Manitoba Hydro
Climate Change Report

Providing unique insight into the strategies, research, planning, advocacy and greenhouse gas reduction actions that have made Manitoba Hydro an industry leader in responding to climate change.

Fiscal Year: 2012-2013

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EXECUTIVE SUMMARY

The core physical processes that regulate the Earth's climate continue to be altered. Science has provided strong evidence that our collective human activities are resulting in climate change. The multidimensional characteristics of climate change require a variety of sustained actions that address both local and global challenges. As a utility and a member of the provincial and North American community, Manitoba Hydro will be challenged by climate change on many fronts but will strive to maintain vision and focus in our response.

This document details Manitoba Hydro's current and historical efforts, actions and initiatives related to climate change. For over two decades the corporation has taken a leadership role in not only understanding the science of climate change and projecting future impacts, but also measuring and reducing our own emissions and advocating for effective policies to achieve national and international greenhouse gas (GHG) reductions.

Manitoba Hydro has established the following five climate change strategies to shape the organization's response to climate change:

- Understand the Changing Climate
- GHG Measurement and Reporting
- Contribute to GHG Emission Reductions
- Support GHG Policy and Market Development
- Adapt and Plan

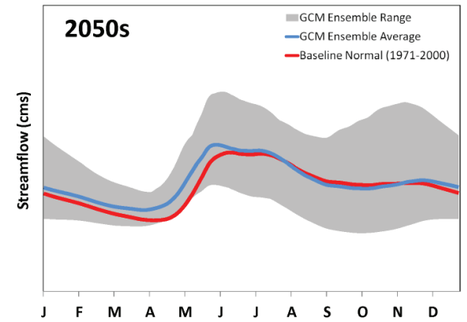
Understand the Changing Climate

Due to the importance of the physical environment to Manitoba Hydro's core business, the corporation has invested resources and deploys the best available technology to ensure a robust understanding of the range of potential implications due to climate change. Manitoba Hydro is currently undertaking a number of initiatives to increase our knowledge of the potential impacts of climate change, with a particular focus on the hydrology of the Nelson-Churchill watershed.

Manitoba Hydro has focused on building a foundation of knowledge and tools to help assess options to adapt operations and activities to the potential physical impacts of climate change. Specifically, we are developing future climate change scenarios using sophisticated Global Climate Models along with techniques which assess more local impacts. For the 2050 timeframe, an ensemble of Global Climate Models project a 2.2°C to 2.7°C increase in annual average temperatures throughout the individual basins of the Nelson-Churchill watershed. The ensemble average also projects a 6.0% to 8.7% increase in average total annual precipitation throughout the basin, with a greater increase in the Northern areas.

Efforts are underway to set-up, calibrate and validate hydrological models for each of the river basins to translate the output of these climate models into projections of river flows. While it is expected to take several years to analyze the entire Nelson-Churchill watershed, the preliminary results available for the Winnipeg River Basin indicate increasing annual average runoff with increased and earlier spring runoff and slightly decreased autumn runoff (see Figure 1).

FIGURE 1: FUTURE STREAMFLOW PROJECTION FOR WINNIPEG RIVER FROM WATFLOOD



Monitoring of the actual climatic conditions will be ongoing to provide modeling feedback and to help guide decisions and adaptation efforts over time. Knowledge of the changing climate facilitates planning for the development of new generating resources and the analysis of the vulnerabilities and opportunities.

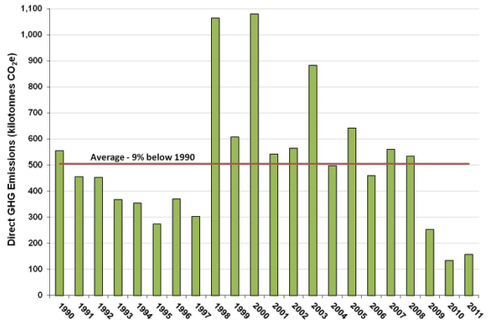
GHG Measurement and Reporting

Accurate greenhouse gas measurement and reporting is vital towards ensuring that Manitoba Hydro understands its emission liabilities, opportunities for further reductions and for demonstrating progress. Investigating the GHG impacts of our future projects helps Manitoba Hydro make resource choices and distinguish our electricity product from others.

The corporation began measuring and reporting its GHG emissions in 1995 and has set aggressive

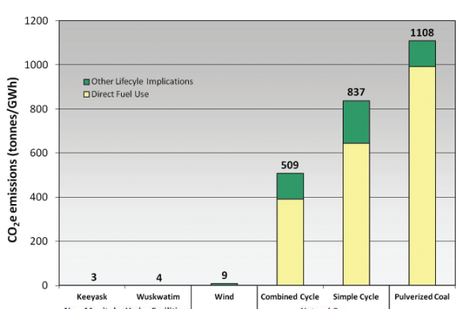
voluntary emission reduction objectives. Manitoba Hydro's GHG emissions are small. They represent only 1% of the emissions within a province that represents only 3% of national emissions. Despite Manitoba Hydro's low emissions starting point, the corporation has achieved substantial further reductions and exceeded its voluntary commitments. While national electricity sector emissions grew by 10 percent since 1990, Manitoba Hydro has achieved an average long-term emissions reduction of 9 percent over the same time period (Figure 2).

FIGURE 2: MANITOBA HYDRO DIRECT GHG EMISSIONS



Manitoba Hydro also estimates the GHG implications of its major projects using life cycle analysis. All forms of electrical generation, including renewable sources, have GHG implications when a facility's design, construction, operation and decommission are all considered. Accounting for all aspects of the project life cycle, Figure 3 compares the levelized lifecycle GHG implications for the Wuskwatim and Keeyask generating stations to various other electricity resources. When taking into consideration lifecycle GHG emissions, these new generating stations result in very low emissions per unit of energy, comparable to a wind farm and 99% less than the most efficient natural gas generation.

FIGURE 3: COMPARISON OF LIFE CYCLE GHG EMISSIONS FROM ELECTRICITY GENERATION



Contribute to GHG Emission Reductions

Manitoba Hydro has very low electrical generation GHG emissions relative to other utilities. Despite this advantageous starting position, Manitoba Hydro has continued to reduce reliance on fossil fuel generation and to pursue renewable electricity development along with the delivery of energy efficiency programs.

Prior to the mid-1990s, Manitoba Hydro operated coal generating units located at Brandon and Selkirk. Subsequent decisions, enabled by increased renewable power production and efficiency programs, resulted in Manitoba Hydro retiring Brandon Units 1-4 and converting Selkirk Generating Station from coal to natural gas.

In 1991, Manitoba Hydro established POWER SMART, the customer oriented brand for all of Manitoba Hydro's Demand Side Management (DSM) programs, initiatives, and activities. Energy conservation initiatives are designed to reduce domestic customer energy requirements through energy-efficient measures that use less energy to obtain comparable or superior services. Manitoba Hydro's Power Smart program has become a continental leader in energy efficiency programming and as documented in the 2010/11 Power Smart Annual Review has resulted in a total annual energy savings of 1,832 GW.h of electricity and 57 million cubic meters pf natural gas. These energy savings contribute to reductions in global GHG emissions of approximately 1,345 kilotonnes of CO2e per year. This is comparable to removing approximately 269,000 vehicles from the road for a full year.

Manitoba Hydro also considers efficiency opportunities within our own operations. By enhancing the generation output of existing generating facilities and transmission systems, Manitoba Hydro is able to maximize the production and availability of renewable electricity to displace fossil-fuel fired electric generation in neighbouring jurisdictions. In addition to activities done to date such as the refurbishment of a number of turbines and the rewinding of generators at Great Falls, Pine Falls, Seven Sisters and Grand Rapids generating stations, a number of supply side enhancement initiatives are currently underway including the Kelsey Rerunnering Project. Several potential projects on the Winnipeg River system are also being considered.

Hydropower has allowed Manitoba Hydro to operate one of the cleanest generation systems in the world. Manitoba Hydro currently has approximately 5,000 MW of hydroelectric generation with the majority of this capacity located in northern Manitoba. In the near-term,

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cap-and-trade program such as the Western Climate Initiative that Quebec is pursuing. The cost of coal generation within Manitoba already accounts for Manitoba's tax on emissions from coal. As of January 1, 2012, coal used in Manitoba is subject to a Provincial emissions tax equal to $10 per tonne of carbon dioxide equivalent (CO_2e) emissions.

The implications of GHG policies implemented outside of Manitoba in export regions are embedded in Manitoba Hydro's Export Price Forecast. The specific details of Manitoba Hydro's electricity price forecast; including details on specific pricing factors such as the assumptions regarding CO_2 premiums, are confidential. Manitoba Hydro has a consultant services agreement with each of the electricity export price forecast consultants, and the services agreement has confidentiality requirements that prevent Manitoba Hydro from publically releasing the forecast reports.

Projecting the future impact of GHG policies ensures that the appropriate costs and revenues are included in the resource planning process for the evaluation of future resource options and development plans.

there is an opportunity to add approximately 2,500 MW of capacity in Manitoba through the development of three new hydropower facilities: Wuskwatim (200 MW), Keeyask (695 MW) and Conawapa (1,485 MW) generating stations. All three plants are models of sustainable hydropower development, including minimal flooding (approximately 50km^2 cumulatively), incorporation of low environmental impact design features and in partnership with local First Nation communities.
To further renewable power development in the province, Manitoba Hydro has also contracted over 250 MW of wind capacity in service at the St. Leon and St. Joseph wind farms under the terms of long-term Power Purchase Agreements.

Hydropower, wind, and Power Smart efficiency improvements all contribute to increased exports. Since 2005, annual electricity exports by Manitoba Hydro have averaged over 10,000 GW.h per year. Electricity exports to neighbouring states and provinces have kept Manitoba electricity rates amongst the lowest in the world and contributed to significant GHG reductions outside of the province. Our actions demonstrate that energy needs can be met in a sustainable and affordable fashion while proactively addressing climate change.

Support GHG Policy and Market Development

Ultimately, GHG policies that deliver broad emission reductions will be required to achieve global climate change objectives. Manitoba Hydro has participated in and supported provincial, regional, and national GHG policy dialogues for more than fifteen years. GHG policies that deliver a meaningful carbon price for emissions, such as a carbon tax or cap-and-trade program, are the most flexible and economically efficient ways to reduce emissions. These policies present significant opportunities for non-emitting and renewable resources. By striving to enable practical policies that are environmentally effective and economically efficient, Manitoba Hydro has developed the expertise needed to navigate a carbon-constrained future.

Over the past twenty years several cap-and-trade bills were proposed in the United States by both Democrat and Republican members of Congress; however none of these were passed into law. Similarly in Canada, various national cap-and-trade frameworks were proposed and designed but were never implemented. The current U.S. Administration also has leveraged the Environmental Protection Agency's (EPA) ability to regulate GHG and other air emissions from major stationary sources. These regulations could put significant constraints on electricity sector emissions. The Government of Canada has aligned its GHG reduction targets with those of the U.S. and is also pursuing a regulatory approach. For the electricity sector, Environment Canada has published its "Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations". These regulations would effectively phase-out conventional coal-fired electricity generation over the long-term. Scheduled to begin in 2015, the proposed regulations would require a GHG emissions performance standard comparable to that of a natural gas combined cycle generator for new coal-fired electricity generation, and for units that have reached the end of a fifty year life. Effectively, this would require the retirement of old units unless they can be converted to alternative fuels or combined with carbon capture and sequestration technology.

In addition to federal legislation and regulation, state and provincially led GHG cap-and-trade initiatives have also been pursued. The Western Climate Initiative (WCI) continues to move with California and Quebec as the only jurisdictions that are working towards implementation of a cap-and-trade agreement in 2013. The Regional Greenhouse Gas Initiative (RGGI), which took effect in January 2009, calls for a 10% reduction in greenhouse gas emissions from 2005 levels by 2018 for nine participating Northeastern states.

Manitoba Hydro actively collaborates with a number of different stakeholders from both inside and outside of the electricity sector on these various regional, national and international initiatives. This includes direct engagement with the Canadian and U.S. federal governments, provincial and state governments along with variety of energy policy stakeholders at the regional level, national and international levels. Manitoba Hydro also is an active member of the Canadian Hydropower Association and facilitates advocacy initiatives on behalf of the hydropower industry.

In North America, voluntary GHG emission reduction programs have emerged as opportunities for proactive companies to transition towards a carbon constrained economy. Manitoba Hydro has also nurtured the development of carbon markets through its participation in programs such as the Chicago Climate Exchange. This helps the corporation to better understand carbon markets through hands-on experience and demonstrates climate change leadership which increases our voice in shaping climate change policies.

Adapt and Plan

Climate change has the potential to influence Manitoba Hydro's resource plans and future operations. Several key inputs to the resource planning process may be sensitive to a changing climate or the human response that may arise in response to climate change. These resource planning considerations include the projections of changes to runoff, the load forecast, and the market price for electricity. Manitoba Hydro is in the process of investigating how best to factor climate change impacts into long-term planning and operation of its system. The intent is to explore the sensitivity of these inputs to climate change and determine the robustness of our development plans. Similarly, where there appears to be implications for our operations, adaptation strategies will be considered.

