Canadian Gas Services International

Synopsis Report

Feasibility Study of Conversion of Diesel Power Plant to Natural Gas in Fort Simpson

Submitted to:

Government of the Northwest Territories

Industry, Tourism and Investment

Mackenzie Valley Pipeline Office

Submitted By:

Canadian Gas Services International

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1. EXECUTIVE SUMMARY

GNWT selected Canadian Gas Services International to complete the feasibility study of replacing diesel with natural gas to generate electricity in Fort Simpson.

This study determined the financial viability of the project by evaluating the revenue requirement for the gas distribution system and the power plant. The study compared the NPV of the total costs of the power plant for each of the gas options compared to the NPV of the power plant remaining on diesel. This study was based on the gas distribution system being in operation in 2016 and the study was conducted for a 20 year period. Furthermore, it was assumed that once natural gas is available in Fort Simpson, residential and commercial customers would also convert to natural gas for space and water heating applications and that natural gas would reach a market share of 80% over 8 years.

The alternatives evaluated in this study were:

1. **Retaining the existing diesel-fired power generation units (Status quo) –** the NPV of NPTC continuing to use diesel for its power plant in Fort Simpson is approximately $30.9 million. If NTPC were to continue to use diesel for its power plant, it can expect the NPV of the life cycle cost of the diesel power plant to be approximately $5.2 million higher than the best natural gas option.

   Furthermore, if the community of Fort Simpson continues to use oil for space and water heating in residential and commercial applications and for power generation, the NPV of the life cycle cost of status quo for the whole community is approximately $64.4 million, which is approximately $9.6 million higher than the best natural gas option.

2. **Conversion of the existing diesel fuelled gensets to natural gas –** this option is not a viable option as standard diesel to natural gas conversion kits are not available from the manufacturer for the existing diesel-fire gensets. While aftermarket conversion kits from third party suppliers may be available, standard conversion kits from the manufacturer were not available for the existing diesel gensets. Therefore, it was concluded that the existing gensets cannot be easily converted to natural gas reliably for the long term.

3. **Full replacement of the current diesel gensets with natural gas-fired turbine gensets –** three Solar Saturn 20-T1600 gas-fired combustion turbine gensets with a generating capacity of 1,200 kW each for a total capacity of 3,600 kW are expected to meet the long term electricity demand for Fort Simpson.

   The NPV of NPTC replacing its generators with natural gas-fired turbine gensets is approximately $32.2 million, which is approximately $1.3 million higher that the status quo. Gas-fired turbine gensets require a capital investment of $11 million and can result in an IRR of 5% for NTPC, which is less than NTPC's allowed rate of return of 9.7%. Consequently, if NTPC were to replace its diesel-fired gensets with gas-fired turbines, it may have to increase its electrical rates to meet its allowed rate of return of 9.7%.

   If the community of Fort Simpson were to convert to natural gas for space and water heating in residential and commercial applications and to gas-fired turbine gensets for electricity generation, the NPV of the life cycle cost of this option for the whole community is approximately $59.9 million, which could result in savings of over $4.5 million in life cycle cost over the status quo for the whole community.

4. **Full replacement of the current diesel gensets with gas-fired reciprocating gensets –** two different gas-fired reciprocating gensets were analyzed.

    a. Three gas-fired Caterpillar G3516B reciprocating gensets with a capacity of 1,300 kW each and total capacity of 3,900 kW.

    b. Three gas-fired Caterpillar G3520C reciprocating gensets with a capacity of 1,600 kW each and total capacity of 4,800 kW.

    If the community of Fort Simpson were to convert to natural gas for space and water heating for residential and commercial customers and to gas-fired reciprocating gensets for electricity generation, the NPV of the life cycle cost of this option is approximately $54.8 million and $55.1 million for the G3516B and G3520C respectively, which could result in savings of over $9.3 million to $9.6 million in life cycle cost over the status quo for the whole community. Gas-fired reciprocating gensets require a capital investment of $5.4 and $6.6 million for the G3516b and G3520C gensets respectively and can result in savings of approximately $4.9 to $5.2 million in life cycle cost for NTPC over remaining on diesel gensets. The IRR of this option is expected to be 13.9% to 15.0%, which exceeds NTPC's allowed rate of return of 9.7%. Furthermore, gas-fired reciprocating gensets can result in an IRR of over 10% for NTPC under most alternative scenarios tested in this study, which exceeds NTPC's allowed rate of return of 9.7%. Consequently, if NTPC were to replace its diesel-fired gensets with gas-fired reciprocating, it could potentially result in lower electricity rates.

Table 1 summarizes the results of the financial analysis of the options analysed in this study.

Table 1. Summary of Financial Analysis

	Status Quo	natural gas-fired turbine gensets	gas-fired reciprocating gensets – 3516B	gas-fired reciprocating gensets – 3520C
NPV - community	$64.4 million	$59.9 million	$54.8 million	$55.1 million
NPV power plant	$30.9 million	$32.2 million	$25.7 million	$26.0 million
Capital cost of power plant	$3.90 million	$11.0 million	$5.4 million	$6.6 million
IRR - power plant over status quo	n/a	5.0%	15.0%	13.9%

Gas-fired reciprocating gensets have the lowest life cycle cost and highest IRR for NTPC. They also have the lowest life cycle cost for the whole community. It is therefore, recommended that the community convert both space and water heating in residential and commercial applications and electricity generation to natural gas. Furthermore, it is recommended that NTPC replace its diesel-fired gensets with natural gas-fired reciprocating gensets and that NTPC should plan to use natural gas for power generation as soon as natural gas becomes available.

