YUKON GREEN: Reducing Greenhouse Gas Emissions from Energy Use in Yukon

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Abstract

In January of 2009 the Yukon Government released its Climate Change Action Plan, calling for a 20% reduction of 2006 greenhouse gas (GHG) emission levels in Yukon by 2020. The objective of this paper is to identify potential changes to Yukon Government legislation, regulations and policies that would help meet or exceed this target while promoting economic growth in the territory.

To do this, we first examine the Yukon's historical emission levels and underlying factors that led to a 28% reduction of emission levels from 1990 to 2006. Then we develop a series of emission forecasts for 2020 using several economic growth rates in a business-as-usual scenario. Factors that are currently inhibiting or aiding the Yukon in emissions reductions are identified. Best practices and the emission reduction of other Canadian jurisdictions' plans are examined, along with relevant theory from the field of environmental economics. This information is used to develop alternatives for the Yukon Government to consider.

Potential alternatives to fossil fuel use in Yukon are then developed and ranked by:

- Their capability to make a significant impact on emission reductions
- Their cost-effectiveness
- Their risk in terms of technology or price uncertainty

Finally we develop a focused list of government actions in the areas of pollution legislation, regulations and policy required to meet or exceed its emission reduction target.

The paper concludes that it will be challenging but possible for Yukon to meet its target emission reductions if major energy–intensive projects can be carbon neutral by 2020.

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1.0 Introduction

In February of 2009 the Yukon Government released its Climate Change Action Plan, calling for a 20% reduction of 2006 greenhouse gas (GHG) emission levels in Yukon by 2020 (Environment Yukon, 2009). Throughout this paper the term emissions is used to mean greenhouse gas emissions.

The objective of this paper is to identify changes that could be made to Yukon Government legislation, regulations and policies that would help meet or exceed this target while at the same time promoting economic growth in the territory.

To accomplish this objective, this paper answers four research questions:

1. What is the background for GHG emissions in Yukon in terms of:
   a. Historical levels of GHG emissions for the various energy sectors from 1990 (original Kyoto baseline date) to 2006?
   b. Forecast energy use from 2006 to 2020?
   c. Current initiatives to reduce or eliminate GHG emissions?
2. What factors are inhibiting or aiding the development of greener solutions for energy use in the Yukon?
3. How are other jurisdictions addressing these factors in terms of environmental management theories and best practices?
4. What government actions can be taken in Yukon to achieve a 20% or greater reduction of 2006 GHG emissions by 2020 that promotes economic growth in the territory?

To answer these questions, this paper is divided into twelve sections including the introduction. Section two examines the background and context of emissions as a pollutant in Yukon. Section three reviews the economic theory of pollution and best practices in controlling pollution. Sections four through six describe the Yukon's historic and forecast emissions as well as the Yukon Government's current emission reduction actions. Sections seven and eight detail the factors inhibiting and aiding emission reduction in Yukon. Other jurisdictions emission reduction plans are reviewed in section nine. Alternatives to fossil fuel use are considered in section ten. Yukon specific alternatives are examined in more detail and ranked in section eleven. Finally section twelve concludes with made in Yukon government actions.

The report excludes emissions arising from non-energy sources such as industrial processes, solvents, other product use and waste. In 1990 such emissions amounted to 12 kt of emissions out of a total of 538 kt or 2.2%. In 2006 they amounted to 17 kt out of a total of 394 kt or 4.3%. The report does not attempt to forecast the effects of or length of the recession that Canada and the rest of the world is currently experiencing. The assumption is that by 2020 Canada and the international community will have recovered.

2.0 Background and Context

In this section, we look at the linkage between carbon dioxide emissions and global warming. Then we describe the Yukon and its energy use by sector. Finally we review the energy markets in Yukon.

2.1 Greenhouse Gas Emissions

Economic activity requires the production, distribution and use of energy. This activity has an impact on the environment. If the activity involves the use of fossil fuels, then one of the major impacts is the production of GHG emissions.

GHG emissions are considered to be a major contributor to climate change and global warming. They are usually measured using a metric called carbon dioxide equivalents (CO_2e). The metric is expressed by weight in units of metric tons called tonnes internationally and in pounds in the U.S. Carbon dioxide is recognized as being the principle contributor to the increase in GHGs in the atmosphere. Other gases also have a global warming potential (GWP) that can be converted to carbon dioxide equivalents using their (GWP) over a 100 year period. Many other gases have a much greater global warming potential than carbon dioxide as shown in Table 2.1. The values in table 2.1 were taken from the IPCC Third Assessment Report (GRID-Aredal, 2003).

Table 2.1 GWP and Atmospheric Lifetimes of Common Gases

Gas	Atmospheric Lifetime (years)	100 Year GWP
Carbon dioxide	5-200	1
Methane	12	23
Nitrous Oxide	114	296
CFC-11	45	4,600
HCFC-21	2	210
HFC-23	260	12,000
SF-6	3,200	22,200

One metric often used to measure the rate of GHG emissions is called the GHG emission intensity. It is defined as the GHG emissions per unit of economic activity. Intensity-based GHG emission reduction targets are seen to be ineffective by many environmental stakeholders because with economic growth total GHG emissions can still increase even if intensity-based targets are met (Dale Marshall, 2007). Statistics Canada uses two key economic activity based GHG emission metrics that the author will also rely on to develop a forecast of 2020 emissions under different economic growth assumptions:

> ***GHG emissions per capita*** is a measure of emission intensity by population. It is calculated by dividing the GHG emissions by the population of the area or jurisdiction, in this report, as measured by a Statistics Canada census.
>
> ***GHG emission intensity*** is a measure of emissions by economic activity. It is calculated by dividing the GHG emissions by the Gross Domestic Product (GDP)

of the jurisdiction. The emissions are stated in Megatonnes (Mt) and the GDP is stated in $Billions.

2.2 The Yukon Energy Sectors

The Yukon Territory is located north of the 60th parallel directly above the province of British Columbia (BC). The climate is sub-arctic continental with temperatures as high as +36 Deg C in the summer and as low as -60 Deg C in the winter (EMR, 2007). In 2006 the Yukon population was 30,372, occupying a land area of 474,711 square kilometers. This gives Yukon a population density of about 0.1 person per square kilometer (Statistics Canada, 2008). Although this makes it the most populated of Canada's three northern territories, Yukon's population density is well below that of its two closest provincial neighbors: BC at 4.4 and Alberta at 5.1 persons per square kilometer.

The Yukon map in Appendix 1 shows there are 14 communities in the Yukon. Every community in the Yukon is accessible by road except for Old Crow, a First Nation (FN) community located above the Arctic Circle near the Beaufort Sea. In 2006, more than 23,000 or 77% of Yukoners lived in Whitehorse (Yukon Bureau of Statistics, 2007).

Yukoners have historically relied on fossil fuels such as diesel fuel and wood for residential and commercial heating purposes. In 2005, 64% of buildings were heated by diesel/stove oil, 18% by wood and 13% by electricity (Yukon Bureau of Statistics, 2008, pg 6). The remaining 5% of buildings were heated by propane. There is currently no natural gas available for consumer use in the Yukon. This would change if the Alaska Highway Pipeline were to be built. Current plans by the two proponents, TransCanada Pipeline and Denali, call for a possible in-service date of 2018. If it goes ahead, this project will change the energy landscape of the Yukon for at least 30 years (estimated life of the North Slope natural gas basin).

Much of the Yukon's electricity comes from legacy hydro power, built in the period from 1953 to 1985 by a Federal crown corporation, the Northern Canada Power Commission (NCPC).This corporation was formed under the Department of Indian and Northern Affairs (DIAND) in the 1950's to develop electrical infrastructure across the north (EMR, 2008). In 2006, 93.2% of the electricity generated in the Yukon was from hydro, 0.2% from wind, and 6.6% from diesel (Yukon Bureau of Statistics, 2008, pg 1). Currently most Yukon communities and all industrial customers are connected to hydro electric grids that use fossil fuel generators for occasional peaking and backup use only. The five communities of Old Crow, Beaver Creek, Destruction Bay/Burwash Landing, Swift River and Watson Lake still rely on local diesel generation for their electricity as they are located too far from the two existing hydro grids to be economically connected. These are small communities. Watson Lake is the largest with a population of 1,594 as of December, 2008. In general the electricity sector is quite green due to its legacy hydro but this existing renewable source of electrical energy will be fully utilized within a couple of years and new sources of electricity will be needed.

The transportation sector accounts for the largest portion of the fossil fuel used in the Yukon. The Yukon has no ports or rail systems to connect it to southern Canada.

Almost all goods and commodities are trucked to and from Skagway, Alaska, the nearest tidewater port, from Alberta via the Alaska Highway and from B.C. via the Stewart Cassiar Highway. In 2006 the transportation sector accounted for 63% of Yukon's emissions, with electricity generation and heating accounting for only 31% (Environment Canada, 2008). All gasoline, diesel, home heating fuel and propane must be imported to the Yukon via truck thus emissions are generated to just deliver these fossil fuels to the Yukon before they are used locally in Yukon for transportation, heating and power generation use.

In 2008 Environment Canada updated their National Inventory report on greenhouse gas sources and sinks covering the years 1990 to 2006 (Environment Canada, 2008). In the report they identify the Yukon as the second lowest province/territory in Canada in emissions per capita at 13 tonnes per person. (Quebec, with their large hydro base for energy use, had the lowest emissions per capita at 10.7 tonnes per person.) In 2006, the Yukon's emission intensity was 0.24 (calculated by dividing the territory's total emissions of 0.394 Mt in 2006 by its GDP of $1.622B). This emission intensity is the lowest in Canada of all the provinces/territories.

2.3 The Yukon Energy Markets

Like other Canadian provinces and territories, the Yukon has an economy that is a mixture of free market and government run industries and programs (such as health care, CPP, OAS, EI). The Yukon's energy markets can be described as follows:

- The heating sector is a free unregulated market, an oligopoly with a few dominant firms in home heating fuel and propane sales. The fire wood market place is a true open market with many players that include home owners as the entry tariff is virtually free (in most cases a $5 permit). Almost all of the wood burned in the Yukon is from trees killed in forest fires. Use of wood as an energy source is considered a zero carbon emission fuel if it is used in a sustainable manner. This is the case using dead wood taken from forest fire burn areas. Use of electric heat is discouraged by both electric utilities despite the fact that 94% of electricity is generated from existing hydro sources. The remaining 6% is generated from diesel fuel using reciprocating diesel engines as their prime mover.
- The electricity market is fully regulated with two major firms that have geographic monopolies. This sector will also be examined with respect to its lack of competition, regulation and policies involving the use of green energy. Rent-seeking by the two firms in the market will be examined as a possible source of government failure to regulate this market (Tientenburg, 2007, p 75).
- The transportation market is comprised of local and national firms. National corporate chain retailers utilize long distance rubber tire hauling from southern ports and distribution centers to Whitehorse and then further distribution with the territory from Whitehorse to the Yukon's smaller communities. There is a large tourist sector that involves long distance driving from southern Canada and the southern United State up the Alaska Highway to the Yukon and often onto Alaska. There are no territorial sources of gasoline, diesel and home heating fuel

or propane at present so all fossil fuels (except for wood) must also be imported. This creates additional emissions and economic leakage to the Yukon's economy.

3.0 Pollution Economic Theory and Best Practices

In this section we review some of the economic theory that is useful for understanding pollution problems. Then we examine market and government best practices to reduce emissions.

GHG emissions are regarded as a pollutant because they cause global warming, which, in turn, leads to climate change and all of its associated negative impacts. The burning of fossil fuels has been identified as one of the major contributors to global warming. One way to reduce GHG emissions is to decrease burning of fossil fuels through either energy conservation or by switching to renewable or green energy sources. This section will explain the reasons why the current high use of fossil fuels is due primarily to the failure to internalize the negative effects of burning fossil fuels. It will also explain the best practices behind government actions in providing incentive, restrictions or penalties aimed at restricting emissions.

Past experience suggests that economic activity is linked to GHG emissions; that is, increasing economic activity typically requires increasing energy use which typically results in more GHG emissions. This paper explores how this linkage may apply to Yukon.

Clean air or an unpolluted atmosphere can be defined as a *public good* as it can be enjoyed by all, including those that don't pay for it, and that one person's or entity's consumption (in this case pollution) does not measurably diminish the amount available for others. This makes it difficult to define the linkage between a source emitter of emissions to a global atmospheric problem.

This lack of a clear linkage can be a lack of accountability for polluting action. This can lead to *free-ridership* where one entity can enjoy the efforts of other entities reducing emissions without having to reduce emissions themselves. Why would firms spend money to reduce their emissions if someone else is prepared to do it and it doesn't affect their profitability?

The concept of economic efficiency can be used to determine the socially optimal level of any activity, including the release of GHG gas into the atmosphere. The reduction of emissions is the concept that allocation of scarce resources should be done in a manner that is economically efficient to maximize the net benefits (Tientenberg, 2007, p 70). If one considers clean air as a resource that can only sustain a limited amount of use (or pollution) then concept of economic efficiency should apply. The great economic efficiency occurs when the marginal damage of the releasing emissions is equal to the marginal cost of reducing emissions.

What factors can inhibit the most efficient allocation of this resource? These allocation inefficiencies are often characterized as market failures or government failures which are discussed in more detail in Sections 3.1 and 2.2.

3.1 Market Factors

The most common factor identified today for the inability of many countries to reduce their emissions is the fact that the negative effects of emissions is not reflected in the value or price the market puts on products that increase emissions. The technical term for this is the market treats the effects of increased emissions as an externality. Because emissions have a negative effect on the environment, they are defined as a negative externality. Fullerton and Stavins (1998) defined externalities as "some consequences of producing or consuming a good or service are external to the market (not considered by the producers or consumers)". This has occurred with GHG emissions due to the difficulty in assessing the value to society of reducing these emissions or even what is the acceptable level of emissions. Currently there are no restrictions on emissions in the Yukon thus the existing markets are treating emissions as an externality with no value or cost associated with it. The OECD (2003) defines externalities as an "economic concept of uncompensated environmental effects of production and consumption that affect consumer utility and enterprise cost outside the market mechanism. As a consequence of the failure to internalize negative externalities, private costs of production tend to be lower than its "social" cost. It is the aim of the "polluter/user-pays" principle to prompt households and enterprises to internalize externalities in their plans and budgets. When negative effects of production or consumption are left as externalities, they are ignored by markets as they are not factored in their cost/benefit or business cases analyses. Hence the cost assigned to these effects is not considered a production cost. This can cause the producer to over-produce or in this case to over pollute as price of the product is lower than it should be if the GHG emission cost was internalized and therefore reflected in their price.

Most economists agree that for economic efficiency, the full or total cost of the resource should be reflected in the price of the resource. The total cost is the sum of the internal and external costs. This can lead to an unlevel playing field or market where competing technologies have different externalities. This is the case with respect to fossil fuels versus renewable energy options where they are competing for the same market and have a different market price when their effect on emissions remain externalized.

So how can GHG emission external costs be internalized? There are several possible solutions for Yukon:

1. Government regulation and standards. This could be source emission regulations on large emitters or vehicle tailpipe emission standards or fleet fuel economy standards.
2. Pigovian taxes. This is a special tax on products that cause pollution in order to put a cost on the negative externalities. This could be in the form of emission charges, carbon fees or taxes.
3. Emission Rights. This would be the issuance of pollution rights and the creation of an emissions trading market.