Based on current research and studies, Manitoba Hydro has projected ranges associated with future runoff. These ranges may be used as sensitivities in resource planning studies. Projections that Manitoba Hydro makes today are based on a much more comprehensive understanding than those made several years ago as they undergo more comprehensive modeling. While Manitoba Hydro is at the forefront of hydrologic and hydroclimatic studies, there is still a significant amount of work to be done. Over the next several years, the modeling work that is currently underway will enhance our understanding and planning projections even further. Through ongoing research and analyses, Manitoba Hydro will continue to advance the state of knowledge about the range of potential climate change impacts at the system-wide scale and improve our understanding of how these impacts could affect existing and proposed facilities.

Operating practices, unlike fixed assets, may change and adapt over time. Therefore current activities are not focused on anticipating future changes in operations but rather are focused on developing the modeling tools that enable us to better meet the needs of today and enhance our understanding and ability adapt to changes. This includes improving short term hydrologic modeling for forecasting upcoming water conditions and possible extreme events.

Changes to temperature have an effect on electrical energy and natural gas demand. In order to understand the potential sensitivity, Manitoba Hydro studied the general implications of a 1°C increase in average daily temperature throughout the year. For electricity, a uniform 1°C warming throughout the year would result in a 200 GW.h decrease in electric heating energy with an increase in cooling electrical energy requirements of 300 GW.h with a corresponding decrease of 40 MW peak demand in the winter, and an increase of 120 MW peak electrical demand in the summer. For natural gas volumes, a uniform 1°C increase would result in a 50,000 103m3 decrease in heating load requirements.

One of the most important adaptation issues relates to responding to emerging climate change or GHG policies. Greenhouse gas policies, typically presented either through a cap-and-trade program or carbon tax framework, will impact the generating costs and the market price for electricity. GHG price assumptions are embedded in Manitoba Hydro's resource planning activities to account for the impact on electricity export prices as well as increased costs related to utilizing thermal generation in Manitoba. While Manitoba Hydro generally assumes that North American GHG price signals will converge or harmonize in the longer term, there will likely be short-term local or regional discrepancies due to differences in timing and policy details. For example, the cost of coal generation within Manitoba already accounts for Manitoba's tax on emissions from coal. As of January 1, 2012, coal used in Manitoba is subject to a Provincial emissions tax equal to $10 per tonne of carbon dioxide equivalent (CO2e) emissions. Projecting the future impact of GHG policies ensures that the appropriate costs and revenues are included in the resource planning process for the evaluation of future resource options and development plans.

Conclusion

Science has provided strong evidence that our collective human activities are resulting in climate change. Reducing greenhouse gas emissions and avoiding the risks associated with climate change requires diverse sustained responses across the spectrum of related challenges. For over two decades, the corporation has taken a leadership role in not only understanding the science of climate change and projecting future impacts, but also measuring and reducing our own emissions and advocating for effective policies to achieve national and international GHG reductions. Manitoba Hydro activities have been organized under five climate change strategies that strive to provide a comprehensive approach that ensures all potential risks are analyzed and all opportunities are enabled. The balance of the document will provide more details of Manitoba Hydro's current and historical efforts, actions and initiatives related to climate change.

For natural gas, Manitoba annual volume requirements are expected to be stable around 2,000,000 10^3m^3 over the next ten years. A 1°C increase over that period would decrease that volume by 2.5%.

There are a couple of limitations of this sensitivity that should be recognized. While Winnipeg does not capture all of the Province's electrical and natural gas heating and cooling loads, it reflects a significant portion of the total. Another limitation of this sensitivity is that climate models do not projected temperature changes to be a uniform increase across the year. While future sensitivity studies may improve on these issues the current results are judged to provide reasonable insight.

Manitoba Hydro updates its Electric Load and Natural Gas Volume Forecasts annually. These documents are a critical input to the resource planning process. Although effect of a 1°C change in temperature is incorporated as sensitivity to climate change within the electric load forecast actual temperature changes are not projected to increase uniformly throughout the year.

6.3 OPERATIONS

From an operational perspective, investigating how climate and hydrology of our watershed have changed and will change are both key to understanding and adapting to the potential vulnerability and opportunities of our system. Any climate changes that may have occurred to date have been accommodated by current operating practices. At this time it is not feasible to prescribe future operational changes. However, unlike the design and construction of a completed generating station, operating practices are not fixed and may change and adapt over time. At this time Manitoba Hydro's key activities focus on improving hydrologic modeling for forecasting upcoming water conditions and possible extreme events.

The improved hydrologic inflow forecasting data is proving to be a useful tool for maintenance scheduling decisions. An example of this is the water forecasts being provided for the Pointe Du Bois spillway project so construction activities can be aligned with predicted favorable water conditions. To facilitate project scheduling, 21-day forecast data have been issued weekly since November 2011. This data has supported construction of the spillway access bridge and will continue to be used through the Pointe Du Bois project.

Understanding and predicting the potential nature of extreme weather events through hydrological modeling activities provides operations groups with information needed to plan for such events, particularly from a dam safety perspective. The hydrologic inflow forecasting data can be utilized in probable maximum flood studies. These studies are required as part of both existing operations for dam safety and for providing estimates for future generation. The WATFLOOD models along with the CaPA precipitation mapping are being developed into the new modeling tool of choice for these dam safety studies.

Potential severe weather related disruptions to Manitoba Hydro's electrical distribution and transmission systems also underscore the importance of furthering the understanding and prediction of severe weather resulting from climate change. With possible increasing frequency, duration, and intensity of extreme weather events, projects which increase system reliability such as Bipole III and the Riel Reliability Project provide additional climate change adaptation benefits.

6.4 GHG PRICE IMPLICATIONS

Greenhouse gas pricing policies, typically presented either through a cap-and-trade program or carbon tax framework, will impact the domestic cost of operating Manitoba Hydro's fossil-fuel fired thermal electric generating stations as well as export electricity market resources and pricing. To ensure the impacts of a carbon premium are included in long-term planning projections, a "GHG component" is embedded in Manitoba Hydro's resource planning activities to account for the impact on electricity export prices as well as increased costs related to utilizing thermal generation in Manitoba.

The nature of GHG price forecasting is inherently uncertain and is dependent on a range of potential GHG emission policies and how those policies are applied. However, even if future legislation requirements for carbon emission were known, there would still be significant uncertainty as to the cost of carbon emission allowances and the associated impact on power prices.

GHG price forecasts are dependent on complex assumptions regarding potential abatement opportunities and associated costs. While Manitoba Hydro generally assumes that North American GHG price signals will converge or harmonize in the longer term, there will likely be short-term local or regional discrepancies due to differences in timing and policy details. Resources within Manitoba will face GHG pricing and other constraints that depend on the circumstances and policies specific to Canada and/or Manitoba such as the possible adoption of a broad carbon tax consistent with British Columbia's approach or the potential membership in a

6 ADAPT AND PLAN

Climate change has the potential to influence Manitoba Hydro's resource plans and future operations. Several key inputs to the resource planning process may be sensitive to a changing climate or the human response that may arise in response to climate change. These resource planning considerations include the projections of changes to runoff, the load forecast, and the market price for electricity. Manitoba Hydro is in the process of investigating how best to factor climate change impacts into long-term planning and operation of its system. The intent is to explore the sensitivity of these inputs to climate change and determine the robustness of our development plans. Similarly, where there appears to be implications for our operations, adaptation strategies will be considered.

6.1 HYDROLOGIC AND HYDROCLIMATIC STUDIES (FUTURE RUNOFF PROJECTIONS)

Manitoba Hydro is one of the largest hydropower utilities in North America. Manitoba is fortunate by virtue of the geographic extent and diversity of its watershed and the contributing river systems including the Winnipeg River, Red River, Saskatchewan River, Churchill River, Nelson River, and smaller tributaries.

Based on current research and studies, Manitoba Hydro has projected ranges associated with future runoff. These ranges may be used as sensitivities in resource planning studies. Projections that Manitoba Hydro makes today are based on a much more comprehensive understanding than those made several years ago, as they are undergoing more comprehensive modeling. While Manitoba Hydro is at the forefront of hydrologic and hydroclimatic studies, there is still a significant amount of work to be done. Over the next several years, the modeling work that is currently underway will enhance our understanding and planning projections even further. This capability may give us the opportunity to supplement our historical records over the last 100 years with a range of potential outcomes over the next 100 years.

It is important to acknowledge that even as our capabilities increase over time there will always be a range of uncertainty associated with climate change due to the complexity and variability of key factors such as water temperature, inflow variability, and the frequency and intensity of system-wide drought. Through ongoing research and analyses, Manitoba Hydro will continue to advance the state of knowledge about the range of potential climate change impacts at the system-wide scale and improve our understanding of how these impacts could affect existing and proposed facilities.

6.2 LOAD FORECAST IMPLICATIONS

Changes to temperature have an effect on electrical energy and natural gas demand. Warmer winters will reduce heating loads during the winter months impacting both electric and natural gas heating energy requirements. Similarly, warmer summers will increase electric air conditioning load during the summer months.

In order to understand the general effect, Manitoba Hydro studied the sensitivity of Winnipeg's electrical load and natural gas demand caused by a 1°C increase in average daily temperature throughout the year. If Winnipeg experienced a uniform 1°C warming throughout the year, winter months would be subject to less heating while summer months would be subject to more cooling. Winnipeg temperature changes are used to model provincial changes as Winnipeg is central to most of the weather-dependent load. Based on information in Manitoba Hydro's 2012 Electric Load Forecast and the 2012 Natural Gas Volume Forecast, the approximate climate change effects associated with this 1°C increase in
average daily temperature would result in the following:

Heating Season:

- Decrease of 200 GW.h annual energy and 40 MW peak demand in the winter.
- Decrease of 50,000 103m3 in annual natural gas volume and a 250 103m3 peak-day reduction in the winter.

Cooling Season:

- Increase of 300 GW.h annual energy and 120 MW peak demand in the summer.

The electrical result overall is an annual increase of 100 GW.h energy, decrease of 40 MW peak demand in the winter, and an increase of 120 MW peak demand in the summer. Manitoba annual electrical energy requirements are expected to grow 4,500 GW.h over the next ten years. A 1°C increase over that period would increase that growth to 4,600 GW.h, an increase in load growth of about 2%. Similarly, Manitoba's winter peak electrical demand would be expected to grow 810 MW over the next ten years. A 1°C increase over that period would reduce that growth to 770 MW, a reduction of 5%. Finally, Manitoba's summer peak electrical demand would be expected to grow 530 MW over the next ten years. A 1°C increase over that period would increase that growth to 650 MW, an increase of 20%.

"Science has made enormous progress toward understanding climate change. As a result, there is a strong, credible body of evidence, based on multiple lines of research, documenting that Earth is warming. Strong evidence also indicates that recent warming is largely caused by human activities, especially the release of greenhouse gases through the burning of fossil fuels."

(The National Academy of Sciences, 2010.)

1 INTRODUCTION

The objective of this report is to provide insight into Manitoba Hydro's climate change activities including research, greenhouse gas reductions, policy advocacy, as well as its planning and adaptation activities.

The Earth's climate is dynamic and has changed significantly in the past; however, the nature and cause of the current climate change is different. Although media and special interest groups on both sides of this issue have confused public discourse, the scientific consensus on the core physical phenomenon and hypotheses have been chronicled and have remained solid through scientific debate. Manitoba Hydro accepts the results of this scientific body of work and recognizes the evidence that emissions from human activities are resulting in climate change.
Coordinated efforts will be required to reduce global emissions and avoid the risk of dangerous climate changes.

Manitoba Hydro has focused on building a foundation of knowledge and tools to help assess options to adapt operations and activities to the potential physical impacts of climate change. Specifically, we are developing future climate change scenarios using sophisticated Global Climate Models along with downscaling techniques which enable the determination of more local impacts. Hydrological models are being set-up for the basins of the Nelson-Churchill watershed and these will be used to simulate future hydrological conditions in these basins. Monitoring of the actual climatic conditions will be ongoing to provide modeling feedback and to help guide decisions and adaptation efforts over time.

Environmental and economic concerns about climate change are driving a variety of societal responses. Energy policies will continue to drive low and non-emitting technology development and deployment. These policies will also result in changes in the market price for electricity and influence the purchasing preferences of energy customers.

While Manitoba Hydro will be impacted by these changes, the Corporation also has the potential to affect and influence outcomes. The Corporation can contribute emission-free electricity, assist in shaping policy frameworks, guide development of efficient technologies and help domestic customers make wise choices regarding their energy use.

1.1 CLIMATE CHANGE SCIENCE

To understand how greenhouse gases (GHGs) act to increase the Earth's temperature, one should consider the Earth's energy balance system, which is essentially driven by solar radiation. Approximately 30% of the sunlight that reaches the top of Earth's atmosphere is reflected back to space. The energy that is not reflected into space is absorbed by the Earth's atmosphere and surface and is converted from visible and other spectra of light into heat. Keeping the energy roughly in balance, the Earth radiates heat back to space as longwave (infrared) radiation. GHGs (e.g. water vapor, carbon dioxide, methane, nitrous oxide, ozone and various chlorine, fluorine, and bromine-containing molecules), absorb the reflected infrared radiation, acting as a partial blanket. By trapping heat, these gasses act like the glass in a greenhouse warming the Earth's surface and hence the process is termed the "greenhouse gas effect". This process is critical in maintaining a habitable planet. In the absence of any GHGs the planet would be too cold to support many life forms.

