



THE UNIVERSITY OF BRITISH COLUMBIA OKANAGAN CAMPUS

FACULTY OF APPLIED SCIENCE, SCHOOL OF ENGINEERING

APSC 305: Engineering Economics

Analysis

Keeyask Hydroelectric Dam

Technical Report

Group 7

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Introduction

The Keeyask Project is a “695-megawatt (MW) hydroelectric generating station that is being developed in a partnership between Manitoba Hydro and four Manitoba First Nations: Tataskweyak Cree Nation, War Lake First Nation, York Factory First Nation, and Fox Lake Cree Nation.” This project is located 725 km North of Winnipeg on the lower Nelson River.

The main purpose of this report is to investigate the pros and cons of the Keeyask Project. As well as to perform an economic analysis to compare the benefits of the hydroelectric plant against potential alternatives.

Literature review

Economic Review of Bipole III and Keeyask

In this report, the writers talk about the hydroelectric plant as a “great success” and having “sharp debate over timing, cost, impact on Indigenous groups, and politics.” This report is written based off of public documents from the Public Utilities Board and the Clean Environment Commission, internal reviews performed by Manitoba Hydro, and documents from Manitoba Hydro and the Government of Manitoba. The purpose of this report is to present a full economic review of the Keeyask project along with comparing its benefits with alternatives to the hydroelectric plant.

Report on the Needs For and Alternatives To (NFAT) Review of Manitoba Hydro’s Preferred Development Plan

This report outlines the NFAT review process that was conducted with regards to the Keeyask project. It goes over the socio-economic benefits, qualitative assessment of resource technology options, as well as the macro environmental considerations.

The Keeyask Project - Environmental Impact Statement

This report mainly includes research and an analysis of the project including topics such as, the public involvement program, physical environment, aquatic environment, terrestrial environment, and socioeconomic environment. The report was written by the Manitoba Hydro environmental team in consultation with the KCNs. The main purpose of this report is to go over the impact the hydro plant has on the environment and compare it to other alternatives.

The Keeyask Hydro Dam Plan in Northern Canada: A Model For Inclusive Indigenous Development?

This study examines the benefits and costs of the Keeyask Hydro Dam, and more exclusively focuses on the impact it has on the Indigenous community. The report looks at the partnership between the hydro utility and four First Nations communities. The study also talks about the

project's promise of an inclusive model and employment and revenue benefits for local people. In opposition of that, the report investigates the negative impact the project has on the environment, which has a significant importance for Indigenous groups, as well as the risk of working for this utility.

Methodology

This report delves into the economic analysis of the Keeyask Hydroelectric Project in Manitoba, Canada. Is the Keeyask Hydroelectric Plant economically beneficial compared to its alternatives. This report is mainly focused on the economic evaluations done by the Keeyask (KSK) and Bipole III Commission. The data is straight from the company that is in charge of construction of the new plant, Manitoba Hydro, as it was all provided to the Public Union Board (PUB) of Manitoba as part of the Needs For and Alternatives To (NAFT) for Manitoba Hydro's preferred infrastructure development plan. The data collected and analysed is comparing the project and its alternatives in a 35 year period, and then extrapolating for 43 years, equalling an analysis period of 78 years, which is the useful life of the Hydroelectric plant. The costs and benefits included in the report are all in millions of 2014 Canadian Dollars. Methodology used by Manitoba Hydro can be found in Manitoba Hydro Application for NFAT to the PUB in Appendix 9.3, Section 1.

The analysis was done for not only the Keeyask Generating (Keeyask) plant but also the infrastructure (KIP) built for it, which was a different project done solely for the plant and started early 2012 and finished July 2014. A series of metrics are used for the economical analysis of the projects such as Net Present Value, Break Even Points, Internal Rate of Return, and Expected Value.