3.1.1 Government Regulation and Standards

Government regulations are often used in restricting source emissions where there is pollution abatement technology available at a reasonable cost. A local example in Whitehorse, Yukon, is the current move by the Yukon Department of Environment to restrict the use of diesel–electric generation in Whitehorse in an effort to improve the air quality in a nearby subdivision where the overwhelming impacts on air quality from fossil fuels use are from vehicles and use of wood for residential heating. The government has been unwilling or unable to pass regulations or standards restricting emissions from these two sources but was able to issue an air emissions permit that restricts the use of local diesel-electric generation. Arguably, the local residents that use wood heat and drive gas and diesel vehicles are getting a free ride. They get the benefit of reduced pollution without reducing their own pollution.

3.1.2 Pigovian Tax

A Pigovian tax is a tax applied to a goods or service in order to internalize a negative externality, effectively transforming an external cost into an internal cost that is reflected in the market price. The purpose of the tax or subsidy is to influence the market by recognizing the externality as a financial cost or benefit that would affect the market price of that goods or service. It is commonly called a polluter-pays tax. The GHG emission Pigovian tax solution is the basis for the carbon user fee. This tax would internalize the GHG emission cost in the price the consumer pays so the market would force the producer with a high carbon footprint to become more efficient (in this case reducing their carbon footprint) or lose market share. The fee could be paid by either the producer or the consumer. Who ends up paying the tax is determined by the demand and supply elasticity of that product.

The result of the tax can be a reduction of consumption caused by the increased cost to the consumer who chooses to practice energy conservation or fuel switching if alternative fuels are available. Firms requiring energy in their processes will try to reduce their carbon footprint by switching to more efficient and/or less carbon-intensive processes. If the tax accurately reflected the societal cost of the emissions then this would decrease the market distortion or deadweight loss. Many jurisdictions are trying to derive a double dividend by using the carbon tax revenues to reduce other areas of distorted taxation such as personal income tax thereby further decreasing the distortion caused by deadweight loss in other areas. Jeroen Van Den Bergh further breaks down the concept of double dividend as the green dividend (pollution tax portion) and the second dividend being a blue dividend. He describes three possible types of blue dividends; a weak double dividend, strong double dividend or employment double dividend. Most economists appear to agree there is at least a weak double dividend potential in a carbon tax but there is no agreement on the last two types which may yield a higher blue dividend (Van Den Bergh, 2002). The blue dividend or redistribution of this green wealth is proving to be very difficult to design and be economically efficient. Politically, this is often being packaged as being revenue neutral.

Considerable work has been done by the European Union in developing a computer model called ExternE for internalizing the externalities related to energy. The latest model released in 2005 deals with the negative impacts related to the environment and global warming (Bickel, 2005).

In Canada the provinces of B.C. and Quebec are using a carbon tax. Their programs are described in section 4.2 of this report. Carbon taxes are used internationally in Denmark, Finland, Netherlands, Norway, Poland and Sweden.

3.1.3 Emission Rights

The emission rights or trading model has successfully been used in the U.S. in the 1990's dealing with controlling sulphur dioxide emissions. In his article *Lessons Learned from SO_2 Allowance Trading* Robert Stavins (2005) describes the SO_2 Allowance Trading Program as successful in meeting its targeted emission reductions with lower abatement cost than anticipated. He estimates the positive welfare effects were up to ten times the abatement costs. Two factors that made the trading model a success for this pollutant were the relatively small size of the affected market and the availability of technological solutions at a known cost.

One of the decisions governments have to make when implementing this solution is whether to issue free credits to the existing polluters in order to keep existing costs of electricity and other carbon intensive products or services at their current rates. This has led to windfall profits by some incumbent market firms if they are over-issued credits. It can also have the effect of raising the entry barrier for new market participants if they have to buy credits to offset their emissions or spend increased capital cost to utilize cleaner technology.

When an existing market firm shuts down their polluting facility the firm has a potential windfall of emission credits that can be applied to another project or can be sold. This is seen by many as an unlevel playing field.

The member countries of the European Union have been using an emission trading system since January 2005 when the European Union launched their GHG Emission Trading Scheme (EU ETS). The price volatility of the emission rights has been a significant issue. Each country was initially allocated a share of emission rights. In turn each country allocated their share of emission rights to their industries. Some of the emission credits issued to industries and companies were so generous they were able sell off the surplus they didn't need and depress the market price for the emission rights. This problem was exacerbated when the economy collapsed in many eastern European countries and companies that had been issued emission rights for their facilities that were shutting down, sold the rights to generate cash flow. This caused large fluctuations on the emission credits pricing and as a result companies were buying the rights as it was cheaper than investing in clean technology. The price per tonne was as high as 30 Euros in 2006 and as low as 0.10 Euros in 2007 during the first phase (2005-2007) of implementation. The second phase (2008-2012) is now underway.

The PEW Center on Global Climate Change at MIT released a report in 2008 on the effectiveness of the ETS. The report gave the first phase a passing grade because it set a price on emissions that businesses incorporated into their decision–making and it established a long-term mechanism in multiple countries for controlling emissions. PEW's criticisms of the scheme for phase 1 were:

- Windfall profits for some countries and companies.
- Over-allocation of credits resulting in less GHG reductions and free allocation of credits giving existing polluters a free ride instead of auctioning off the credits (Ellerman & Joskow, 2008).

The over-allocation of credits issued to some countries (and re-issued to some firms) and the "over-supply" of emission rights due to the downturn in the economy is seen as a failure of this process to remove some rights to pollute that could have been removed with minimal impact on the economies of the EU member countries. As a result, real reductions in emissions will have to take place in the future with a higher overall emissions starting point.

An imperfect market structure can also create environmental problems when one or more of the sellers or buyers have an inordinate amount of power over the outcome of the relationship between the seller and buyer. Often this is seen in a market with one (as a monopoly) or a few dominate sellers (oil cartel) or buyers (Walmart in the retail consumer goods market). The electricity market in Yukon has two sellers, both with natural monopolies. The electricity market in Yukon is reviewed in more detail in section 3.2.

3.2 Government Factors

Government failure to provide adequate incentives to the market and private sector can also cause environmental issues. If government responds to special interest group lobbying efforts and issues by protectionist legislation or regulations that provide net benefits to the special interest groups or industry but lower net benefits to society then they are the victims of *rent-seeking* by these groups (Tientenberg, 2007 p 75).

There are currently no direct incentives for reducing emissions being offered in the transportation sector by the Yukon government despite the fact it is the biggest polluter, accounting for 63% of the Yukon's emissions. The Yukon does impose a revenue tax on fuels as shown in Table 3.1 (Yukon Department of Finance, 2009) but clearly the tax is not a carbon tax as it does not reflect the carbon content of the fuels.

Table 3.1 Yukon Fuel Tax Rates

Fuel Type	Rate
Gasoline	6.2 cents per litre
Diesel	7.2 cents per litre
Aviation	1.1 cents per litre
Heating	no tax
Heating or Cooling other than for space heating	0.2 cents per litre
Propane	no tax

There is no reduction in the tax rate for cleaner gasoline or bio-diesel blends of fuel nor are the tax rates for gasoline or diesel high enough to affect vehicle usage. In BC the current fuel tax rates are 14.6 cents per litre for gasoline and 15 cents per litre for diesel, more than double the Yukon fuel rates. In addition B.C. consumers pay a carbon tax of 2.34 cents per litre for gasoline and 2.69 cents per litre for diesel. For gasoline the BC combined tax is 16.84 cents per litre or 272% of the current Yukon tax rate. In BC the ethanol and bio-diesel components of blended fuel are tax exempt.

In the heating sector there are no government incentives for reducing emissions in terms of tax rates as all heating fuels are tax exempt. The Yukon Government does have an energy efficiency heating appliance rebate program and several home improvement programs that are described in more detail in Section 6.

The electricity sector in Yukon is fully regulated by a territorial government appointed quasi-judicial board called the Yukon Utilities Board (YUB). It consists of three to five members, one being the chair, another being the vice-chair. All members are appointed by the Yukon government for terms not exceeding three years. The Board is provided direction from government through acts, regulations and ministerial directives. Its mandate is to:

- set retail and wholesale electricity rates
- set various accounting methods for utility assets such as amortization
- set standards and practices for customer connections and reliability
- approve capital additions to rate base
- approve return on equity (ROE) rates for utilities
- determine utility service areas

- address customer complaints

The cost of regulation is high in Yukon's electricity sector due to the small customer base of less than 20,000. The cost to apply for a change in electrical rates including a public hearing can exceed $1M, or $50 per customer (YUB, p A4, 2009). Historically there were rate applications every two years so this would cost $25 per customer per year, adding about $2 to the average monthly residential electricity bill. The residential and small business electrical rates have two inverted energy block charges and the industrial rate has a simple demand and energy charge. There are no seasonal, peak and off-peak or time-of-use rates to encourage customer demand side management. There are no net metering or independent power producer (IPP) policies or rate schedules. As a result there are no net metering customers or IPP generators in Yukon that are regulated. There are several privately owned micro hydro plants that are not connected to the electrical grids that serve private customers. These include a 150 kW Rancheria Hotel and 250 kW Fraser Highway Camp micro–hydro plants that were constructed in the early 1990's.

Since November 28, 2005 all energy projects in Yukon must be assessed for their environmental and socio-economic effects from an independent assessment agency called the Yukon Environmental and Socio-Economic Assessment Board (YESAB). This Board is empowered to conduct all assessments on Yukon projects and issue recommendations to government (Federal, Territorial and First Nation) decision bodies. The entities then issue a decision document(s) for the project that can accept, reject or vary the recommendations of this Board. A decision document must be issued before any government permits can be issued with respect to the project. In Yukon emissions are not considered in an environmental assessment as there are no acts, regulations or permits that restrict emissions. YESAB cannot make recommendations that are unenforceable by regulatory enforcement entities. This new assessment process is intended to provide a truly integrated assessment of environmental and socio-economic impacts based on both shareholder (economic) and stakeholder (social) values. Without government action this assessment process is powerless to restrict emissions. Two areas that government can assist in this process would be to set source emission standards to restrict emissions and broader emissions caps that would be captured under the cumulative effects section of the assessment. A mandatory 5-year review of YESAB act and regulations is currently underway that could also lead to improvements to this process from both an efficiency and effectiveness perspective.

The Yukon does have a strong Environmental Act that was proclaimed in 1991. One of the most telling definitions in the Act that applies to emissions is that of public trust: "the collective interest of the people of the Yukon in the quality of the natural environment and the protection of the natural environment for the benefit of present and future generations" Section 38(1) of the Act defines the Yukon government as the trustee of the public trust (Environment Yukon, 2008). The Act stipulates that every three years the government shall release a State of the Environment Report. The report shall identify emerging environmental problems including long term and cumulative environmental effects. The last report released was in 2005. It contained a section on climate change and noted that the Yukon's emissions in 2005 were more than 20% lower than their 1990 emissions, primarily due to the downturn of mining in Yukon. There were no specific action plans identified in the report (Environment Yukon, 2005). The Yukon's Air Emission Regulations were proclaimed in 1998. They contain no specific restriction of emissions. They limit fugitive emissions such as particulates and sulphur. Section 6 of the regulations is the only existing section that could be applied to emissions. It states that no person shall allow the release of any air contaminant that may cause irreparable damage to the environment or cause eminent harm to public health or safety (Environment Yukon, 2008).

4.0 Yukon Historic Emissions and Underlying Factors

In this section, we first examine the historic emissions, population and GDP in Yukon starting in 1990, the original Kyoto Agreement baseline year for emission reductions. Then we examine the underlying factors that affected the historic emissions on a sector basis. Finally we develop an inflation adjusted economic growth forecast in the Yukon during this period from 1990 to 2006.

The Yukon's emissions from energy use and economic activity from 1990 to 2006 are summarized in Table 4.1.

Table 4.1 Summary of Selected Years of Yukon GHG Emissions and Economic Metrics

Yukon Totals from Energy Use	**1990**	**1995**	**2000**	**2006**
Yukon GHG Emissions (kt)	526	532	430	377
Yukon Emissions % change from 1990	0%	1%	-18%	-28%
Yukon Population[1]	29,362	31,778	30,776	31,803
Yukon Population % change from 1990	0%	8%	5%	8%
Yukon GDP[2] ($B)	1.056	1.047	1.190	1.622
Yukon GDP % change from 1990	0%	-1%	13%	54%
GHG Emissions per Capita (tonnes/person)	17.91	16.74	13.97	11.85
GHG Emissions per Capita % change from 1990	0%	-7%	-22%	-34%
GHG Emissions per GDP (Mt/$B)	0.50	0.51	0.36	0.23
GHG Emissions per GDP % change from 1990	0%	2%	-27%	-53%
Energy Sector Emissions[3]				
Stationary Combustion Emissions	226	248	191	123
Stationary Combustion Emissions % change from 1990	0%	10%	-15%	-46%
Transportation Emissions	300	280	240	250
Transportation Emissions % change from 1990	0%	-7%	-20%	-17%
Other/fugitive Emissions	0	4	3	1
Other/fugitive Emissions % change from 1990[4]	N/A	N/A	N/A	N/A

[1]These population estimates are annual averages which are statistically based on the Yukon Health Care Registration file.
Source: Yukon Bureau of Statistics and Yukon Department of Health & Social Services.
[2]Income-based estimates, GDP at market prices.
Source: Statistics Canada. Table 384-0001 - Gross domestic product (GDP), income-based, provincial economic accounts, annual (dollars), CANSIM (database).
http://cansim2.statcan.gc.ca/cgi-win/cnsmcgi.exe?Lang=E&CNSM-Fi=CII/CII_1-eng.htm
(accessed: March 2, 2009)
[3] Energy sector emissions were obtained from 2006 National Inventory Report, Table 11-22 p 588
[4] % change from zero is not a meaningful number

There are a number of factors that contributed to the reduction of emissions, emissions per capita and emissions intensity from 1990 to 2006.

From 1990 to 2006 total emissions decreased by 28%, emission per capita decreased by 34% and emissions per GDP decreased by 53%. During the same period the Yukon population grew by 8% and GDP by 54%. This is all good news but what were the underlying factors behind these numbers? A more detailed breakdown of emissions by sector and description of other economic factors that were at play in the Yukon during this period is required to understand whether these reduced emission levels are sustainable and can be reduced further in the future. Will the 28% reduction of emissions from 1990 to 2006 be problematic in the future that will see 2006 levels used as the new base line for emission reductions?

At the sector level, stationary combustion emissions decreased by 46% and transportation emission decreased by 17%. The significant changes in emissions in the stationary combustion sector were:

- A decrease in electricity and heat from 94 kt in 1990 to 8 kt of emissions in 2006, a 92% reduction. In 1990 the lead/zinc mine at Faro was in operation and 27 kt of emissions were related to use of diesel-electric power to supply the mine. The mine was also supplying most of its building and process heating using coal. The mine shut down for good in early 1998 eliminating this emission. In 1990, 21 kt of emissions were a result of diesel-electric generation to supply isolated Yukon communities with power. With the completion of the Mayo to Dawson transmission line in 2003 the emissions to supply the isolated communities was reduced by 10 kt.
- An increase in fossil fuel industry from 3 kt of GHG emission in 1990 to 38 kt in 2006, a 1300% increase. This was driven by natural gas field production from the Kotaneelee field in southeast Yukon which was not in operation in 1990 but produced 152,660 thousand cubic metres of natural gas in 2006. There are two gas wells in production in this field which is the only natural gas produced in the Yukon. It is all shipped by pipeline to BC and Alberta.
- A decrease in the commercial/institutional use from 82 kt of emissions in 1990 to 30kt in 2006, a 63% reduction. In the early 2000's Yukon Energy started

actively marketing use of interruptible surplus hydro power to displace commercial/institutional fossil fuel heating systems. By 2006 this program was displacing more than 20 GWh of fossil heating use, up to an additional 8 kt of emissions. The increased use of propane from virtually zero percent to a five percent market share of the heating market by 2006 has reduced emissions, with the majority of the market volume being commercial and institutional.