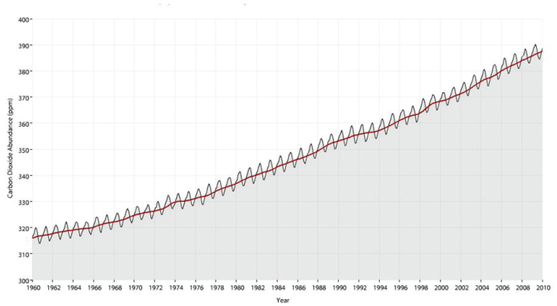
The current concern is that the burning of fossil fuels such as coal, natural gas, and oil is releasing additional heat-trapping gases, intensifying the natural greenhouse effect, thereby changing the Earth's climate. Since the industrial revolution, humans have burned more fossil fuels each decade. Figure 4 shows the recent atmospheric trend in one of the key greenhouse gases that human activities release - carbon dioxide. The carbon dioxide (CO2) values are presented in parts per million (ppm). The gray line shows seasonal changes in monthly measurements while the red line shows the annual average trendline. Although greenhouse gas composition within the atmosphere has changed over the course of

As a result of human activities, the present carbon dioxide concentration of about 385 ppm is about 30 percent above its highest level over at least the last 800,000 years.

(Karl, et al, 2009)

the Earth's history, the magnitude and rate of the recent changes appears to be unprecedented.

FIGURE 4: ATMOSPHERIC CARBON DIOXIDE MEASURED AT NOAA'S MAUNA LOA OBSERVATORY ON HAWAII.



SOURCE: NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION HTTP://WWW.CLIMATEWATCH.NOAA.GOV/ARTICLE/2009/CLIMATE-CHANGE-ATMOSPHERIC-CARBON-DIOXIDE

In addition to GHG concentrations in the atmosphere, there are many other climate change indicators which demonstrate changes to the global physical environment. Surface temperatures that have been measured on land and at sea for more than a century show that Earth's (globally averaged) surface temperature is experiencing a long-term warming trend. Arctic sea ice is another useful climate change indicator. In the Arctic Ocean the area covered by sea ice grows and shrinks over the course of the year. The increased sunlight and higher temperatures of summer typically result in the sea ice shrinking to its minimum extent each September. Sea ice responds to warmer temperatures by retreating further. Minimum sea ice observed each September has decreased by an average of 12 percent per decade compared to the 1979-2000 average. An additional consequence of reduced ice cover is a decrease in the reflected sunlight from the surface. Snow covered surfaces reflect incoming solar radiation and provide a cooling effect, however, when the extent of snow covered areas is reduced, solar radiation is absorbed by the Earth and contributes to additional warming. This is an example of "positive feedback", which reinforces the warming cycle.

1.2 CLIMATE CHANGE STRATEGIES

The science has made it clear that our collective human activities are resulting in climate change. Reducing GHG emissions and avoiding the risks associated with climate change requires a wide variety of actions that address the local through global challenges. Manitoba Hydro strives to understand and manage risks, liabilities and opportunities related to climate change with a focus on providing leadership on social, environmental and economic issues. In alignment with Manitoba Hydro's corporate strategic plan and existing corporate goals, Manitoba Hydro has established the following five climate change strategies to shape the organization's response to climate change:

- Understand the Changing Climate
- GHG Measurement and Reporting
- Contribute to GHG Emission Reductions
- Support GHG Policy and Market Development
- Adapt and Plan

Understand the Changing Climate

Manitoba Hydro strives to understand the implications of climate change. This includes maintaining a comprehensive understanding of the science of anthropogenic climate change, and the resulting local, regional and global hydrological impacts. A comprehensive understanding is vital to ensure that Manitoba Hydro can plan for and adapt to a
changing physical environment.

GHG Measurement and Reporting

Accurate greenhouse gas measurement and reporting are vital towards ensuring that Manitoba Hydro understands emission liabilities, opportunities for further reductions, and demonstrates progress. Since Manitoba Hydro began its voluntary reporting efforts both the Provincial and Federal governments have introduced mandatory reporting requirements for some of Manitoba Hydro's facilities. Investigating the GHG impacts of our future projects helps Manitoba Hydro make resource choices and distinguish our product against other non-renewable and renewable alternatives.

Renewable Electricity Energy Markets

Climate change and related energy policy development can also have a direct impact on the supply and demand for renewable electrical energy. There exists a close relationship and overlap between existing and potential carbon and renewable energy polices and markets. Approximately thirty (30) U.S. states that have enacted renewable portfolio standards (RPS) which enforce mandatory participation of utility companies to meet renewable energy targets. States must provide the required number of renewable energy credits (RECs) to correspond with their RPS obligations in a specific year. Qualifying renewable technologies differ by region and program type and are driven by a variety of motivations. Manitoba Hydro has been actively marketing RECs since 2008 in both the RPS and voluntary green power markets.

ket-based and multi-sector cap-and-trade mechanism to help achieve those reduction targets. After releasing a model cap-and-trade rule in 2010, the participating states and province did not continue pursuing their GHG goals through the Accord.

5.2 CARBON MARKETS AND PROGRAMS

In North America, voluntary GHG emission reduction programs have emerged as opportunities for proactive companies to transition towards a carbon constrained economy. Participation in these initiatives not only provides valuable tactical market experience, it also displays the corporation's commitment to climate change leadership along with providing an opportunity to shape emerging mandatory policy frameworks.

Chicago Climate Exchange (CCX)

Manitoba Hydro participated in the design of the CCX and was an active member for the duration of the program from 2003 through 2010. The program met all of its significant objectives such as demonstrating that a rules-based cap-and-trade program can be cost effectively delivered and managed. The program was very influential in the
establishment of the European Trading System, the Regional Greenhouse Gas Initiative (RGGI) as well as the emerging Western Climate Initiative. Upon completion of Phase II, the members of CCX had completed eight years of continuous progress in reducing greenhouse gas emissions through a rules-based market.

Manitoba Hydro's participation in CCX was based on the understanding that a carbon trading scheme would be an effective and practical path forward in managing GHG emissions. The Corporation's participation in the CCX
committed Manitoba Hydro to progressively step up its CO_2 emission reductions to 6% of its baseline emissions (defined as average emissions over the 1998-2001 period) through 2010. With respect to the CCX commitment, Manitoba Hydro maintained full compliance with these legally binding emission reduction targets. Manitoba Hydro also participated in the committee structure that managed the CCX including serving as the chair of the Offset Committee. Some of the benefits to Manitoba Hydro of participating in the CCX included:

- Reduced emissions through high compliance standards and standardized third party verification.
- Better understanding of carbon markets, through practical, hands-on experience.
- Establishment of an early track record in reductions and experience with carbon and GHG markets.
- Demonstrated climate change leadership, increased Manitoba Hydro's voice towards shaping future climate change policies.

Voluntary Challenge and Registry

The Climate Change Voluntary Challenge and Registry (VCR) Program was a formal national initiative created in 1995 that called on Canadian organizations to voluntarily take actions to limit or reduce net greenhouse gas emissions. It was a joint initiative of federal, provincial, and territorial governments. Under this program, Manitoba Hydro began to report its emissions and made a voluntary commitment to reduce its average corporate net greenhouse gas emissions to 6% below the 1990 level. Manitoba Hydro's emission reduction obligations under the VCR program were met. Average net emissions during the program prior to its conclusion in 2007 were 36% below the 1990 level, far exceeding the 6% commitment. During Manitoba Hydro's participation in the VCR, Manitoba Hydro received Gold Champion Level recognition five consecutive times from the VCR for its emission reduction reporting and activities. In 2003, Manitoba Hydro received the VCR Leadership Award in the electric utility category, recognizing the corporation's outstanding contributions in voluntarily meeting Canada's commitment to reduce greenhouse gas emissions. Our commitment was also recognized by the Pembina Institute, in their last assessment of VCR reports, to be the best of all Canadian utilities.

Greenhouse Emission Reduction Trading Pilot (GERT)

The GERT Pilot Project was a collaborative effort between provincial and federal government agencies, industry associations, and environmental and non-governmental agencies. The Pilot was launched in June 1998 with the objective of learning about emission reduction credit trading through experimentation. Manitoba Hydro participated in this process to gain practical experience with this market-based approach and to foster the development of strategies and policies for meeting Canada's international climate change commitments.

Contribute to GHG Emission Reductions

Manitoba Hydro has low generation GHG emissions relative to other electrical utilities. Despite this advantageous starting position, the corporation has set aggressive voluntary emission reduction objectives over the past fifteen years. Manitoba Hydro has continued to pursue hydro, wind and Power Smart energy efficiency programs while reducing emissions from its own facilities and contributing to reduced emissions outside Manitoba through electricity exports.

Support GHG Policy and Market Development

Effective GHG policies will be required to achieve necessary emission reductions. Manitoba Hydro has participated in and supported provincial, regional and national GHG policy dialogues for more than fifteen years. Manitoba Hydro has also nurtured the development of carbon and renewable energy markets. Through Manitoba Hydro's expertise in energy technologies and practical experience in environmental markets, it strives to enable practical policies that are environmentally effective and economically efficient.

Adapt and Plan

Successfully responding to a changing physical environment requires that Manitoba Hydro's plans are robust under various potential climate scenarios and that its operations are positioned to adapt to changing operating parameters such as flow conditions and electrical loads. Manitoba Hydro must also adapt to the human response to climate change that may include changes in societal preferences for energy sources, energy policies and their implications on the market price for electricity.

The following chapters provide the details of Manitoba Hydro's significant and coordinated efforts within the framework of these five climate change strategies.

"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea levels"

(IPCC 2007b)

2 UNDERSTAND THE CHANGING CLIMATE

Due to the importance of the physical environment to Manitoba Hydro's core business, the corporation has invested resources and deploys the best available technology to ensure a robust understanding of the range of potential changes due to climate change. Manitoba Hydro is currently undertaking a number of initiatives to increase our knowledge of the potential impacts of climate change, particularly the hydrology within the Nelson-Churchill watershed.

2.1 GLOBAL CLIMATE CHANGE

Prior to understanding the impact of climate change on the physical environment and how this impacts Manitoba Hydro's water resources, it is important to provide some global context. When studying climate change, it is important to understand the difference between weather and climate. Weather refers to the day-to-day variable state of the atmosphere, and is characterized by temperature, precipitation, wind, clouds, and various other weather elements (IPCC, 2007a). Weather results from rapidly developing and decaying weather systems and is difficult to predict on a daily basis. Climate, on the other hand, refers to the weather statistics in terms of its means, variability, extremes, etc. over a certain timespan and area (IPCC, 2007a). Climate varies from place to place depending on the latitude, vegetation cover, distance to a large body of water, topography, and other significant geographic features.

It is understood that the Earth's climate has changed in the past; however, the cause(s) of current climate change trends differ from the past. While natural factors may have contributed to the observed warming in the first half of the 20th century, "it is extremely unlikely (<5% probability) that global climate change of the past 50 years can be explained without external forces, and very likely (>90% probability) that it is not due to known natural causes alone" (IPCC, 2007a, pg.10). The United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) have established the Intergovernmental Panel on Climate Change (IPCC) which is the leading body for the assessment of climate change. The IPCC brings together many of the world's leading scientists to conduct comprehensive assessments of the current state of knowledge on climate change and its potential environmental and socio-economic consequences.

The IPCC refers to climate change when there is a statistically significant variation to the mean state of the climate (or of its variability) that usually persists for decades or longer and which includes shifts in the frequency and magnitude of sporadic significant weather events as well as the slow continuous rise in global mean surface temperature (IPCC, 2007a). The climate system is extremely complex with many physical, chemical, and biological interactions occurring along various temporal and spatial scales. Changes, either natural or anthropogenic, in a component of the system, can cause climate change. Climate change scientists have projected potential changes in temperature and precipitation patterns, frequency and intensity of severe weather events, and sea level rise as a result of rising concentrations of greenhouse gases in the atmosphere.

2.2 CLIMATE CHANGE AND MANITOBA HYDRO

For hydroelectric power companies, changes in temperatures and precipitation patterns, rising sea levels, and the possibility of an increase in the frequency and severity of extreme weather events are of interest as they have the potential to influence energy production, infrastructure and energy demand. Physical assets are planned, constructed, and operated based on historical climatic and hydrologic conditions and changes in climate may alter their performance. Transmission and distribution systems may be exposed to a number of vulnerabilities of climate change such as extreme weather events. Manitoba Hydro is striving to assess the risks associated with climate change and how to adapt to future conditions.

It is important to understand the potential for climate change to impact the physical environment at regional and local scales. Manitoba Hydro is committed to conducting studies of future climate change scenarios and

energy policy stakeholders at the regional level, national and international levels. Manitoba Hydro also is an active member of the Canadian Hydropower Association (CHA) and facilitates advocacy initiatives on behalf of the hydropower industry.

Highlighted below is a list of GHG policy frameworks that Manitoba Hydro is actively engaged in.

