Economic, Load, and Environmental Impacts of Fuel Switching in Manitoba

MANITOBA HYDRO

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EXECUTIVE SUMMARY

This report outlines the economic, load and environmental impacts of using electricity (including geothermal technology) instead of using natural gas for space and water heating purposes. The economic impact is assessed from the customer's and the utility's perspective along with a high level assessment of provincial leakage (i.e. the net impact of changes to extra-provincial natural gas purchases and electricity export sales). The environmental (greenhouse gas emission) impact is assessed from both a provincial and a global perspective. The scope of this assessment does not consider future uncertainty associated with a number of influential factors, including potential electricity rate structure changes (e.g. inverted rates) and potential changing Canadian and US government policies related to greenhouse gas (GHG) emissions. The assessment also does not account for any costs which may result from large-scale upgrading of Manitoba Hydro's electrical infrastructure due to significant energy demand changes.

||| Space Heating

The following table summarizes the load, economic and environmental impacts of using electricity instead of natural gas for space heating in a typical Manitoba residential home. Impacts are analyzed over the life of the equipment (i.e. 25 years). Values in brackets indicate a negative impact from an economic perspective and represent a reduction in GHG emissions from an environmental perspective.

Impact of Converting from Natural Gas to Electric Space Heat

Average Residential Home from Natural Gas to:	Electric Furnace	Geothermal (SCOP 2.5)
Annual Energy Load Impact		
Electric Load Impact (kW.h)	16,391	6,556
Natural Gas Load Impact (cu.m)	(1,776)	(1,776)
Economic Impact		
Utility Perspective (Electric)	($3,223)	($1,563)
Utility Perspective (Natural Gas)	($4,107)	($4,107)
Customer Perspective	($7,737)	($11,276)
Integrated Utility / Customer Perspective	($15,067)	($16,946)
Net Provincial Inflow (Leakage)	($6,271)	$1,061*
Annual Environmental Impact		
Manitoba (kg $C0_2e$/year)	(3,374)	(3,374)
US - MISO Region** (kg $C0_2e$/year)	0 to 12,293	0 to 4,917
Net Global**(kg $C0_2e$/year)	(3,374) to 8,919	(3,374) to 1,543

**The provincial inflow benefits will be offset by higher cost of geothermal units relative to the cost of natural gas furnaces and air conditioners (i.e. estimated at $2,000 to $3,000).*

***The US-MISO Region and Net Global impacts are shown as a range, which includes the impact under today's emission policies in export regions and recognizes what the potential impacts could be under more aggressive emission policies in export regions.*

From the customer, utility and provincial leakage perspectives, there are substantive benefits when customers use natural gas rather than electricity for space heating purposes. The directional impact for each of these factors are also the same when using natural gas for space heating relative to using geothermal systems, except for the provincial leakage impact. In the latter case, a more complete analysis would need to account for the higher cost of geothermal furnace units which are imported into Manitoba relative to the cost of importing natural gas furnaces and air conditioners.

Using electricity for space heating in Manitoba as opposed to natural gas will reduce GHG emissions in Manitoba; however the global GHG emissions will be higher due to reduced electricity exports from Manitoba (i.e. electricity exports would no longer displace fossil generation). In the future, the global impacts may change depending on future environmental policies (e.g. if a cap on GHG emissions was introduced within the U.S. in the future, changes in Manitoba electricity exports would potentially have no incremental impact on US GHG emissions). Given the possible future outcomes, the US and global environmental impacts are shown as a range of possible outcomes.

||| Water Heating

The following table summarizes the impact of using electricity instead of natural gas for water heating applications in a typical Manitoba residential home, analyzed over the life of the equipment (i.e. 10 years). Values in brackets indicate a negative impact from an economic perspective and represent a reduction in GHG emissions from an environmental perspective. The impacts are assessed for using electric hot water tanks relative to a conventional natural gas unit.

Impact of Converting from Natural Gas to Electric Water Heat

Average Residential Home from:	Conventional Gas to Electric Water Heat
Annual Energy Load Impact	
Electric Load Impact (kW.h)	3,489
Natural Gas Load Impact (cu.m)	(491)
Economic Impact	
Utility Perspective (Electric)	($10)
Utility Perspective (Natural Gas)	($317)
Customer Perspective	($727)
Integrated Utility / Customer Perspective	($1,054)
Net Provincial Inflow (Leakage)	($297)
Annual Environmental Impact	
Manitoba (kg $C0_2e$/year)	(933)
US - MISO Region* (kg $C0_2e$/year)	0 to 2,617
Net Global* (kg $C0_2e$/year)	(933) to 1,684

**The US-MISO Region and Net Global impacts are shown as a range, which includes the impact under today's emission policies in export regions and recognizes what the potential impacts could be under more aggressive emission policies in export regions.*

Similar to space heating, there are benefits to using natural gas relative to electricity for water heating purposes. The environmental (GHG) impacts of using electricity rather than natural gas for water heating applications are similar to space heating however the impacts are much lower on a per unit basis as the equipment uses less electricity/natural gas.

||| Manitoba - Fuel Choice Trends & Impacts

A trend towards more customers using electricity for space and water heating is evident in Manitoba. For water heating, a trend toward the increased use of electric water heaters is currently taking place and is forecast to continue into the future. For example, virtually 100% of the new home market is installing electric water heaters. A small shift towards the increased use of electricity for space heating is expected however this shift has been declining due primarily to the continuation of low natural gas prices.

As indicated in the following table, the impact of fuel switching from natural gas to electricity is approximately 3% of the expected 2030/31 domestic electric demand for both space and water heating and a 5% reduction in the provincial natural gas demand forecast in 2030/31.

2011 Load Forecast	**Portion of 2011 Forecast Attributed to Fuel Switching 2030/31**		
	Total Load Forecast	**Space & Water Heating**	**% of Load**
Net Firm Energy (GW.h)	32,465	874	**3%**
Total Natural Gas Sales ($10^6 m^3$)	1,924	-103	**-5%**

There are substantive economic impacts from the increased use of electricity (i.e. fuel switching) for heating purposes based on Manitoba Hydro's 2011 energy forecasts. The following table presents the net economic costs to the utility and to customers over a 30 year period. In addition, reduced export power revenue is not fully offset by the reduced imported natural gas purchases and is therefore expected to result in lower net provincial cash inflows.

Net Economic Costs & Provincial Leakage

2011 Forecast	**Net Cost**
Utility Perspective (Electric)	$132 million
Utility Perspective (Natural Gas)	$69 million
Customer Perspective	$311 million
Electricity Export Revenues	$505 million
Natural Gas Import Purchases	($251 million)
Net Provincial Leakage	$254 million

The following table provides the environmental (GHG) impact of fuel switching in space and water heating as per the 2011 forecasts.

Potential Annual GHG Impacts
(Attributed by Region due to Energy Use)

Year	Manitoba (tonnes C02e / year)	US - MISO Region* (tonnes C02e / year)	Net Global Impact* (tonnes C02e / year)
2012/13	(11,970)	38,753	26,783
2022/23	(154,166)	0 to 496,268	(154,166) to 342,102
2032/33	(203,699)	0 to 687,473	(203,699) to 483,774

** The US-MISO Region and Net Global impacts are shown within a range, which includes the impact under today's emission policies in export regions and potentially what the impacts would be under more aggressive emission policies in export regions.*

||| Hypothetical Impact of Total Conversion

The following analysis provides insight into the hypothetical maximum load impacts if all customers in Manitoba replaced their existing space and water heating equipment with an alternative natural gas, electric or geothermal system. The results simply provide a technical range of hypothetical impacts in terms of electricity and natural gas demand in Manitoba. The table provides:

- the existing electricity and natural gas load for space and water heating in Manitoba; and
- the hypothetical potential electricity and natural gas loads under extreme fuel conversion scenarios (i.e. all customers immediately fuel switch to either all natural gas use, all electric use or all geothermal use for space and water heating purposes).

Impacts are based on the electric and natural gas forecast for 2011.

Hypothetical Annual Load Impact
If All Customers in Manitoba Immediately Switched to One Type of Heating Fuel

	Natural Gas (1000 m3)	Electricity (GW.h)	Geothermal SCOP 2.5 (GW.h)
Current load situation - space heat	938,723	3,473	67
Current load situation - water heat	194,925	1,097	0
A. Immediate fuel switch to natural gas - space	1,339,429	---	---
A. Immediate fuel switch to natural gas - water	349,251	---	---
B. Immediate fuel switch to electric - space	---	11,341	67
B. Immediate fuel switch to electric - water	---	2,482	---
C. Immediate switch to geothermal - space	---	---	4,603
C. Immediate switch to geothermal - water	---	---	2,081

The magnitude of the hypothetical potential impact of all customers switching to electric space and water heating would add 7,868 GWh and 1,385 GWh respectively of annual electric load in Manitoba. Combined, this additional electric load would be equivalent to approximately two generating stations the size of Conawapa. **It is important to recognize that the implications to the utility go beyond the analysis provided within this report.** The consequence of a significant fuel switching scenario would also require a substantial investment in additional generation, transmission and distribution infrastructure. In addition, the utility would be confronted with managing a more diverse winter/summer load.