- An increase in residential use from 29 kt of emissions in 1990 to 39 kt in 2006, a 34% increase. There has been significant new housing construction from 1990 to 2006 to handle the 8% growth in population, almost entirely in the urban centre of Whitehorse. During this period home heating fuel was the primary residential heating system of choice due to its low price.

The significant changes in emissions in the transportation sector were:

- A decrease in light duty gas vehicle use from 79 kt of emissions in 1990 to 29 kt in 2006, a 64% decrease. Some of the decrease was due to the use of more fuel efficient vehicles as Yukoners drive a lot longer distances than many residents of southern Canada. Some of the decrease was due to vehicles switching from gasoline to diesel as diesel light trucks became available and more economic for high annual mileage use.
- An increase in heavy duty diesel vehicle use from 57 kt of emissions to 73 kt, a 27% increase. This was due largely to fuel switching from gasoline to diesel vehicles which are very popular in Yukon and the increase in tourism traffic (buses and motor homes/RV's).
- A decrease in off-road diesel and gasoline vehicle use from 100 kt of emissions in 1990 to 80 kt in 2006, a 20% reduction. The largest component of this reduction was the decrease in off-road vehicles used in mining due to the shutdown of the Faro mine and drop in base metal prices during this period.

The Yukon saw significant swings in its population from 1990 to 2006 due to changes in base metal prices causing several mines in the Yukon to start up and shut down. The largest of these mines was the lead zinc mine at Faro, Yukon. At its peak in 1997 the Yukon's population reached 33,519 (Yukon Bureau of Statistics, 2006). It reached its lowest point in 2003 with a population of 29,967 (Yukon Bureau of Statistics, 2007).

The Yukon's GDP spending increased 54% from 1990 to 2006. Table 4.2 shows that the private sector in 1990 contributed 46% of the GDP for the Yukon. This shrunk to 37% by 2006. The 54% increase in Yukon GDP from 1990 to 2006 was almost entirely made up of a 79% increase in Yukon government spending from 1990 to 2006, largely due to increases in Federal transfer funding. The information for table 4.2 was derived from Statistics Canada CANSIM tables 384-0002.

Table 4.2 Yukon GDP Spending Levels of Government and Private Sector in selected years

	1990	1995	2000	2006
Yukon GDP ($B)	1.056	1.047	1.190	1.622
Yukon GDP % change from 1990	0%	-1%	13%	54%
Yukon GDP Government O&M Expenditures($B)	0.386	0.484	0.606	0.765
Yukon GDP Government Capital Expenditures($B)	0.186	0.156	0.086	0.261
Yukon Government spending($B)	0.572	0.640	0.692	1.026
Yukon Government % change in spending from 1990	0%	12%	21%	79%
Yukon Government spending % of GDP	54%	61%	58%	63%
Yukon Government % of GDP increase from 1990	0%	13%	7%	17%
Private Industry spending($B)	0.484	0.407	0.498	0.596
Private Industry spending % of GDP	46%	39%	42%	37%

The largest area of growth in the GDP was in Yukon Government O&M which grew from $386M in 1990 to $765M in 2006, an increase of 98%. From 2001 to 2003 the management of a number of natural resources such as forestry, mineral and oil and gas, were devolved from the Federal Government to the Territorial Government which would have resulted in an increase in Yukon Government GDP, largely funded by an increase in annual Federal transfer funds. By 2006 public sector employment was 6,500 (39%) of the total employment population in Yukon of 16,500 (Yukon Bureau of Statistics, 2009). The devolution was accomplished largely by transferring of Federal responsibilities, assets and employees to Yukon Government which would have increased the Yukon Government's GDP without increasing its carbon footprint. Much of the job of government is administrative in nature and is not as energy intensive compared to some private industry sectors such as mining and manufacturing. The increase in public sector GDP from 54% to 63% and decrease in private sector GDP from 46% to 37% from 1990 to 2006 undoubtedly was part of the reason the emissions fell so dramatically during the same period.

In review of economic factors, the effect of inflation is often considered and removed. This is called inflation adjusting or expressing financial terms in real dollars as opposed to nominal dollars. Inflation is often measured by looking at the changes in purchasing power of money. The most widely used measure of purchasing power is the consumer price index (CPI). In Yukon, this is measured using the Whitehorse CPI which represents the largest spending area in Yukon due to the fact that 77% of the population of Yukon reside in Whitehorse. The CPI rates in Table 4.3 were obtained from the Yukon Government (Government of Yukon, 2009). Table 4.3 shows the impact removing the inflation effect on the GDP growth in Yukon.

Table 4.3 Yukon Inflation Adjusted Emissions per GDP

	1990	**1995**	**2000**	**2006**
Yukon GDP ($B)	1.056	1.047	1.190	1.622
Yukon GDP % change from 1990	0%	-1%	13%	54%
Whitehorse CPI (base of $100 in 1990)	$100.00	$113.65	$123.26	$135.02
Yukon Inflation from 1990	0%	13.65%	23.26%	35.02%
Yukon Inflation adjusted GDP in 1990$B	1.056	0.921	0.965	1.201
Yukon Inflation adjusted GDP % change from 1990	0%	-13%	-9%	14%
GHG Emissions per Real GDP (MT/$B)	0.498	0.577	0.445	0.314
GHG Emissions per Real GDP % change from 1990	0%	16%	-11%	-37%

The Yukon's emissions per real GDP actually increased 16% from 1990 to 1995 due to continued use of diesel-electric power to supply the mining sector, coupled with a decrease in real GDP due to the 14% inflation that occurred in the same period. Continued inflation of about 2% per year occurred from 1995 to 2000, coupled with the shutdown of the Faro mine, resulting in a further 11% decrease in real GDP. The large growth of nominal and real GDP from 2000 to 2006 was due to:

- 20% growth in the private sector GDP due to tourism
- Construction of several large big-box retail stores
- 48% growth in the Yukon Government GDP

These three factors, coupled with a further decrease in electricity and heating emissions, resulted in a significant decrease in GHG (Intensity) emissions per GDP.

5.0 Yukon Forecast GHG Emissions to 2020

In this section, we first develop a population forecast for Yukon using low, medium and high growth scenarios. We then develop an electricity forecast for the same scenarios. We further develop an emissions forecast and finally new emission reduction targets based on the 2020 business as usual forecast for each of the growth scenarios.

So what is likely to happen in the future in Yukon, from 2006 to 2020 in the status quo scenario (i.e. with no changes in Yukon and Federal Government legislation, regulation, policy or other intervention in the marketplace)? Note that the objective of this report is not to produce a definitive forecast of emissions for Yukon, but rather to produce a range of estimates for the purpose deciding if government actions will be required for meeting their GHG emission reduction targets in a variety of economic growth scenarios. Forecasting simplifications and assumptions are therefore made.

Emissions are tied to economic activity. Reviewing the population and economic forecast for this period is a good starting point. In October of 2008 the Yukon Bureau of Statistics released its population forecast to 2018 in 3 growth scenarios; low medium and high (Yukon Bureau of Statistics, 2008). A linear extrapolation was performed to extend the forecast to 2020 which is shown in Table 5.1.

Table 5.1 Yukon Population Projection to 2020

	Low	Medium	High
Population in 2008	33,274	33,274	33,274
2018 forecast[1]	31,776	35,104	38,606
2020 forecast by extrapolation	31,476	35,470	39,672
Population in 2006[2]	31,608	31,608	31,608
2020 % change in population from 2006	-0.4%	12.2%	25.5%

[1] Source Yukon Bureau of Statistics Population Projections to 2018
[2] Source Yukon Bureau of Statistics 2006 Population Report

In Yukon, the government sector contribution to economic activity as measured by GDP is closely tied to the Federal transfer funds it receives from Canada under the Territorial Formula Financing agreements that are in place with all three northern territories. The funding is indexed to both inflation and population. By using real GDP numbers we can remove the effect of inflation and can focus strictly on population changes. Table 5.2 shows the forecast percent changes in Yukon population from 2006 to 2020 as -0.4%, 12.2% and 25.5% for the low, medium and high scenarios. These population changes can be used as a rough proxy for forecasting long term changes in Yukon Government's contribution to GDP.

Forecasting changes in the private sector contribution to economic activity is another matter. Given that most forms of economic activity require electricity, it's prudent to look at the long term electricity forecast of the Territory. In 2005, Yukon Energy completed a 20-year resource plan that included electricity forecasts to 2025 using low, medium and high economic growth scenarios (Yukon Energy, 2006). Table 5.2 was prepared starting with the 2006 information from Chapter 4.

Table 5.2 Yukon Electrical Generation Projection to 2020

Annual Electrical Generation in GWh/yr	Low	Medium	High
Annual electrical generation in 2006	336	336	336
2006 renewable generation	312	312	312
2006 diesel generation	24	24	24
Forecast annual electrical generation	366	436	486
2020 renewable generation	340	400	400
2020 diesel generation	26	36	86
Forecast % growth in electrical generation	8.9%	29.8%	44.6%
Forecast % growth in diesel generation	8.3%	50.0%	258.3%

As of 2006 the long term energy available from existing hydro and wind generation facilities was 400 GWh per year; 360 GWh from the Whitehorse area grid and 40 GWh from the Mayo-Dawson grid. In 2006 there was approximately 22 GWh per year of diesel generation used for the five Yukon communities that do not have access to these two hydro-based power grids. Due to the current surplus of renewable generation on the Yukon two main hydro-based grids, there is no forecast need for diesel generation in the low scenario. In this scenario, there are no new mines starting and non-mining customer growth is assumed to be less that 1% (Yukon Energy, 2006 p 4-5). In the medium scenario, the forecast growth in electrical generation is 30% by 2020, requiring a 50% increase in the 2006 diesel generation. This scenario is based on 1.85% growth in non-mining customers and two small mines starting. In the high growth scenario, the overall growth is forecast at 45% by 2020 requiring a 258% increase in diesel generation. This scenario is based on 3% growth in non-mining customer loads and three mines starting.

Completion of the Alaska Highway Pipeline Project (AHPP) in 2018, with an estimated 30 year life, could have a profound effect on emissions in Yukon. TransCanada's current project plan calls for ten natural gas powered compressor stations in Yukon, averaging 30 MW of compressor capacity. Using a life-cycle GHG emission rate of 464 t/GWh for a gas turbine (Meier & Kulcinski, 2000) and a 75% capacity factor, these stations would generate 1,971 GWh of energy and release 915 kt of emissions per year. This would be almost 2.5 times the 2006 emissions of 377 kt of the entire Yukon. It is also estimated this project would increase the Yukon's GDP by approximately 25% during its first three years of operation (McCracken, 2002).

With the above information an estimate of Yukon's growth in emissions under several scenarios and growth assumptions can be made.

Table 5.3 shows the two methods we used to estimate future emissions. One method is to use the population forecast with the 2006 emissions per capita as a multiplier. This method estimates low emissions due to the fact that growth in the private sector emissions is not as closely tied to population growth. The best example of this is the AHPP forecast in which emissions are increased by 250% and yet the population increase is forecast to be 0.6%. The second method is to use the forecast growth in public and private sector spending and the 2006 emissions per GDP as a multiplier. This seems to yield reasonable answers except for the AHPP where the forecast growth in GDP for Yukon is 25% yet the forecast increase in emissions in 250%. The final forecast is therefore made using GDP growth except for the high with AHPP scenario in which the 915 kt emissions were simply added to the high scenario emissions.

Table 5.3 Forecast Growth in Yukon GHG Emissions by 2020

	Low	Medium	High	AHPP
2006 GDP ($B)	1.622	1.622	1.622	1.622
2006 Government GDP	1.026	1.026	1.026	1.026
2006 Private Sector GDP	0.596	0.596	0.596	0.596
2020 Government growth using population change	1.022	1.151	1.288	N/A
2020 Government GDP growth (%)	-0.4%	12.2%	25.5%	
2020 Private sector growth using power change	0.652	0.782	0.875	N/A
2020 Private sector GDP growth (%)	9.4%	31.3%	46.9%	
2020 Yukon total GDP ($B)[1]	1.674	1.934	2.163	2.704
2020 Yukon total GDP growth (%)	3.2%	19.2%	33.4%	66.7%
2006 GHG Emissions (kt)	377	377	377	377
2006 Population	31,608	31,608	31,608	31,608
2006 GHG Emissions per Capita (tonnes/person)	11.93	11.93	11.93	11.93
2006 GHG Emissions per GDP (Mt/$B)	0.232	0.232	0.232	0.232
2020 Yukon Population forecast[2]	31,476	35,470	39,672	39,910
2020 Yukon Population growth (%)	-0.4%	12.2%	25.5%	26.3%
2020 GHG Emissions using GDP growth	389	449	503	628
2020 GHG Emissions using population growth	375	423	473	476
2020 Adjusted GHG Emissions using GDP and AHPP[3]	389	449	503	1,418
2020 GHG Emission change from 2006 (kt)	12	72	126	1,041
2020 GHG Emission % change from 2006	3.2%	19.2%	33.4%	276.1%

1 Yukon increase in GDP due to AHPP estimated at 25% by McCracken (2002, p 14/15)

2 Yukon population forecast to increase by less than 0.6% due to AHPP by McCracken (2002, p 15)

3 Emission forecast using GDP growth except for AHPP impact. Due to the fact it is a very energy intensive project, its 915 kt emissions are directly added.

As shown in Table 5.3 Yukon's emissions were 377 kt in 2006. By 2020, in the business-as-usual forecast, this is forecast to increase to 389, 449, 503 and 1418 kt in the low, medium, high and AHPP growth scenarios respectively. Note that the business as usual forecast growth in emissions is considerable from 2006 to 2020. ***The forecast growth by 2020 in emissions from 2006 levels will have to be eliminated or offset in addition to the 20% reduction required from 2006 levels*****.**

A 20% reduction of 2006 emissions is 75 kt or a reduction from 377 kt to 302 kt per year. Table 5.4 shows the magnitude of emissions reductions required under the four growth scenarios to achieve a reduction to the same level of emissions by 2020. These range from reductions of 22.5% up to 78.7%, or from 87 kt up to 1,116 kt of emissions.