Canadian GHG Policy

Manitoba Hydro has participated in Canadian national GHG policy development directly and through initiatives coordinated by the CHA, Canadian Electrical Association (CEA) and the Province of Manitoba. In the past the Federal Government had a comprehensive climate change process which Manitoba Hydro played a significant role in by co-chairing the Electricity Table and providing one of the leading authors for its Tradable Permits Working Group. Manitoba Hydro also contributes through many other processes such as those sponsored by the National Round Table on Environment and Economy, the Winnipeg Consensus Group and Sustainable Prosperity. Through all of these fora, Manitoba Hydro has the opportunity to directly consult with the federal government or otherwise influence national dialogue around GHG regulations for the electricity sector.

United States Federal and State Government

Manitoba Hydro is in active discussion with U.S. utilities and policymakers to explain the role that our hydroelectricity can play in helping the U.S. meet its energy needs and climate policy goals. There are several features of our existing and potential exports which are communicated to U.S. stakeholders:

- As demonstrated above through the life-cycle assessments, hydropower is virtually GHG free electricity and can thus play a role in the achievement of emission reduction or renewable energy targets.
- Hydropower is a mature and cost-effective means to address climate policy goals.
- Expanding U.S. and Canadian hydropower could provide a portion of the resources necessary to transition towards vehicle electrification.
- Hydropower offers unique operational flexibility which is well positioned to complement development of other renewable electricity generation technologies such as wind, solar and biomass.

There are several avenues through which Manitoba Hydro engages policymakers in the U.S. Manitoba Hydro participates with in various conferences and other policy fora such as those sponsored by Powering the Plains, the Midwest Governors' Association and the Minnesota Chamber of Commerce. We also meet with policy leaders including politicians, political staff, think tanks and non-governmental organizations (NGOs). Meetings, events, presentations and communication pieces are often coordinated through the Canadian Embassy (and Consulates), the CHA and the CEA.

Regional Climate Initiatives

Climate policy models developed on a smaller regional level have the capacity of obtaining national attention and are typically designed with the objective of providing a model for future national emissions-reduction programs. Manitoba Hydro, both individually and in cooperation with the Province of Manitoba have participated in a number of regional climate initiatives described below.

The Western Climate Initiative (WCI) cap-and-trade program was launched in February 2007, signaling a long-term commitment by participating states and provinces to significantly reduce regional GHG emissions. The partners share a commitment to identify, evaluate, and implement collective and cooperative ways to address climate change through a regional reduction of GHGs. Manitoba Hydro participated in the WCI through stakeholder consultations and the Province of Manitoba. Currently only California and Quebec are implementing this cap-and-trade program with the first compliance period to begin in 2013. The Province of Manitoba has completed public consultation on this program, but has not moved towards enacting legislation as it is examining a number of options and alternatives to addressing climate change.

In 2001, the non-profit Great Plains Institute convened a diverse group of stakeholders including Manitoba Hydro to launch its Powering the Plains program. The culmination of this work is documented in the roadmap report which represents a consensus among leaders from Iowa, Manitoba, Minnesota, North Dakota, and South Dakota on how best to meet the energy needs of a growing Midwestern economy while reducing the greenhouse gas intensity of regional energy production.

Manitoba Hydro has engaged with the Midwest Governors Association (MGA) on a number of climate initiatives. For example, the Midwestern Greenhouse Gas Reduction Accord (Midwestern Accord) was a regional agreement by members of the MGA and the Premier of Manitoba to reduce greenhouse gas emissions to combat climate change. The Midwestern Accord aimed to establish greenhouse gas reduction targets and to develop a mar-

5 SUPPORT GHG POLICY AND MARKET DEVELOPMENT

Ultimately, GHG policies that deliver broad emission reductions will be required to achieve global climate change objectives. Manitoba Hydro has participated in and supported provincial, regional, and national GHG policy dialogues for more than fifteen years. Manitoba Hydro has also nurtured the development of carbon markets through its participation in the design and operation of the Chicago Climate Exchange. Through Manitoba Hydro's expertise in energy technologies and practical experience in environmental markets, it strives to enable practical policies that are environmentally effective and economically efficient. GHG policies that deliver a meaningful carbon price for emissions, such as a carbon tax or cap-and-trade program, are the most flexible and economically efficient ways to reduce emissions. These policies present significant opportunities for non-emitting and renewable resources.
Climate change first emerged as a policy issue in 1988 when the U.S. Senate held a hearing on the issue and the United Nations formed its Intergovernmental Panel on Climate Change (IPCC). At the Rio Earth Summit in 1992 world leaders, including George H.W. Bush, signed the United Nations Framework Convention on Climate Change (the UNFCC). This provided an international framework for measuring and reporting national emissions as well as committing developed nations to hold emission at 1990 levels by 2000. In 1997 the Kyoto Protocol took this further by establishing individual national reduction targets from 1990 levels. While this protocol came into force internationally, the U.S. never ratified or signed on to the protocol and more recently Canada withdrew from the Protocol. In the 2010 Copenhagen Accord both Canada and the U.S. pledged to reduce their emissions by 17
percent from 2005 levels.

One way to reduce GHGs across the economy is to establish a price for carbon. Over the past 20 years several cap-and-trade bills were proposed by both Democrat and Republican members of Congress; however none of these were passed into law. Similarly in Canada, various national cap-and-trade frameworks were proposed and designed but were never implemented.

While federal climate change legislation remains elusive, the U.S. Environmental Protection Agency (EPA) has recently regulated GHG emissions from major stationary sources. These and other air emission regulations could put significant constraints on electricity sector emissions should they withstand a variety of legal and legislative challenges.

The Government of Canada has aligned its GHG reduction targets with those of the U.S. and is also pursuing a regulatory approach. For the electricity sector, Environment Canada has published its "Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations". These regulations would effectively phase-out conventional coal-fired electricity generation over the long-term. Scheduled to begin in 2015, the proposed regulations would require a GHG emissions performance standard of a natural gas combined cycle generator for new coal-fired electricity generation, and for units that have reached the end of their economic life. The government has indicated that it will move to regulate the oil and gas sector in the near future.

In addition to federal legislation and regulation, state and provincially led GHG cap-and-trade initiatives have also been pursued. The Western Climate Initiative (WCI) continues to move with California and Quebec working towards implementation of a cap-and-trade agreement in 2013. The Regional Greenhouse Gas Initiative (RGGI), which took effect in January 2009, calls for a 10% reduction in greenhouse gas emissions from 2005 levels by 2018 for nine participating Northeastern states. The program launched a strategic review in September 2011 to examine RGGI experiences and to review the program's emission cap during its second control period, which will run from 2012 to 2014. There are some discussions about linking RGGI and WCI. The governors representing the partner jurisdictions in the Midwestern Greenhouse Gas Reduction Accord (MGGRA) confirmed that the MGRRA program is no longer moving forward.

Manitoba Hydro has actively participated in and contributed to prominent policy fora that address climate change along with participating in activities to encourage and demonstrate the feasibility of carbon markets. The corporation continues to advocate for GHG price signals that capture the environmental externalities associated with climate change and create a financial incentive for renewable resources.

5.1 POLICY DEVELOPMENT

Opportunities to reduce emissions depend on the development of a coherent set of coordinated regional or national policy frameworks that will create an appropriate incentive to develop more low and non-GHG emitting energy resources. Manitoba Hydro actively collaborates with a number of stakeholders from both inside and outside of the electricity sector on various regional, national and international initiatives. This includes direct engagement with the Canadian and U.S. federal governments, provincial and state governments along with variety of

the impact of climate change on Manitoba Hydro's water resources. The scope includes impact studies on all of the basins which make up the Nelson-Churchill watershed. This area is vast at 1.4 million km2 covering a sizable portion of central North America and includes a range of different climate zones and geographic areas. Despite challenges, Manitoba Hydro has worked to create a robust strategy for conducting climate change impact studies.

2.3 CLIMATE CHANGE IMPACT STUDIES

A series of comprehensive studies have been initiated to increase the corporation's knowledge of the implications of historical and future climate change on the water cycle and water availability in the Nelson-Churchill watershed. The main objective of these studies is to incorporate outcomes into long-term planning and operations and consequently adapt infrastructure and business practices as required. These studies are divided into:

- Past and Present Historical Climate/Hydrology Analysis
- Climate Change Scenarios
- Hydrologic Modeling
- Runoff Scenarios and Uncertainty Analysis

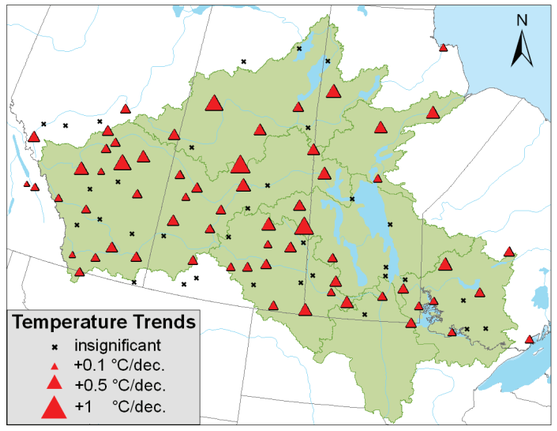
The approach is to adapt existing models and to use the outputs from climate change modeling centers. Manitoba Hydro has been working with some of the world's leading scientists (such as those involved in the Ouranos Consortium) in climatology and hydrology. As new models and tools become available, the ability to project changes in climatic variables at the regional level will evolve.

2.3.1 PAST AND PRESENT HISTORIC CLIMATE / HYDROLOGY ANALYSIS

The objective of these studies is to collect all relevant historical hydrology and climate data to characterize the hydrological and climatic (hydroclimatic) conditions in the Nelson-Churchill watershed. This information will provide the foundation for understanding future hydroclimatic variability and change. Temperature and precipitation play an important role in the hydrologic cycle and these two variables are of particular interest in historic trend analysis studies.

Figure 5 shows results from a historic trend analysis of mean annual temperature and average total annual precipitation over time periods, greater than 30 years in duration. In general, the historic temperature series at most locations show statistically significant trends ranging from +0.1°C/decade to +1°C/decade. Statistically significant changes to precipitation were also found in the historic record, however, the results are less conclusive. Many stations indicated no significant trend (black crosses), several stations indicated positive significant trends (upward pointing red triangles) and two stations indicated decreasing significant trends (downward pointing blue triangles). Despite the variability in precipitation trend direction and magnitude, there seems to be evidence that precipitation has been increasing across the south-eastern portion of the Nelson-Churchill watershed. It is important to note that trend analyses results can be sensitive to the record length and the use of different record periods can contribute to some of the variability. Trend analysis results, such as those presented in Figure 5, are intended to develop an understanding on the direction and significance of historic climate change and not to project the change into the future.

FIGURE 5: HISTORIC TRENDS FOR ANNUAL TEMPERATURE (TOP) AND ANNUAL PRECIPITATION (BOTTOM) FOR ENTIRE PERIOD OF RECORD.

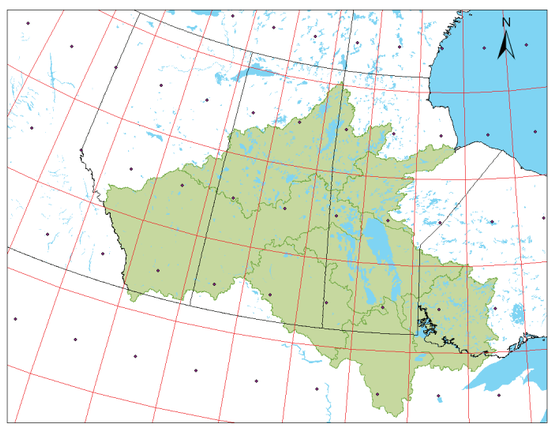


Manitoba Hydro will continue to monitor changes in the regional climate using climate information, which includes measurements of temperature, precipitation and wind speed provided byMeteorological Services of Canada.

2.3.2 CLIMATE CHANGE SCENARIOS

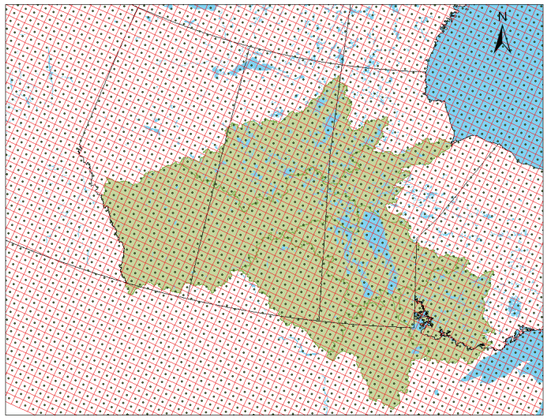
The IPCC leads research, compiles information and provides guidance for use in climate change studies.
The IPCC also brings together international modeling agencies that have developed Global Climate Models (GCMs). GCMs are numerical models through which GHG emissions can be translated into physically consistent effects on climate and are currently the most advanced tools available for projecting future climate. They are based on the equations of motion and physics of transport and exchange of heat, momentum and water. GCMs depict the climate using a three dimensional grid over the Earth. They typically have a horizontal resolution between 250 and 600 km, 10 to 20 vertical layers in the atmosphere and sometimes as many as 30 layers into the oceans. Output from an ensemble of international GCMs and three GHG emission scenarios are currently being used to develop future climate change scenarios of temperature and precipitation throughout the Nelson-Churchill watershed for the future time periods; 2020, 2050 and 2080. While GCMs tend to agree on the future warming of the planet, the projection of precipitation and other climatic parameters at the regional or local scale is less consistent and has a greater degree of uncertainty.