If NTPC were to replace its diesel gensets with gas-fired gensets, it should consider using the diesel gensets that have not reached the end of their life expectancy at some of its other power plants. This can further improve the financial viability of using natural gas for power generation.

Developments in new technology such as high pressure flexible pipe and CNG may have the potential to reduce the cost of the pipeline lateral from MVGP to Fort Simpson and the gas distribution system. GNWT should investigate developments in such new technologies as it may further improve the project's financially viability

Gas-fired reciprocating gensets result in the lowest cumulative GHG produced by the whole community over 20 years. The whole community is expected to produce 375,000 tonnes of CO_2 under the status quo vs. 351,000 tonnes with gas-fired turbines, and 282,000 tonnes with gas-fired reciprocating gensets. Use of gas-fire reciprocating gensets for power generation and use of gas for space and water heating by commercial and residential customers can reduce the CO_2 produced by the whole community by approximately 25% over 20 years. Furthermore, NTPC can expect to produce 137,480 tonnes of CO_2 under the status quo vs. 149,940 tonnes with gas-fired turbines, and 95,710 tonnes with gas-fired reciprocating gensets. Gas-fire reciprocating gensets can reduce the CO_2 produced by the power plant by approximately 30% over 20 years.

2. Introduction

The Mackenzie Gas Project (MPG) is planning to develop gas fields in the Northwest Territories and a 1.2 Bcf/day gas pipeline down the Mackenzie Valley. This project provides a potential opportunity to convert the communities in NWT to natural gas for electrical power and/or heating.

In 2008, GNWT retained Encor International, one of the partners in Canadian Gas Services International (CGSI) to complete the Mackenzie Valley Gas Conversion Feasibility Study. The study concluded that using natural gas for power generation can result in lower electricity costs and natural gas should be used in the power plants as soon as gas becomes available.

GNWT has now selected CGSI to complete an analysis of the technical and financial viability of using natural gas to fuel the power plant in Fort Simpson, NWT.

3. Overview and Objectives

The primary objectives of this study are to evaluate the technical and financial viability of using natural gas for the power plant in Fort Simpson. The alternatives evaluated in this study were:

1. Retaining the existing diesel-fired power generation units (Status quo).
2. Conversion of the existing diesel-fired generator sets (gensets) to natural gas.
3. Full replacement of the current diesel-fired gensets with natural gas-fired turbine gensets.
4. Full replacement of the diesel-fired gensets with gas-fired reciprocating engine gensets.

This study updated technical and financial viability of using natural gas to fuel the power plant in Fort Simpson, which was conducted as part of the Mackenzie Valley Gas Conversion Feasibility Study for GNWT in 2008. This study updated:

1. The capital cost and feasibility of converting the diesel-fired reciprocating gensets in Fort Simpson to natural gas.
2. The capital cost and feasibility of replacing the diesel-fired reciprocating gensets in Fort Simpson with gas-fired gensets.
3. The operation and maintenance costs of natural gas-fired gensets.

4. METHODOLOGY

Fuel prices, electricity and natural gas demand, cost of the gas distribution system, and capital and operating costs of the power plant are key factors in determining financial viability of converting the power plant from to natural gas. This study determined financial viability of the project by analyzing the revenue requirement for the gas distribution system and the power plant.

The study determined electricity load forecast and sized the power plant to meet the forecast. The study then determined the natural gas load forecast for power generation as well as for space and water heating for residential and commercial sectors. The study also obtained natural gas, diesel, and electricity price forecasts for the 20 year period of the study. The natural gas load forecast and capital and operating costs of the gas distribution system from the 2008 Encor study were used to determine the revenue requirement for the gas distribution system. Capital and operating costs were estimated for a number of gas-fired gensets and the revenue requirement for the power plant was determined to recover the cost of providing service. The financial viability of the project was analyzed by first analyzing the NPV of the life cycle cost of providing gas to Fort Simpson vs. remaining on diesel. Once it was determined that the whole community would benefit from lower energy costs for electricity and space and water heating, the financial viability of converting the power plant to natural gas was analyzed from NTPC's perspective.

This study used the capital and operating costs for the gas distribution system provided in the 2008 study and escalated them at rate of 1.5% per year. Developments in new technology may have the potential to reduce the cost of the pipeline lateral from MVGP and the gas distribution system. These new technologies include developments in the use of high pressure flexible pipe, and developments in CNG.

The power plant's peak gas demand as well as the peak demand due to residential and commercial customers was used to allocate the capital and operating and maintenance costs of the gas distribution system between the power plant and residential and commercial customers.

The study assumed that once gas becomes available in the community, residential and commercial customers would convert from oil to natural gas and natural gas would reach a market penetration of 80% over 8 years. This assumption was based on the information provided by GNWT for the 2008 study.

The financial viability of gas-fired power generation was evaluated relative to the status quo. The natural gas options analyzed in this study included:

1. Full replacement of the diesel gensets with natural gas-fired turbine gensets
2. Full replacement of the diesel gensets with natural gas-fired reciprocating gensets

The conversion of the existing diesel-fired gensets from diesel to natural gas was eliminated after technical analysis indicated that standard conversion kits from manufacturers are not available.