From the natural gas perspective, the remaining annual natural gas load would be 40% of the existing load and as such, the scenario would require a rate increase to the remaining natural gas customers to cover fixed costs (i.e. the fixed costs would need to be recovered from a much smaller customer base). It should be noted that the theoretical potential impact of all customers switching to natural gas space and water heating is also not possible with today's natural gas infrastructure. The implications of this theoretical scenario would also require extensive new infrastructure at an extraordinarily high cost.

The potential impacts of fuel switching in Manitoba for space and water heating can be significant. Given the economic drivers from a customer's perspective, it is unlikely that the Manitoba market will experience any overwhelming shift in space heating from natural gas to electricity, provided customers are informed on their choices. With water heating, the drivers are substantial enough that Manitoba Hydro expects to see a continued market shift from natural gas to electricity.

Manitoba Hydro recognizes the value customers place on having choice and the Corporation does not intend on mandating a specific fuel be used for space and water heating. Where appropriate, the Corporation prefers to use market intervention mechanisms (e.g. education, direct financial incentives, rate design options, etc.) to influence the market.

1.0 INTRODUCTION

This report outlines the economic, load and environmental impacts of using electricity (including geothermal technologies) instead of natural gas for space and water heating purposes. The economic impact is assessed from both the customer's and utility's perspective and includes a high level assessment of provincial leakage. The environmental (greenhouse gas emission) impact is assessed from both a provincial and global perspective. The scope of the assessment does not consider future uncertainty associated with a number of influential factors including potential electricity rate structure changes (e.g. inverted rates), electricity export price markets and potential changing Canadian and US government policies related to greenhouse gas (GHG) emissions.

The price of natural gas has a major influence on consumer's fuel choice. Prior to 2008, increased demand for natural gas combined with fears of limited supplies, drove prices upward. Colder/longer winters, increased use of natural gas for electrical generation, growth in the residential and commercial markets, the use of natural gas in Alberta oil sands production, and hurricanes Katrina and Rita, all contributed to natural gas price increases and price volatility. As the cost to heat with natural gas approached the cost to heat with electricity, customers questioned which choice was best. In 2008, Manitoba saw primary natural gas prices peak at 33¢/cu.m. However, more recently, improvements in drilling technology have made it more cost effective to access vast shale gas reservoirs across North America. This increase in economically accessible supply has contributed to a steady decrease in market prices since 2008. Lower, more stable natural gas prices are now forecast into the future and are expected to increase customer interest in natural gas as a competitive space and water heating option.

2.0 BACKGROUND

||| 2.1 Available Space & Water Heating Options

There are a number of different types of space and water heating systems available in the market.

Space Heating
The most common types of space heating options include:

- Natural Gas
  Natural gas space heating systems in Manitoba are predominantly forced air (furnace) systems while a small percentage uses hot water (boiler) distribution systems. Residential natural gas heating equipment is rated in Annual Fuel Utilization Efficiencies (AFUE). High efficiency condensing equipment have AFUE ratings range between 90% and 98%, while mid-efficient equipment are between 78 and 84%. Conventional equipment (pre 1992) was never rated under the AFUE test procedures, therefore a seasonal efficiency of 60% has been assumed. Recent changes in the residential building regulation in Manitoba prevent the sale of natural gas heating systems with an AFUE of less than 92%.

  For the purpose of this report, Manitoba Hydro calculates the energy consumption of home heating systems using “seasonal efficiency” estimates, to be equitable to all systems. Seasonal efficiency estimates are always slightly lower than AFUE ratings to take into consideration not only normal operating losses but also the reality that field installations are less ideal than the laboratory environment where AFUE tests are performed. Seasonal efficiency considers:
    - start-up and shut down cycling losses,
    - reduced air flow volumes due to undersized ductwork
    - lack of system maintenance (air filters etc.)
    - improper system commissioning
    - colder climate than assumed in AFUE calculation method.

- Electric
  Conventional electric space heating systems include forced air furnaces, hot water boiler systems and baseboard heating systems. All electric systems are considered 100% efficient as there are no venting/combustion losses.

- Geothermal Heat Pumps
  Geothermal heat pump systems use the thermal energy stored in the earth (ground or water) as a primary heat source/sink. These systems use electricity to undertake the heat transfer and are usually designed to use a backup heating system to meet peak heating requirements. These backup systems are typically electric furnaces which are a component of a geothermal heating unit. Although most heat pumps have a Coefficient of Performance (i.e. efficiency) rating of over 3.0 (or 300% efficient), most systems operate with a lower Seasonal Coefficient of Performance (SCOP) in the range of 2.0 – 3.0 (200-300% efficient) depending on the quality and configuration of the system. For the purposes of this analysis, performance based on a SCOP of 2.5 is presented as an average.

However, to demonstrate the impact of system configuration and quality, a sensitivity analysis assuming an improved SCOP of 3.5 is included in Section 5.1.

- Other
  This category includes a variety of heating systems utilizing fuel oil, propane, wood, etc. Typically, oil and propane systems are expensive and are rarely chosen in new construction applications.

The following tables provide an estimate of the capital and operating costs for conventional electric, natural gas and geothermal heating equipment bought, installed, and operating in an average residential home (i.e. 1,200 sq. ft. home).

The first table provides the costs to replace space heating equipment at the end of its life in an existing home, while the second table provides the capital and operating costs when installing space heating equipment for the first time in a new home. It should be noted that the capital cost associated with each system will vary considerably in the marketplace due to various factors including individual contractor bidding practices and marketing strategies. Therefore, typical low, high and average prices are provided. Prices, however, may fall outside the lower and higher bounds as some suppliers could offer extreme price variations. Prices also vary between new construction and retrofit (end of life) applications.

Annual operating costs presented below are based on rates in effect on May 1, 2012 (natural gas rate of $0.2220 per cubic metre and electric rate of $0.0677 per kilowatt hour) and the average heating requirement of all homes in Manitoba.

Space Heating: End-of-Life Replacement (Existing Homes)

System Description	Annual Operating Costs	Cost to Purchase and Install Equipment (Includes Labour, Equipment & Material Costs)		
		Low	**High**	**Average**
Natural Gas High Efficiency Forced Air Furnace *(no ductwork allowance)*	$562*	$3,500	$5,500	$4,500
Electric Forced Air Furnace *(no ductwork allowance)*	$1,110	$2,000	$3,000	$2,500
24,000 Btu/h Split System Air Conditioner (A.C.)	$50	$2,000	$3,000	$2,500
Ground Source Closed Loop Heat Pump SCOP 2.5 *(no ductwork allowance)*	$444	$15,000	$20,000	$17,500
Electrical Service and Panel Upgrade to 200 Amp Service *(required for electric & heat pump systems)*	---	$2,000	$3,000	$2,500
Average incremental capital cost of choosing electric over natural gas furnace				**$500**
Average incremental capital cost of choosing geothermal over natural gas furnace (with A.C.)				**$13,000**

** The Annual Operating Costs presented for natural gas furnaces includes the Basic Monthly Charge of $14/month.*

Space Heating: New Construction

System Description	Annual Operating Costs	Cost to Purchase and Install Equipment (Includes Labour, Equipment & Material Costs)		
		Low	High	Average
Natural Gas High Efficiency Forced Air Furnace *(no ductwork allowance)*	$562*	$3,500	$4,500	$4,000
Electric Forced Air Furnace *(no ductwork allowance)*	$1,110	$3,500	$4,500	$4,000
24,000 Btu/h Split System Air Conditioner (A.C.)	$50	$2,000	$3,000	$2,500
Ground Source Closed Loop Heat Pump SCOP 2.5 *(no ductwork allowance)*	$444	$20,000	$25,000	$22,500
Electrical Service and Panel Upgrade to 200 Amp Service *(required for electric & heat pump systems)*	---	$500	$1,000	$750
Average incremental capital cost of choosing electric over natural gas furnace				**$750**
Average incremental capital cost of choosing geothermal over natural gas furnace (with A.C.)				**$16,750**

** The Annual Operating Costs presented for natural gas furnaces includes the Basic Monthly Charge of $14/month.*

As indicated in the above tables, there are trade offs between operating and capital costs when choosing among space heating options. Geothermal systems are the most capital intensive but have the lowest operating costs. Geothermal systems can cost more than $15,000 incrementally to install when compared to a conventional natural gas heating system and air conditioner.

The price difference between a conventional natural gas and an electric heating system depends on the prices quoted by suppliers. Due to widely varying prices, either system could be higher or lower in cost. Using an average, the cost of installing an electric heating system is more expensive than natural gas by $500 for an end-of-life replacement and $750 for a new construction application (including the cost of the electrical service and panel upgrade to a 200 amp service). The operating cost of using a conventional electric heating system is also more expensive than the operating cost of a conventional natural gas heating system. This differential in operating cost also varies depending on whether the basic monthly charge for natural gas is included in the analysis.

Water Heating

The most common types of water heating options include:

- <u>Natural Gas</u>

  The majority of natural gas water heating systems use either a conventional or side vent hot water heating system. Conventional systems use a chimney for venting (usually shared use with the existing conventional or mid-efficient natural gas furnace) while side vented systems vent horizontally. Both systems operate under similar efficiencies (57% to 59%), with side venting slightly more efficient due to a more optimal vent size. Emerging tankless water heating systems improve the efficiency to 80% by reducing standby losses. These systems, however, have a high up-front capital cost.