FIGURE 6: CANADIAN GLOBAL CLIMATE MODEL GRID EXAMPLE



GCMs typically have resolutions on the order of hundreds of kilometers which make it difficult to interpret projected changes in precipitation and temperature at the watershed scale. Figure 6 illustrates the coarse grid spacing of the Canadian Center for Climate Modeling Analysis Canadian Global Climate Model at approximately 400km resolution. Therefore, agencies have developed Regional Climate Models (RCMs) which are numerical models at a finer resolution than the GCMs and simulate the climate for a limited area such as North America. Just like the GCMs, these models are physically based but their resolution is typically 50km or less allowing them to be able to account for important local forcing factors such as water bodies and other geographic features which GCMs are unable to resolve (Figure 7).

FIGURE 7: CANADIAN REGIONAL CLIMATE MODEL GRID EXAMPLE



Most climate models (GCMs and RCMs) have a tendency to under or over estimate climate variables such as temperature and precipitation. When these differences in climate models occur consistently they are often called biases. In general, this means the raw climate simulations need to be adjusted before their input to the hydrological models. A statistical method must be used to handle the inconsistencies between the observations and simulations and once adjusted are used in a hydrological model.

To assist with the development of quality, regional climate change projections, Manitoba Hydro has become an affiliated member of the Ouranos Consortium. This consortium is composed of scientists from around the world that are studying climate change, with a focus on Canada. Through its affiliation Manitoba Hydro gains access to the Canadian climate change community including their Canadian Regional Climate Model data, expertise and training. The Ouranos Consortium has provided guidance for analytical processes used to resolve key features of regional climate.

The corporation's world class and state-of-the-art energy efficient Head Office building project in downtown Winnipeg illustrates Manitoba Hydro's desire to develop a workplace that provides an excellent work environment with low energy consumption. The natural synergies of bringing people together from several locations into one reduces travel time for meetings and helps to lower greenhouse gas emissions. A number of green transportation options for employees working in the new head office were also implemented.

The building is the most energy efficient office tower in North America and was designed to achieve a 65% reduction over the Model National Energy Code for Buildings (MNECB). With a host of other sustainable features Manitoba Hydro's head office has received many awards including:

- The annual Council on Tall Buildings and Urban Habitat (CTBUH) Best Tall Building award. Manitoba Hydro was the winner of the America's for 2009. This award recognized Manitoba Hydro Place as the number one office tower in North America with regard to design, quality of space, urbanism, sustainability and energy efficiency.
- Received the LEED Platinum award in 2012 (becoming the first office tower in Canada to receive a platinum level)
- Canadian Architect Award of Excellence (2006)

Vehicle Electrification

Manitoba Hydro also has a keen focus on new electric transportation technologies that could result in a major market fuel shifts. Plug-In Hybrid Electric Vehicles (PHEV) are a plug-in battery electric vehicles that also have an internal combustion engine capable of improving range, performance, or both. A PHEV offers most of the environmental benefits of clean battery electric vehicle operation without giving up the advantages of a fossil fueled vehicle, such as the ability to utilize the existing fossil fuel refueling infrastructure. PHEVs have the potential to change the way Manitobans travel and commute by dramatically lowering gasoline consumption and substituting it with renewable electricity.

Manitoba Hydro has purchased several regular hybrid vehicles for as part of its fleet. Manitoba Hydro has also converted several regular hybrid vehicles to plug-in hybrids. Manitoba Hydro has also been evaluating alternative transportation fuels, such as biodiesel, for fleet vehicle use.

Engaging Employees

There are a number of internal initiatives at Manitoba Hydro to inform staff of corporate activities and to assist employees in reducing their own GHG emissions. Although most of the benefits to the company are indirect, potentially including higher productivity/efficiency through improved staff morale, these initiatives are consistent with the corporation's commitment to sustainable business practices.

Manitoba Hydro actively participates in Winnipeg Transit's Ecopass program. Under this program, the cost of monthly transit pass is reduced by over 50% to promote transit ridership thereby reducing carbon emissions related to employee commuting. Approximately 65% of the 2,000 employees working downtown at Manitoba Hydro Place commute via Transit.

Manitoba Hydro also provides support for active transport options such walking and bicycle commuting. For example, the Commuter Challenge is an annual national, sustainable transportation event held to raise awareness of the environmental impact each person can make in their daily routine. In 2010 and 2011, Manitoba Hydro was awarded the gold medal in the Commuter Challenge as a result of high employee participation.

- Geothermal heat pump systems, with 1,198 Residential Earth Power Loan participants up to June 2012. Manitoba Hydro provides these loans to assist customers in financing geothermal systems
- Manitoba Hydro is showcasing five biomass-to-energy pathways (Pyrolysis Oil, Synthesis Gas, Waste Heat, Biogas, and Biocarbon) for converting raw sources of biomass inputs to useful energy outputs. These five demonstration projects, installed at customer sites across Manitoba, are part of the Corporation's comprehensive Power Smart Bioenergy Optimization Program, intended to encourage and facilitate the installation, operation, and maintenance of customer-sited load displacement generation systems using combined heat and power (CHP) systems and renewable fuels, specifically biomass. The demonstration projects are being co-funded through the Government of Canada's Clean Energy Fund.
- Manitoba Hydro is actively engaged in the development of improved energy efficient codes and standards. It is estimated that 481 GW.h and 113 MW in electric savings and 4.4 million cubic meters in natural gas savings were achieved up to 2010/11 due to energy efficient codes and standards.

Manitoba Hydro's Power Smart program has become a continental leader in energy efficiency programming and as documented in the 2010/11 Power Smart Annual Review has resulted in a total annual energy savings of 1,832 GW.h of electricity and 57 million cubic meters of natural gas. These energy savings reduce greenhouse gas emissions globally by approximately 1,345 kilotonnes of CO_2e per year. This is comparable to removing approximately 269,000 vehicles from the road for one full year based on typical passenger vehicle GHG emission estimates from the U.S. Environmental Protection Agency. The majority (92%) of these greenhouse gas emission reductions results from electric Power Smart program activity through indirect emission reductions from Manitoba Hydro export sales displacing coal and natural gas fuelled generation outside of Manitoba. The remaining 8% emission reductions are direct reductions that occur as a result of lower natural gas consumption in Manitoba.

4.4 SUPPLY SIDE ENHANCEMENTS

Manitoba Hydro also considers efficiency opportunities within internal electric generation operations. The system is reviewed for opportunities to upgrade infrastructure to enhance the supply of power. Supply Side Enhancement (SSE) projects go beyond routine maintenance required to maintain supply and often result in major maintenance upgrades. SSE projects are subject to economic and financial evaluations, similar to other major resource projects.

By enhancing the generation output of existing generating facilities and transmission systems, Manitoba Hydro is able to maximize the production and availability of renewable electricity to displace fossil-fuel fired electric generation both within the province and in our export region. In addition to activities done to date such as the refurbishment of a number of turbines and the rewinding of generators at Great Falls, Pine Falls, Seven Sisters and Grand Rapids generating stations, a number of SSE initiatives are currently underway including the Kelsey Rerunnering Project as well as several potential projects on the Winnipeg River system described below.

Kelsey rerunnering is a major upgrade of Kelsey Generating Station that consists of the replacement of all seven turbine runners and generator windings which will result in increased plant capacity and greater utilization of
Nelson River inflows. This upgrade is expected to be fully completed in the 2012/13 fiscal year and has the potential to increase the plant rating by 77 MW.

There are also several rerunnering opportunities on the Winnipeg River, as these plants are over 50 years old and are undergoing major equipment maintenance and repairs. Winnipeg River plants were originally estimated to provide 560 MW of capacity, which has degraded somewhat over the years. The recent upgrades mentioned above have, in part, restored the Winnipeg River to original ratings as opposed to increasing the nominal plant rating.
Currently there are ongoing evaluations of supply side enhancement opportunities for Pine Falls, Great Falls and Slave Falls at various stages. It is anticipated that these upgrades will result in a combination of restored and increased plant capability providing improved efficiency, as well as a gain of up to 30 GW.h/year of dependable energy.

4.5 OTHER CORPORATE ACTIONS

There are a number of additional actions that Manitoba Hydro has taken to lower our corporate greenhouse gas emissions and promote reduced emissions from our employees.