Data Description

In the economic report and the NFAT, Manitoba Hydro had chosen 14 different alternatives to its Preferred Infrastructure plan, which included the construction of the Keeyask Hydroelectric Plant:

Table 1: Manitoba Hydro's 15 Development Plans

Plan	Short Name	Description
1	All Gas	Natural Gas-Fired Generation starting in 2022/23
2	K22/Gas	Keeyask 2022/23, Natural Gas-Fired Generation starting in 2029/30
3	Wind/Gas	Wind Generation starting in 2022/23 supported by Natural Gas-Fired Generation starting in 2025/26
4	K19/Gas24/250MW*	Keeyask 2019/20, Natural Gas-Fired Generation starting in 2024/25, 250 MW Export/50 MW Import U.S. Interconnection 2020/21, 250 MW MP Sale
5	K19/Gas25/750MW(WPS Sale & Inv)**	Keeyask 2019/20, Natural Gas-Fired Generation starting in 2025/26, 750 MW Import/Export U.S. Interconnection 2020/21, 250 MW MP Sale, Proposed 300 MW WPS Sale
6	K19/Gas31/750MW	Keeyask 2019/20, Imports, Natural Gas-Fired Generation starting in 2031/32, 750 MW Import/Export U.S. Interconnection 2020/21, 250 MW MP Sale
7	SCGT/C26	Simple Cycle Gas Turbine in 2022/23, Conawapa 2026/27, Natural Gas-Fired Generation starting in 2038/39
8	CCGT/C26	Combined Cycle Gas Turbine in 2022/23, Conawapa 2026/27, Natural Gas-Fired Generation starting in 2039/40
9	Wind/C26	Wind in 2022/23, Conawapa 2026/27, Natural Gas-Fired Generation starting in 2036/37
10	K22/C29	Keeyask 2022/23, Conawapa 2029/30, Natural Gas-Fired Generation starting in 2040/41
11	K19/C31/250MW*	Keeyask 2019/20, Natural Gas-Fired Generation starting in 2024/25, Conawapa 2031/32, 250 MW Export/50 MW Import U.S. Interconnection 2020/21, 250 MW MP Sale
12	K19/C31/750MW	Keeyask 2019/20, Imports, Conawapa 2031/32, Natural Gas-Fired Generation starting in 2041/42, 750 MW Import/Export U.S. Interconnection 2020/21, 250 MW MP Sale
13	K19/C25/250MW*	Keeyask 2019/20, Conawapa 2025/26, Natural Gas-Fired Generation starting in 2040/41, 250 MW Export/50 MW Import U.S. Interconnection 2020/21, 250 MW MP Sale
14	K19/C25/750MW (WPS Sale & Inv) Preferred Development Plan**	Keeyask 2019/20, Conawapa 2025/26, Natural Gas-Fired Generation starting in 2041/42, 750 MW Import/Export U.S. Interconnection 2020/21, 250 MW MP Sale, Proposed 300 MW WPS Sale
15	K19/C25/750MW	Keeyask 2019/20, Conawapa 2025/26, Natural Gas-Fired Generation starting in 2041/42, 750 MW Import/Export U.S. Interconnection 2020/21, 250 MW MP Sale

*Described as hypothetical due to Minnesota Power seeking regulatory approval for a 750 MW interconnection

**Adjusted to remove Wisconsin Public Service investment in the Great Northern Transmission Line

Source: NFAT Submission, Chapter 8

Due to the high number of alternatives, only the choices with the least Net Costs were chosen for analysis by Manitoba Hydro. The alternatives chosen were, **All Gas**, Keeyask 2022/23 with Natural Gas starting in 2029/2030 (**K22/Gas**), and Keeyask 2019/20, Natural Gas-Fired Generation starting in 2024/25, 250 MW Export/50 MW Import U.S. Interconnection 2020/21, 250 MW MP Sale (**K19/Gas24/250MW**). The following table has the Economic Costs and Benefits for each plan.

Table 2: Market Valuation of Each Plan

	Preferred Development Plan	K19/G24/ 250MW	K22/Gas	All Gas
Incremental capital exp.	7,373.9	3,812.1	3,338.0	1,158.9
Less: residual asset value (relative to all gas)	[1,933.3]	[804.6]	[849.6]	0.0
Fuel exp (excl tax)	307.7	856.3	767.6	1,151.2
Imports	971.0	893.0	847.7	1,030.9
O&M, other (excl tax)	2,220.5	2,227.6	2,170.3	2,171.2
Taxes and carbon charge	3,008.1	2,729.8	2,676.7	2,445.2
Total Expenditures	11,947.9	9,714.1	8,950.7	7,957.4
Firm export sales	4,513.6	2,685.1	1,606.0	1,331.7
Spot / opportunity sales	4,818.5	4,430.2	4,458.4	3,355.8
Total Revenues	9,332.1	7,115.3	6,064.4	4,687.5
Net Cost	2,615.8	2,598.8	2,886.3	3,269.9
Difference from Development Plan	0	(17.0)	270.5	654.1