- <u>Electric</u>

  Electric water heaters do not require venting and the majority of standard electric water tanks, which are in service today, have efficiencies in the range of 90%. The efficiency of the standard electric water tank (270L) has improved over the years from 84% to 91%. Some available tanks have slightly higher efficiencies of 92%.

- Geothermal
  Geothermal systems can be used in hot water heating applications; however these systems typically operate as a supplement to a conventional hot water heating system. In these joint system applications, the geothermal space heating system is used (through a desuperheater) to pre-heat water. This is accomplished during the space heating or cooling process. Under these applications, the overall energy requirements for water heating purposes are lower than a typical stand alone conventional hot water tank. A geothermal assisted system combined with a Power Smart Gold electric tank can improve system efficiencies to approximately 115%.

The following tables provide estimated capital and operating costs for conventional electric and both conventional and side vented natural gas water heaters. The first table provides costs associated with replacing a water heater in an existing home at the end of its life, while the second table provides the costs associated with installing a water heater for the first time in a new home. For geothermal systems, the incremental capital cost of a desuperheater is added to the cost of a conventional electric water heater. The operating costs presented below are typical for an average residential home (i.e. 2.4 occupants per home) and are based on energy rates in effect on May 1, 2012 (natural gas rate of $0.2220 per cubic metre and electric rate of $0.0677 per kilowatt hour).

Water Heating: End-of-Life Replacement (Existing Homes)

	Annual Operating Costs	Cost to Purchase and Install Equipment (Includes Labour, Equipment & Material Costs)		
System Description		**Low**	**High**	**Average**
Electric Tank Type Water Heater (270 L)	$236	$800	$1,200	$1,000
Natural Gas Side Vent Tank Type Water Heater	$105	$1,500	$2,000	$1,750
Natural Gas Conventional (Natural Draft) Water Heater	$109	$800	$1,000	$900
Natural Gas Tankless Water Heater	$78	$3,000	$4,000	$3,500
Heat Pump Desuperheater and one 270 L electric preheat tank	$198	$1,700	$2,000	$1,850
Average incremental capital cost of choosing electric over natural gas side vent water heater				**($750)**
Average incremental capital cost of choosing electric over conventional natural gas water heater				**$100**
Average incremental capital cost of choosing heat pump desuperheater (with one electric tank**) over natural gas side vent water heater**				**$100**

Water Heating: New Construction

	Annual Operating Costs	Cost to Purchase and Install Equipment (Includes Labour, Equipment & Material Costs)		
System Description		**Low**	**High**	**Average**
Electric Tank Type Water Heater (270 L)	$236	$800	$1,200	$1,000
Natural Gas Side Vent Tank Type Water Heater	$105	$1,750	$2,250	$2,000
Natural Gas Tankless Water Heater	$78	$3,000	$4,000	$3,500
Heat Pump Desuperheater and one 270 L electric preheat tank	$198	$1,700	$2,000	$1,850
Average incremental capital cost of choosing electric over natural gas side vent water heater				**($1,000)**
Average incremental capital cost of choosing heat pump desuperheater (with one electric tank) **over natural gas side vent water heater**				**($150)**

Tankless and side-vent tank natural gas water heating systems offer the lowest operating cost, however the capital cost associated with these systems is much higher. Simple payback periods for tankless natural gas water heating systems range from 19 years, when compared to a conventional electric hot water tank, to 50 years compared to a natural gas side vent hot water tank. Provided a customer has a geothermal system for space heating, geothermal assisted systems offer the second lowest operating cost. Their incremental capital costs are up to approximately $100 to install the desuperheater and a conventional electric hot water tank, when compared to the natural gas side vent option. The desuperheater is supplemental equipment for a conventional geothermal space heating system. Electric hot water tanks have the highest operating cost with the lowest installation costs.

The new home market is virtually 100% transformed with electric water heaters being the equipment of choice for home builders. In retrofit and new construction applications, the capital cost of installing an electric hot water tank is less expensive than a natural gas side-vent water heater, primarily because of the additional cost associated with incremental piping and venting required for the side-vent natural gas water heating equipment. As a result, a natural gas side vent water heater is approximately $750 more than an electric water heater. In the retrofit market, where the existing venting is adequate, a conventional natural gas water heater is less costly to install than an electric water heater. However, in some retrofit applications where the furnace has been upgraded to a high efficiency model, the existing chimney may need to be sleeved or adjusted to adequately vent a conventional natural gas water heater; if required, this could increase installation costs by approximately $550, making the conventional natural gas water heater cost approximately $450 more than an electric water heater.

2.2 Residential Space/Water Heating Market Trends

For an average residential application, space and water heating represents approximately 70% of a customer's annual energy use.

For the purposes of this report, 'fuel switching' is defined as:

- Customers in existing homes who replace their natural gas space and water heating equipment with electric equipment when it reaches the end of its' life;
- Customers (or homebuilders) building new homes who build where natural gas service is available, but instead choose to install electric heating equipment.

2.2.1 Space Heating

Currently, conventional electric, natural gas and geothermal space heating systems are used to meet 89% of the residential space heating requirements in individually metered homes in Manitoba. Approximately 11% is provided through other sources such as oil, propane and wood systems, or through traditional sources where a resident is not billed for heating (e.g. apartments where heat is provided through a common system). The following table provides the detailed breakdown of the various system applications for space heating in today's residential market and the forecast market composition to 2030/31[1].

[1] All forecasts presented are based upon Manitoba Hydro's 2011 Electric Load Forecast and 2011 Natural Gas Load Forecast.

Breakdown of Key Residential Space Heating Technologies in Manitoba by Fuel Type

2011 Load Forecasts				
Year	**Natural Gas**	**Electric**	**Geothermal**	**Other**
2011/12	52.9%	34.3%	1.8%	11.0%
2020/21	51.1%	36.6%	2.4%	9.8%
2030/31	49.8%	38.4%	3.0%	8.8%

The forecasted trend in the market is for a slight shift towards the use of conventional electric space heating and geothermal applications. The market share for natural gas customers is projected to drop by approximately 3% to 49.8% by 2030/31.

2.2.2 Water Heating

With water heating applications in Manitoba, there is a trend towards using electric water heaters rather than natural gas water heaters. The following table provides the existing and forecast breakdown of natural gas and electric water heating applications to 2030/31 across the Province.[2]

Breakdown of Residential Water Heating Technologies in Manitoba by Fuel Type

2011 Load Forecasts		
Year	**Natural Gas**	**Electric**
2011/12	45%	55%
2020/21	32%	68%
2030/31	22%	78%

The shift in fuel choice for water heating applications is significant, with natural gas water heating systems expected to drop to 22% of the total market by 2030/31. This shift in fuel choice is attributed primarily to capital cost considerations. This move toward electric water heating is taking place in both the replacement market (existing homes) and new construction market (new homes). Almost 100% of new homes being built will have electric water heaters.

The following table presents the market breakdown and forecast for natural gas heated homes. By 2030/31, over 59% of natural gas heated homes are expected to use electric water heaters. Currently, this market share is 25%.

[2] All forecasts presented are based upon Manitoba Hydro's 2011 Electric Load Forecast and 2011 Natural Gas Load Forecast.

Residential Water Heating

2011 Load Forecast	
Year	% of Gas Space Heat Customers Using Electric Water Heat
2011/12	25%
2020/21	45%
2030/31	59%

2.2.3 Factors Influencing Market Shifts in Fuel Choice

There are a number of factors influencing the market shift from using natural gas to electricity for space and water heating purposes including economic, environmental and marketing related issues. The following section discusses these driving factors in detail.

- **Higher Natural Gas Prices:** The commodity component of a customer's natural gas bill (Primary Gas) has experienced an increase from approximately $0.20/m^3 in 2000 to a high of $0.33/m^3 in 2008. Although prices have recently retracted substantially and long-term price projections show a sustainable commodity price in the $0.15-$0.19/m^3 ($4-5/GJ)[3] range, many consumers still expect natural gas rates to increase or fluctuate in the future. With electricity, customers have experienced modest increases in rates for a number of years and generally expect future electricity prices to continue to be relatively stable.

  For the operating costs of using natural gas with a high efficient furnace to equal the operating costs of using electricity, the bundled natural gas rate would need to increase to the following levels:
  - $0.65/m^3 excluding the basic monthly service charge for natural gas service (i.e. for customers who would choose to continue taking natural gas service for other end uses such as fireplaces or stoves); or
  - $0.55/m^3 including the basic monthly service charge.

  This means Manitoba Hydro's primary natural gas rate would be in the range of $0.42 - $0.52/m^3, assuming all other rate components and fees in effect as of May 1, 2012. This is equivalent to a commodity market price of $11-14/GJ which is considerably higher than today's market price forecasts.

- **Greater Natural Gas Price Volatility:** Prior to the past decade, the cost of natural gas remained fairly consistent within the $0.08-$0.11/m^3 ($2-3/GJ) range, resulting in low, stable prices for natural gas consumers. Since 2000, natural gas market prices have experienced a considerable amount of volatility fluctuating from $0.08-$0.49/m^3 ($2-13/GJ)[4]. As a result, general consumers' perception is that natural gas retail rates will continue to be volatile and result in considerable uncertainty associated with consumers' future energy costs and bills.