FIGURE 8: GCM ANNUAL TEMPERATURE AND PRECIPITATION PROJECTIONS – 2050s

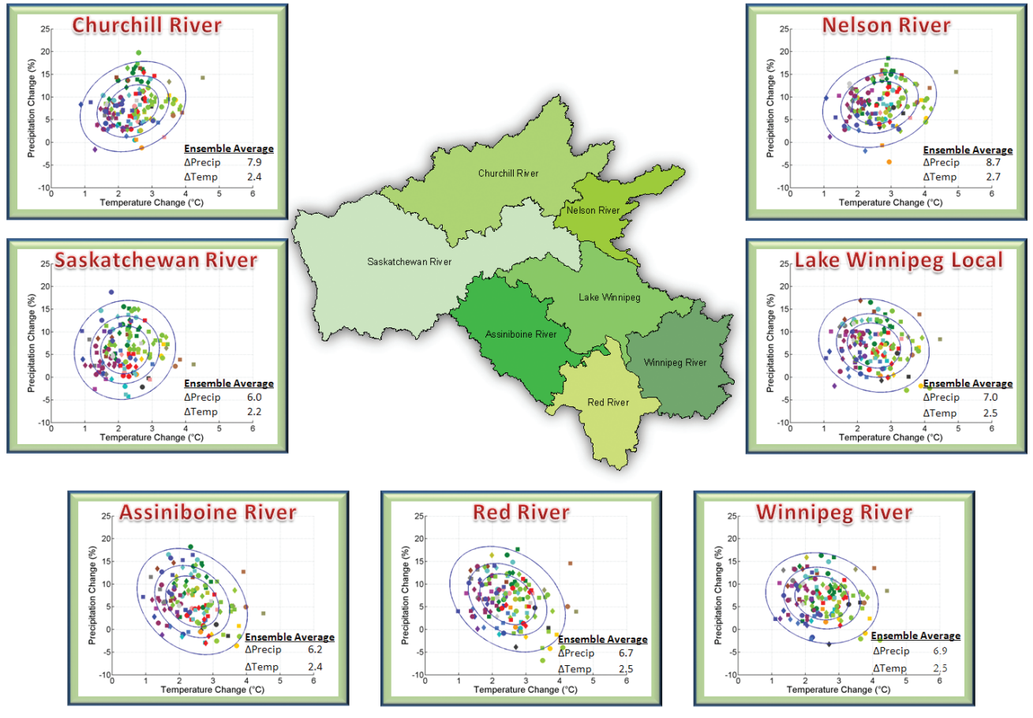


FIGURE 9: RCM ANNUAL TEMPERATURE AND PRECIPITATION PROJECTIONS – 2050s

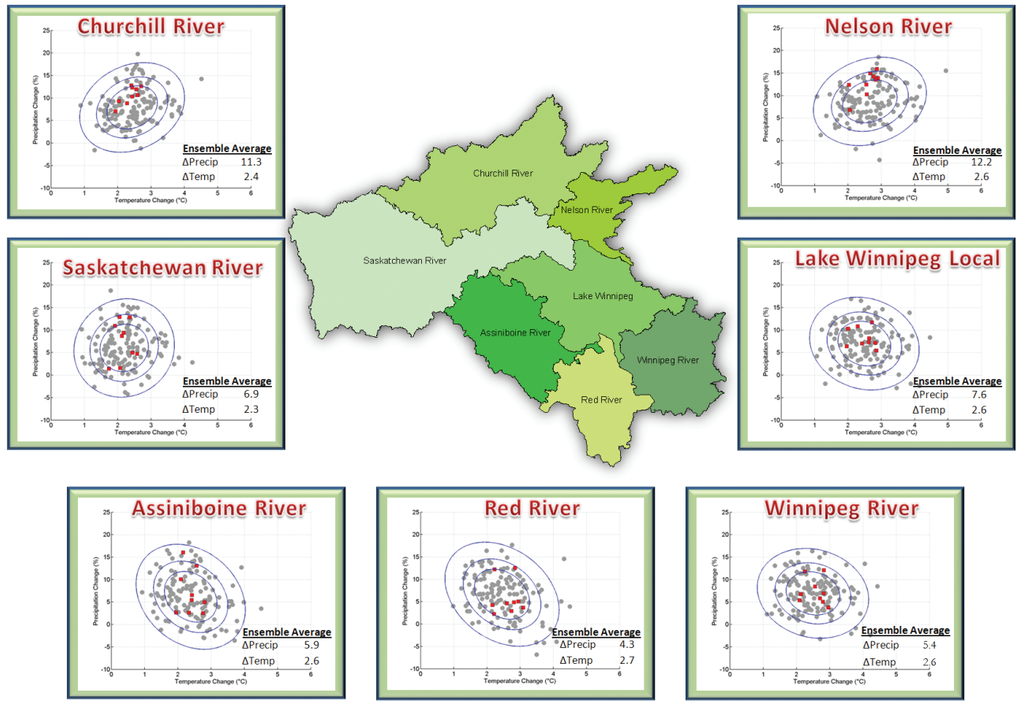


FIGURE 10: ANNUAL 2050S TEMPERATURE PROJECTION – EXAMPLES OF GCM (LEFT) AND RCM (RIGHT) FOR THE A2 EMISSION SCENARIO

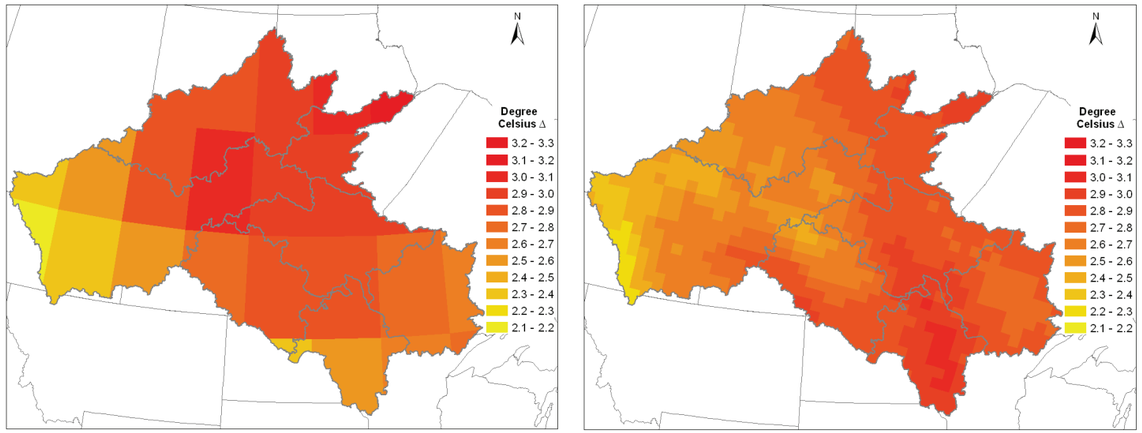
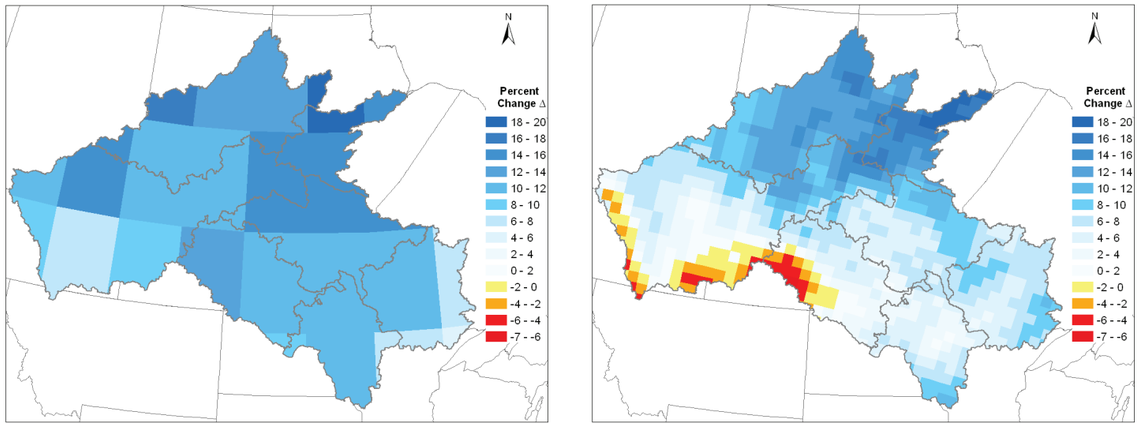


FIGURE 11: ANNUAL 2050S PRECIPITATION PROJECTION – EXAMPLES OF GCM (LEFT) AND RCM (RIGHT) FOR THE A2 EMISSION SCENARIO



Climate change projections for the 2050s time horizon are shown in Figure 8 through Figure 11. The scatter plots in Figure 8 and Figure 9 illustrate changes in annual mean temperature (x axis) and average annual total precipitation (y axis), as projected by the ensemble of climate models for individual basins. Each point on the scatter plots is derived from one climate simulation and a total of 139 simulations were used in GCM study (Figure 8) and 6 simulations in the RCM study (Figure 9). Blue distribution ellipses are imposed on the scatter plots and represent confidence bands, encompassing 50% (inner ellipse), 75% (middle ellipse) and 95% (outer ellipse) of the climate model projections. This indicates the percentage of models which fall within each ellipse area. These figures help to demonstrate the spread in annual projections and how temperature and precipitation changes can be correlated in different regions. For example, annual scatter plots for Northern basins show a relationship suggesting that increasing temperatures may result in increasing precipitation while Southern basins show a relationship suggesting that increasing temperatures may result in decreasing precipitation.

For individual basins of the Nelson-Churchill watershed, the GCM ensemble average projects annual average temperatures to increase by +2.2°C to +2.7°C and average total annual precipitation to increase by +6.0% to +8.7%, in the 2050s. CRCM projections shown fall within the range of GCM projections and tend towards the GCM ensemble average.

Figure 10 and Figure 11 show an annual GCM simulation and a RCM simulation for temperature and precipitation for the 2050s. These figures show added value of using a RCM with finer resolution, and therefore, greater spatial detail.

These generating stations are estimated to contribute to the following annual global emission reductions and passenger vehicle GHG emission reductions estimates (based on typical values from the US Environmental Protection Agency):

- Wuskwatim Generating Station: GHG emission displacement equivalent to approximately 1,000 kilotonnes CO2e annually, the equivalent of 200,000 cars,
- Keeyask Generating Station: GHG emission displacement equivalent to 3,000 kilotonnes CO2e annually, the equivalent to 600,000 cars.
- Conawapa Generating Station: GHG emissions displacement equivalent to 4,700 kilotonnes CO2e annually, the equivalent to 900,000 cars.

Hydro opportunities typically come in large increments, often exceeding several hundred megawatts. These increments are much larger than current domestic load requirements and as such it is critical to find export markets for the surplus energy until Manitoba can grow into their full utilization. Manitoba Hydro may also advance the development of plants to take advantage of export market opportunities in advance of domestic needs.

Electricity exports to neighbouring states and provinces has kept Manitoba electricity rates amongst the lowest in the world and contributed to significant GHG reductions outside of the province. Since 2005, annual electricity exports by Manitoba Hydro have averaged over 10,000 GW.h per year.

In addition to hydropower, Manitoba Hydro also has pursued wind resources in the province. Currently Manitoba Hydro has over 250 MW of contracted capacity in service at the St. Leon and St. Joseph wind farms under the terms of long-term Power Purchase Agreements. A total of 63 wind turbines, capable of deliver 99 MW, were erected over a 93km^2 area in St Leon. Constructed in 2010, with 60 wind turbines with a rated capacity of 138 MW, covering 125 km^2, St. Joseph is the largest wind farm in the province, generating enough power to meet the needs of 50,000 homes. The second phase of St. Leon with an additional 16.5 MW of wind capacity began generating electricity in 2012. The emissions reductions associated with wind are included in Manitoba Hydro's accounting of net emissions displaced from exports.

Manitoba Hydro also considers a wide array of additional emerging electricity technologies in its generation planning and actively researches and supports their concept development. This work helps to ensure that Manitoba Hydro's development plans continue to make the most sense from economic, environmental, technical, and social perspectives. Emerging energy technologies being studied and evaluated by Manitoba Hydro include but are not limited to:

- Bio-energy: including direct combustion, gasification, pyrolysis, landfill gas to energy, anaerobic digestion, and biofuels
- Microturbines
- Energy storage including: batteries, capacitors, pumped hydro, compressed air, fly wheels, solar thermal, and superconducting magnetic energy storage
- Solar Energy: both photo-voltaic (PV) and thermal
- Thermal to electric conversion technologies such as enhanced geothermal and small steam
- Fuel cells including: hydrogen, metal, direct carbon, phosphoric acid, and redox flow

Manitoba Hydro stays informed on emerging technologies through detailed evaluations of their potential implications. These evaluations take many forms and may include in-house research, consultants' reports, literature searches as well as collaborations with academia and industry associations.

4.3 THE POWER SMART PROGRAM

In 1991, Manitoba Hydro established POWER SMART, the customer oriented brand for all of Manitoba Hydro's Demand Side Management (DSM) programs, initiatives, and activities. DSM resource options are assessed and are included in Manitoba Hydro's Integrated Resource Planning process. Energy conservation initiatives are designed to reduce domestic customer energy requirements through energy-efficient measures that use less energy to obtain comparable or superior services. These programs demonstrate the economic benefits of efficiency and proactively addressing climate change for our customers, Manitoba Hydro and the province.

Manitoba Hydro's POWER SMART strategy typically focuses on creating a sustainable market change where energy efficient technologies and practices become the standard. The Power Smart DSM initiative is designed to encourage the efficient use of energy in the commercial, agricultural, residential, institutional, and industrial customer sectors. More than fifty-five incentive-based, customer service, cost-recovery and rate-based initiatives and programs have been offered over the last twenty-three years with impact evaluations of all incentive-based programs prepared regularly. A number of examples follow that demonstrate the breadth of the program offerings.

4 CONTRIBUTE TO GHG EMISSION REDUCTIONS

Responding to climate change requires a diversity of sustained actions throughout the local to global continuum. As shown previously in Figure 21, Manitoba Hydro has a very low electric generation GHG intensity relative to other electrical utilities. Despite this advantageous starting position, the corporation has set aggressive voluntary emission reduction objectives over the past fifteen years. Manitoba Hydro has continued to pursue hydro and wind developments along with Power Smart energy efficiency programs while also reducing emissions from our own facilities within the province. Outside of Manitoba, our electricity exports have contributed to significant GHG reductions.

4.1 REDUCTIONS IN FOSSIL FUELED GENERATION

Manitoba Hydro has been able to reduce its reliance on fossil fueled electrical generation as a result of our increasing reliance on renewable generation and energy conservation. Prior to the mid-1990s, Manitoba Hydro operated coal-generating units located at Brandon and Selkirk. Subsequent decisions, that included multiple corporate objectives including GHG emission reductions, led to the decommissioning of Brandon Units 1-4 and conversion of Selkirk Generating Station from coal to natural gas. The latter action received an Honorable Mention in the 2002 Canadian Council of Ministers of the Environment Pollution Prevention Awards – Greenhouse Gas Reduction Category.

Since December 31, 2009, the Province of Manitoba's Climate Change and Emissions Reductions Act C.C.S.M. c. C135, has restricted the use coal to generate power, except to support emergency operations. In the case of Manitoba Hydro's one remaining coal unit, Brandon Unit 5, this means that power generation is minimally used to maintain the facility in a state of readiness to support emergency operations. From 2005 through 2010 the average annual emissions for Brandon Unit 5 were approximately 400,000 tonnes CO2e per year (with fluctuating periods of high/low operation intensity). Under the new Act, the annual GHG emissions will typically be less than 130,000 tonnes in the absence of protracted emergency circumstances such as drought or major equipment outages. While Manitoba Hydro has significantly reduced its typical and average GHG emissions, under circumstances such as severe drought or major equipment outages, Manitoba Hydro's annual GHG emissions from Brandon Unit 5 could as approach 1 million tonnes CO2e.

In addition to our actions on coal, Manitoba Hydro has extended the power grid to nine remote northern communities, reducing the number of communities that are served by diesel generation to four.

Manitoba Hydro will continue to operate a small fleet of thermal generating units and also rely on the potential to import electricity to ensure customer needs are met under all circumstances including the lowest possible water flows. Manitoba Hydro's thermal electric generators also provide the following system functions: system stability, voltage regulation and responding to generation and transmission outages. The availability of natural gas generating units also allows Manitoba Hydro to firm up additional export sales of electricity, essentially guaranteeing the electricity will be available to fulfill contracts regardless of water conditions. This guarantee means Manitoba Hydro can sell additional electricity within the long-term firm export market assuring revenue that will help keep domestic rates low while reducing emissions outside of the province.

4.2 RENEWABLE GENERATION DEVELOPMENT

Renewable electrical generation facilities have allowed Manitoba Hydro to operate one of the cleanest generation systems in the world. Manitoba Hydro currently manages approximately 5,000 MW of hydroelectric generation with the majority of this capacity being located in northern Manitoba. In the near-term, there is an opportunity to add approximately 2,500 MW of capacity in Manitoba through the development of three new hydropower facilities: Wuskwatim, Keeyask and Conawapa generating stations.