Source: Manitoba Hydro NFAT Submission, Chapter 13: Integrated Comparisons of Development Plans

The Keeyask Hydroelectric Plant also brings in economic benefits as well such as the labour for construction and maintenance of the plant, which directly affect the National GDP. The plant would also bring in annual benefits for the indigenous tribe, Keeyask Cree Nations, surrounding the land.

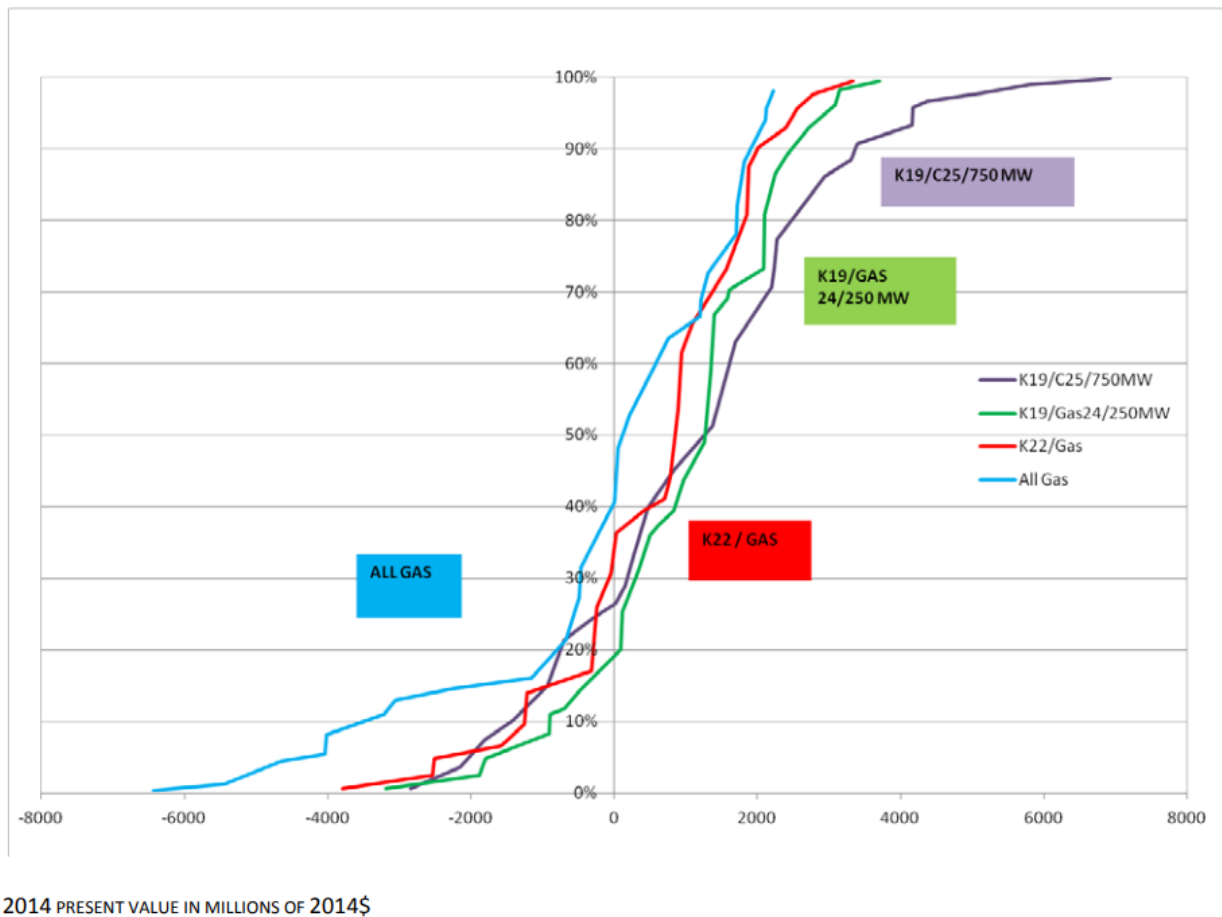
Table 13.9: Socio-economic Impacts Relative To Preferred Plan