- **Climate Change:** Customers are becoming increasingly more aware and conscious of climate change issues. Locally, the use of natural gas has generally shifted toward a negative perception

[3] http://www.hydro.mb.ca/regulatory_affairs/energy_rates/natural_gas/centra_pricing_chart.pdf (Monthly Alberta Firm Index and Futures Price at AECO)
[4] http://www.nrcan.gc.ca/eneene/sources/natnat/hishis-eng.php (AECO Price from November 2000 forward.)

as the electricity generated within Manitoba is predominately renewable and from clean hydraulic generation.

- **Capital Cost:** Electric water heaters can have a slightly higher capital cost relative to conventional natural gas water heaters. When compared to side-vent natural gas water heaters, however, electric water heaters are less expensive. The cost of side-vent natural gas water heaters has increased over the past decade at a faster rate than electric water heaters. In some retrofit applications where the natural gas furnace has been upgraded to high efficiency, the existing chimney may need to be sleeved or adjusted to adequately vent a conventional natural gas water heater; if required, this will increase the cost of the furnace installation. In some situations, contractors may encourage these customers to also install an electric water heater rather than assessing the need for adjusting the venting or installing a more costly side-venting natural gas water heater which will eliminate the need for a chimney. The capital cost gap, combined with the narrowing of operating costs (real and perceived) associated with the two fuel choice options, has resulted in contractors and homeowners being more inclined to install electric water heaters.

3.0 EVALUATION ASSUMPTIONS

The impacts of using electricity versus natural gas for space and water heating purposes is assessed from a load, economic and environmental perspective. The assumptions used in the assessments are outlined in the following sections.

||| 3.1 Load Impact Assumptions

The energy consumption for residential space heating is calculated for an average home of approximately 1,200 square feet. Actual consumption for specific homes will vary due to a range of factors, including weather, type of heating equipment, size, insulation levels, air tightness and lifestyle. For the water heating impacts, the energy consumption provided is based on the typical usage of the average Manitoba household with 2.4 occupants living in the residence.

The following table provides the energy use assumptions used for the various residential space and water heating options.

Function	Heating Fuel	System Details	Seasonal Efficiency / Energy Factor	Energy Units consumed/year
Space Heating	Natural Gas	High-Efficiency Forced Air	92%	**1,776 m^3**
	Geothermal	Forced Air/Hydronic SCOP = 2.5	250%	**6,556 kWh**
	Electricity	Forced Air Furnace/ Baseboard	100%	**16,391 kWh**
Water Heating	Natural Gas	Conventional	57%	**491 m^3**
	Geothermal	Combined w/ PS Gold Tank	99%	**2,925 kWh**
	Electricity	40 gallon	83%	**3,489 kWh**

Recognizing the potential installed performance ranges of geothermal heat pump systems, a sensitivity analysis outlining the impacts of achieving an SCOP of 3.5 is presented in Section 5.1.

||| 3.2 Economic Impact Assumptions

The economic impact is assessed from the customer, utility and provincial perspective. Generic assumptions include:

- A discount rate of 6.1% for all present value calculations.
- Electricity and natural gas rates are based upon Manitoba Hydro's 2012 electricity and natural gas price forecasts. The electric rates are adjusted to include the interim approved rate increase of 2.0% effective April 1, 2012.
- Electricity and natural gas marginal benefits are based upon Manitoba Hydro's 2012 Marginal Benefits Forecast.
- For per household impacts, the net present value is calculated over the life of the equipment (25 years for space heating and 10 years for water heating).

- For impacts included within the 2011 Load Forecast, the present value analysis is undertaken over a 30 year forecast period.
- The forecast period includes 2011 to 2040 with customer and appliance forecasts based upon the 2011 Manitoba Hydro Load Forecasts.

3.2.1 Customer Perspective:

To assess the economic impact of fuel choice options for space and water heating applications from the customer's perspective, the following formula was used:

		PV (Customer Natural Gas Bill Reductions)
		-
Customer Perspective	=	PV (Customer Electricity Bill Increases)
		-
		PV (Capital Cost Differences)

In the context of switching from natural gas to electricity:

- PV (Customer Natural Gas Bill Reductions) - refers to the present value of the reduced cost arising from decreased natural gas consumption due to a customer choosing to use electricity rather than natural gas. For the purposes of the analysis, it will be assumed that a customer no longer has natural gas service when using alternative fuels for space heating. Under this circumstance the customer would not pay a natural gas basic monthly charge.
- PV (Customer Electricity Bill Increases) - refers to the present value of the additional cost from increased electricity consumption due to a customer choosing electricity over natural gas.
- PV (Capital Cost Differences) - includes the total incremental costs associated with a particular heating system and the difference in installation costs between the natural gas technology and the electric/geothermal technology installed.
- Assumptions regarding capital and operating costs are provided in Section 2.0.

3.2.2 Utility Perspective:

The economic impact to the utility, with respect to an electric and natural gas perspective, was examined separately. The analyses on fuel choice options for space and water heating applications were based upon the following formulas:

		PV (Customer Electricity Bill Increases)
Utility Perspective $_{\text{electricity}}$	=	-
		PV (Electric Marginal Costs)

Where:

- PV (Customer Electricity Bill Increases) - refers to the net present value of additional revenue from increased domestic electricity consumption due to customers using electricity rather than natural gas.

- PV (Electric Marginal Costs) - includes reduced export power revenue from increased domestic use and the cost of new infrastructure advancement (e.g. electric transmission and distribution facilities).

		PV (Natural Gas Marginal Benefits)
Utility Perspective $_{natural\ gas}$	=	-
		PV (Customer Natural Gas Bill Reductions)

Where:

- PV (Natural Gas Marginal Benefits) - includes Manitoba Hydro's avoided cost of purchasing natural gas and avoided transportation costs. The value of reduced greenhouse gas emissions (GHGs) is not included in this analysis. At this time, there is no monetary value resulting from reduced greenhouse gas emissions under existing policies.
- PV (Customer Natural Gas Bill Reductions) refers to the present value of reduced revenue from decreased natural gas consumption due to customers using electricity rather than natural gas.

CONSIDERATIONS EXCLUDED FROM THE ABOVE ANALYSES:

The analysis provided within this report is intended to give a high level assessment of future economic impacts on Manitoba Hydro when customers choose to use electricity rather than natural gas for space and water heating applications.

It should be noted that the marginal benefits/costs utilized in this analysis are applicable for analyzing smaller, incremental energy impacts. The assessment does not include the economic impacts to Manitoba Hydro that would result from changes to the electricity load profile in Manitoba due to significant fuel shifting towards using electricity for space heating within natural gas serviced areas. For example in gas serviced areas, the electrical system is not designed to accommodate high electricity consumption increases. Major electrical distribution infrastructure upgrades would be required should such a shift occur (e.g. overhead and underground supply lines, transformers etc.). The impact on electrical distribution infrastructure is even greater in the scenario where a substantial number of customers shift to using geothermal technology.

3.2.3 Integrated Utility/Customer Perspective:

To assess the economic impact of fuel choice options for space and water heating applications from the perspective of the utility and the customer combined, the following formula was used.

		PV (Natural Gas Marginal Benefits)
		-
Integrated Utility/Customer Perspective	=	PV (Electricity Marginal Costs)
		-
		PV (Capital Cost Differences)

Where:

- PV (Natural Gas Marginal Benefits) - includes Manitoba Hydro's avoided cost of purchasing natural gas and avoided transportation costs. The value of reduced greenhouse gas emissions (GHGs) is not included in this analysis. At this time, there is no monetary value resulting from reduced greenhouse gas emissions under existing policies.
- PV (Electric Marginal Costs) - includes reduced export power revenue from increased domestic use and the cost of new infrastructure advancement (e.g. electric transmission and distribution facilities).
- PV (Capital Cost Differences) - includes the total incremental costs associated with a particular heating system and the difference in installation costs between the natural gas technology and the electric/geothermal technology installed.

3.2.4 Provincial Perspective (Inflow/Leakage):

Provincial Inflow/Leakage refers to the change in dollars flowing into and out of Manitoba due to the impact of using electricity rather than natural gas for space and water heating applications, the following formula was used.

Provincial Inflow/Leakage Impact	=	NPV of changes in dollars flowing into and out of the Province

- Includes the avoided cost of purchasing and transporting natural gas to the Manitoba border.
- Includes the lost revenue from reduced export electricity sales.

3.3 Environmental (GHG) Impact Assumptions

The environmental (GHG) impact of using alternate fuel sources is quantified by the change in the amount of GHG emissions produced when using each type of fuel. The measure of GHG emissions are stated in CO_2e (equivalent), which includes carbon dioxide (CO_2) and the other major GHG emissions including, methane (CH_4) and nitrous oxide (N_2O).

The source of GHG emissions are characterized as being either direct or indirect as follows:

- **Direct Emissions –** These are the combustion emissions that would be created by consuming a fuel for a specific purpose in Manitoba (e.g. operating space or water heating equipment). The base emissions factor for natural gas (1.9 kg CO_2e /m^3) is a standardized factor utilized globally in the calculation of GHG emissions. In Canada, this emissions factor is utilized by Environment Canada in their GHG inventory assessments.[5]

- **Indirect Emissions –** Indirect emissions capture the secondary impact of changing electricity use in Manitoba and take into account the impacts of increased or decreased electricity exports.

