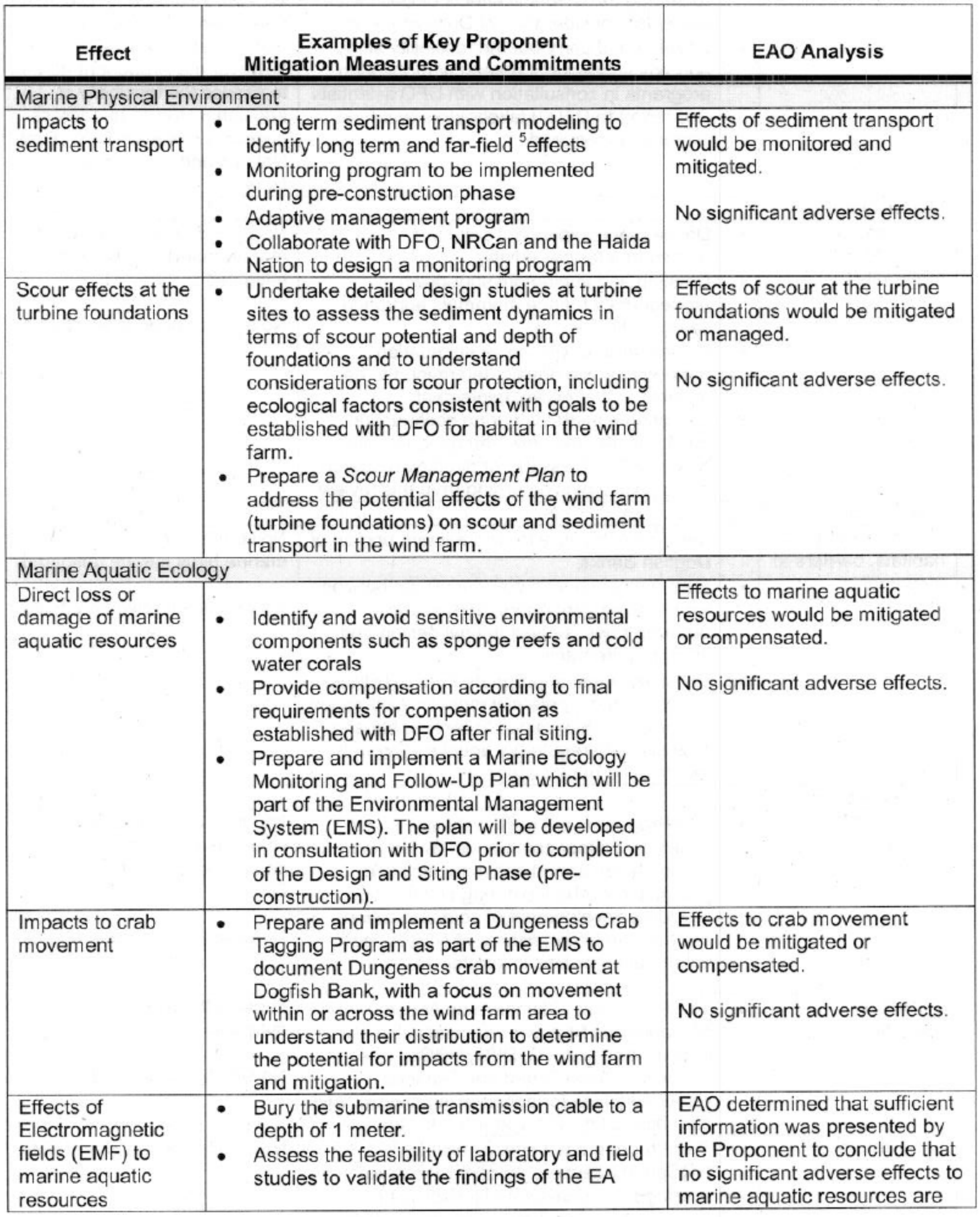
Green Credits at $15/MWh

- CAPEX of $2 billion incurred over initial three years of project in equal amounts of $667 million each
- OPEX of $30 million a year starting in first operational year
- insurance costs of $20 million a year starting in first operational year
- total capacity of 396 MW
- production capacity factor of 41%
- price of electricity paid by BC Hydro of $150
- Green credits earned at $15/MWh

Worst case scenario

- CAPEX 20% higher
- OPEX 10% higher
- insurance costs of $20 million a year starting in first operational year
- total capacity of 350 MW
- production capacity factor of 40%
- price of electricity paid by BC Hydro of $97
- operations start two years late (2018 instead of 2016)
- Green credit value retained by BC Hydro