NTPC indicated that it wants to retain the existing diesel generators to provide 100% redundancy for the natural gas option. As a result, the study allowed for the cost of operating the existing diesel generators for a few hours every week. Although this was allowed for in the study, it is not recommended to retain the existing diesel generators for 100% back up of gas power generation. Gas-fired generators are very reliable; retaining the existing generators provides redundancy that currently is not available and adds additional costs to the gas options.

The study used a discounted cash flow model to compare the NPV of the life cycle cost of the power plant for each of the gas options compared to the NPV of the life cycle cost of the power plant remaining on diesel. The costs included the capital investment in gensets, maintenance costs, scheduled overhauls, fuel costs, cost of debt, return on equity, and depreciation.

This study was based on the gas distribution system being in operation in 2016 and the study was conducted for a 20 year period. The capital and operating costs were estimated in 2010 $ and escalated to obtain costs for 2016 and beyond. The costs associated with the gas distribution system were escalated at a rate of 1.5% per year, while the costs associated with the power generation equipment were escalated at 3% per year.

4.1. Updates to the Financial Model

CGSI reviewed the revenue requirement model used in the 2008 study and updated some of the input parameters to reflect more recent data.

4.2. Overview of Scenarios Analyzed

The status quo in this study is defined as the option whereby the power plant and residential and commercial customers remain on diesel fuel for the next 20 years.

The natural gas option in this study is the alternative when in 2016 the power plant begins operating using new natural gas-fired genset sets and 80% of the residential and commercial customers change from oil to natural gas over an 8 year period for heating beginning in 2016.

The base case represents the most likely scenario based on information available at the time of this study. The impact to changes to some of the main variables was then tested by changing the values of these parameters. The base case and the alternative scenarios are discussed below.

4.3. Base Case

The base case scenario used the following data and assumptions:

- Oil and gas price forecasts were based on the GLJ forecast effective as of April 2010.
- Capital & operating costs for the gas distribution system and lateral were based on the 2008 study and escalated at 1.5% per year.
- Capital and operating costs for the new power generation equipment were based on prices obtained from equipment vendors for this study and escalated at 3% per year.

- Market penetration of natural gas in the residential and commercial sectors was estimated based on information provided by GNWT for the 2008 study. Market penetration for Fort Simpson was estimated at 80% over 8 years.
- The analysis period was from 2016 to 2035.
- The number of residential and commercial accounts was extrapolated from those used in the 2008 study, where the analysis period was from 2015 to 2034.
- Discount rate of 10% was used in the discount cash flow analysis.
- Consistent with the 2008 study, cost of converting the heating equipment from oil to natural gas for residential and commercial customers were not included in the analysis.
- The NTPC opening plant and accumulated depreciation are the 2016 data sourced from an NTPC provided spreadsheet summarizing rate base data.
- $300,000 in capital expenditures was allowed for all gas options for other contingencies.

4.4. Alternative Scenarios

The financial viability of the project was tested against changes to a number of parameters. The variables tested in the alternative scenarios were fuel price, project capital cost, and demand. The alternative scenarios tested included:

- Natural gas and fuel price forecast from April 2008
- Natural gas and fuel price forecast from January 2006
- Gas distribution cost 35% higher than the base case
- Gas distribution cost 35% below the base case
- Natural gas demand 20% above the base case
- Natural gas demand 20% below the base case
- **Optimistic Scenario** – 35% lower gas system capital costs and 20% higher demand

5. ELECTRICITY LOAD FORECAST

CGSI used data from NTPC's web site and its latest report[1],to forecast the electricity load for Fort Simpson. According to NTPC's website, the annual power generation requirements in 2008 were 8,419 MWh per year. The latest annual power requirements for Fort Simpson were escalated at 1% per year to determine the forecasted power needs for Fort Simpson for the in-service date of 2016 and beyond. The electricity load forecast for the 20 year period applicable to this feasibility study is shown in Figure 1. The annual power generation requirements in 2035 were 11,014 MWh

[1] http://www.ntpc.com/RegulatoryAffairs/Documents/Generation,%20Sales%20&%20Revenue%20-%202006_07%20and%202007_08.PDF

per year. This load forecast was used to determine the appropriate equipment to meet the long term electricity demand for the community.

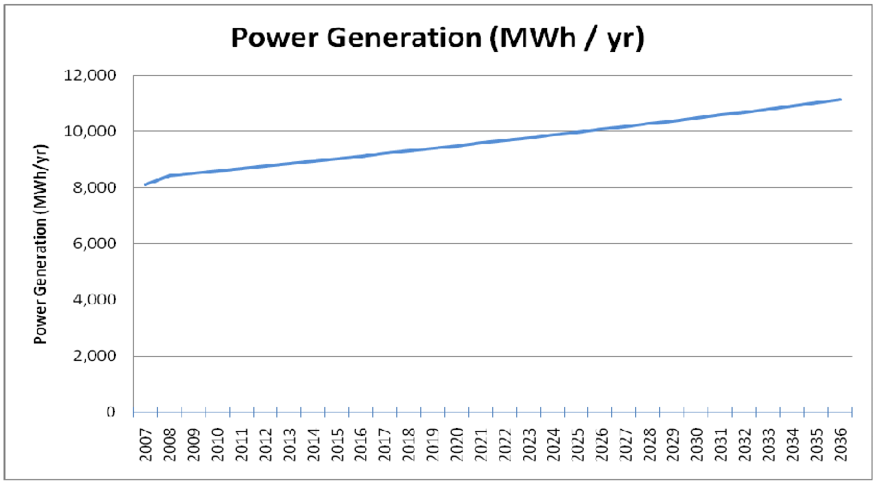

Figure 1. Annual Electricity Generation Forecast

6. Power Generation Equipment

The capacity of the power plant was estimated to meet the electricity load forecast and to provide for efficient operation. Three gensets were used to meet the total power requirements of the community to reduce the risk of complete lack of power in case of the failure of one genset and during routine maintenance. The power generation equipment considered for this study included:

1. Retention of existing diesel gensets
2. Conversion of existing diesel gensets to natural gas
3. Replacement of existing diesel gensets with gas- fired combustion turbines
4. Replacement of existing diesel gensets with gas-fired reciprocating engines

The cost of relocating the power plant was not included in this study since NTPC has indicated that it may have to relocate the power plant due to concerns about erosion from the river**.**

The capital costs used in this study are based on the replacement of the existing gensets and connecting the new generators to the existing distribution system.

6.1. Existing Diesel Gensets

NTPC currently uses 4 diesel-fired gensets in Fort Simpson with total capacity of 3,210 kW.

While aftermarket conversion kits from third party suppliers may be available, standard conversion kits from the manufacturer were not available. Therefore, for the purposes of this study it was concluded that the existing gensets cannot be easily converted to natural gas.

Since manufacturer recommended life of gensets is about 100,000 hours, CGSI assumed that the Caterpillar 3516 is replaced in 2010, as it had 124,121 operating hours. Furthermore, it was assumed that the gensets are staged and that each genset operates for approximately 3,375 hours per year. This was used to determine the estimated operating hours on the engines in 2016. The Caterpillar 3508 will reach in the end of its life expectancy in 2016, while the other units still have several more years of life. NTPC may be able to use these units to replace other gensets at other power plants in its service territory.

It is assumed that gensets will be maintained as per manufacturer's recommended maintenance schedule, Maintenance costs were estimated in 2010 $ and escalated by 3% per year.

Based on the 2008 fuel consumption and power generation data from NTPC, the fuel consumption of the existing gensets is estimated at 3.715 kWh per Litre.

6.2. Gas-Fired Combustion Turbine Gensets

Based on the forecasted load growth, three Solar Saturn 20-T1600 gas-fired combustion turbine gensets with a generating capacity of 1,200 kW each for a total capacity of 3,600 kW are expected to meet the long term electricity demand for Fort Simpson. The installed cost of the Solar Saturn 20-T1600 gas-fired combustion turbine gensets is estimated at US$3.125 per unit in 2010 $ for a total of C$11 million. Using three identical units will allow NTPC to reduce its maintenance costs and the spare parts it has to carry for the equipment. Each unit is assumed to operate for 4,500 hours per year to meet the electricity requirements of the community.

Annual maintenance and major overhaul costs are estimated based on an Extended Service Agreement (ESA) plus US$3.68 (2010 $) per fired hour on the machine for cost of the overhaul, which is expected to occur at 30,000 hours.

Allowance was made for a small standby diesel genset to supply power to the power plant if all three gas gensets fail or gas supply to the power plant is temporarily disrupted. This will ensure that heat in the power plant can be maintained. The cost of standby diesel genset is estimated at US$71,300 in 2010$ and escalated at 3%/year to obtain a cost of US$82,656 in 2015$.

The fuel consumption of the gas-fired combustion turbines is based on manufacturer's data and is estimated at 9.5 MMBtu per MWh for an efficiency of 24%.

6.3. Gas-Fired Reciprocating Gensets

Two different gas-fired reciprocating gensets were sized to meet the forecasted electricity load.

1. Three gas-fired Caterpillar G3516B reciprocating gensets with a capacity of 1,300 kW each and total capacity of 3,900 kW. The installed cost of these three units is estimated at US$1.56 million per unit in 2010 $ for a total of C$5.4 million in 2010 $.
2. Three gas-fired Caterpillar G3520C reciprocating gensets with a capacity of 1,600 kW each and total capacity of 4,800 kW. The installed cost of these three units is estimated at US$1.92 million per unit in 2010 $ for a total of C$6.6 million.

Both options can meet the long term electricity demand. Using three identical units allows NTPC to reduce its maintenance costs and cost of spare parts. Each G3516B unit is assumed to operate for 4,500 hours/year. Each G3520B unit is assumed to operate for 3,000 hours/year.

Allowance was made for a small standby diesel genset to supply power to the power plant if all three gas gensets fail or gas supply to the power plant is disrupted. This will ensure that heat in the power plant can be maintained. The cost of the standby diesel genset is estimated at US$71,300 in 2010$ and escalated at 3%/year to obtain a cost of US$82,656 in 2015$.

It is assumed that the gensets will be maintained as per the manufacturer's recommended maintenance schedule. Costs were estimated in 2010 $ and escalated by 3% per year.

The fuel consumption of the gas-fired reciprocating gensets is based on manufacture data and is estimated at 9.0 MMBtu per MWh for an efficiency of 38%.