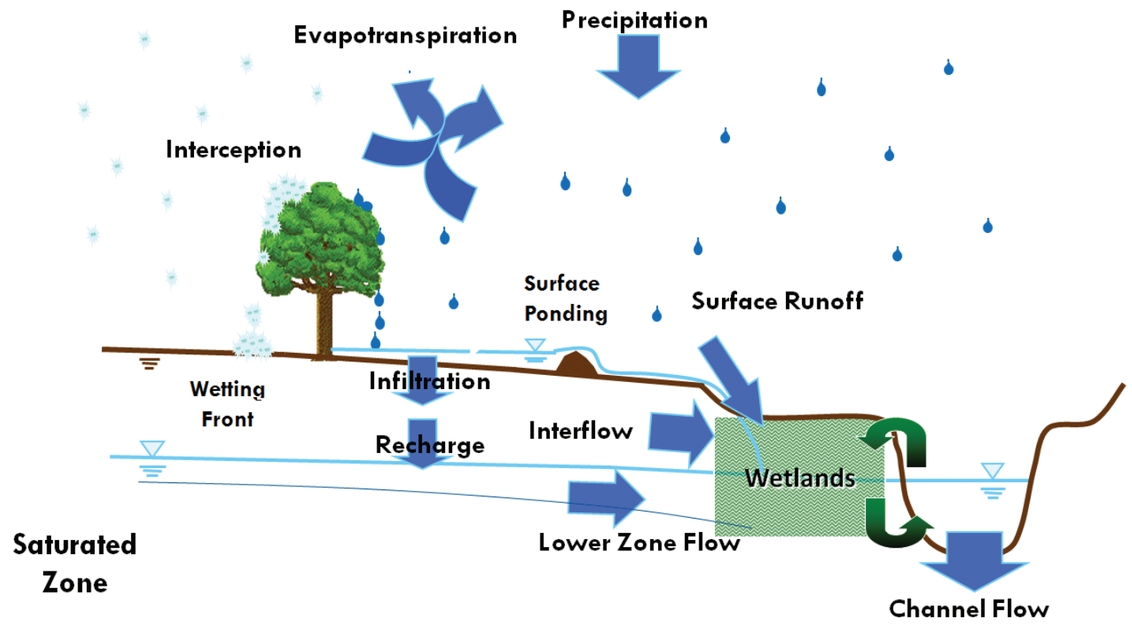
Construction of the 200 MW Wuskwatim Generating Station, located on the Burntwood River, is nearing completion and the first of three units is generating electricity. In the planning stages, the 695 MW Keeyask and 1,485 MW Conawapa facilities are targeted for operation by 2019/20 and 2025/26 respectively. All three plants are models of sustainable hydropower development, including minimal flooding (approximately 50km^2 cumulatively), incorporation of low environmental impact design features and joint equity partnerships with local First Nation communities.

2.3.3 HYDROLOGICAL MODELING

Hydrologic models are simplified, conceptual representations of a part of the hydrologic cycle. They are primarily used for hydrologic prediction and for understanding hydrologic processes. These models numerically represent the physical processes observed in the real world. Typically, such models contain representations of surface runoff, subsurface flow, evapotranspiration, and channel flow, but they can be far more complicated (Figure 12).

The WATFLOOD model is a partially physically-based, distributed model that maintains a high computational efficiency and incorporates specialized processes that are able to handle the complex and highly variable hydrologic influences throughout Manitoba Hydro's main watersheds. WATFLOOD allows for the incorporation of remotely sensed topographical, land cover, and meteorological forcing data to derive more physically representative and distributed watershed responses.

FIGURE 12: SCHEMATIC OF THE PROCESSES SIMULATED BY WATFLOOD



WATFLOOD models are currently being setup for all the basins within the Nelson-Churchill watershed. Figure 13 shows the massive scale of the basin and the key water bodies being studied. Preliminary calibration results at basin outlets are presented in Figure 14.

FIGURE 13: NELSON-CHURCHILL WATERSHED

2.3.4 RUNOFF SCENARIOS

The ensemble of future climate change scenarios and the hydrological model produced can be used to project scenarios of runoff changes in the Nelson-Churchill watershed. Thirty year averages of future and baseline conditions are compared in order to reduce year to year variability. Parameters of interest include changes to the average and annual available streamflow, changes to the timing and rate of spring freshet, and the change to the frequency and magnitude of extreme events. These runoff scenarios are developed to understand the uncertainties in order to make decisions that are robust under a wide range of possible futures. Figure 15 illustrates streamflow projections for the 2020, 2050 and 2080 time periods at the outlet of the Winnipeg River basin as simulated by WATFLOOD. The following describes the general findings:

- Increasing future runoff in the Winnipeg River Basin throughout the 2020s through 2080s.
- Increasing and earlier spring water availability.
- Slightly decreased autumn water availability.

FIGURE 14: MODELED VERSUS OBSERVED STREAMFLOWS

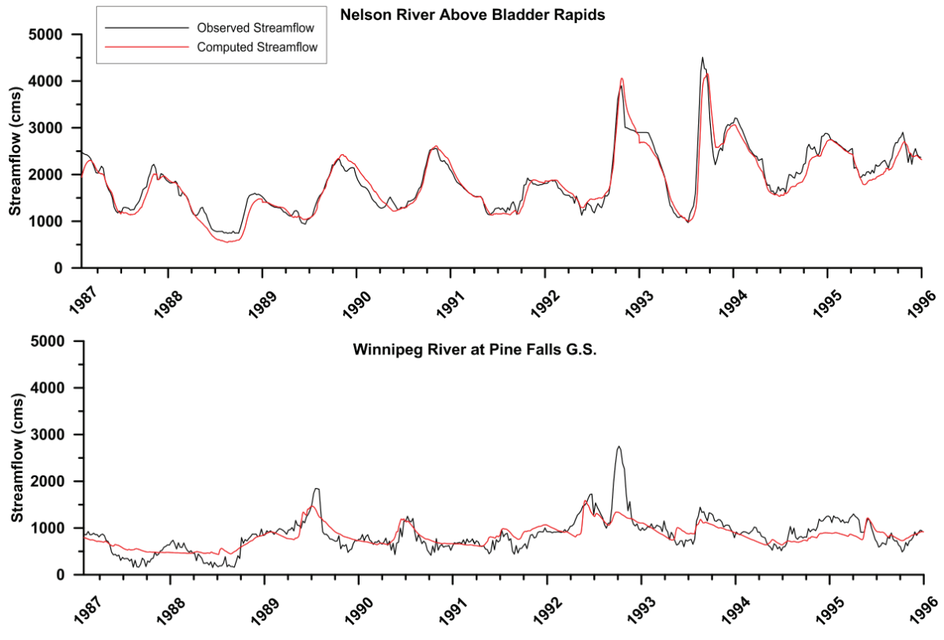
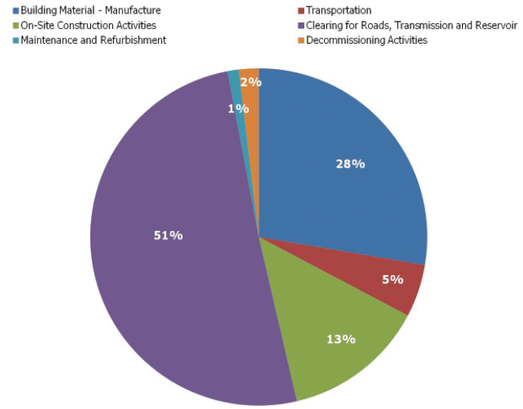


FIGURE 22: KEEYASK LIFE CYCLE ASSESSMENT RESULTS – GHG EMISSIONS PER PRIMARY ACTIVITY

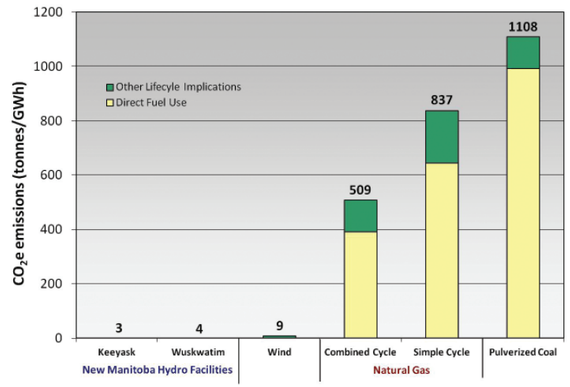


Use of a lifecycle analysis ensures all the significant GHG impacts of a project are considered and allows for an equitable comparison between various electricity generating technologies. The levelized life cycle GHG comparison is produced to compare various conventional and renewable power generation options. For fossil fuel generators such as coal and natural gas, the analysis highlights that lifecycle GHGs are dominated by the fuel combustion needed to generate power. In comparison, for renewable sources such as wind and hydro, the bulk of lifecycle GHGs are associated with the construction stage.

Accounting for all stages of the project life cycle, Figure 23 compares the levelized lifecycle GHG implications for the Wuskwatim and Keeyask generating stations to various other electricity resources. When taking into consideration lifecycle GHG emissions, these new generating stations result in very low emissions per unit of energy, comparable to a wind farm and 99% less than the most efficient natural gas generation.

One component of these analyses is the land-use change including the reservoir formation associated with new hydroelectric facilities. The emission implications associated with flooding in northern ecosystems are often misrepresented. All bodies of water naturally produce and emit varying levels of GHG's. An area of flooded biomass will temporarily increase GHG production. However scientific research has shown boreal reservoir GHG emissions typically return to natural levels after about 10 years. Based on the vintage of a majority Manitoba's hydropower generation, the reservoir implications associated with existing Manitoba facilities are long over.

FIGURE 23: COMPARISON OF LIFE CYCLE GHG EMISSIONS FROM ELECTRICITY GENERATION



Building upon the pioneering work of Canada's Department of Fisheries and Oceans, Manitoba Hydro has studied GHG dynamics in Manitoba hydroelectric reservoirs as well as other Manitoba water bodies and terrestrial environments. This work began in 2003 and continues to the present. The work includes continuous monitoring greenhouse gas concentrations at five existing generating stations representing the three river systems - The Winnipeg, Saskatchewan and Nelson Rivers. Manitoba Hydro is also monitoring pre-construction greenhouse gas concentrations in the Wuskwatim, Keeyask, and Conawapa regions with post-construction monitoring planned for all three locations.

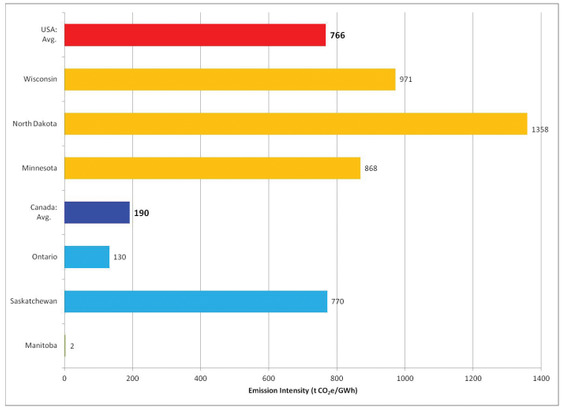
These life cycle assessments, supported by our reservoir monitoring efforts, continue to demonstrate that GHG emissions are not a significant issue for the planned hydroelectric facilities in Manitoba in part due to the minimal amount of flooding and limited impacted forested areas. In order for North America to achieve reductions in GHG emissions it is necessary to reduce fossil fuel dependence and develop renewable sources of electricity such as hydropower.

3.3 GLOBAL EMISSION REDUCTIONS

Manitoba Hydro operates an electrical system that facilitates the production and sale of surplus electricity to interconnected neighbouring jurisdictions. As a result, electricity production and use in Manitoba can impact GHG emissions both within Manitoba (the provincial perspective) and outside of the province (global perspective) as export sales displace electric generation and associated emissions in these other regions. The combined implication of the GHG emissions within and outside of the province is referred to as the Manitoba Hydro's global perspective. The most significant contribution that Manitoba Hydro makes toward GHG reductions is due to the displacement of fossil fuelled generation in neighbouring states and provinces.

Figure 21 below compares the generation emission intensity of Manitoba Hydro with these other jurisdictions. As is shown in this figure, Manitoba Hydro's low emission intensity makes our exports a valuable resource to help reduce global GHG emissions. When considering incremental changes to electricity consumption through energy efficiency or fuel switching applications, Manitoba Hydro evaluates these decisions based on the global GHG consequences. Manitoba Hydro currently uses a factor of 750 tonnes CO2e/GW.h which reflects an estimate of the incremental effects of consumption changes within the broader regional electricity market that we are interconnected with.

FIGURE 21: GHG EMISSION INTENSITY COMPARISON OF ELECTRICITY GENERATION: 2010



SOURCES: CANADIAN EMISSION INTENSITY DATA FROM: ENVIRONMENT CANADA. NATIONAL INVENTORY REPORT: 1990-2010. (2012). ANNEX 13 US EMISSION INTENSITY DATA FROM: US ENERGY INFORMATION ADMINISTRATION (EIA). STATE ELECTRICITY PROFILES 2010. REPORT DOE/EIA-0348(01)/2. (JAN. 2012)

In 2011 alone, electricity exports from Manitoba reduced global GHG emissions by an estimated 7,400 kilotonnes of CO2e. According to typical passenger vehicle GHG emission estimates from the US Environmental Protection Agency, this is equivalent to removing nearly 1.5 million vehicles from the road.