[5] http://www.ec.gc.ca/pdb/ghg/ghg_home_e.cfm

Manitoba Hydro's primary export market is the Midwest Independent System Operator (MISO) region. The marginal generation in MISO is fossil fuel based (primarily coal). The average of emission factors for additional units of generation needed or avoided due to changing Manitoba electricity exports has been conservatively estimated at approximately 750 kg CO_2e/MW.h. This estimate was devised under today's market conditions and existing policies and only includes the burner tip emissions from generation outside of Manitoba; it does not include other lifecycle considerations such as fuel extraction, processing and transportation.

Longer term impacts are more uncertain as the emission impacts will be directly influenced by potential greenhouse emission policy changes that may be implemented within the export market (e.g. a policy placing restriction or a cap on greenhouse gas emissions).

The chart below outlines the emission factors used within this analysis.

Heating Fuel GHG Intensity Factors (kg $C0_2$e / kW.h)

Fuel Type	**Direct End Use** (Manitoba Emissions)	**Indirect Displacement** (US Emissions)
Natural Gas	0.1836	
Electricity		0.75

The table below compares the change in GHG emissions attributed to using each fuel source for space and water heating applications in an average residential home. The net GHG impacts in the U.S. are based on current policies.

Potential Annual GHG Impacts

(Attributed by Region due to Fuel Use by MB Residential Customer)

Function	**Heating Fuel** (Manitoba Residential Customer)	**Manitoba** (kg C02e / year)	**Us - MISO Region** (kg C02e / year)	**Net Global Impact** (kg C02e / year)
Space Heating	**Natural Gas**	3,374	---	3,374
	Geothermal SCOP 2.5	---	4,917	4,917
	Geothermal SCOP 3.5	---	3,512	3,512
	Electricity	---	12,293	12,293
Water Heating	**Natural Gas (Side Vent)**	901	---	901
	Natural Gas (Conventional)	933	---	933
	Geothermal	---	2,194	2,194
	Electricity	---	2,617	2,617

The Western Climate Initiative (WCI) projects carbon market abatement costs to reach \$33/tonne CO_2e by 2020[6].

For comparison purposes, the following formula was used to assess the relative cost of the GHG impacts of converting from natural gas to electric heating:

$$\text{Levelized Cost per tonne GHG} = \frac{\text{PV (Integrated Utility/Customer Costs)}}{\text{PV (Annual kg } CO_2e \text{ GHG impacts) / (1000 kg/tonne)}}$$

Where:

- PV (Integrated Utility/Customer Costs) – represents the net costs from the perspective of the utility and the customer combined of converting from natural gas heating to electric as outlined in Section 3.2.3.
- PV (Annual kg CO_2e GHG impacts) – represents the annual GHG reduction realized by converting from natural gas heating to electric over the life of the heating equipment.

[6] http://www.westernclimateinitiative.org/document-archives/Economic-Modeling-Team-Documents/Updated-Economic-Analysis-of-the-WCI-Regional-Cap-and-Trade-Program/

4.0 Impacts of Fuel Switching in Manitoba

4.1 Per Household Impacts

This section provides the impacts for an average residential household where a natural gas heating system is replaced with either an electric or geothermal system for space and water heating. Energy load, economic, provincial leakage and environmental impacts are assessed by presenting three different fuel switching scenarios:

1. Switching from a gas to an electric furnace;
2. Switching from a gas furnace to a geothermal system (assuming SCOP of 2.5); and
3. Switching from a conventional natural gas hot water tank to an electric hot water tank.

Recognizing the potential installed performance ranges of geothermal heat pump systems, a sensitivity analysis outlining the impacts of achieving an SCOP of 3.5 is presented in Section 5.1.

4.1.1 Energy Load Impact

The following table provides the annual electric and natural gas load impact associated with a typical residential household fuel switching from gas to electric.

Load Impact of Fuel Switching
Average Residential Home

	Gas to Electric Furnace	Gas to Geothermal (SCOP 2.5)	Conventional Gas to Electric Water Heat
Electric Load Impact (kW.h)	16,391	6,556	3,489
Natural Gas Load Impact (m^3)	(1,776)	(1,776)	(491)

4.1.2 Economic Impact

The following table provides the electric and natural gas economic impact associated with an average residential household using electricity as opposed to natural gas for space and water heating applications. The economic impact is a net present value assessment taken over the life of the equipment, and includes the incremental capital cost of choosing electric over natural gas equipment in addition to operating costs. Operating costs are based on forecasted natural gas and electricity rates. Maintenance costs are not included in the calculation.

Net Economic Impact of Fuel Switching (over the life of the equipment)
Average Residential Home

	Gas to Electric Furnace	Gas to Geothermal (SCOP 2.5*)	Conventional Gas to Electric Water Heat
Utility Perspective (Electric)	($3,223)	($1,563)	($10)
Utility Perspective (Natural Gas)	($4,107)	($4,107)	($317)
Customer Perspective - Remaining Natural Gas Service	($9,146)	($12,685)	($727)
Customer Perspective - No Remaining Natural Gas Service	($7,737)	($11,276)	n/a
Integrated Utility / Customer Perspective	($15,067)	($16,946)	($1,054)

**A sensitivity analysis outlining the impacts of using a geothermal system with SCOP of 3.5 is presented in section 5.0.*

Utility Perspective – Changing to an electric space heating or water heating system results in a negative economic impact from the utility's perspective for both electricity and natural gas operations.

From the electric perspective, customers would be using more electricity, resulting in increased domestic electric revenues. However, reduced export revenues and the cost of advancing new electric infrastructure would be higher than the additional revenue gained domestically, therefore resulting in an overall negative impact.

From the natural gas perspective, customers would be consuming less natural gas, thereby decreasing revenues to Manitoba Hydro. This loss outweighs the avoided costs of purchasing natural gas and transportation costs. Therefore, the net result is a negative impact to the utility.

Customer Perspective – Changing from a natural gas space or water heating system to an electric system results in a negative economic impact to a residential customer over the life of the system. It is important to note that in an existing home, choosing an electric water heater over a less costly conventional natural gas water heater results in a negative economic impact to the customer <u>assuming no adjustments are required to the chimney ventilation</u>. If adjustments to the chimney are required, installation costs could increase by approximately $550.

The analysis for the Customer Perspective - Remaining Natural Gas Service assumes that the customer maintains their gas service for other appliances in the home (e.g. fireplace, stove, BBQ). If the customer were to completely eliminate natural gas service to the home, they would also save the cost of the basic monthly charge. The NPV of the natural gas basic monthly charge over 25 years (i.e. the assessment period for space heating) is $2,257. As such, the negative impact of switching from natural gas to an electric furnace decreases for the customer, as outlined in the Customer Perspective – No Remaining Gas Service.

Integrated Utility/Customer Perspective – From a combined utility and customer perspective, changing to an electric space heating or water heating system in an average residential home results in an overall negative economic impact.

4.1.3 Provincial Inflow/Leakage Impact from Primary Energy Transactions

The following table provides an estimate of the net economic inflow/leakage that would result from typical residential household using electricity as opposed to natural gas for space and water heating applications. The following assessment considers changes to export electricity revenues that flow into Manitoba and changes to natural gas purchase costs that flow out of Manitoba, using a net present value analysis over the 25 year life of space heating equipment, and 10 year life of water heating equipment.

Provincial Inflow (Leakage) Over the Life of the Equipment

Revenue / Cost Stream	Gas to Conventional Electric Furnace	Gas to Geothermal (SCOP 2.5)	Conventional Gas to Electric Water Heat
Lost Export Revenue	($12,331)	($4,999)	($1,247)
Avoided Gas Supply Costs	$6,060	$6,060	$950
Net Provincial Cash Inflow (Leakage)	**($6,271)**	**$1,061**	**($297)**

A net incremental provincial leakage over the life of space and water heating equipment results when electricity is used instead of natural gas. In the case of using a geothermal system relative to a natural gas heating system, there is a net inflow to the Province. However, a more complete analysis would need to account for the higher cost geothermal furnace units which are imported into Manitoba relative to the cost of importing natural gas furnaces/air conditioning units (note geothermal units are estimated to cost $2000 - $3000 more).

4.1.4 Environmental (GHG) Impact

The following table provides the annual GHG emission impacts associated with a typical residential customer choosing electricity as opposed to natural gas for space and water heating applications.

Potential Annual GHG Impacts

(Attributed by Region due to Energy Use)

	Gas to Electric Furnace	Gas to Geothermal (SCOP 2.5)	Conventional Gas to Electric Water Heat
Manitoba (kg $C0_2e$ / year)	(3,374)	(3,374)	(933)
US - MISO Region* (kg $C0_2e$ / year)	0 to 12,293	0 to 4,917	0 to 2,617
Net Global* (kg $C0_2e$ / year)	**(3,374) to 8,919**	**(3,374) to 1,543**	**(933) to 1,684**

** The US-MISO Region and Net Global impacts are shown within a range, which includes the impact under today's emission policies in export regions and potentially what the impacts would be under more aggressive emission policies in export regions*

As the table indicates, an average residential home choosing to use electricity instead of natural gas for space and water heating would result in lower annual GHG emissions in Manitoba.