# Appendix 2: Mitigation Measures



| Effect | Examples of Key Proponent Mitigation Measures and Commitments | EAO Analysis |
|---|---|---|
| **Marine Physical Environment** | | |
| Impacts to sediment transport | - Long term sediment transport modeling to identify long term and far-field [5]effects<br>- Monitoring program to be implemented during pre-construction phase<br>- Adaptive management program<br>- Collaborate with DFO, NRCan and the Haida Nation to design a monitoring program | Effects of sediment transport would be monitored and mitigated.<br>No significant adverse effects. |
| Scour effects at the turbine foundations | - Undertake detailed design studies at turbine sites to assess the sediment dynamics in terms of scour potential and depth of foundations and to understand considerations for scour protection, including ecological factors consistent with goals to be established with DFO for habitat in the wind farm.<br>- Prepare a *Scour Management Plan* to address the potential effects of the wind farm (turbine foundations) on scour and sediment transport in the wind farm. | Effects of scour at the turbine foundations would be mitigated or managed.<br>No significant adverse effects. |
| **Marine Aquatic Ecology** | | |
| Direct loss or damage of marine aquatic resources | - Identify and avoid sensitive environmental components such as sponge reefs and cold water corals<br>- Provide compensation according to final requirements for compensation as established with DFO after final siting.<br>- Prepare and implement a Marine Ecology Monitoring and Follow-Up Plan which will be part of the Environmental Management System (EMS). The plan will be developed in consultation with DFO prior to completion of the Design and Siting Phase (pre-construction). | Effects to marine aquatic resources would be mitigated or compensated.<br>No significant adverse effects. |
| Impacts to crab movement | - Prepare and implement a Dungeness Crab Tagging Program as part of the EMS to document Dungeness crab movement at Dogfish Bank, with a focus on movement within or across the wind farm area to understand their distribution to determine the potential for impacts from the wind farm and mitigation. | Effects to crab movement would be mitigated or compensated.<br>No significant adverse effects. |
| Effects of Electromagnetic fields (EMF) to marine aquatic resources | - Bury the submarine transmission cable to a depth of 1 meter.<br>- Assess the feasibility of laboratory and field studies to validate the findings of the EA | EAO determined that sufficient information was presented by the Proponent to conclude that no significant adverse effects to marine aquatic resources are |

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[5] Effects to areas further away from the proposed wind farm such as Graham Island.

| | | |
|---|---|---|
| | regarding the potential effects of EMF, with particular consideration of Dungeness crab.<br>• Develop and carry out the feasibility study and any subsequent research/ monitoring programs in consultation with DFO scientists and report to DFO, stakeholders and First Nations, as required. | expected from EMF. EAO did not require the Proponent to conduct additional studies, however the Proponent agreed to assess the feasibility of additional studies to address concerns raised by DFO, First Nations and Area A crab fishery. |
| Marine Mammals | | |
| Noise and pressure effects to marine mammals | • Develop and implement soft-start procedures for pile driving.<br>• Develop and implement shut-down procedures if marine mammals approach safety radii.<br>• Review and assess noise attenuation methods for pile driving determined to be feasible and effective, implement appropriate methods during construction, and continue to review emerging literature and examine feasibility of directed research on specific topics emerging from this review. | Noise and pressure effects to marine mammals would be mitigated.<br>No significant adverse effects. |
| Marine Birds | | |
| Displacement from habitats, barriers to movements | • Keep infrastructure toward eastern portion of Dogfish Banks.<br>• Maintain continuous corridor widths between wind turbine generators, across and between rows, subject to final design and siting requirements.<br>• Utilize the most appropriate form of lighting to minimize the potential night time attraction for birds, as determined to be feasible and effective with regulatory agencies through the detailed design stage. | Noise and pressure effects to marine birds can be mitigated.<br>No significant adverse effects. |
| Socio-economic | | |
| Impacts to the crab fishery | • The Proponent will work with Area A crab fishers and other commercial fishers to look for additional opportunities to minimize potential disturbance during construction, including development of communications protocols to inform fishers of construction timing and activities in landfall areas. | Impacts to the crab fishery would be mitigated or compensated as required by DFO.<br>No significant adverse effects. |
| Impacts to navigation | • The Proponent will finalize an Access Management Plan prior to certification in consultation with TC, DFO, NRCan, the Canadian Coast Guard and fisheries representatives for approval in principle, and complete a final Plan prior to construction. | Impacts to navigation would be mitigated.<br>No significant adverse effects. |
| Land tenure | • The Proponent will consult with ILMB, NRCan and tenures holders to resolve overlapping interests and jurisdictions.<br>• Proponent will engage in ongoing meetings with Shell and Chevron (Companies), as | No significant adverse effects. |

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| | reasonably required to establish a constructive working relationship by providing regular project updates to the Companies and ensure that they are informed about relevant design, construction and operations activities, and any Project amendments.<br>• Proponent commits to reviewing engineering plans with the Companies during early detailed design of the Project in a workshop format. | |
| First Nations Interests | | |
| Impacts to First Nations' interests | Proponent commitments include undertaking the following consultation and related discussion with participating First Nations:<br>• With the Metlakatla, Lax Kw'alaams and Gitxaala in relation to establishing an appropriate process for the protection and/or treatment of culturally modified trees.<br>• With the Metlakatla, Lax Kw'alaams and Gitxaala Nations to seek input in confirming/ensuring the cable alignment minimizes potential impacts to known archaeological resources. | Impacts to First Nations' interests would be mitigated or compensated.<br>No significant adverse effects. |

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