3.4 LIFE CYCLE ASSESSMENTS

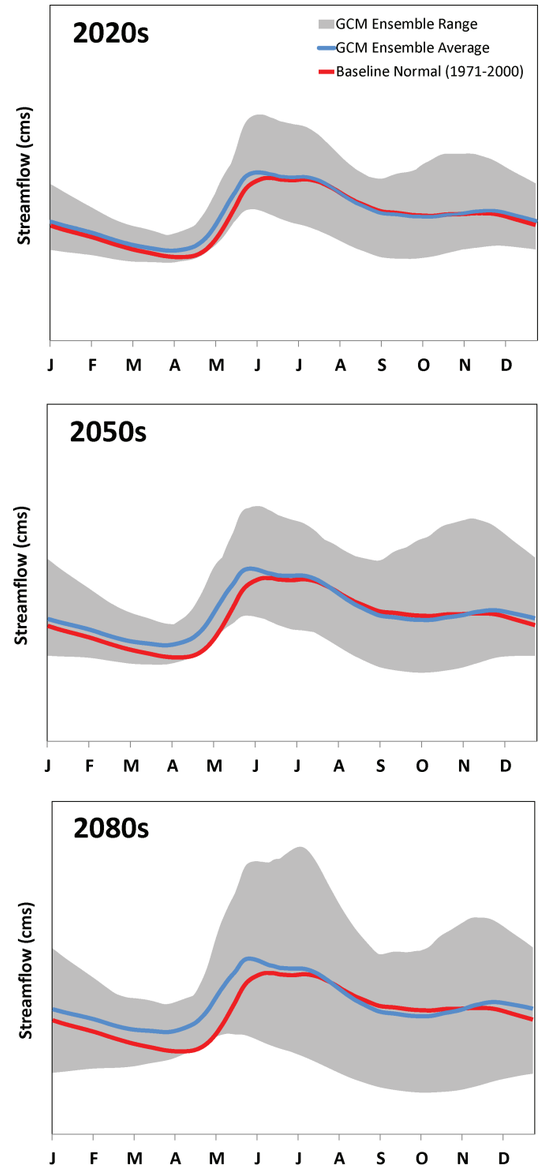
For new major facilities being constructed, a life cycle assessment of the GHG implications is undertaken. These analyses help screen and evaluate different resource types as part of the power planning process as well as meeting regulatory requirements such as for the Environmental Impact Assessments. This tool assesses the GHG emission implications throughout a facility's life from construction and operation through to eventual decommissioning. Manitoba Hydro works with The Pembina Institute to assess the lifecycle greenhouse gas implications of major projects such as Wuskwatim, Keeyask, Conawapa, and Bipole III.

These scientific studies follow the International Organization for Standardization (ISO) 14040 principles and framework utilizing a complete "cradle to grave" analysis of the GHG emissions. A life cycle assessment fully considers GHG implications of all aspects of a project: design, construction, operation, and decommissioning activities. For our new generation projects, this includes those GHG emissions associated with:

- Construction components and materials used (including emissions from raw material extraction, production and transportation);
- Construction activities and equipment operation on site (primarily vehicle fuel);
- Land clearing and other land-use change impacts (including reservoir formation);
- Operation throughout the life of the project including emissions associated with maintenance activities;
- Impacts associated with ultimately decommissioning the project

The GHG implications of each project are unique depending on the results of analysis of the above parameters. For example, Figure 22 illustrates the GHG emissions by primary activity for the proposed Keeyask generating station. In the case of Keeyask, the majority of GHG emissions are associated with land-use change implications and the production of raw building materials needed for construction of the facility.

FIGURE 15: FUTURE STREAMFLOW PROJECTIONS FOR WINNIPEG RIVER FROM WATFLOOD



WATFLOOD models are currently being set-up, calibrated, validated, and evaluated for all of the basins (Winnipeg River, Red River, Assiniboine River, Saskatchewan River, Nelson River and Churchill River) within the Nelson-Churchill watershed. During this process areas will be identified where specialized model developments could be made to enhance the model's ability to simulate the water balance. The WATFLOOD model will be customized to meet the unique aspects of each basin. This process is an iterative process but first generation runs for all the basins should be completed within a three to five year time horizon.

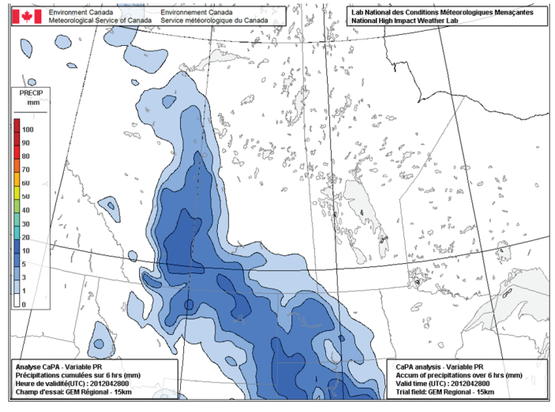
2.4 RESEARCH AND DEVELOPMENT

As part of Manitoba Hydro's climate change strategy, Manitoba Hydro has been working with some of the world's leading scientists in climatology and hydrology through Research and Development projects to determine how climate change has affected the water supply and what we can expect in the future. Three additional research and development projects currently underway are as follows.

Canadian Precipitation Analysis for Hydrological Modeling at Manitoba Hydro

The objective of this research proposal is to develop the Canadian Precipitation Analysis (CaPA) product for the entire Churchill-Nelson watershed. CaPA is a computer optimization model that produces gridded estimates of precipitation (Figure 16). Once developed CaPA will then be combined with existing WATFLOOD watershed model technology to improve streamflow forecasts for operations and future water availability under climate change. In addition to facilitating climate change induced changes to long-term streamflows, the development of the CaPA has the potential to improve Manitoba Hydro's short-term operating modeling to enhance efficiency and profitability.

FIGURE 16: EXAMPLE OF CAPA MAP PRODUCT



Incorporating of Non-Stationary Landcover into WATFLOOD Climate Change Scenarios

There has been a growing awareness of the uncertainty inherent in climate change projections that results through the assumption that landcover and other parameter remain constant while the climate changes. Parameters are defined based on calibration to historical or current (hydrologic) conditions and may not necessarily be representative of future conditions. For example, in WATFLOOD and other comparable hydrologic models, river and landcover-specific parameters are calibrated based on comparison of simulated to observed historical streamflow, with the model topography defined using present-day landSAT landcover imagery data. Such methodologies are now thought to be limited in long-term (i.e., 30+ year climate change) simulations because landcover cannot be assumed to be unchanged. This will effect overall hydrologic prediction due to resulting changes in soil moisture capacity, evaporation, infiltration, and runoff. This project will develop a pre-processing model utility for the WATFLOOD hydrological model that enables landcover to be modified over long-term simulations.

Isotope Monitoring Network

Water sampling for stable water isotopes can help to distinguish water sources and examine the progressive downstream evolution of (and contributions to) streamflow on a large scale. This data enables us to quantify evaporation losses and to quantify contributions from different water sources. This information is used to ensure components of the hydrological cycle including surface flow, sub-surface flow and groundwater are properly being simulated by the hydrological model. Accurate calibration is essential in order to have confidence in future streamflow projections.

3 GHG MEASUREMENT AND REPORTING

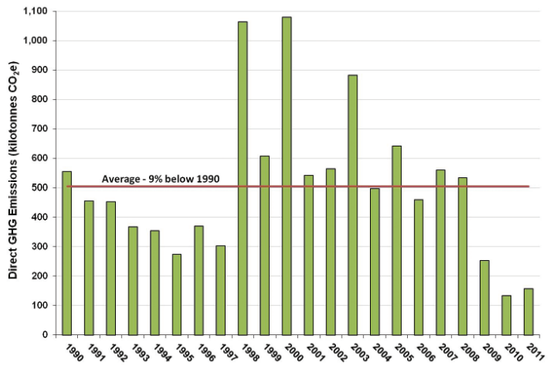
Accurate greenhouse gas measurement and reporting are vital towards ensuring that Manitoba Hydro understands its emission liabilities, opportunities for further reductions, and demonstrating the results of actions taken. The corporation began measuring and reporting its corporate emissions in 1995 and has set aggressive voluntary emission reduction objectives. Since Manitoba began its voluntary reporting efforts mandatory both the Provincial and Federal governments have introduced mandatory reporting requirements for some of Manitoba Hydro's facilities.

Manitoba Hydro also estimates the GHG implications of its major projects using life cycle analysis. All forms of electrical generation, including renewable sources, have GHG implications when a facility's design, construction, operation and decommission are all considered.
This chapter presents measurement and reporting of emissions, voluntary commitments, as well as the GHG life cycle assessments associated with major projects.

3.1 VOLUNTARY REPORTING

Manitoba Hydro's emissions are small. They represent only 1% of the provincial emissions within a province that represents only 3% of national emissions. Despite Manitoba Hydro's initial low emissions starting point, the corporation has achieved substantial further reductions.

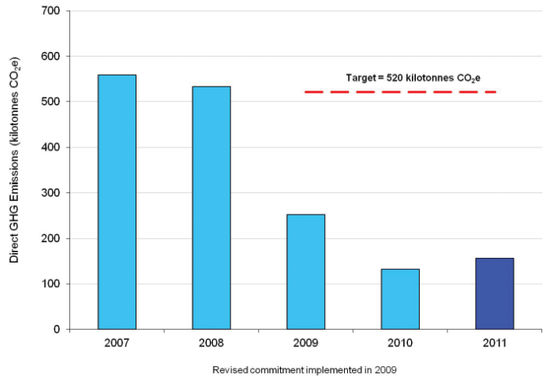
FIGURE 17: MANITOBA HYDRO DIRECT GHG EMISSIONS SINCE 1990



The scope of Manitoba Hydro's voluntary GHG reporting is broad and includes emissions from the following sources: fossil fuelled electric generation, natural gas transmission and distribution system, fleet vehicles, insulating gas for electrical equipment (SF6), and natural gas used in buildings owned by Manitoba Hydro.
While national electricity sector emissions grew by 10 percent since 1990, Manitoba Hydro has achieved an average long-term emissions reduction of 9 percent over the same time period as shown in Figure 17.

Manitoba Hydro's voluntary commitment maintains an annual GHG emission target threshold of 520 kilotonnes of carbon dioxide equivalent (CO2e), representing GHG emissions 6% below 1990 levels. In the 2011 calendar year, total direct GHG emissions were 157 kilotonnes CO2e, 70% below the target threshold. Figure 18 depicts Manitoba Hydro's recent performance relative to the voluntary commitment.

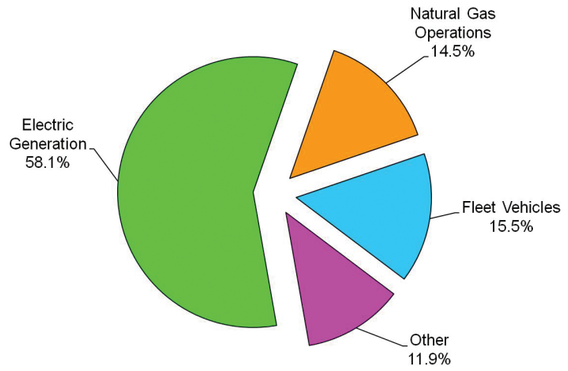
FIGURE 18: MANITOBA HYDRO DIRECT EMISSIONS RELATIVE TO TARGET.



GHG Measurement Results

Manitoba Hydro emits GHGs through its thermal power generation facilities, natural gas transmission and distribution system, fleet vehicles, and other miscellaneous sources. Miscellaneous sources include emissions from insulating gas for electrical equipment (SF6), diesel power generation for remote northern communities, and natural gas used in buildings owned by Manitoba Hydro. Electric generation accounted for 58% of the total corporate GHG emissions in 2011, with fleet vehicles and natural gas operations at 16% and 15% respectfully. The emissions of each of these sources are shown below in Figure 19.

FIGURE 19: MANITOBA HYDRO GREENHOUSE GAS EMISSIONS BY SOURCE: 2011 ACTUAL EMISSIONS



Greenhouse gas emissions expressed in CO2e are composed of the six identified Kyoto Accord greenhouse gasses: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs). Manitoba Hydro does not emit any HFC's or PFC's. Emissions of CH4, N2O, and SF6 are expressed in CO2e as calculated using their appropriate Global Warming Potential (GWP) factor as published by Environment Canada. CO2 is the primary GHG emission from Manitoba Hydro's operations, accounting for 83% of the total 2011 emissions. CH4 and N2O accounted for approximately 14% and 1% of the total 2011 emissions respectfully. The emissions of each of these greenhouse gasses are shown below in Figure 20.

FIGURE 20: MANITOBA HYDRO GREENHOUSE GAS EMISSIONS BY GREENHOUSE GAS: 2011 ACTUAL EMISSIONS

3.2 MANDATORY REPORTING REQUIREMENTS

Both the federal and provincial governments have requirements to report certain GHG emissions. In compliance with their respective Environmental Act Licenses, the provincial government requires that Manitoba Hydro report the total direct GHG emissions associated with electric generation from each of the fossil fueled units at the Selkirk and Brandon generating stations. Federally, Environment Canada requires reporting on GHG emissions from Canadian facilities through its GHG Emissions Reporting Program under the authority of Section 46 of the Canadian Environmental Protection Act, 1999. This program has collected GHG information on an annual basis since 2004. Canadian entities that produce over 50,000 tonnes of GHG emissions (CO2e) are required to formally report the source, type and quantity of those emissions as per provided reporting protocols. To date, only the GHG emissions associated with Brandon Generating Station have met this minimum reporting threshold.