7. GAS LOAD FORECAST

The 2008 study had determined that both the power plant and the residential and commercial customers must convert to natural gas for the conversion of the community to natural gas to be economically viable. As a result, for the purposes of this study it was assumed that natural gas will be used for space and water heating by commercial and residential customers as well as for power generation. Furthermore, the forecasted residential and commercial gas consumption from the 2008 study was used in this study. This forecast was based on natural gas reaching a market penetration of 80% over 8 years in the residential and commercial markets.

The forecasted natural gas consumption by the power plant was based on NTPC's forecasted electricity generation requirements (see section 5) and gas consumption data supplied by the manufacturers of the gensets identified in section 6.

Figure 2 shows the 20 year gas demand forecast f. The left hand axis shows equivalent oil demand in million Litres per year. Residential and commercial gas demand is forecasted at 12 TJ/year in 2016, increasing to 128 TJ/year in 2035. Gas demand for the reciprocating power plant is forecasted at 85 TJ per year in 2016, increasing to 102 TJ/year in 2035 and forecasted at 135 TJ/ year in 2016, increasing to 162 TJ/year in 2035 for the gas turbine power plant.

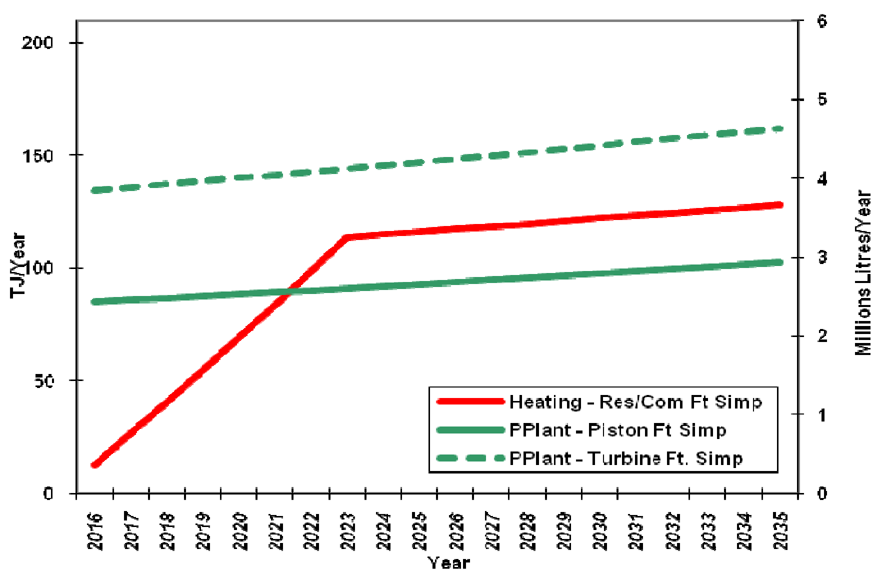

Figure 2. Gas Demand Forecast

8. FUEL PRICE FORECAST

The base case forecasts for heating oil and natural gas prices were obtained from GLJ Petroleum Consultants Ltd. As of April 2010, natural gas prices at AECO for 2015 and 2035 are forecasted to be $6.68 and $10.49 per GJ, while the Edmonton API 40 fuel price is forecasted to be $0.62 and $0.92 per liter in 2015 and 2035 respectively.

GLJ's price forecast for API 40 was used as the baseline for oil price forecast and adders applied to the Edmonton API 40 price for diesel delivery in Fort Simpson. For this study, the adders used for power plant delivery was $0.43/Liter and for residential and commercial delivery it was $0.57/liter. Both adders were escalated at 1.5% per year.

Natural gas price delivered at the MVGP tap is expected to be set at the AECO price, less the TCPL Alberta toll, less half the MVGP toll. MVGP fuel is expected to be provided by the shippers "in kind". The MVGP toll for "Firm Service 20 (FS20)" and fuel rate was provided in Table 3.2 of the March 2007 update on costs, tolls and fees provided by Imperial Oil to the NEB. Figure 3 show the natural gas and diesel price forecast for delivery to Fort Simpson. Although natural gas is typically priced in $ per GJ and diesel is priced in $ per Litre, the left axis in Figure 3 shows gas and diesel prices in $ per GJ and the right axis shows the same prices in $ per Litre. Natural gas prices at Ft. Simpson MVGP tap were forecasted at $4.99/GJ in 2015 increasing to $9.91/GJ in 2035. Diesel for residential and commercial applications was forecasted at $1.25/Litre in 2015 increasing to $1.77/Litre in 2035. Diesel for the power plant was forecasted at $1.09/Litre in 2015 increasing to $1.53/Litre in 2035. Based on data provided by GNWT, the heating value of diesel used in Fort Simpson was estimated at 0.035 GJ per Litre.