Manitoba Hydro recognizes that the impact of fuel choices made within Manitoba has an indirect implication outside of Manitoba. Manitoba Hydro's primary export market, the MISO region of the U.S. Midwest, uses fossil fuel based generation (primarily coal) to generate electricity. Electricity exports from Manitoba currently displace emissions from fossil fuel generation in export regions. The marginal emission factors are estimated to be 750 kg CO2e/MW.h.

Based on this, the use of electricity as opposed to natural gas in Manitoba will decrease exports and increase annual emissions in these external markets by 12,293 kg/year (electric heat versus natural gas for space heating), 4,917 kg/year (geothermal versus natural gas for space heating) and 2,617 kg/year (electric hot water tanks versus natural gas).

In the longer term, the indirect emission reductions may diminish if future energy and environmental policies in export regions change. The US-MISO region and net global emission impacts are shown within a broad range which includes the impact under today's emission policies in export regions and potentially what the impact would be under more aggressive future emission policies in export regions. Under today's policies from a global perspective, the increasing movement from natural gas to electricity in Manitoba for space and water heating would increase net annual emissions by 8,919 kg/year if an electric furnace is installed, 1,543 kg/year if a geothermal system is installed and by 1,684 kg/year for an electric water heater.

The Western Climate Initiative (WCI) projects carbon market abatement costs to reach $33/tonne CO_2e by 2020[7]. The following table demonstrates that the relative cost per tonne of CO_2e reduction in Manitoba achieved by converting from natural gas heating to electric heating is higher than the projected abatement costs.

Levelized Cost per Tonne GHG Reduction in Manitoba – Average Residential Home

Space Heating	
Convert Natural Gas Furnace to Electric Furnace	$333
Convert Natural Gas Furnace to Geothermal Heat Pump with 2.5 SCOP	$377
Water Heating	
Convert Conventional Natural Gas Water Heater to Electric Heater	$154

4.2 2011 Energy Forecasts

The following section presents the projected impacts of customer fuel switching based upon Manitoba Hydro's 2011 energy forecasts. The following table summarizes the projections for the cumulative number of residential and commercial customers switching from natural gas to electric equipment in existing homes and buildings as well as customers installing electric equipment instead of natural gas equipment in new homes and buildings in natural gas serviced areas. The forecast of overall electric and natural gas customers is provided for comparison.

[7] http://www.westernclimateinitiative.org/document-archives/Economic-Modeling-Team-Documents/Updated-Economic-Analysis-of-the-WCI-Regional-Cap-and-Trade-Program/

Year	Cumulative # of Fuel Switched Customers				Total # of Customers (Meters)			
	Space Heating		Water Heating		Electric		Natural Gas	
	Residential	Commercial	Residential	Commercial	Residential	Commercial	Residential	Commercial
2020/21	23,511	440	72,868	440	502,547	71,267	261,356	25,405
2030/31	47,592	920	146,316	920	555,142	76,298	282,131	26,206

4.2.1. Energy Load Impact

The following table provides the impact on Manitoba Hydro's electric load relative to the 2011 Electric Load Forecast.

2011 Load Forecast (Net Firm Energy) 2030/31 (GW.h)	**Portion of 2011 Forecast Attributed to Fuel Switching** **2030/31**		
		GW.h	**% of Load**
32,465	Space Heating:	605	**2%**
	Water Heating:	269	**1%**

From an incremental perspective, the 2011 forecast includes increased domestic electric load due to fuel switching of 874 GW.h by 2030/31, which represents 3% of the expected 2030/31 domestic electrical load.

The table below provides the impact of fuel switching on Manitoba Hydro's domestic natural gas load in 2030/31 (Total Gas Volume Forecast) which is included in the 2011 Natural Gas Volume Forecast.

2011 Load Forecast (Total Natural Gas Sales) 2030/31 (10^6m^3)	**Portion of 2011 Forecast Attributed to Fuel Switching** **2030/31**		
		(10^6m^3)	**% of Load**
1,924	Space Heating:	(65)	**-3%**
	Water Heating:	(38)	**-2%**

The 2011 forecast includes a reduction in provincial natural gas sales of 5% in 2030/31. From an incremental perspective, the 2011 forecast includes decreased domestic sales of 103 million cubic metres by 2030/31.

4.2.2 Economic Impact

The net present value economic impact under the 2011 load forecasts over the next 30 years for space and water heating applications is outlined in the following table.

Net Economic Impact – 2011 Energy Forecasts

(Net present value over 30 year forecasting period)

Space Heating	$ millions
Utility Perspective (Electric)	($107)
Utility Perspective (Natural Gas)	($38)
Customer Perspective	($223)
Integrated Utility / Customer Perspective	($368)
Water Heating	
Utility Perspective (Electric)	($25)
Utility Perspective (Natural Gas)	($31)
Customer Perspective	($88)
Integrated Utility / Customer Perspective	($144)

Utility Perspective – Overall, the economic impact of the expected market change to Manitoba Hydro's electric business is negative by approximately $132 million, with changes in space heating and water heating negatively contributing $107 million and $25 million respectively. Manitoba Hydro's natural gas operations are also negatively impacted by approximately $69 million, with changes in space and water heating negatively contributing $38 million and $31 million respectively.

Customer Perspective - Installing electric space and water heating equipment in natural gas serviced areas results in a negative economic impact to customers overall of $223 million and $88 million respectively. This analysis assumes that both residential and commercial customers choose electric water heaters over conventional natural gas water heaters.

Integrated Utility/Customer Perspective - From a combined perspective, the scenario results in a negative overall economic impact of $512 million, with changes in space heating and water heating negatively contributing $368 million and $144 million respectively.

4.2.3 Provincial Inflow/Leakage Impact from Primary Energy Transactions

The following table provides the 2011 forecasted impact on the provincial economic inflow/leakage over the next 30 years that would result from reduced export power revenue net of reduced natural gas purchases.

Provincial Inflow (Leakage)

(Net present value over 30 year forecasting period)

Revenue / Cost Stream	2011 Forecast ($ millions)
Lost Export Revenue	($505)
Avoided Gas Supply Costs*	$251
Net Provincial Cash Inflow (Leakage)	**($254)**

The 2011 forecasted market change results in an estimated net provincial leakage of $254 million.

4.2.4 Environmental (GHG) Impact

The following table provides the environmental (GHG) impact of the 2011 forecasted market fuel switching in space and water heating.

Potential Annual GHG Impacts

(Attributed by Region due to Energy Use)

Year	Manitoba (tonnes C02e / year)	US - MISO Region* (tonnes C02e / year)	Net Global Impact* (tonnes C02e / year)
2012/13	(11,970)	38,753	26,783
2022/23	(154,166)	0 to 496,268	(154,166) to 342,102
2032/33	(203,699)	0 to 687,473	(203,699) to 483,774

** The US-MISO Region and Net Global impacts are shown within a range, which includes the impact under today's emission policies in export regions and potentially what the impacts would be under more aggressive emission policies in export regions.*

Under current emissions and energy policies, the net environmental (GHG) impact of the 2011 forecast results in reduced annual emissions in Manitoba and increased annual global emissions. Over the long term, the impact in the US-MISO region and the net global impacts will be dependent upon future emissions policies.

5.0 Sensitivity Analysis

||| 5.1 Impact of Improved Performance in Geothermal Systems

As stated in section 2.1, most geothermal systems operate with a Seasonal Coefficient of Performance (SCOP) in the range of 2.0 – 3.0 (200-300% efficient) with some systems achieving SCOP as high as 3.5 depending on the quality and configuration of the system. The following analysis shows the load, economic and environmental impacts of a geothermal system performing at an improved performance level of SCOP 3.5 compared to the average geothermal system achieving an SCOP of 2.5 that is presented in the main analysis.

Net Impact of Fuel Switching to Geothermal (over 25 years)
Average Residential Home

	Gas to Geothermal (SCOP 2.5)	Gas to Geothermal (SCOP 3.5)
Annual Energy Load Impact		
Electric Load Impact (kW.h)	6,556	4,683
Natural Gas Load Impact (cu.m)	(1,776)	(1,776)
Economic Impact (NPV over the life of the equipment*)		
Utility Perspective (Electric)	($1,563)	($1,117)
Utility Perspective (Natural Gas)	($4,107)	($4,107)
Customer Perspective - Remaining Natural Gas Service	($12,685)	($10,806)
Customer Perspective - No Remaining Natural Gas Service	($11,276)	($9,397)
Integrated Utility / Customer Perspective	($16,946)	($14,621)
Net Provincial Cash Inflow (Leakage)	$1,061	$2,489
Annual Environmental Impact		
Manitoba (kg $C0_2e$ / year)	(3,374)	(3,374)
US - MISO Region (kg $C0_2e$ / year)	0 to 4,917	0 to 3,512
Net Global (kg $C0_2e$ / year)	(3,374) to 1,543	(3,374) to 138

Overall, the results are directionally the same. There is a negative impact to the utility and customer when switching from a gas furnace to a geothermal system (SCOP 3.5) and a net Provincial cash inflow. Compared to the geothermal SCOP 2.5, the negative impacts are less with a SCOP of 3.5 because the system is performing at a higher efficiency (i.e. using less electricity but displacing the same amount of natural gas).

||| 5.2 Water Heating Technology Options

Installing a high efficiency natural gas furnace may require modification to the home's venting system. In order to avoid costly venting upgrades, customers often choose to install an electric hot water tank. However, another option is to install a natural gas water heater that vents out the side wall.