	Preferred Development Plan	K19/G24/250MW	K22/Gas	All Gas
Market Valuation				
Net revenues (cost) to MH and partners	--	17.0	(270.5)	(654.1)
Customer Account	Preferred Development Plan has highest rate increases in first 20 years (cumulatively 16 to 18 percentage points more than the alternative plans) but has lowest rate increases over long term (cumulatively by year 50 approximately 34 to 37 percentage points less than the two alternatives with Keeyask G.S. and 70 percentage points less than the all gas plan).			
Cumulative rate increase				
Reliability	Preferred Development Plan and to lesser extent the alternative with the smaller interconnection provides greater load carrying capability, lower expected loss of unserved energy and greater ability to manage extreme drought			
Government				
Incremental revenues net of costs/risk	--	(353.5)	(395.9)	(674.2)
Manitoba Economy				
Employment net benefits	--	(100.7)	(120.1)	(192.7)
Environment				
Manitoba GHG external cost	--	(208.6)	(174.3)	(320.3)
Global GHG impact	Preferred Development Plan and to lesser extent the two plans with Keeyask G.S. would contribute to a reduction in global emissions by displacing thermal generation in US.			
Manitoba CAC damage cost	--	(8.6)	(7.1)	(13.3)
Residual biophysical	Aquatic and terrestrial impacts with hydro projects in Preferred Development Plan and plans with Keeyask G.S.; subject to detailed environmental hearings, residual effects and local external cost expected to be relatively small with initial design, extensive mitigation, monitoring, compensation and benefit-sharing arrangements.			
Social	Significant net returns from up to 25% interest in Keeyask G.S. and income benefits from Conawapa G.S. in Preferred Development Plan; significant benefits from up to 25% interest in two alternatives with Keeyask G.S., greater with new sales and interconnection.			
Partner net return				
Community impacts	Wide range of potential impacts on local employment and business; population, infrastructure and service; social and community well-being; owners of land needed for rights of way and easements; major commitments and plans to minimize adverse residual effects with extensive mitigation, monitoring, compensation and partnership arrangements.			
Other Manitoba	Potentially significant bequest value from the hydro assets remaining at end of planning period; greatest with Preferred Development Plan and to a lesser extent in the alternatives with Keeyask G.S.			
Overall Monetized Net Benefit (Cost)	--	(654.4)	(967.5)	(1,854.6)

IFAT REFERENCE SCENARIO ASSUMPTIONS (2014 PRESENT VALUE IN MILLIONS OF 2014\$)

Source: Manitoba Hydro NFAT Submission, Chapter 13: Integrated Comparisons of Development Plans, Table 13.9

Figure 13.11: Manitoba Hydro Net Revenue S-Curves



Source: Manitoba Hydro NFAT Submission, Chapter 13: Integrated Comparisons of Development Plans, Figure 13.11