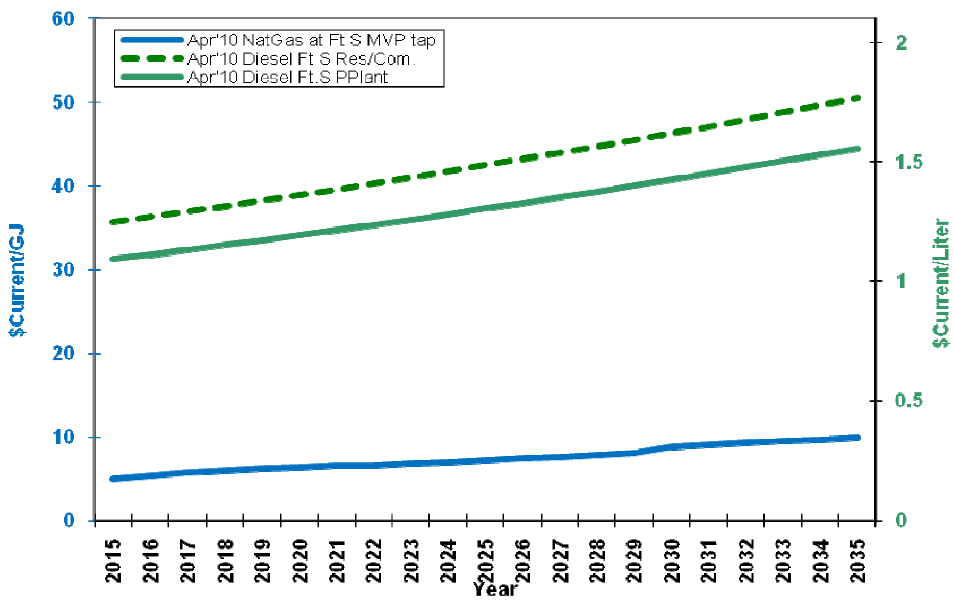

Figure 3. Natural Gas Price at MVGP Tap and Diesel Price Forecast

Figure 4 shows the natural gas and diesel price differential for the power plant. As the graph clearly indicates the forecasted price differential between natural gas and diesel for the power plant in Fort Simpson has increased from 2006 and 2008. This should improve the economic viability of using natural gas for power generation in Fort Simpson.

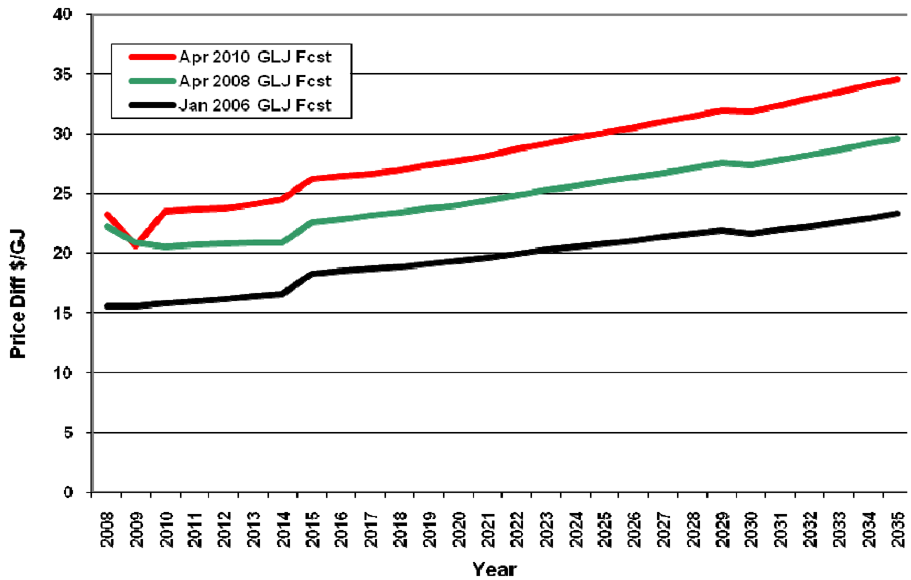

Figure 4. Natural Gas and Diesel Price Differential for Power Plant

9. Financial Analysis Results

The study analyzed the financial viability of the following three gas-fired power generations options relative to the existing diesel-fired power generation.

1. Three gas-fired Caterpillar G3516B reciprocating gensets with a capacity of 1,300 kW each and total capacity of 3,900 kW.
2. Three gas-fired Caterpillar G3520C reciprocating gensets with a capacity of 1,600 kW each and total capacity of 4,800 kW.
3. Three gas-fired Solar Saturn 20 T1600 combustion turbine gensets with a capacity of 1,200 kW each and total capacity of 3,600 kW.

The study used a discounted cash flow model to compare the NPV of the life cycle cost of each of the above gas options compared to the NPV of the life cycle cost of the existing diesel plant if the whole community were to convert to natural gas for power generation as well as for space and water heating in residential and commercial applications. The costs included the capital investment in new or replacement gensets, the annual maintenance costs, scheduled overhauls, fuel costs, cost of debt, return on equity, and depreciation.

Table 2 summarizes the NPV of the savings for the whole community for each of the gas options over the status quo under the base case scenario. The results show that if the whole community were to convert to natural gas for power generation and for space and water heating in residential and commercial applications, the whole community can expect lower energy costs. Under the base case scenario the NPV of the savings are estimated at $9.6 million for the G3516B gas-fired reciprocating gensets, $9.3 million for the G35120C gas-fired reciprocating gensets, and $4.5 million for the Saturn 20 gas-fired turbine gensets.

Table 2. Savings Over Status Quo for Whole Community – Base Case

Description	NPV of Savings over Status Quo (2010 MM$)
Gas-fired Caterpillar G3516B reciprocating genset	$9.6
Gas-fired Caterpillar G3520C reciprocating genset	$9.3
Gas-fired Solar Saturn 20 T1600 combustion turbine genset	$4.5

The NPV of the savings for the whole community for reciprocating gensets was lower than the status quo under all alternative scenarios tested. The NPV of the savings for the whole community for each of gas turbine gensets was lower than the status quo under all alternative scenarios tested except if capital cost of the gas distribution system were 35% higher than the base case or the price differential between diesel and natural gas were at 2008 and 2006 levels.