The following analysis demonstrates the impacts if a customer was switching from a side-vent natural gas tank to an electric hot water tank. The impacts of changing from a conventional natural gas tank are also shown as a basis for comparison.

Net Impact of Fuel Switching to Electric Water Heating (over 10 years)
Average Residential Home

	Conventional Gas to Electric Water Heat	Side-Vent Gas to Electric Water Heat
Annual Energy Load Impact		
Electric Load Impact (kW.h)	3,489	3,489
Natural Gas Load Impact (cu.m)	(491)	(474)
Economic Impact (NPV over the life of the equipment*)		
Utility Perspective (Electric)	($10)	($10)
Utility Perspective (Natural Gas)	($317)	($306)
Customer Perspective - Remaining Natural Gas Service	($727)	$176
Customer Perspective - No Remaining Natural Gas Service	n/a	n/a
Integrated Utility / Customer Perspective	($1,054)	($140)
Net Provincial Cash Inflow (Leakage)	($297)	($330)
Annual Environmental Impact		
Manitoba (kg $C0_2e$ / year)	(933)	(901)
US - MISO Region (kg $C0_2e$ / year)	0 to 2,617	0 to 2,617
Net Global (kg $C0_2e$ / year)	(933) to 1,684	(901) to 1,716

Compared to a conventional gas hot water tank, a side-vent gas tank is only marginally more efficient (474 cu.m per year vs 491 cu.m per year). Therefore the impact to the utility is similar for both technologies. The notable difference is within the Customer Perspective which results in a net benefit of $176 to the customer when choosing between a side-vent natural gas and an electric hot water tank. Customers are better positioned economically when using electricity for water heating due to the high upfront capital cost of the side-vent natural gas tank (which the customer would be saving if they switched to electric). This is common in new home construction where chimneys are no longer required for venting high efficiency natural gas furnaces, thereby limiting natural gas water heater options to the higher capital cost side-vent options. In the retrofit market where the existing venting is adequate, the customer is better positioned economically using natural gas for water heating if choosing a conventional natural gas water heater.

||| 5.3 Impact of Increased Primary Natural Gas Prices

As stated in Section 3.2, the economic impacts presented with this report are based upon Manitoba Hydro's 2012 natural gas price forecast. Recognizing the influence of natural gas prices on consumers' fuel choices, the following sensitivity explores the economic impact of using electricity instead of natural gas for space and water heating in an environment of high primary natural gas prices. The following analysis provides the economic impact from the customer's and utility's perspective along with a high level assessment of provincial leakage assuming primary natural gas prices remain at $0.33/cu.m over the forecast period, the highest recorded level as observed in August 2008.

5.3.1 Economic Impact

The following table provides the electric and natural gas economic impact associated with an average residential household using electricity as opposed to natural gas for space and water heating applications under increased primary natural gas prices.

Net Financial Impact of Fuel Switching (over the life of the equipment)
Average Residential Home

	Gas to Electric Furnace	Gas to Geothermal (SCOP 2.5)	Conventional Gas to Electric Water Heat
Utility Perspective (Electric)	($3,223)	($1,563)	($10)
Utility Perspective (Natural Gas)	($4,107)	($4,107)	($317)
Customer Perspective - Remaining Natural Gas Service	($6,697)	($10,236)	($285)
Customer Perspective - No Remaining Natural Gas Service	($4,440)	($7,979)	n/a
Integrated Utility / Customer Perspective	**($11,770)**	**($13,649)**	**($612)**

Utility Perspective – Increases to the primary natural gas component of Manitoba Hydro's rates do not affect the economic impact to the utility of changing to an electric space heating system as primary natural gas is a flow-through cost to the customer.

Customer Perspective – Under increased primary natural gas prices, changing from a natural gas space heating system to an electric or geothermal system continues to result in a negative economic impact to the customer. In addition, a conventional natural gas water heater remains more economic to the customer than an electric water heater under 2008 primary natural gas prices.

5.3.2 Provincial Inflow/Leakage Impact from Primary Energy Transactions

The following table provides an estimate of the net economic inflow/leakage that would result from typical residential household using electricity as opposed to natural gas for space and water heating applications under increased primary natural gas prices.

Provincial Inflow (Leakage) Over the Life of the Equipment

Revenue / Cost Stream	Gas to Electric Furnace	Gas to Geothermal (SCOP 2.5)	Conventional Gas to Electric Water Heat
Lost Export Revenue	($12,331)	($4,999)	($1,247)
Avoided Gas Supply Costs	$8,509	$8,509	$1,393
Net Provincial Cash Inflow (Leakage)	**($3,822)**	**$3,510**	**$146**

Assuming 2008 primary natural gas prices, changing from a natural gas space heating system to a conventional electric system continues to result in a lower net incremental provincial leakage over the life of the equipment. However, with increased natural gas prices, using electricity for water heating shifts to become a net incremental provincial inflow.

In the case of using a geothermal system relative to a natural gas heating system, the net inflow to the Province increases if primary natural gas prices increased to that observed in 2008.

5.4 Hypothetical Potential Analysis – Impacts of Total Conversion

The following analysis provides insight into the hypothetical load impacts if all customers in Manitoba replaced their existing space and water heating equipment with an alternative natural gas, electric or geothermal system.

The following table presents:

- the existing annual electricity and natural gas load for space and water heating; and
- the hypothetical potential annual electricity and natural gas loads under extreme fuel conversion scenarios (i.e. immediate fuel switching to either all natural gas use, all electric use or all geothermal use for space and water heating purposes).

Hypothetical Annual Load Impact
If All Customers in Manitoba Immediately Switched to One Type of Heating Fuel

	Natural Gas (1000 m3)	Electricity (GW.h)	Geothermal SCOP 2.5 (GW.h)
Current load situation - space heat	938,723	3,473	67
Current load situation - water heat	194,925	1,097	0
A. Immediate fuel switch to natural gas - space	1,339,429	---	---
A. Immediate fuel switch to natural gas - water	349,251	---	---
B. Immediate fuel switch to electric - space	---	11,341	67
B. Immediate fuel switch to electric - water	---	2,482	---
C. Immediate switch to geothermal - space	---	---	4,603
C. Immediate switch to geothermal - water	---	---	2,081

Impacts are based on the electric and natural gas forecast for 2011.

From the electric utility perspective, the magnitude of the hypothetical potential impact of all customers switching to electric space and water heating would add 7,868 GWh and 1,385 GWh. respectively of annual electric load in Manitoba. Combined, this additional electric load would be equivalent to approximately two generating stations the size of Conawapa. Furthermore, it is important to recognize that the implications to the utility go beyond the analysis provided within this report. The consequence of a wholesale fuel switching scenario would also require a significant investment in additional generation, transmission and distribution infrastructure. In addition, the utility would be confronted with managing a more diverse winter/summer load. From the natural gas utility perspective, the remaining annual natural gas load would be 40% of the existing load and as such, the scenario would require a rate increase to the remaining natural gas customers to cover fixed costs (i.e. the fixed costs would need to be recovered from a much smaller customer base).

It should be noted that the hypothetical potential impact of all customers switching to natural gas space and water heating cannot be supported with today's natural gas infrastructure. The implications of this hypothetical scenario would also require extensive new infrastructure at an extraordinarily high cost.

6.0 A Review of Other Jurisdictions

Discussions with counterparts in BC Hydro, SaskPower, Ontario Power Authority and Quebec Hydro indicated their practices are consistent with Manitoba Hydro's current approach, which involves taking steps to educate consumers to assist them in making an informed decision. On the other hand, Canadian natural gas companies tend to promote natural gas for all uses; for example, some Canadian natural gas utilities, including Fortis BC and Gaz Metro, currently offer rebates to encourage the installation of natural gas home heating systems or water heating systems. The rebates are aimed at increasing market share for these natural gas utilities. A general review of US utilities found two integrated electric and natural gas companies promoting the use of natural gas for space and water heating. The following table outlines the incentives offered by utilities to support conversion to natural gas equipment.

Natural Gas Utility	**Incentive per Conversion**			**Note**
	Space Heating	**Water Heating**	**Other Equipment/ Appliances**	
Fortis BC	$1,000	n/a	n/a	Only conversions from oil/propane to natural gas eligible. Also offer high efficiency equipment rebates.
Gaz Metro (Quebec)	$900 - $1,100	$300 - $550	n/a	Also offer high efficiency equipment rebates.
Efficiency Nova Scotia Corporation	$500 for gas furnace $2,250 for gas boiler	$500 - $750	n/a	Additional incentive for 100% of the costs to remove electric baseboards and install new distribution system, up to a maximum of $3,000.
Puget Sound Energy – Electric & Natural Gas (Washington State)	$500 - $2,500	$950	n/a	$1,950 - $3,950 for both home heating and water heating combined Also offer high efficiency equipment rebates.
Avista Energy – Electric & Natural Gas (Washington State)	$750	$250	n/a	$750 is for conversion of conventional electric heating to natural gas or central heat pump Also offer high efficiency equipment rebates.