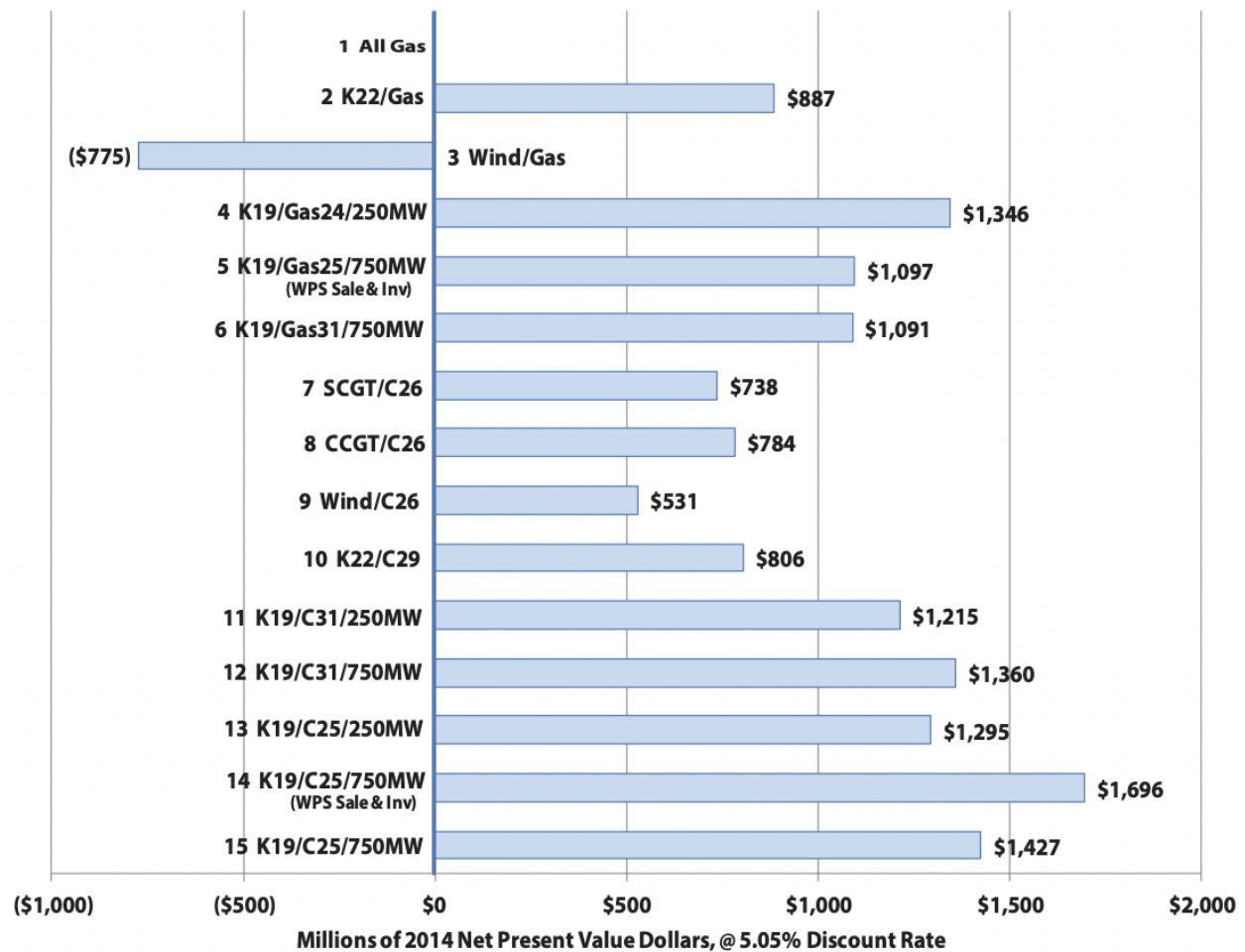
Manitoba Hydro also calculated the internal rate of return of the project as well as the break even points for each alternative. The study was done for a 78-year period. They also conducted an NPV analysis of each alternative for the 78-Year period at an interest rate of 5.05%.

Table 5: CPV, IRR and Break Even Data

Plans	78 Year CPV of					78 Year IRR	Break Even Year (All Gas) Base Case
	Total Capital	78 NPV	50 CPV	35 CPV	20 CPV		
1 All Gas	\$2,764	\$0	\$0	\$0	\$0	N/A	N/A
2 K31/Gas29	\$4,429	(\$38)	(\$349)	(\$798)	(\$1,781)	5.28%	N/A
4 K19/Gas40/250MW	\$5,774	\$604	\$239	(\$284)	(\$1,541)	6.26%	2055
5 K19/Gas31/750MW (WPS)	\$6,215	\$410	\$10	(\$523)	(\$1,899)	5.92%	2062
6 K19/Gas40/750MW	\$6,175	\$386	(\$5)	(\$555)	(\$1,876)	5.90%	2063
12 K19/C40/750MW	\$8,421	(\$18)	(\$954)	(\$2,261)	(\$2,395)	5.36%	N/A
14 K19/C31/750 (WPS)	\$9,528	\$45	(\$863)	(\$2,173)	(\$5,298)	5.42%	2089

As shown in Table 5, the 78 Year IRR for the Preferred Plan is 5.42%, with a break even point in 2089. Also as shown in Figure 1, the preferred plan has the highest NPV of \$1696 Million at a 5.05% rate.