Once it was determined that the whole community can benefit from converting the power plant and the space and water heating in residential and commercial applications to gas, the study analyzed the financial viability of converting the power plant to gas from NTPC's perspective. The IRR was used as a measure of the financial viability of converting the power plant to gas. The study considered the capital investment in new or replacement gensets, the annual maintenance costs, scheduled overhauls, fuel costs, cost of debt, return on equity, and depreciation in a discounted cash flow model to determine the IRR for the project for NTPC.

Under the base case scenario, the G3516B gas-fired reciprocating gensets have an IRR of 15.0%, the G3520C gas-fired reciprocating gensets have an IRR of 13.9%, and the Solar 20 gas-fired turbines have an IRR of 5.0%. Both gas-fired reciprocating gensets analyzed in this study exceed NTPC's allowed rate of return of 9.7%.

The IIR of the three gas options from the perspective of NTPC were tested under the alternative scenarios to determine whether or not conversion to natural gas would still be financially viable if some of the key variables for the project were to change. The results indicated that both gas-fired reciprocating gensets result in IRR of greater than 10% under all alternative scenarios except when the difference in natural gas and diesel prices is at the levels of the 2006 study.

Figure 5 shows the NPV of the power plant remaining on diesel vs. the gas options for the base case and how capital and O&M and fuel costs contribute to the NPV. It shows that gas-fired turbines have an NPV of $32.2 million vs. $30.9 million for status quo. The G3516B and G3520C gas-fired reciprocating unit have an NPV of $25.7 million and $26.0 million respectively; resulting in savings of over $5.2 and $4.9 million for NTPC, which may translate into lower electricity rates. While converting the power plant to natural gas-fired reciprocating gensets requires considerably more capital investment, it results in significantly lower fuel costs over the long term, which in turn contributes to the lower life cycle cost for natural gas-fired reciprocating gensets. The capital cost shown in status quo represents the cost of replacing one of the diesel unit.

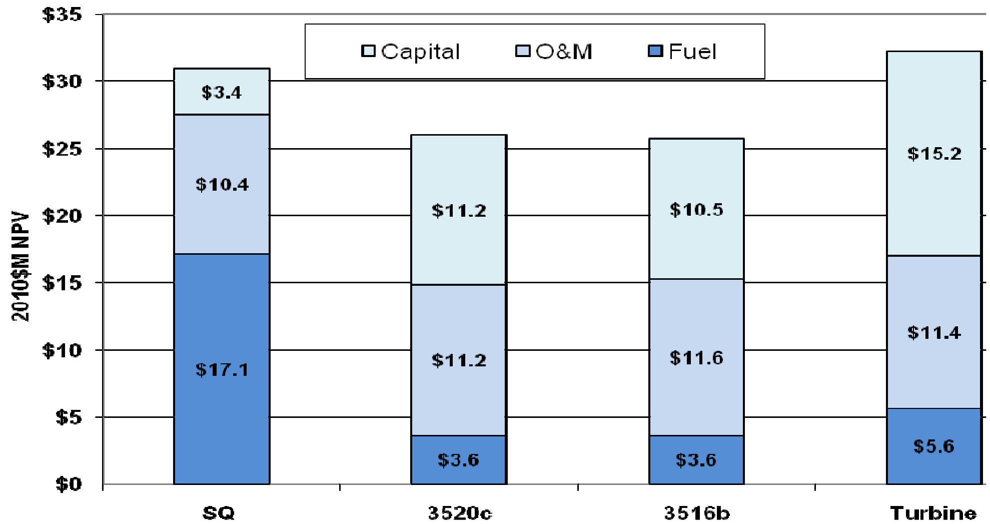

Figure 5. NPV Power Plant Status Quo vs. NG (O&M vs. Capital)

10. Greenhouse Gas Emissions

The study estimated the expected CO_2 production for the status quo as well as the gas options.

Table 3 shows the cummulative CO_2 produced by the power plant and the whole community. The results indicate that if NTPC were to use gas-fired receiprocating gentsets, CO_2 emissions by the power plant and the whole community will be lower by approximately 30% and 25% respectively. If NTPC were to use gas turbines the CO_2 emissions will be approximately 9% higher for the power plant and 6% lower for the whole community.

Table 3. Comulative CO_2 Production over 20 Years

Description	Tonnes of CO_2 Power Plant	Tonnes of CO_2 Whole Community
Status quo	137,480	375,000
Gas-fired reciprocating genset	95,710	282,000
Gas-fired turbine genset	149,940	351,000

11. Conclusions

The following conclusions were drawn from the results of this study:

- Standard diesel to natural gas conversion kits are not available from the manufacturer for the existing diesel-fire gensets.
- The existing diesel gensets cannot be easily converted to natural gas.