7.0 Future Considerations - Proposed Federal Regulations

Natural Resources Canada (NRCan) is proposing higher efficiency requirements for natural gas water heaters used in both residential and commercial applications and, in June 2010, began formal industry and stakeholder consultations. These changes, if adopted, will likely have a further impact on customer's fuel choices for water heating.

NRCan is proposing a minimum efficiency factor (EF) of 0.67 for residential natural gas water heaters effective April 1, 2016, and a minimum EF of 0.80 effective January 1, 2020. This regulation is aggressive, considering most residential water heaters currently available on the market have an EF between 0.57 and 0.60.

Residential customers replacing their water heater pay an average of $1,000 for an electric water heater while a standard natural gas side vented water heater with an EF of 0.59 costs $1,750. A preliminary market review indicates that water heaters with an EF of 0.67 can cost approximately $800 more than a side vent natural gas hot water tank, and few are currently available within the Manitoba market. In addition, the only water heaters currently available in Manitoba that offer an EF of 0.80 are condensing natural gas water heaters which can cost up to an additional $3,000 compared to a side vent natural gas water tank.

At current Manitoba energy rates, the incremental cost of natural gas water heaters (first time or conversion costs) under the proposed regulations will not be recovered through reduced operating costs over the life of the water heater. The large incremental product costs and limited availability of qualifying water heaters are anticipated to further accelerate the market conversion to electric water heating in the residential and commercial sector.

In addition to the above proposed regulations, NRCan is proposing a minimum Thermal Efficiency (TE) of 80% (effective date to be announced) and 92% effective January 1, 2018 for larger water heaters (greater than 75,000 btu/h input), which are typically used by commercial customers. The majority of commercial grade water heaters sold today in Manitoba have a TE of 80% and will meet the standard. Water heaters with a minimum TE of 92% have a higher initial cost but are less costly to operate versus an electric water heater; especially for heavy hot water users. Due to higher operating costs for electric water heaters, it is anticipated that these proposed changes will not materially influence heating fuel choices for high use commercial customers. They could however, have an impact on the fuel choice of customers with low to medium hot water usage, such as offices, warehouses and non-food retail buildings.

8.0 Conclusions

The following table summarizes the impact of using electricity instead of natural gas for space and water heating in a typical residential home. The economic impact to the customer includes the incremental cost of installing electric instead of natural gas heating equipment in new homes and existing homes. The economic impact is taken over the life of the equipment[8], whereas energy and environmental (GHG) impacts are shown on an annual basis.

Impact of Fuel Switching
Average Residential Home

	Gas to Electric Furnace	Gas to Geothermal (SCOP 2.5)	Conventional Gas to Electric Water Heat
Annual Energy Load Impact			
Electric Load Impact (kW.h)	16,391	6,556	3,489
Natural Gas Load Impact (cu.m)	(1,776)	(1,776)	(491)
Economic Impact (NPV over the life of the equipment)			
Utility Perspective (Electric)	($3,223)	($1,563)	($10)
Utility Perspective (Natural Gas)	($4,107)	($4,107)	($317)
Customer Perspective - Remaining Natural Gas Service	($9,146)	($12,685)	($727)
Customer Perspective - No Remaining Natural Gas Service	($7,737)	($11,276)	n/a
Integrated Utility / Customer Perspective	($15,067)	($16,946)	($1,054)
Net Provincial Cash Inflow (Leakage)	($6,271)	$1,061*	($297)
Annual Environmental Impact			
Manitoba (kg $C0_2e$ / year)	(3,374)	(3,374)	(933)
US - MISO Region** (kg $C0_2e$ / year)	0 to 12,293	0 to 4,917	0 to 2,617
Net Global** (kg $C0_2e$ / year)	(3,374) to 8,919	(3,374) to 1,543	(933) to 1,684

**The provincial inflow benefits will be offset by higher cost of geothermal units relative to the cost of natural gas furnaces and air conditioners (i.e. estimated at $2,000 to $3,000).*
***The US-MISO Region and Net Global impacts are shown as a range, which includes the impact under today's emission policies in export regions and recognizes what the potential impacts could be under more aggressive emission policies in export regions.*

Overall, from the customer, utility, provincial leakage and global environmental perspectives, there are substantial benefits when customers use natural gas for space heating purposes. The directional impact for each of these factors is the same for using natural gas for space heating relative to using geothermal systems, except when considering provincial leakage impacts; however in the latter case, a more complete analysis would need to account for the higher cost geothermal furnace units which are imported into Manitoba relative to the cost of importing natural gas furnaces/air conditioning units (note geothermal units are estimated to cost $2000 - $3000 more). For water heating, the directional impact is the same as space heating. As a cautionary note, it should be recognized that this analysis is

[8] Space heating equipment is assumed to have a 25 year life, whereas water heating equipment is assumed to have a 10 year life.

using average cost estimates. Capital costs (i.e. quoted installation prices) can vary greatly in the market place and actual customer specific situations will vary considerably.

Electric Business Perspective

Manitoba Hydro's electric operations are better positioned economically when a consumer uses natural gas for space and water heating purposes as the utility's marginal costs (export revenues and avoided infrastructure costs) are higher than the domestic revenue realized through the sale of electricity in Manitoba. The value to the Corporation is $3,223 for each conventional space heating application, $1,563 for each geothermal application and $10 for each water heating application.

Natural Gas Business Perspective

Manitoba Hydro's gas operations are better positioned economically when a consumer uses natural gas for space and water heating purposes as the utility collects additional revenue from its customers through its fixed charges and distribution charges (assuming rates for these services remain unchanged). Primary Gas costs are a "pass through" cost and therefore, have no impact on the natural gas business. For this analysis, transportation costs are also considered a "pass through" cost as it is assumed that Manitoba Hydro could avoid these costs if customers reduced their use of natural gas. The value to the Corporation is $4,107 for each space heating system and $317 for each water heating system over the life of the equipment.

Customer Perspective

Caution must be exercised in reviewing the analysis from a customer's perspective due to the wide range of installation costs charged by industry for installing space and water heating systems. In addition, this analysis is for first time or conversion costs associated with installing a natural gas water heater.

For the purpose of this analysis and based on average costs, a customer is:

- $7,737 better off by installing a natural gas space heating system relative to a conventional electric furnace;
- $11,276 better off by installing a natural gas space heating system relative to a geothermal system achieving an average SCOP of 2.5; and
- $727 better off by installing a conventional natural gas water heater relative to an electric water heater.

Provincial Leakage

Over the life of the equipment, net provincial cash inflows are reduced by $6,271 and $297 respectively, when electric systems are used for space and water heating as compared to using a natural gas furnace or conventional gas hot water tank. Relative to using natural gas, using geothermal systems for space heating increases provincial cash inflows by $1,061 over 25 years.

Environmental (GHG) Impacts

Relative to using natural gas, using electricity for space and water heating in Manitoba will reduce provincial GHG emissions. Impacts on global GHG emissions, however, are less certain. In the short term, and potentially in the longer term, global GHG emissions will be increased due to reduced electricity exports from Manitoba under existing environmental policies. Manitoba's electricity exports replace fossil generation in export regions, thereby reducing more global GHG emissions than could be reduced provincially through less natural gas use. In the longer term, however, global impacts are less certain and will depend on environmental policies at the time. For example, fewer electricity exports from Manitoba would not necessarily result in an increase to GHG emissions in an export region that imposed a GHG emissions cap. With lower electricity exports from Manitoba, the export region may need to take alternative action to ensure that emissions do not exceed an established cap. Manitoba's electricity may be just one of a number of other possible options for meeting that cap.

Market Trends

For water heating, a trend towards increased use of electric water heaters has been evident and is forecast to continue into the future. The new home market is effectively 100% transformed, with almost all new homes located within natural gas serviced areas now being constructed without chimneys and using electric hot water heaters. This shift from using natural gas water heaters is being driven primarily by economics, as the cost of installing natural gas water heaters has risen substantially due to new designs incorporating safety measures and due to the adoption of more energy efficient side-vented hot water tanks. In addition to the increased capital cost of natural gas hot water tanks, the gap in operating costs between an electric and natural gas hot water tank narrowed substantially during the past decade due to increased natural gas prices. More recently natural gas prices have fallen dramatically and the price gap in operating costs is again widening, The impact on customer preferences for natural gas hot water tanks at this time are uncertain; however, it is doubtful that homebuilders will be promoting the use of natural gas hot water heaters due to the higher capital cost associated with these units.

For space heating, a slight trend towards more customers using electricity has been observed. This trend was reflected in Manitoba Hydro's 2011 Energy Forecasts where a drop of approximately 3% in the use of natural gas for space heating is forecast.

Discussion

The potential impacts of fuel switching in Manitoba for space and water heating can be significant and the Corporation is monitoring market trends very closely. Given the economic drivers from a customer's perspective, it is unlikely that the Manitoba market will experience any overwhelming shift in space heating from natural gas to electricity, provided customers are informed on their choices. With water heating, the drivers are substantial enough that Manitoba Hydro expects to see a continued market shift from natural gas to electricity.

Manitoba Hydro recognizes the value customers place on having choice and the Corporation does not intend on mandating a specific fuel be used for space and water heating. Where appropriate, the Corporation prefers to use market intervention mechanisms (e.g. education, direct financial incentives, rate design options, etc.) to influence the market.