Table 5.4 GHG Reductions Required by 2020 in Yukon in Various Growth Scenarios

	Low	Medium	High	AHPP
2006 GHG Emissions (kt)	377	377	377	377
20% reduction from 2006 (kt)	302	302	302	302
2020 Forecast GHG Emissions (kt)	388	447	500	1,415
2020 Electricity Sector	65	75	84	915
2020 Heating Sector	63	72	81	81
2020 Transportation Sector	256	295	330	330
Reduction Required by 2020 (kt)	87	146	198	1,113
Reduction Required by 2020 (%)	22.3%	32.6%	39.6%	78.7%
2020 Electricity Sector Reduction (kt)	15	25	33	720
2020 Heating Sector Reduction (kt)	14	24	32	64
2020 Transportation Section Reduction (kt)	57	96	131	259

Using the premise that the most likely forecast is the medium growth scenario, ***the emission reduction target is actually 146 kt of emissions from the status quo forecast, almost double the 75 kt GHG emission reduction required from 2006 emission levels***. The other scenarios are not discussed further except to identify the challenge in further reductions needed to offset economic growth, in particular with major projects such as AHPP.

Table 5.4 breaks down 146 kt emission reductions target by sector. This can be done by using each sector's contribution to the 2006 total Yukon emissions from energy:

- Electricity and heating sectors accounted for 33% which would be a 49 kt GHG emission reduction target. By knowing the medium forecast for diesel electricity generation of 36 GWh one can convert this emissions using a life cycle emission rate of 700 tonnes per GWh for stationary diesel–electric generation. This works out to an electricity forecast of 25 kt, leaving the balance of 24 kt of emissions for heating use.
- Transportation sector accounted for 66% which would be 98 kt GHG emission reductions.

The remaining 1% is from fugitive emissions which will be ignored as it is not significant.

6.0 Yukon Government Current Emission Reduction Actions

In this section, Yukon Government policy and programs that are in place to reduce or eliminate emissions are reviewed. We then examine government regulations and the newly released Yukon Climate Change Action Plan.

In the heating sector, the government has implemented several programs designed to reduce heating requirements (Yukon Housing Corporation, 2009)

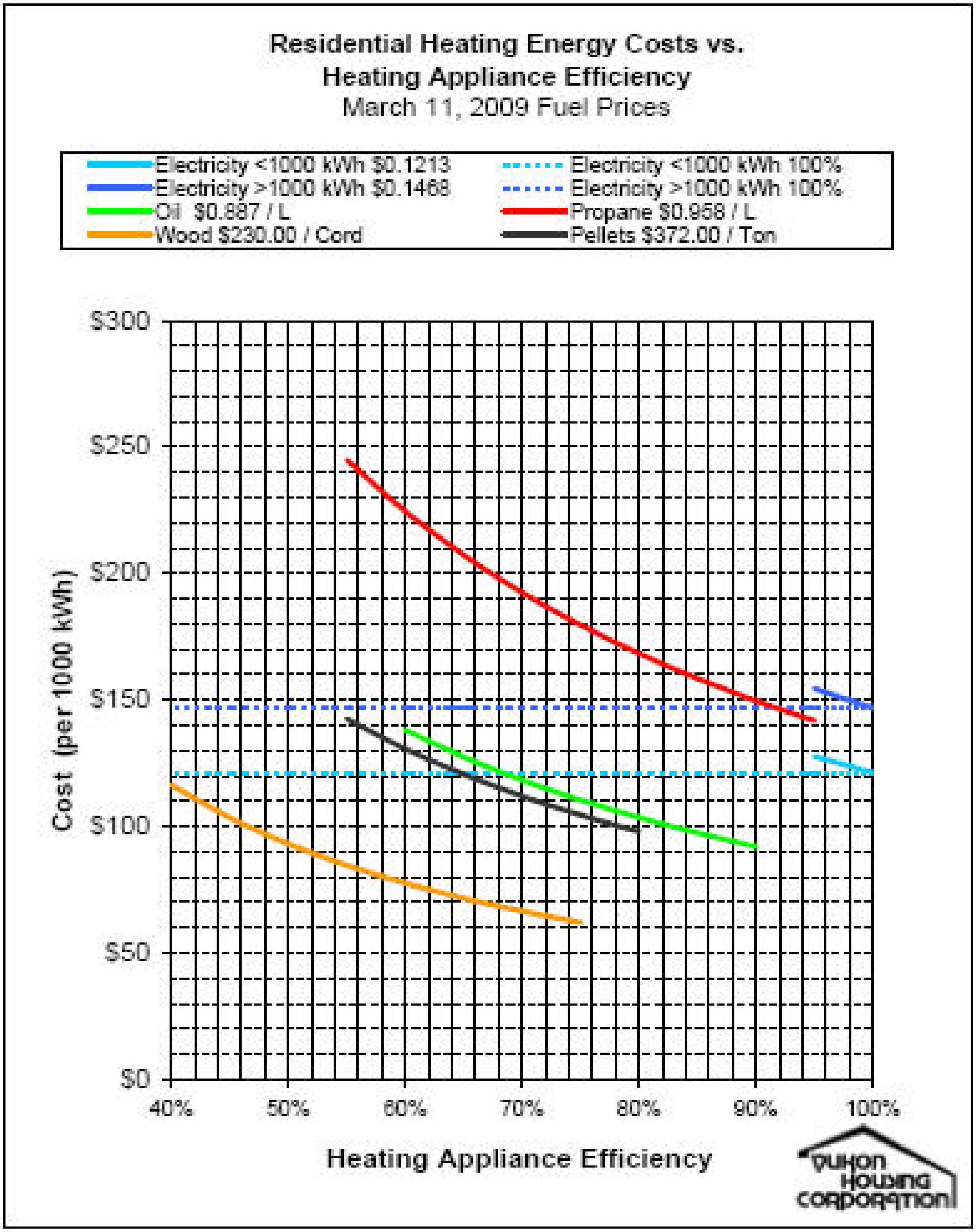
- Yukon Housing Corporation (YHC) GreenHome Certification Program involving a reduced interest rate mortgage up to $360,000 with a 5% minimum down payment. The house must meet an EnerGuide energy rating of at least 80 and pass an air leakage test.
- YHC Home Repair Enhancement Program involving reduced interest loans for qualified repairs such as building insulation and vapour barrier upgrades, energy efficient windows, heating and ventilation systems.
- YHC EnerGuide for Houses Programs involving subsidized home energy audits.

The Yukon's Department of Energy, Mines and Resources (EMR) administers energy efficiency related programs involving the heating and electricity sector called the Good Energy Rebate Program (EMR, 2009) that offers:

1. Rebates of up to $200 for Energy Star rated home electrical appliances such as refrigerators, freezers, washers and dryers. There are two rebate levels, the higher rebate is offered in Yukon communities that are on local diesel power. If the purchaser is replacing an older appliance, it must be disposed of, thereby ensuring a net reduction of electricity use.
2. Rebates of up to $500 for energy efficient heating appliances such as wood pellet, oil furnaces/boilers and propane furnaces/boilers, 90% or higher efficiency required for the highest rebate level.
3. Rebates of up to $500 for solar hot water heating systems and $100 for a drain water heat recovery system.
4. Rebates of up to $500 for outboard motors that have a California Air Resources Board (CARB) 3 star rating.

In the electricity sector, the electrical rates for residential and small business use inverted block or increasing block based rates where customers pay a higher energy charge when they use more. There are two energy blocks. The first block is an equalized rate throughout the territory and is for energy use up to 1,000 kWh per month for residential customers and up to 2,000 kWh per month for small business customers. This rate design is intended to reduce customer energy use by price elasticity caused by the higher price for the second block use (Hughes, 2004). Due to the current cross-subsidization of residential and small rates by government class customers and a further rate subsidy on the first block, electricity remains one of the cheapest energy sources for heating in Yukon except for wood. Fig 1 shows the Whitehorse residential heating costs for the fuels types available. Electricity was less expensive than the home heating oils and propane for most of 2008 with the spike in oil prices. The recent return of crude oil to the USD $40-60 per bbl in reflected in cheaper heat from oil. Heating by wood remains the cheapest even delivered to your door at $230/cord.

Figure 1 March 2009 Residential Heating Fuel Cost in Whitehorse (YHC, 2009)



The Yukon government has taken several positive steps in reducing emissions in the electricity sector in the past 10 years:

1. In 2003, Yukon Energy, a wholly owned subsidiary of a Yukon crown corporation, completed a 223 km transmission line connecting Dawson City and Stewart Crossing to a hydro grid. This displaces 10 kt of emissions annually from local community based diesel generators.

2. In 2008, YE completed a 100 km transmission line to Pelly Crossing and a 28 km distribution line to the Minto copper mine from its Whitehorse area hydro grid, displacing a further 23 kt of emissions annually from local diesel generators. The Yukon Government made a $10M contribution to this project.

In the transportation sector, no significant actions have been taken to reduce emissions.

The Yukon's current air emission legislation and regulations do not restrict or eliminate emissions unless there is also a direct linkage to public health risks caused by small particulate emissions or sulphur emissions from wood smoke and stationary diesel use.

In January 2009 the Yukon Government released its Energy Strategy for Yukon (EMR, 2009) calling for 20% increase in energy efficiency and 20% increase in renewable energy use in Yukon by 2020. Appendix B contains a summary of the Energy Plan vision, principles and priority actions.

In February 2009, the Yukon Government released the Yukon Government Climate Change Action Plan (Environment Yukon, 2009) calling for a wide range of activities to reduce internal government emissions by 20% by 2015 and become carbon neutral by 2020. It also commits to setting up a climate change secretariat within government to ensure the government's internal department climate change programs are implemented and monitored for their performance. Appendix C lists the government's climate change action plans.

7.0 Factors Inhibiting Emission Reductions in Yukon

There are a number of factors inhibiting reducing emissions in Yukon today:

1. The current trend of falling emissions is misleading and reduces the perceived need, urgency and value of taking action now.
2. The biggest source of emissions is the transportation sector, which may be the most difficult and costly to reduce. A lack of a rail system and long distances to/from other markets make it expensive and fossil fuel intensive to ship products in and out of the Yukon. Transportation and heating fuels must be trucked in to the Yukon, thereby increasing their carbon footprint because they must be transported considerable distances to the Yukon retail market before they are used.
3. Tourism is a major economic player in Yukon and depends on fossil fuels to get their customers to the Yukon by air and ground transportation. Once in the Yukon tourists often travel to their Yukon destination by float plane, bus or boat, consuming additional fossil fuels. Much of the Yukon's tourism business has an eco-tourism focus, so customers may be willing to pay a little more for their experience if they know it will reduce emissions and global warming. The rubber–tire based tourism traffic, primarily Americans going north to Alaska, may not be so willing to pay and we may see some price elasticity causing a reduction of this traffic.

4. New mines are significant energy users in Yukon due to their relative size (compared to Yukon as a jurisdiction) and energy use intensity due to the need to process the product to a higher concentrate level to make it economic to transport to the market using trucks, rather than by rail or water. Mining in the Yukon historically has been the biggest economic stimulator thus this sector has significant lobbying power in Yukon.
5. Lack of legislation on carbon use fees, GHG emission offsets or other means of restricting, penalizing or charging for emissions makes it difficult to assign a value to the reduction or elimination of emissions.
6. Lack of cost-of-service based electric rates for non-government residential and small business sends an inefficient price signaling for electricity use. For the ten year period from 1994 to 2003 there was a steady decrease in the average annual usage per residential customer in Whitehorse from 11,842 kWh to 10,377, a decrease of 12%. From 2004 to 2007 there has been a slight increase back to 10,472 kWh. From 1994 to 2007 the average annual usage for small business has grown from 63,951 kWh to 67,572, an increase of 6% (Yukon Utilities Board, 2008, sect 2).
7. Lack of competition in the electricity sector. There are only two firms in the industry, one has about 15,000 or 90% of customers with the other serving the balance of 1700 or 10% of customers. Using the Herfindahl Index (HHI) as a measure of competition in the industry, the HHI is $0.9^2 + 0.1^2 = 0.82$ which is several times the typical threshold of 0.18 used to determine acceptable competition levels in industry. The industry currently has regulated monopolies by geographical areas as defined in a Yukon Government 1987 Order-In Council (YG, 1987). There is a high cost of entry as the industry is very capital intensive and a high cost of regulation as it is a fully regulated jurisdiction with less than 20,000 customers. There is a lack of government policy in the electricity sector. The combination of these factors has led to little innovation in this sector. There are no Independent Power Producers selling renewable energy displacing electrical grid diesel generation.
8. In the heating sector, there is some competition between heating fuel and propane but with propane only having a 5% market share and with it being the highest cost heating option at present, they are not likely to increase their market share based on a 14% improvement in emissions. Wood heat is expected to remain the least expensive option but is unlikely to attract other consumers as it is labour intensive and does emit particulates that are a health concern. Electricity could become a major market force based on its current clean source of power being 98% hydro.
9. In the transportation sector there are few options for heavy hauling of goods. There are consumer options for light vehicle use such as non-powered and public transportation for commuting in the larger urban centers such as Whitehorse.

8.0 Factors Aiding Emission Reductions in Yukon

There are a number of factors that are or could aid in reducing emissions in Yukon today:

1. Current surplus of hydro based electricity, of which approximately 20 GWh per year is being used to displace fossil fuel heating use on an interruptible basis. It is priced at two thirds of the avoided cost of using home heating fuel and is available whenever surplus hydro power is available. Customers are required to maintain a backup heating system which would be used when surplus hydro is not available. This program is reducing emissions by approximately 6 kt per year based on 80% efficient home heating fuel systems being displaced.
2. Potential future development of hydro and geothermal to displace fossil fuel use for electricity production, heating and transportation (electric vehicles). Yukon Energy is currently assessing a number of hydro developments involving enhancements to existing hydro facilities, new green field hydro developments and is exploring potential high temperature geothermal sites in Yukon for electric power generation.
3. Hot water aquifers exist under many Yukon communities with potential for district heating. Use of heat pump technology to use this untapped resource is under assessment (EMR, 2008).
4. Potential future development of local natural gas to displace diesel, home heating fuel and propane.
5. There are significant volumes of fire killed and spruce beetle killed trees in Yukon.

9.0 Other Jurisdictions Action Plans

In this section, emission reduction plans and actions of other Canadian jurisdictions are examined.

Other Canadian provinces and territories are being more proactive than Yukon. In the Federal Government's “Turning the Corner” climate change plan update released in March 2008, a list of provincial and territorial GHG emission reduction programs is contained in the section on detailed emissions and economic modeling (Environment Canada, 2008).

Some jurisdictions are more advanced than Yukon in developing and implementing their emission reduction plans. BC, Alberta, Saskatchewan and Quebec will be reviewed as they each have specific plans that show leadership in this area. The Northwest Territories recent focus on wood pellets for heating use will also be reviewed as it may be applicable to Yukon.

British Columbia

BC has shown considerable leadership in its plans to reduce its emissions 33% below 2007 levels by 2020. Key features of its plans include:

- Phasing in a revenue neutral carbon tax starting at $10 per tonne of carbon in 2008, increasing by $5 per tonne per year to $30 per tonne by 2012. Figure 2 shows the five year phase in of BC carbon taxes being applied to the different types of carbon based fuels (BC Ministry of Small Business and Revenue, 2009). The carbon tax rates reflect the different carbon content or footprint of the different fuel types. The use of a revenue neutral pollution tax at a time in Canada where emission trading was seen as the favoured system demonstrates leadership. The 2008 concept behind the revenue neutral aspect was that two thirds of the carbon tax would be paid by suppliers and one third by consumers and the tax refunds would be distributed on the basis of one third to suppliers and two thirds to consumers. In theory, the carbon tax revenues would be redistributed to those consumers that would be either most affected or least able to pay their share of the carbon tax. As tax refunds occur retroactively, up to 18 months after taxes are paid, the government also gave all consumers a $100 carbon tax "dividend" or rebate up front when the tax was implemented in July of 2008. So how has BC chosen to redistribute the carbon tax revenue? At the time the tax was being implemented, the BC government announced fours areas of personal tax reductions:
    1. A climate action tax credit of $100 per adult and $30 per child per year to assist low income families and individuals.
    2. A 2% reduction of provincial income tax on the two lowest tax brackets.
    3. A reduction in general corporate tax from 12% to 11%.
    4. A reduction in small business corporate income tax from 4.5% to 3.5%.