Figure 1: NPV Of All Projects



Source: Manitoba Hydro, NFAT Submission, Chapter 9: Economic Evaluations – Reference Scenario

Data Analysis & Results

Manitoba Hydro compared their preferred project plan with 14 alternatives in terms of their net present worths, of which the preferred plan had the highest of 1696 million Canadian dollars. Furthermore, in order to simplify analysis, they focused their attention on the 4 with the lowest net costs, one of which was the preferred plan. They then compared these alternatives on the basis of their net expenditures and revenues on a 6% discount rate to an estimate of 78 years, as can be seen in Table 2. Here, it can be observed that the plan with Keeyask G.S and no new interconnections is preferable to the all gas plan, and that the plans containing new interconnections are both preferable to the aforementioned without. As for the difference between the two plans with interconnections, the smaller interconnection yields a faint advantage in the net present value of revenues, but otherwise there is little difference. Therefore, it is considered advantageous to proceed with a Keeyask G.S plan which includes construction of an interconnection and to compare the two plans from a public interest perspective.

As can be observed in Table 13.9, there is a considerable advantage in terms of customer reliability, government, economy, and GHG emissions in the long term for the Keeyask G.S plans, especially when compared to the all gas plan. By taking these factors into account, there is a massive advantage of the preferred plan in relation to the smaller interconnection plan. To be more specific, the predicted net present value of the monetized net benefits of the preferred plan is greater than the smaller interconnection, no interconnection and all gas by 654, 867 and 1855 million respectively.

So far, it has been established that the development of Keeyask G.S offers certain advantages over all gas; that the construction of interconnections is more beneficial than without; and that the preferred plan is the best overall from a broad provincial perspective in the long run. Despite this, there exists a considerable level of uncertainty regarding the consequences of each of the plans, and thus it is important to determine whether it is of a high enough magnitude to consider different options. In order to help determine this, probability distributions of a wide range of incomes was calculated based on several underlying assumptions and plotted on the S-Curve in Figure 13.11. It can be observed that the preferred plan (purple line) has the greatest possible upside, while the all gas plan has the greatest possible downside. When comparing the preferred plan to the small interconnection plan, the smaller interconnection has a 50% probability of being better with an overall lower downside risk. However, there is an equal probability of the preferred plan being better with its greater upside potential as previously mentioned.

Discussion & Conclusion

The objective of this report was to analyze the advantages and disadvantages of the Keeyask Project and to conduct an economic analysis, comparing the benefits of the hydroelectric plant vs. possible alternatives. Within the report, the writers mention the hydroelectric plant as successful, however going through vigorous discussions “over timing, cost, impact on Indigenous groups, and politics.” Additionally, the report inspects the affects the hydro plant has on the environment in comparison to additional options. Furthermore, the study emphasizes the impact the project has on the Indigenous community and their environment. Also, the study mentions the project’s agreement of employment and revenue benefits for the local population.

The analysis was completed for the Keeyask Generating plant and infrastructure plant. A succession of metrics were used for economical analysis including, Net Present Value, Break Even Points, Internal Rate of Return, and Expected Value. Within the economic report and NFAT, fourteen alternatives to the preferred infrastructure plan were chosen, one of which was the construction of the Keeyask Hydroelectric plant. Because of the high number of choices, the options with the least Net Costs were selected for further analysis (Table 2). Moreover, the Keeyask Hydroplant provides economic benefits for labour of the plant, which directly affects the National GDP annually for the Keeyask Cree Nations.

Manitoba Hydro analyzed the NPV of the 14 choices, the favoured plan had the highest NPV of \$1696 million Canadian dollars. Thus, the plan with Keeyask G.S and no new interconnections is preferred due to advantages in customer reliability, government, economy, and GHG emissions long term (Table 13.9). However, there was still uncertainty for the consequences of the plan, so probability distributions of an extensive variety of incomes was calculated. Although, the preferred plan was still advantageous as it had the greatest possible upside (Figure 13.11). Therefore, the preferred Keeyask G.S plan is the greatest overall choice from a comprehensive provincial perspective.

References

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