- Price differential between diesel & natural gas prices has increased since the 2008 study, improving the viability of the project.
- If Fort Simpson were to convert space and water heating for residential and commercial customers to gas and to gas-fired reciprocating gensets, the NPV of this option is about $54.8 million and $55.1 million for the G3516B and G3520C respectively, resulting in savings of over $9.6 to $9.3 million over the status quo for the whole community.
- Gas-fired reciprocating gensets require a capital investment of $5.4 and $6.6 million for the G3516B and G3520C respectively, and can result in savings of approximately $5.2 and $4.7 million in life cycle cost for NTPC over remaining on diesel gensets.
- Gas-fired reciprocating gensets can result in an IRR of 13.9% to 15.0% for NTPC, which exceeds NTPC's allowed rate of return of 9.7%.
- Gas-fired reciprocating gensets result in an IRR of over 10% for NTPC under most alternative scenarios tested, which exceeds NTPC's allowed rate of return of 9.7%.
- If NTPC were to replace its diesel-fired gensets with gas-fired reciprocating, it could potentially result in lower electricity rates.
- If Fort Simpson were to convert to gas for space and water heating for residential and commercial customers and to gas-fired turbines for electricity generation, the NPV of the life cycle cost of this option is approximately $59.9 million, resulting in savings of over $4.5 million in life cycle cost over the status quo for the whole community.
- Gas-fired turbines require a capital investment of $11 million and can result in extra costs of approximately $1.3 million in life cycle cost for NTPC over remaining on diesel gensets.
- Gas-fired turbine gensets can result in an IRR of 5.0% for NTPC, which is less than NTPC's allowed rate of return of 9.7%.
- If NTPC were to replace its diesel-fired gensets with gas-fired turbines, it may have to increase its electrical rates to meets its allowed rate of return of 9.7%.
- Gas-fired reciprocating gensets have the lowest life cycle costs and highest IRR for NTPC and exceed NTPC's allowed rate of return under most alternative scenarios tested, therefore they represent the least risky option.
- Gas-fired reciprocating gensets have the lowest life cycle costs for the whole community.
- Natural gas-fired gensets are very reliable and keeping the diesel gensets for 100% backup of gas gensets increases the life cycle cost of the gas options and provides redundancy that NTPC currently does not have.
- Some of the diesel-fired gensets will not have reached the end of their life expectancy if they were to be replaced with gas-fired gensets.
- The diesel-fired gensets that have not reached the end of their life expectancy may be used at other NTPC power plants. This can further improve the financial viability of using natural gas for power generation in Fort Simpson.

- Developments in new technology such as high pressure flexible pipe and CNG may potentially reduce costs of the pipeline lateral from MVGP and the distribution system.
- Gas-fire reciprocating gensets result in the lowest cumulative CO_2 produced by the whole community and the power plant over 20 years.
- Use of gas reciprocating gensets for power generation and use of gas for space and water heating by commercial and residential customers can reduce the CO_2 produced by the power plant and the community over 20 years by about 30% and 25% respectively.

12. Recommendations

Based on the conclusions of this study, it is recommended that:

- The community of Fort Simpson convert both space and water heating in residential and commercial applications and electricity generation to natural gas from the Mackenzie Valley Pipeline Project.
- NTPC replace its diesel-fired gensets with natural gas-fired reciprocating gensets.
- NTPC plan to use natural gas for power generation as soon as natural gas is available.
- If NTPC were to consider gas-fired turbine gensets, it should evaluate opportunities for waste heat recovery to improve their viability.
- Use the diesel-fired gensets that have not reached the end of their life expectancy at other power plants to further improve the financial viability of the project, rather than keep them as back up for 100% redundancy.
- Investigate the viability of CNG and/or LNG supplies to the community.
- Investigate developments in new technology such as high pressure flexible pipe and CNG that may potentially reduce the cost of the pipeline lateral from MVGP to Fort Simpson and the gas distribution system.

13. Proposed Project Development Plan

- Educate and promote the communities on the benefits of gas for space and water heating
- Develop a strategy for using the savings in electricity costs to reduce gas heating costs.
- Continue to work with MGP industry on taking advantage of synergies between the two projects.
- Continue to monitor oil and gas prices, as the price differential shall have a significant impact on the economics of the project.
- Evaluate developments in new technology such as high pressure flexible pipe and CNG that may potentially reduce the cost of the pipeline lateral from MVGP to Fort Simpson and the gas distribution system.

- Investigate potential new locations for the power plant.

Appendix A. GLOSSARY

AECO	AECO (Alberta Energy Corporation) gas price reference point
AHL	Annual heating load
API 40	Light sweet crude (American Petroleum Institute gravity of 40)
Bcf	Billion Cubic Feet
Btu	British Thermal Units
CGSI	Canadian Gas Services International
CNG	Compressed Natural Gas
CPCN	Certificate for Public Convenience and Necessity
GHG	Greenhouse Gases
GLJ	Gilbert Lautsen Jung Associates
GNWT	Government of the Northwest Territories
GJ	Gigajoule
IOL	Imperial Oil Limited
ITI	NWT Department of Industry, Tourism and Investment
IRR	Internal Rate of Return
kW	Kilowatt
kWh	Kilowatt Hour
LNG	Liquefied Natural Gas
MGP	Mackenzie Gas Project Industry
MMBtu	Million Btu
MVGP	Mackenzie Valley Gas Pipeline
MVGCS	Mackenzie Valley Gas Conversion Feasibility Study
MW	Megawatt
MWh	Megawatt Hour
NEB	National Energy Board
NPV	Net Present Value
NTPC	Northwest Territories Power Corporation
NTPUB	Northwest Territories Public Utilities Board
O&M	Operating and Maintenance
RFP	Request for Proposal
Scf	Standard Cubic Feet
TCPL	Trans Canada Pipe Line
U.S.	United States