  In February of 2009 the BC government announced their 2009 carbon tax would generate $2.27B over three years and pay out $2.5B, broken down to $1.25B for businesses and $1.25B for individuals. In less than one year from its implementation date, the tax is no longer revenue neutral (it is paying out more than the revenue collected) and businesses are getting 50% of the tax breaks, up from 33% and individuals are getting 50%, down from 66% (BC, 2009).
- In the electricity sector, all electricity in BC on their integrated grid must have net-zero emissions by 2016. This will be easier for BC to achieve with their high hydro generation component but their use of thermal generation (1043 MW of natural gas at Burrard, Ft Nelson and Prince Rupert) will require action.
- In the transportation sector, new tailpipe emission standards will reduce emissions from automobiles by 30% by 2016. This policy is based on the California model which auto manufactures will certainly attempt to meet.
- In the housing sector, implementation of new building standards by 2010 is expected to reduce energy use by between 14 and 37%.
- Implementing a 10% carbon reduction in fuels by 2020 and 5% renewable fuel standard for diesel by 2010. This is a conservative target that can be easily met.
- Government has committed its internal operations to be carbon neutral by 2010.
- Government has joined the Western Climate Initiative (WCI) in 2007 which includes a regional cap and trade mechanism. This may be problematic as there

may be a conflict in BC's pollution tax versus the WCI's cap-and trade plan to reduce emissions.

Figure 2 BC Carbon Tax Rates from 2008 to 2012

Ministry of Small Business and Revenue

BRITISH COLUMBIA
The Best Place on Earth

www.gov.bc.ca/sbr June 20, 2008

Carbon Tax Rates by Fuel Type						
	Units for Tax Rates	July 1 2008	July 1 2009	July 1 2010	July 1 2011	July 1 2012
Liquid Fuels						
Gasoline	¢/Litre	2.34	3.51	4.68	5.85	7.02
Light Fuel Oil *	¢/Litre	2.69	4.04	5.38	6.73	8.07
Heavy Fuel Oil	¢/Litre	3.15	4.73	6.30	7.88	9.45
Aviation Fuel	¢/Litre	2.46	3.69	4.92	6.15	7.38
Jet Fuel	¢/Litre	2.61	3.92	5.22	6.53	7.83
Kerosene	¢/Litre	2.54	3.81	5.08	6.35	7.62
Naphtha	¢/Litre	2.55	3.83	5.10	6.38	7.65
Methanol	¢/Litre	1.09	1.64	2.18	2.73	3.27
Gaseous Fuel						
Marketable Natural Gas	¢/GJ** or ¢/M^3 ***	49.66 1.90	74.49 2.85	99.32 3.80	124.15 4.75	148.98 5.70
Raw Natural Gas	¢/M^3 ***	1.90	2.85	3.80	4.75	5.70
Propane	¢/Litre	1.54	2.31	3.08	3.85	4.62
Butane	¢/Litre	1.76	2.64	3.52	4.40	5.28
Ethane	¢/Litre	0.98	1.47	1.96	2.45	2.94
Refinery Gas	¢/M^3***	1.76	2.64	3.52	4.40	5.28
Coke Oven Gas	¢/M^3***	1.61	2.42	3.22	4.03	4.83
Solid Fuels						
Low Heat Value Coal	$/Tonne	17.77	26.66	35.54	44.43	53.31
High Heat Value Coal	$/Tonne	20.77	31.16	41.54	51.93	62.31
Coke	$/Tonne	24.87	37.31	49.74	62.18	74.61
Petroleum Coke	¢/Litre	3.67	5.51	7.34	9.18	11.01
Combustibles						
Tires – shredded	$/Tonne	23.91	35.87	47.82	59.78	71.73
Tires - whole tires	$/Tonne	20.80	31.20	41.60	52.00	62.40
Peat	$/Tonne	10.22	15.33	20.44	25.55	30.66

* Light fuel oil – subcategories of light fuel oil include:

- diesel,
- locomotive fuel, and
- heating oil.

** GJ = Gigajoule

*** M^3 = cubic meters

Alberta

Alberta introduced legislation in 2007 to reduce its business-as-usual emissions by 20 Mt by 2010 and 60 Mt by 2020 and a 50% reduction by 2050 using:

- Corporate in-house reductions.
- Contributing to the Albertan technology fund at $15/t.
- Contributing to an Alberta offset project.
- Increasing in provincial electricity portfolio of renewable energy to 12.5% by 2008 and 20% by 2020.
- Creating a Renewable Energy and Energy Efficiency Revolving Fund with a goal of achieving a 25% reduction in energy consumption of fossil fuels within 5 years.
- Going to minimum 5% ethanol content in gasoline/diesel fuel by 2010.
- Requiring all new coal–fired power stations must have GHG emission levels equal to a combined cycle gas turbine.

Saskatchewan

Saskatchewan has committed to a 32% reduction in 2004 emissions by 2020 and 80% reduction by 2050 through:

- Ensuring all new electrical generating facilities are GHG-free or fully offset by emission credits.
- Development of an energy conservation program to reduce the provincial electrical loads by 300 MW by 2017.
- A minimum of 1% ethanol content in unleaded gasoline in 2005, increasing to 7.5% in 2007 and working with industry to move to E85 standard (up to 85% ethanol).
- Encourage establishment of agricultural soil sinks.
- Climate change education to be funded starting at $2M.
- Government commitment to 30% improvement in energy efficiency in all new government buildings.

Quebec

Quebec has committed to reduce its 1990 GHG emissions by 6% by 2012 through:

- Establishing a carbon tax based on the amount of carbon dioxide each fuel produces. Starting October 2007, the tax on gasoline and diesel was just under 1 cent per litre.
- Requiring up to 4,000 MW of wind energy by 2015 and 4500 MW of new hydro – electric projects.
- Requiring all new commercial and industrial buildings to use 25% less energy by 2008.
- Using 60% of revenues from carbon tax to develop public transportation.
- Requiring a minimum of 5% ethanol in gasoline and 20% improvement in vehicle fuel efficiency by 2012. Giving a tax exemption of $1,000 for purchase of a new hybrid vehicle.

North West Territories
NWT has recently been in the media with their plans to utilize wood pellet heating systems as a means of reducing emissions and reducing their heating costs. In early 2009 they announced the formation of the NWT Wood Pellet Committee with a mandate to "increase the use of wood pellets for space heating… as a replacement for fossil fuels" (NWT, 2009).

10.0 Alternatives to Fossil Fuel Use in Yukon

In this section, we look at fossil fuels in use in Yukon today and the size of their carbon footprint. We then consider alternatives that have smaller or no carbon footprint. Finally we discuss the energy conservation option.

Each fossil fuel has its own carbon footprint. Table 10.1 contains a list of the carbon content, energy content and CO2 emissions per unit energy of common fossil fuels used in Yukon, taken from a more comprehensive list from the U.S. Government's Environmental Information Administration (EIA, 2000).

Table 10.1 CO_2 Emissions for Common Fossil Fuels used in Yukon

Fossil Fuel Type	GHG Emissions lbs/M Btu	GHG Emissions Ranking (Coal=100)
Bituminous coal	205.3	100.0%
Diesel/home heating fuel	161.4	78.6%
Kerosene	159.5	77.7%
Jet fuel	157.3	76.6%
Gasoline	156.4	76.2%
Av Gas	152.7	74.4%
Propane	139.2	67.8%
Natural Gas	117.1	57.0%

Using "King" Coal as a benchmark the right hand column in Table 10.1 shows the relative emissions of common Yukon fuels compared to bituminous coal which is the type of coal found at the Yukon's most well-known coal deposit at Division Mountain. This deposit is located about 90 km north of Whitehorse. Diesel fuel generates only 78.6% of the emissions from coal. Natural gas generates only 57% of the emissions of coal, making it the cleanest of the common fossil fuels in use today.

Ethanol and Bio-Diesel
With the transportation sector contributing the overwhelming percentage (63%) of Yukon emissions in 2006, actions to reduce this sector's emissions are paramount to the Yukon being able to meet its emission reduction targets. Increased use of ethanol and bio-diesel are alternatives to continued use of unleaded gasoline and conventional

diesel fuel. These two fuels are made from biomass. Ethanol is actually ethyl alcohol. It is currently made commercially from grains, most commonly corn and sugar cane. It is controversial at present due to the arable land it takes to grow, its displacement of corn as a food crop, the energy it consumes and the pollution it generates in its production.

Ethanol made from cellulose fibers is in the research and development stage. Cellulose fibers are in many agricultural products and considered waste materials. They are also contained in wood, which the Yukon has in abundance compared to its population, and native grasses. Many jurisdictions are already moving to E10 ethanol/gasoline which is a blend of 10% ethanol and 90% unleaded gasoline. According to Natural Resources Canada, use of E10 fuel reduces emissions by up to 4% if made from grain and up to 8% if made from cellulose fibers. Work is underway in the development of flex-fuel vehicles, called FFVs, which are capable of burning ethanol and gasoline mixtures of up to 85% ethanol (called E85). Use of this fuel is estimated to reduce emissions by up to 35%. Bio-diesel is a biodegradable fuel made up of alkyl esters from the transesterification of vegetable oil, waste cooking oil, animal fat or fish oil (House-Energy, 2009). It can also be extracted directly from vegetable seeds such as rapeseed, corn or safflower. Bio-diesel can reduce emissions by more than 65% compared to conventional diesel fuel and can be used in diesel engines built after 1994. Up to 5% bio-diesel blends are commonly accepted today by North American diesel engine manufacturers (Natural Resources Canada, 2008). Potential local sources of cellulostic ethanol are spruce beetle killed wood in the Haines Junction area. This resource of standing dead wood is estimated to be up to 30 million cubic metres. Fire killed trees are also prevalent in Yukon, with up to 200 hectares of fire killed trees generated annually from forest fires. There are no significant local sources of bio-diesel available today in Yukon.

Natural Gas

There are two potential sources of natural gas for Yukon consumption. The development of the AHPP would bring Alaska North Slope natural gas to Yukon along the Alaska Highway. The other potential is development of one or more of the eight natural gas basins in Yukon. These have an estimated potential of 17,111 Bcf as identified in the Yukon's Energy Strategy (EMR, 2009). Of interest is the Whitehorse Trough that is located in close proximity to Whitehorse and the major hydro electric grid. Natural gas is a well proven fuel substitute for diesel and home heating fuel use and would reduce emissions by 27% in heating and diesel electric generation. Natural gas exploratory drilling has indicated the gas is sweet and would require very little processing for pipeline quality.

Local Oil

The gas basins mentioned in 7.3.2 also have a potential of 772 MMbbls of oil that could be developed and refined to produce local diesel, home heating fuel and gasoline, displacing the GHG emissions related to transporting these fuels to Yukon. A refinery would be required in Yukon to make use of the local oil.

Local Wood
In general, trees grow slowly due to the semi-arid weather, cooler climate and thin layer of top-soil in much of the Yukon. There are little to no hardwood species indigenous to Yukon. The prevalent software species are white spruce and fir in the dryer/higher elevation areas of Yukon, with black spruce in the boggy areas. Aspen and willows are the most common lower heating value species. Historically tree farming and logging has not been competitive with Alberta and B.C. due to the slow tree growth rates in Yukon. The large geographic areas and low population density mean that forest fires are often left to burn naturally, resulting with large areas of fire killed wood. There is a major spruce beetle infestation near Haines Junction, about 90 km west of Whitehorse that is a potential source of biomass. These two sources of local biomass material have the potential to be used for feedstock for:

- Residential /commercial fire wood as logs.
- Residential commercial heating as wood pellets or wood chips.
- Bio-mass district heating plant.
- Bio-mass electricity generation or combination of heat/electricity.
- Celluostic ethanol production.

Use of wood for heat and energy is considered zero emissions if it is sustainable. In Yukon, due to the short growing season, the use of standing dead wood or other waste wood products is regarded as the only potential local source of sustainable wood products.

Geothermal
Energy from below the earth’s surface can be utilized to produce energy for heating, cooling and power generation purposes. The difference in subsurface temperatures to surface and air temperatures can be used to generate energy using ground source heat pump technology (GSHP). Deeper, geological formation may yield considerably hotter temperatures of the rock and water at depths up to four km that can potentially be used to generate electricity. There are several well known hot springs in Yukon such as the Takhini Hot Springs and MacCarther Hot Springs. This is not surprising as the Yukon is part of the Pacific Rim of Fire, a rim of volcanoes and high earthquake activity surrounding the Pacific Ocean (World Geography Research Guide, 2009).

A survey of hot water aquifers under Yukon communities was done in 2003 by the Yukon Government that confirmed the presence of water up to 15 Deg Celsius under many Yukon communities (EMR, 2003). This means that there is potential to provide district heat in these communities using conventional ground source heat pump technology. In 2003 Yukon Energy began heating its salmon fish hatchery in Whitehorse using a heat pump connected to its warm water well (water temp of 6 Deg C) and was able to disconnect its propane heating system altogether (Yukon Energy, 2009).

In 2008 Yukon Energy began an assessment of deeper and hotter geothermal resources in Yukon. On January 12, 2009 David Morrison, the President and CEO of

Yukon Energy, discussed the potential of up to 1,500 MW of geothermal power generation in Yukon in an interview with CBC (CBC, 2009).

Electricity

Electricity is known as a secondary energy source which means it is converted from other sources of energy like coal, natural gas, oil, nuclear, biomass, wind, geothermal or hydraulic sources. These are called primary energy sources. These sources can be renewable or non-renewable but electricity itself, as a secondary energy source, is neither renewable nor non-renewable (EIA, 2007). This is an important distinction as electricity, as are other forms of secondary energy, is assigned the environmental attributes of its primary energy source. Many consumers do not realize this and assume electricity is clean because its end use is clean. This is the reason why different jurisdictions and countries assign different emission values to their grid power.

In 2006, 94% of the Yukon's electricity needs came from renewable energy, with the exception of the five Yukon communities too far from the hydro grid to be connected economically. These communities are currently on full-time diesel. As identified in Yukon Energy's 20-year Resource Plan (from 2006 to 2025), there are a number of potential renewable energy projects in various stages of planning and development to continue utilizing high capital and low operating cost renewable energy. Essentially all the electricity on the Territory's two hydro grids come from renewable hydro and wind energy and have zero emissions. The electricity within the five Yukon communities on local diesel generation emits approximately 700 t of emissions per GWh of electricity generated. If no further renewable energy projects are built as was the case in the 1990's in Yukon, the default power source is diesel generation. Western Copper, in their recent pre-feasibility study for their Casino copper/gold/molybdenum property (located 300 km northwest of Whitehorse), have proposed shipping in coal by boat and truck for a coal-fired generator located at their mine site as a cheaper alternative to diesel. Their power requirements are large for diesel generation, up to 100 MW and require up to 650 GWh of electricity annually (Western Copper, 2008). This would emit 455 kt of emissions from diesel (at 700 t per GWh) or a whopping 578 kt from coal (a 27% higher emission rate than diesel).

There are currently no plans to displace the 6% diesel currently being used to supply the five isolated communities on diesel generation.

Yukon Energy is currently in the planning and development stage of a number of renewable energy projects that were identified in their 20-year resource plan:

- Mayo B, a 10 MW addition to the existing hydro facility at Mayo. This would triple the capacity and double the energy output of the existing plant. It would add up to 40 GWh per year of renewable energy at an estimated cost of $120M and could be in service by 2012. This project is currently under environmental assessment by YESAB, the Yukon's environmental assessment agency.
- Atlin River Storage, a modest regulating structure on the Atlin River that would regulate the flow of water out of Atlin Lake in the fall and winter into the Yukon River, resulting with up to an additional 18 GWh per year of winter energy

production from Yukon Energy's existing hydro facility in Whitehorse with no changes required to that facility. Environmental baseline data collection and preliminary engineering are scheduled to start in 2009.

- Gladstone Creek Diversion, a small diversion of a creek into an existing hydro-electric facility. This project would add up to 18 GWh of winter energy production with no changes required to the generating facility. Environmental baseline data collection began in 2008 with preliminary engineering scheduled to start in 2009.
- Marsh Lake Fall Storage. This would require an amendment to the Whitehorse Hydro facility's water licence to allow an additional 0.3 meters of water to be stored in Marsh Lake. This would provide up to 8 GWh a year of winter energy production at the Whitehorse Hydro plant with no changes needed to that facility. Planning work is scheduled to start in 2009.
- Aishihik Third Turbine, a new turbine addition to the existing 30 MW hydro station that would add 7 MW of capacity and up to 5 GWh per year of renewable energy. This project is already underway with a $5M funding from the Yukon and Federal Governments with an in-service date expected in 2011.
- Carmacks-Stewart Stage 2 Transmission Project, a 138 kV transmission line 74 km long, running from Pelly Crossing to Stewart Crossing. This would complete the connection of the two hydro grids in Yukon. Stage one of this project was completed in 2007. This project is expected to cost between $40M and $50M. It would allow hydro energy to flow from any of the three hydro plants and the future additions mentioned above to wherever the energy was required on both grids.
- Larger hydro pre-feasibility studies – long term engineering and environmental assessment of hydro options in the 20-40 MW and 150-275 GWh per year production size on the upper reaches of the Pelly River, one of the main tributaries of the Yukon River.

One possible future use of electricity is for transportation. The concept of electric or plug-in SUV's is under development by most of the major auto makers. Historically, electric cars were thought to be viable only if they met the following criteria:

1. Their performance was on par with gasoline cars
2. Their shape/styling was comparable
3. They could get 400 km between recharges
4. Their purchase price was competitive with gas cars

Automakers have been able to meet most of these criteria with gas/electric hybrid vehicles but the conventional battery energy storage technology is proving to be expensive, heavy, bulky and is stalling the commercial development of an all-electric vehicle. There are several low cost, low performance electric vehicles currently on the market outside of Canada. One Canadian manufacturer of an electric vehicle called Zenn Motor Company, based in Quebec, manufactures a low speed electric utility vehicle. They are banking on the development of a new form of energy storage called an ultra capacitor, based on the technology used to recycle photography flashes. This technology is under development by a company in Texas called EEStor with a target of a five minute charge being able to power a vehicle for up to 400 km between charges (Nikiforuk, 2009).

Hydrogen
Hydrogen is considered secondary energy as it can rarely be collected in its natural state but is a byproduct of various hydro carbon processes and can be separated from water through electrolysis. It is often considered to be a very green fuel, but like electricity, it is only as green as the attributes of its primary energy source. Consumers are easily misled by the fact that it can be burned or converted chemically to produce heat or electrical energy with the only byproducts being water. Conversion of water to hydrogen by conventional electrolysis is only about 67% efficient. To store hydrogen efficiently requires compressing or cooling it to its liquid state which is very energy intensive. There are ongoing developments with hydrogen gas storage at near room temperatures using carbon nano-fibers and metal hydrides.

Inexpensive power is a prerequisite for generating hydrogen using electrolysis. In 2000 Yukon Energy conducted a study on the potential for developing a hydrogen economy in Yukon using the abundant surplus hydro power available at that time due the closure of the Faro lead/zinc mine in 1998. The concept that interested the power company was the potential to truck hydrogen along Yukon's highways to generate power in the isolated communities as an economic alternative to building expensive and long transmission lines to connect these communities to the hydro grids. The technology was readily available to convert the stationary diesel generators to run on pure hydrogen until larger stationary fuel cells were available on a commercial basis. The shortcoming in 2000 was the high cost to store and transport the hydrogen. To a large extent the same shortcomings still exist today. Stationary commercial fuel cells in the 200 kW and larger size are still in the developmental stage today. The hurdle with development of a hydrogen economy for transportation use is the lack of distribution infrastructure. California is a grim reminder of a major jurisdiction that has failed to implement a hydrogen economy despite very significant and costly attempts spanning decades.

In 2007 YG conducted a study on a wide variety of energy strategies in use by other jurisdictions in Canada as part of its efforts to develop its own energy strategy. The report listed only minor efforts by BC and PEI towards developing hydrogen as a viable fuel source (Kishchuk, 2007). In BC's case this is a clear link to their close relationship with California and their attempt to develop a hydrogen economy. PEI's efforts are specifically focused to broaden their wind development work into a hybrid system that uses hydrogen as a secondary energy that is produced by electrolysis when there is more wind energy than can be used by the grid. The hydrogen is used to generate electricity when there is insufficient wind to meet the grid demand using a fuel cell or converted diesel generator. Neither jurisdiction has hydrogen as a primary element of their energy strategy.

Energy Conservation
Energy conservation has been described as the practice of decreasing the quantity of energy used while achieving a similar outcome of end use. The following areas should be considered for the application of energy conservation practices:

- Improvements in building insulation and building envelopes as the Yukon has a range of heating degree days (HHD) per year of between 6811 in Whitehorse up to 9761 in Old Crow. This is well above the national average of 4500 HHD (Natural Resources Canada, 2009).
- Improvements in appliances that use less electricity.
- Improvement in fossil fuel heating systems that are more fuel efficient.
- Improvement in vehicle fuel efficiencies.
- Lifestyle changes that reduce use of fossil fuels such as riding public transit, car pooling, walking or bicycle use.
- Lowering thermostats during periods of non-occupancy, during the day at home, during the weekend at work.

Reduced consumption of electricity may not reduce emissions directly but if the electricity can be redeployed to reduce emissions as a result, this becomes a benefit. In Yukon the electrical grid peaks in the wintertime due to the reduced daylight and use of electrical appliances. The peak periods are typically during the weekdays between 8 and 9 am and between 6 and 7 pm. As electrical loads grow, so does the peak demand. In the Yukon the hydro grids run out of hydro capacity in wintertime before they run out of energy. This means there is hydro energy available at off-peak times on a daily basis most days and on a summer seasonal basis. Diesel generation is required when the grid demand exceeds the hydro capacity. Demand side management programs used in other jurisdictions may be effective in Yukon in peak–shifting (moving some of the peak load by a few hours) or valley-filling (deferring some load by timers or other means to shift electrical loads to periods of lower demand). Currently none of these programs are in place in Yukon.

Many jurisdictions feel a consumer education program is a key component of energy conservation. They are providing tools such as smart meters for consumers to view their consumption and power rate in order to know what their savings would be by deferring or reducing their electrical consumption. The smart house concept is slowly starting to take hold on the market. This is an application where the electrical smart meter talks to smart appliances in the house and the appliances adjust their operation to minimize their power bill. In 2003 Uwe Dulleck and Sylvia Kaufmann published a paper on the effects of customer information systems in reducing residential electricity demand in Ireland. At that time Ireland had no electrical grid connections to England or the rest of the European Union thus was totally dependent on their own generation to meet their demand, as is the Yukon. They reported two principal findings. First, the education programs reduced electricity demand by 7%. Second, the effects were felt in the long run but not in the short run. This was due to consumers making purchasing choices on replacement and new purchases of more energy efficient home appliances rather than making short term changes in usage patterns (Dulleck & Kaufmann, 2003).

11.0 Yukon Emission Reduction Alternatives

In this section, alternative Yukon solutions for emission reductions are presented and ranked.

The use of carbon offsets (local, national or international) is not reviewed as they are an alternative that does not require action except to come up with the funds to purchase the offsets. They certainly may be an economic solution if the made in Yukon solution to reducing emissions is more expensive than the offset market price.

11.1 Electricity and Heating Sector Alternatives

There are a number of technology options that the Yukon could choose to meet or exceed the sector reduction target of 49 kt of emissions. Each will be discussed separately and ranked at the end of the section by their emission reduction capability, cost effectiveness and risk.

Natural Gas for Heating Use

Natural gas may become available in Yukon due to the completion of the AHPP or development of one or more local natural gas fields in Yukon before 2020. The use of natural gas to displace home heating fuel would reduce the emissions by 27.5%. Complete displacement of the home heating fuel market would result in a GHG reduction of 19 kt. There would be one time conversion costs for each residence or business to convert their heating system and cost of a natural gas distribution system to distribute the gas from the nearest gas transmission pipeline. The capital cost to install a natural gas fired furnace or boiler are significant (between five and ten thousand dollars for a residential system). This would require a rebate or low interest loan government program to get a reasonable conversion uptake. According to the 2006 census taken by the Yukon Bureau of Statistics there were 9005 dwellings in Whitehorse (Yukon Bureau of Statistics, 2007). Assuming no intake in the communities due to lack of natural gas infrastructure and the fact that 64% of homes/businesses in Yukon are heated by home heating fuel, this would leave a target market of 5,763 homes in Whitehorse heated by home heating fuel. The program would cost an estimated 5,763 times an average of $7,500 per dwelling or about $43.2M, without consideration of the distribution costs. It would displace up to 19 kt of emissions from the home heating fuel market annually which would only be 79% of the target reduction of 24 kt for this sector. This would result with a $2.3M capital cost per kt.

Use of Wood or Wood Pellets for Heating Use

Eighteen percent of Yukoners currently choose to heat their home or business with wood. It is the least expensive source of heat but is quite labour intensive (to collect, feed the wood stock to the heating appliance and remove the ash waste). Use of high efficiency wood stoves, furnaces and boilers is commonplace in Yukon today by the sector of the Yukon population that wants to either save money or reduce their emissions. High efficiency wood burning appliances already qualify under the Energy Star rebate program. Particulate emissions from wood burning appliances are problematic and in some areas of Whitehorse there are wood burning bans during periods of temperature inversions. Use of wood pellet appliances is increasing due to their reduced labour and cleanup times. At present there is no local source of pellets so they must be trucked in from B.C. A number of companies are currently investigating the use of spruce beetle kill wood as a possible raw material source for a wood pelletizing plant in the Haines Junction area. Most residential wood burning homes use wood as a supplemental heating source. It is not a forced air system so electric heat is often used to heat the more remote areas of their houses. Residential use of wood heat is more of a lifestyle choice and it is unlikely that a significant shift of heating sources can occur. Use of wood pellets to heat commercial buildings and district heating use is more likely to occur as it is more price-driven.

Use of Electricity for Heating Use

Thirteen percent of Yukoners currently heat their homes and businesses using electricity. It does not make economic sense for diesel-generated electricity to be used for heating. The efficiency of a stationary diesel generator is less than 40% whereas a home heating fuel appliance can exceed 90%. Electricity generated from a renewable resource such as water, geothermal, biomass, wind or solar can be used for heating with virtually zero emissions. So why isn't it used more? The reason is that the high capital cost associated with renewable energy projects can have a very large impact on power rates and the difficulty in renewable energy producing sufficient power in the wintertime when heating is required the most. This is also the time when the power grids are peaking due to non-heating loads. Conversion to electric heat is one of the least expensive conversions. Electric heating elements can be installed in existing heating ducts and electric boilers typically have a smaller footprint than their fossil fuel peers. Electric baseboard heating is easy to retrofit and by far the cheapest heating system to install in a new home or business. There are currently no rebates being offered for the installation of electric heating systems despite the fact that they are up to 98% efficient.

The heating market available for electric heat conversion from a GHG emission reduction perspective would be the home heating fuel and propane heating market which generates almost 100% of the sector emissions. Converting the home heating fuel market in Whitehorse would require about 76 GWh of electricity, assuming ten percent electrical losses. This would reduce heating emissions by up to 23 kt.

Use of Geothermal for Heating Use

Air source heat pumps are rare in Yukon due to its lower seasonal temperatures. Hallowell International from Bangor Maine have developed an all climate air-to-air heat pump system that will extract heat from ambient air down to -34 Deg C without use of secondary electric or fossil fuel heat. This has promise for use in Yukon. Ground source heat pumps are few and far in Yukon between due to their high cost of installation. The abundance of hot water aquifers under many Yukon communities makes this a viable option if the drilling and regulatory costs can be managed. Use of community wells and district heating systems may be a viable solution in many communities in Yukon to displace home heating fuel and propane heating systems.

Use of Renewable Energy for Electricity Generation

The development of several hydro projects by Yukon Energy is expected to be the mainstay of new electricity generation in Yukon until at least 2015, according to their 20-year resource plan. The projects identified for development by 2015 are listed in Table 11.1 (Yukon Energy, 2006).

Table 11.1 Planned Near-Term Hydro Projects for Yukon

Project	Capacity (MW)	Annual Energy (GWh)
Aishihik Third Turbine	7.0	5.0
Mayo B Hydro Project	10.0	38.0
Atlin River Storage	2.0	18.0
Gladstone Diversion Project	2.0	18.0
Marsh Lake Fall Storage	1.0	8.0
Carmacks-Stewart Transmission	5.6	15.0
TOTAL	27.6	102.0

As shown in Table 11.2, there are six potential hydro energy projects that could be constructed with a total generating capacity of 28 MW. These projects could generate up to 102 GWh per year on average. If this energy were to displace stationary diesel generation, it would reduce emissions by 71 kt. If hydro energy were to be used to displace 75% efficient home heating fuel systems, the emission reduction would be cut in half to about 35 kt per year.

It is too early in the resource assessment stage of high temperature geothermal power generation to assess the potential size and cost. A major benefit of geothermal is the ability to base load the geothermal station as it is not dependent on seasonal weather for a continuous supply of steam. It is dependent on extracting the resource at a rate that does no exceed its recharge rate. If steam is extracted at too high a rate it becomes a depleting resource and its production will drop over time.

Use of waste wood for power production is an option. When this resource can also be used for direct high efficiency heating applications, wood pellet production for heat or for ethanol production the highest value use of the resource should be selected. For displacement of emissions the production cost, process efficiency and alternatives for its other uses must also be considered which would favour wood being used to displace fossil fuel heating or displacing unleaded gasoline use in vehicles.

Use of energy conservation or DSM

Energy conservation opportunities for Yukon that would reduce emissions would be an improvement in building insulation, envelope and windows in buildings heated with fossil fuels. Buildings heated with electricity would also generate a benefit as the electricity saved could be redeployed elsewhere to displace fossil fuels and also reduce the need to construct additional energy projects. There are other electricity related programs that are targeted to reduce or shift the electricity grid peak demand which often requires fossil fuel generation just to meet peak demand. This translates to reduced fossil fuel use and savings in the need to install new electrical plants required to meet peak demands on the power grids. In the five communities in Yukon still on their own isolated diesel, any reduction of electricity use results in a much greater reduction in emissions compared to reducing fossil fuel used for heating purposes. The subsidized replacement of aging low efficiency appliances with high efficiency appliance should be continued and perhaps the subsidy increased, as the efficiency gains often exceed 200%[1].

A review of Statistics Canada data on electrical generation and sales in Yukon indicate total electrical system losses of 31 GWh/year which is 9% of the total generation (Statistics Canada, 2008). An internal DSM program by both utilities would yield a good benefit as neither utility has undertaken a program to date. BC Hydro initiated an Internal DSM type program they called Resource Smart in the late 1980's. It has resulted with an increase of more than 1,300 GWh of annual production (BC Hydro, 2008).

Ranking of the options is based on the capability to achieve significant reductions, cost-effectiveness and risk of failure or uncertainty. By using a simple matrix table a value of low, medium or high to each of the three areas is shown in Table 11.2. A high rating in the capacity category is good, meaning it can make a significant contribution. A high rating in cost effectiveness is also good, meaning the technology is considered more cost-effective than others. A high rating in risk means the technology and its implementation in Yukon has a low level of uncertainty or failure potential. This would be considered a good risk.

Table 11.2 Ranking of Heating/Electricity Alternatives

Options	Capability	Cost-Effectiveness	Risk	Rank
Natural Gas for Heat	L	M	M	M-
Wood for Heat	L	H	H	M+
Electricity for Heat	H	M	H	H-
Geothermal for Heat	M	M	M	M
Renewables for Electricity	H	M	H	H-
Energy Conservation/DSM	L	H	M	M

Natural gas was assessed as a low capability as it can only replace 28% of the emissions from home heating fuel as it has its own carbon footprint. Wood was assessed as a low capability due to the lifestyle change required for widespread conversion in the residential heating market. Geothermal was assessed as a medium capability due to the technology under development for low temperature air source heat pumps which still requires an alternative heating source. Full market penetration is likely not achievable due to lack of economic access to this resource if the aquifers are deep or not accessible. Energy conservation was assessed as low capability as most jurisdictions recognize that it can only displace a small percentage of total energy consumption and demand, usually in the range of 10-20%.

[1] The author recently replaced a 25-year old deep freeze that consumed about *280* kWh *per month* with an upright freezer that consumes *340* kWh *per year.*

The best method to reduce emissions, as indicated by the ranking, is the use of renewables for electricity and electricity for heat, followed by wood heat, then geothermal and energy conservation with natural gas ranked the lowest.

11.2 Transportation Sector Alternatives

There are a number of alternatives that the Yukon could choose to meet or exceed the transportation sector reduction target of 96 kt of emissions. Each will be discussed separately then they will be ranked by their GHG reduction capability, cost effectiveness and risk.

Use of Ethanol and Bio-diesel

Moving to an E10 ethanol/gasoline blend is an obvious option but using grain based sources of ethanol only results with a reduction of 4% of emissions compared to unleaded gasoline. Use of ethanol from cellulose doubles the reduction up to 8%. Moving to an E85 standard increases the GHG reduction up to 35% but requires a new class vehicle designed to burn this high ethanol blend called FFV's. There is potential to use fire killed and spruce beetle killed wood to produce cellulostic ethanol. This technology is still under development and expected to be expensive in the short-term, even with a nearly free source of raw material. It would generate local economic benefits and reduce fossil fuels used to import gasoline to the Yukon today. Use of bio-diesel is also a good option but at present there is insufficient local oil or fat sources to make this fuel in Yukon to make a major dent in this market. Redesign of vehicle diesel engines is also required to use bio-diesel and diesel fuel mixture of more than 5% bio-diesel.

Use of More Fuel Efficient Vehicles

In a jurisdiction of very low population density there is significant potential to reduce emissions through the use of more fuel efficient vehicles and improvements in driving practices to increase fuel economy. Transport Canada estimates that the difference in driving habits between truck drivers can affect fuel economy by as much as 25% (Transport Canada, 2007). Low urban densities, particularly in Whitehorse, means longer commuting distances making public transit less viable and unpowered commuting not feasible for many residents. Moving to more fuel efficient vehicles makes sense if consumers are given incentives to do so. A 10% improvement in vehicle fuel economy would reduce Yukon emissions by almost 10 kt per year. The use of hybrid vehicles in this area would also be considered a means of improving vehicle fuel economy.

Use of Local Fuel

In Yukon today up to 8.7 million litres of fuels are burned each year just to transport by truck the 128 million liters of gasoline, diesel and heating fuel consumed annually in the Yukon, according to Forest Pearson, a respected practicing geological engineer in Whitehorse (Pearson, 2009). This translates to 23kt of emissions just to import these fossil fuels to the Yukon. There are potential sources of local oil in Yukon but with the small volumes involved, the cost of a local refinery to process the crude oil is prohibitive. The 7% multiplier effect of having to use imported fuels brought in by truck demonstrates a need to review the transportation medium used to deliver all goods and services to Yukon. It may be viable to convert a significant percentage of truck transportation to rail and boat access via Skagway, Alaska. The U.S Department of Energy reports that rail transport consumes only 10% of the energy of truck transport and boat transport consumes 15% of the energy consumption of truck transport (U.S. Department of Energy, 2008). Clearly there is fuel savings and emission reductions if boat and rail transport can be utilized as an alternative to truck transport.

Use of Electric Vehicles

Use of electric vehicles should be seriously considered, especially for commuter use in the Yukon. The Yukon night time electrical loads are up to 25% less than the day time loads so an increased demand at night time to recharge electric vehicles would not increase the system demand. It can be met largely using renewable energy which typically has higher demand or capacity costs but lower energy costs than fossil fuel alternatives. In addition there is a surplus of hydro power in Yukon in the summertime on both of its hydro grids. The summertime increase in electricity use for electric vehicles may be at a very small marginal cost. The key in this case would be to provide the right incentive for consumers to purchase the new electric vehicles and ensure the adequacy of electrical supply.

Use of Public Transit

Public transit in Whitehorse has not worked well due to its large geographical areas and low population density that has resulted with high costs and low ridership. Public transportation will not become widely used in Whitehorse unless it is focused in delivery of improved service to a much smaller core area. Car pooling from the more remote country residential sub-divisions could be increased.

Ranking of the above options is done in Table 11.4.

Table 11.4 Ranking of Transportation Alternatives

Options	Capability	Cost-Effectiveness	Risk	Rank
Ethanol	L	L	L	L
Bio-diesel	L	L	L	L
Increase in Fuel Efficiency	M	H	H	H-
Development of Local Fuel Sources	L	L	M	L+
Electric Vehicles	H	M	M	M+
Public Transit	L	M	M	M-

The capability of ethanol and bio-diesel was assessed low due to the relatively small availability to make a major contribution to emission reductions at low percentage blended fuels and the cost of technology to go to higher blends of fuels. Improvements in vehicle fuel efficiencies from both new technology and driving patterns is significant but can only reduce the volume of fossil fuels used for the same output. Use of local fuels was assessed low as the primary reduction would be the 7% of emissions generated by the trucks hauling the fuel to Yukon. In the longer term, use of electric vehicles, providing the electricity is produced from a renewable source, will result in significant savings, in particular when the energy storage technology matures and vehicle ranges are up to 300-400 km between charges. Public transit options were assessed as low capability to have a significant impact on emissions.

The best method to reduce emissions, from a ranking perspective, is increasing vehicle fuel efficiencies ranked the highest, followed by electric vehicles and public transit. In the low ranking were ethanol, bio-diesel and development of local fuel sources.

12.0 Made in Yukon Actions

In this section, we first examine the actions the government should focus on to achieve their emission reduction plans. We then identify the key challenges facing Yukon in its emission reduction plans. Finally we reach conclusions on the ability of the Yukon to achieve its emission reduction targets.

The actions that the Yukon government should focus on are:

1. Use of renewable energy sources for electricity. This should be the cornerstone of the Yukon’s emission reductions due to its flexibility as a secondary energy source for displacement of stationary diesel electric generation, fossil fuel heating and transportation. The development of hydro as the best short term option (to 2015) should continue. The future use of geothermal should also continue to be assessed for development in the 2015 to 2020 timeframe. Government should continue to ensure funding is available for hydroelectric development, in particular if it can provide winter energy which is needed for displacing fossil fuel heating. Government should continue to implement energy policy to incite the development of IPP’s to displace base load stationary diesel generation. A net metering policy for development of a small wind/solar/hydro market should also continue as planned. Government policy should be developed for encouraging use of electric heat. This would include re-design of electrical rates. An incentive for electric heat in new construction is not required as it already has the lowest capital cost. A carbon tax on home heating fuel should be implemented as an incentive to switch from heating fuel to electricity (best), wood (better) or propane (a 14% reduction compared to home heating fuel).
2. An in-depth assessment of the waste wood resource in Yukon and the technology is required to develop business cases for the potential use of this valuable sustainable resource for the production of cellulostic ethanol, wood pellets for widespread use, or for bio-mass district heating/power production in the isolated diesel communities in Yukon. If the assessment is positive, the government should provide funding for a pilot plant for a proof of concept for cellulostic ethanol production and a small scale commercial wood pelletizing plant, if the wood resource is sufficient for both.
3. Existing energy conservation initiatives should continue. A market survey should be done to assess market penetration to assess possible adjustments of rebate levels for energy appliance rebate programs as a cost effective method of converting energy savings to serving diesel or heating loads with existing and renewable energy base electricity. Government should develop new policy mandating DSM as a compliment to the development of new renewable electricity sources.

4. Creating incentives to improve vehicle fuel efficiency is required. The government can make a significant difference with improving their own internal fleet fuel efficiency. A carbon tax on fuel should be implemented to encourage all vehicle users to drive less and/or improve their fuel economy through improved driving habits or the purchase of more fuel efficient vehicles. Some of the carbon fuel tax revenue should be applied as a subsidy on the purchase of a hybrid or electric car. The low carbon component of blended fuels (i.e. ethanol and bio-diesel) should be exempt from the carbon tax as is being done in B.C. A tax on diesel use would provide a stimulus for boat/rail access to be restored to Whitehorse through Skagway, Alaska. This would result in significant emission savings related to the 23 kt of truck emissions from truck transport of goods to Yukon. Depending on actions taken in the neighboring jurisdictions of Alaska and B.C., there may be sufficient incentive created by GHG emission reduction programs in these jurisdictions to drive development of the B.C./Alaska rail link. This could provide Yukon businesses and industrial customers with a means to reduce their carbon footprint by using a railway to ship their goods to and from the Yukon. This project has been in the feasibility stage for years. Carbon taxes are widely used and accepted in Denmark, Finland, Netherlands, Norway, Poland and Sweden. They are in use in Canada in the provinces of B.C. and Quebec.
5. The government should legislate use of E85 fuel as soon as it is readily available. A four percent reduction is better than none. This is consistent with other provinces and can be accomplished with very low administrative burden.
6. The government must deal with the large final emitters such as the Alaska Highway Pipeline Project and large industrials such as mines in order to achieve their emission reduction targets in the higher growth scenarios. The short answer to this dilemma is that these projects must be carbon neutral by 2020 in order for Yukon to meet its targets. The AHPP will have a project footprint far larger than the Yukon as it will span Alaska, Yukon, B.C. and Alberta. Given the international scope of this project, an emission cap and trade system should be implemented by government as it will involve Canada and the U.S. Mining customers prefer hydro grid power already if it is available so paying a carbon tax on the diesel fuel or coal they consume would provide added incentive. The revenues raised should then be invested in the development of renewable electricity sources. To address the project requiring more than 100 MW there are two options for government to pursue for a made-in-Yukon solution. One is to pursue development of hydro sufficient to meet the energy demand of this group of customers. The other option is to continue development of the potential geothermal resource to meet the demand.

It must be recognized that the Federal Government is also developing a national emission reduction plan and whatever the Yukon decides to do must also enable it to meet its national commitments once the federal plan is implemented. It would be incorrect to expect the Federal plan will mesh exactly with what the Yukon needs to do to meet its territorial reduction targets for several reasons:

- The mix of energy related emissions is different. The 2006 Federal mix of energy emissions is 56% for electricity & heat and 33% for transportation. The Yukon mix is 33% for electricity & heat and 66% for transportation.

- The Yukon has a large public sector and small private sector. This means the Yukon should be able to achieve considerable GHG emission reductions with its own operation. The Yukon Government is the largest employer and user of fossil fuel in the territory.
- The Federal government has not finalized its plan and now appears headed to do whatever the U.S. decides to do, which is favouring a cap and trade emission rights plan.
- The use of an emission fee or tax is politically unpopular due to the reputation it garnered at the last federal election and the fact that President Obama has staked his claim on the emissions rights alternative.

On a sector basis, Yukon can exceed the targeted emission reduction for heat and electricity. It will be challenged to meet the transportation sector reductions. The ability to meet these targets can only be realized with the right mix of legislation, regulations and policy to provide the proper incentives to businesses and consumers to reduce their emissions.

It will be challenging for Yukon to meet these targets if high economic growth occurs, especially if it involves major industrial customers without the ability to meet the new demand with renewable energy. Examples of this would be major projects such as AHPP needing 300 MW of compressor power and large mines wanting 100 MW's or more of power. The uncertainty surrounding the development of renewable resources of this magnitude is threefold: lead times required to develop these projects may be up to ten years, the amount of dollars needed to develop the projects is in the billions, which is very large for a jurisdiction the size of Yukon; and finally, the load risk involved with construction of long-lived renewable projects for shorter life loads is very high. The solution to the energy–intensive projects is that they must be legislated to be carbon-neutral.

Does the Yukon have the capability of meeting or exceeding its 20% reduction of 2006 GHG emission levels by 2020, equivalent to a forecast reduction of 33% from the most likely 2020 forecast levels? The answer is yes.

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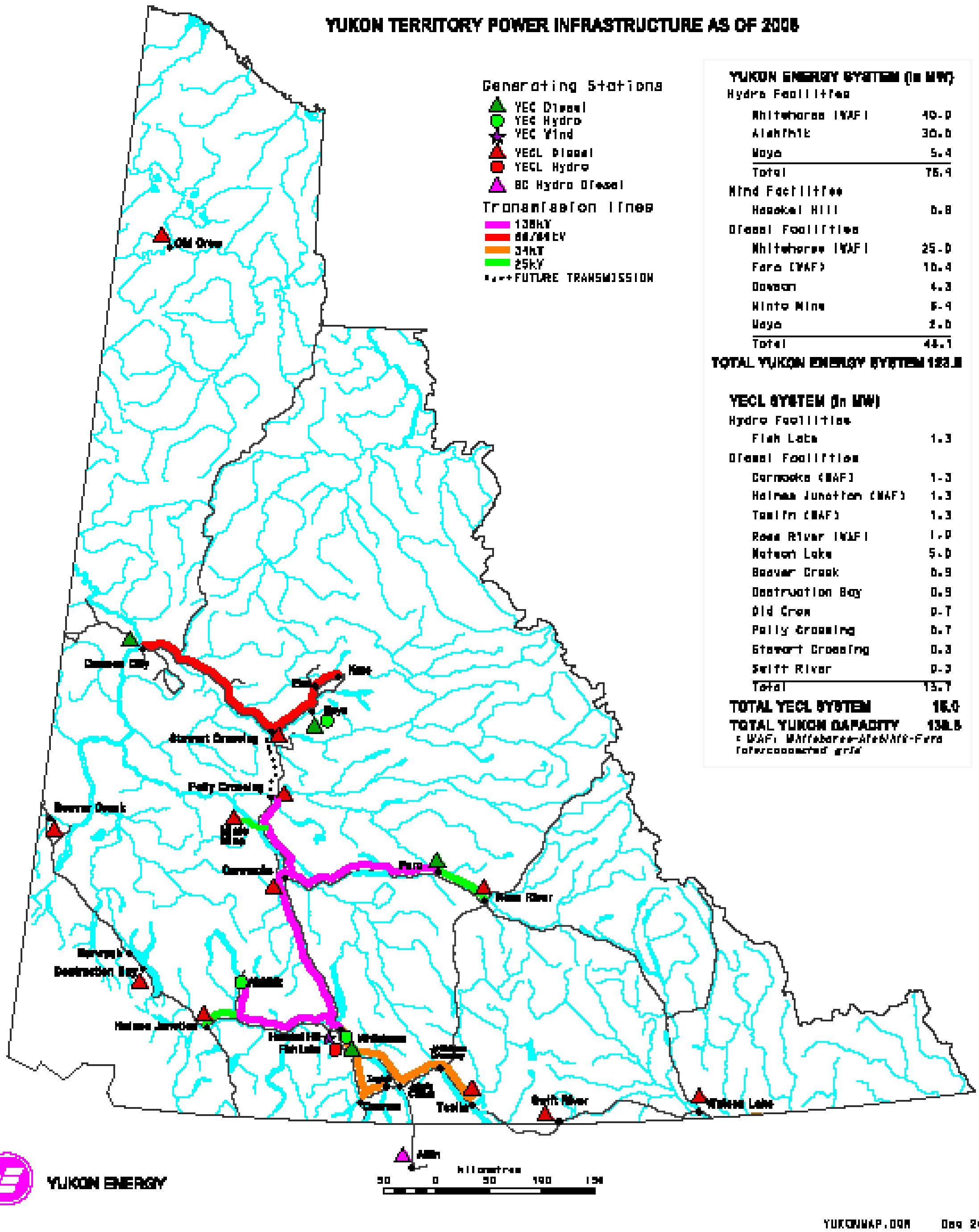
14.0 Appendix A Yukon Map



15.0 Appendix B Summary of Yukon's Energy Strategy

Summary

The *Energy Strategy for Yukon* identifies energy priorities for the Yukon government. It proposes a vision for the energy sector and principles to guide Yukon government decisions. Goals, strategies and actions for efficiency and conservation, renewable energy, electricity, oil and gas and energy choices are identified. The Strategy will provide direction for developing, managing and using energy over the next ten years.

This Strategy focuses on the Yukon government's roles and responsibilities for developing and managing energy resources. The Yukon government's energy policies and programs will also play a role in guiding other government, industry, business and individual decisions about energy. The Strategy is intended to complement and be coordinated with the government's Climate Change Strategy and Action Plan.

Vision and Principles

The Yukon government's vision is for a sustainable and secure energy sector that is environmentally, economically and socially responsible; developing and using energy resources to meet Yukon's energy needs and generate benefits for Yukon people, both now and for generations to come.

These principles will guide the government's decisions.

- Sustainability: building an environmentally, economically and socially sustainable energy sector.
- Energy security: providing a secure and reliable supply of energy for Yukon.
- Self-sufficiency: responsibly developing Yukon's energy resources to meet energy needs.
- Optimize benefits: benefiting from energy development, conservation and use.
- Climate change coordination: coordinating climate change and energy policies.
- Leadership: the Yukon government will be a leader.
- Partnerships: working in partnership to develop and manage energy resources.

Energy Priorities

This Strategy describes the government's priorities to improve energy efficiency and conservation, produce more renewable energy, meet electricity needs, responsibly develop oil and gas and make good energy choices.

Efficiency and Conservation

Energy efficiency and conservation will be a priority to reduce energy consumption, energy costs and emissions.

Priorities for efficiency and conservation:

- Increase energy efficiency in Yukon by 20% by 2020.
- Reduce energy consumption in Yukon buildings.
- Reduce energy consumption for transportation in Yukon.
- Promote the use of energy efficient products by providing incentives for products that meet energy performance standards.
- Improve energy efficiency for Yukon government operations.

Renewable Energy

Energy production from renewable sources will be increased to reduce fossil fuel use and greenhouse gas emissions.

Priorities for renewable energy:

- Increase renewable energy supply in Yukon by 20% by 2020.
- Develop a policy framework for geothermal energy.
- Support and demonstrate renewable energy projects in communities off the electrical grid to reduce diesel use.
- Conduct pilot studies to assess the feasibility of renewable energy initiatives.
- Promote renewable energy sources for heating and transportation.

Oil and Gas

Oil and gas resources will be developed responsibly for local use in Yukon and for export.

Priorities for oil and gas:

- Support strategic opportunities to replace imported diesel fuel with Yukon's oil and gas resources.
- Develop a competitive and comprehensive oil and gas regulatory regime which will emphasize performance-based compliance.
- Prepare for northern pipeline development such as the Alaska Highway Pipeline.
- Promote private sector investment in the development of Yukon's oil and gas resources.
- Finalize and implement an agreement with the federal government for sharing management and revenues for offshore oil and gas.

Electricity

Electricity supply will be increased and demand will be managed to meet current and future electricity needs.

Priorities for electricity:

- Support strategic investments in infrastructure to increase the supply of electricity from renewable sources.
- Assess the feasibility of expanding the Yukon transmission system to connect to other communities, industrial projects or jurisdictions.
- Update and develop a policy framework for electricity that emphasizes efficiency, conservation and renewable energy.
- Develop and implement demand management programs and incentives to promote energy efficiency and conservation.
- Support research and development of technologies and policies to optimize the use of hydroelectricity.
- Consider appropriate roles, responsibilities, and corporate structure for Yukon Development Corporation and Yukon Energy Corporation to ensure effective management and operation, and optimize the efficiency and reliability of electricity generation and distribution.

Energy Choices

The *Energy Strategy for Yukon* will set long term direction and define short term priorities for the Yukon government.

Priorities for making energy choices:

- Assess new and existing energy sources that could be developed in Yukon.
- Hold public consultation on a policy framework for coal bed methane, coal and nuclear power before permitting any development.
- Monitor implementation of the Energy Strategy and report regularly on progress. The first progress report will be released by the end of 2010.

16.0 Appendix C Yukon Government's Climate Change Actions

Goal 1 – Enhance Knowledge and Understanding of Climate Change

- Establish a Yukon Research Centre of Excellence
- Establish climate change research study areas
- Develop climate scenarios

Goal 2 – Adapt to Climate Change

- Complete a Yukon infrastructure risk and vulnerability assessment and determine adaptation strategies in response
- Develop an inventory of permafrost information for use in decision making
- Complete a Yukon water resources risk and vulnerability assessment
- Create a tool to facilitate the collection and distribution of water quantity and quality data
- Conduct a Yukon forest health risk assessment
- Conduct treatments to reduce forest fuel loads and protect communities
- Conduct a Yukon forest tree species and vulnerability assessment

Goal 3 – Reduce our Greenhouse Gas Emissions

- Yukon government's internal operations: cap GHG emission in 2010, reduce GHG emission by 20% by 2015 and become carbon neutral by 2020
- Report on Yukon government operations through 'The Climate Registry'
- Develop a carbon offset policy for internal operations
- Incorporate environmental performance considerations in the government's procurement decisions
- Government-funded new residential construction will meet GreenHome energy efficiency standards
- Government-funded commercial and institutional, construction and renovation will meet or exceed the LEED Certified Standard for energy efficiency
- Improve energy efficiency and reduce the greenhouse gas emissions of the government's light vehicle fleet
- Implement an Environmental Stewardship Initiative for the Department of Education and Yukon schools
- Establish 'green action committees' in all departments
- Conduct an energy analysis of all Yukon government buildings and complete energy saving retrofits
- Develop best management practices for industry to reduce GHG emissions
- Undertake an extensive study of the transportation sector and recommend options to reduce emissions
- Develop incentives for fuel efficient transportation
- Develop pilot projects to demonstrate home and commercial energy efficiency and heating technology
- Improve access to home energy evaluations by providing evaluator training
- Develop wood energy opportunities for residential and institutional heating

Goal 4 - Lead Yukon Action in Response to Climate Change

- Forecast potential future GHG emissions for Yukon
- Work with federal partners to ensure national GHG Inventory is accurate and consistent for Yukon
- Set a Yukon-wide emissions target within two years
- Create a Climate Change Secretariat
- Determine the potential of a Yukon carbon economy
- Incorporate climate change considerations into government decision making
- Create a community engagement forum for taking action on climate change

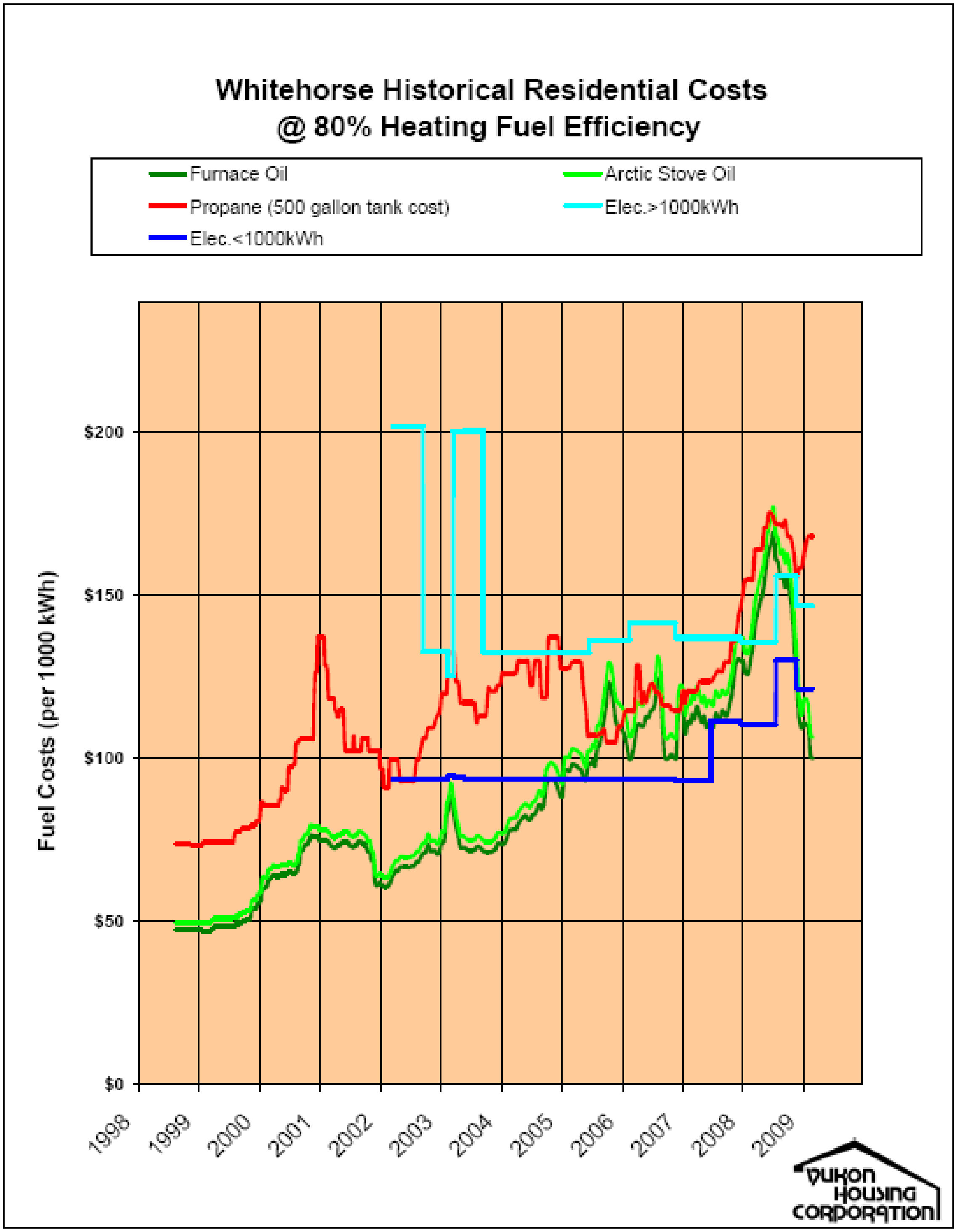
17.0 Appendix D 1990-2006 GHG Summary for Yukon

Greenhouse Gas Categories	1990	1995	2000	2001	2002	2003	2004	2005	2006
TOTAL (kt CO2 eq)	**538**	**547**	**445**	**433**	**444**	**440**	**414**	**398**	**394**
ENERGY	**526**	**532**	**430**	**418**	**428**	**424**	**398**	**382**	**377**
a. Stationary Combustion Energy	**226**	**248**	**191**	**168**	**169**	**163**	**131**	**126**	**123**
Electricity and Heat	93.6	53.3	17.0	14.6	17.2	10.7	7.99	7.53	7.81
Fossil Fuel Industries	2.9	91	84	56	48	28	11	29	38
Mining & Oil and Gas	4.12	10.3	1.54	2.09	2.90	2.11	1.73	3.08	0.53
Manufacturing	8.01	0.47	-	0.03	-	-	-	-	-
Construction	5.46	4.45	2.40	1.64	1.58	2.65	1.95	1.07	1.06
Commercial / Institutional	81.9	60.8	52.9	51.2	53.1	58.5	40.0	39.8	30.4
Residential	29	19	33	29	31	41	55	39	39
Agriculture & Forestry	1.24	7.56	0.95	13.9	14.7	19.9	13.2	6.27	6.02
b. Transportation Energy	**300**	**280**	**240**	**250**	**250**	**260**	**260**	**250**	**250**
Domestic Aviation	21	21	23	16	15	20	22	22	27
Road Transportation (total)	180	218	162	165	168	164	160	157	144
Light Duty Gas Vehicles	79.1	72.5	48.9	47.2	45.6	45.0	39.1	34.3	28.5
Light Duty Gas Trucks	30.4	41.7	39.6	41.4	42.5	44.2	40.3	37.7	33.5
Heavy Duty Gas Vehicles	10.2	9.69	5.89	6.28	6.08	6.31	5.83	5.28	4.49
Motorcycles	0.46	0.41	0.32	0.32	0.35	0.38	0.35	0.32	0.27
Light Duty Diesel Vehicles	0.55	0.51	0.35	0.34	0.33	0.34	0.32	0.28	0.24
Light Duty Diesel Trucks	0.60	0.96	2.51	2.55	2.58	2.71	2.53	2.65	2.68
Heavy Duty Diesel Vehicles	57.2	88.0	63.5	65.5	69.0	63.6	69.9	75.2	72.7
Propane & NG Vehicles	1.5	4.0	0.68	1.0	1.6	1.9	2.1	1.1	1.5
Others (total)	100	40	50	70	70	70	80	70	80
Off Road Gasoline	10	8	10	10	10	10	3	3	2
Off Road Diesel	90	30	40	60	60	60	80	70	80
c. Fugitive Sources	**-**	**3.77**	**2.71**	**2.15**	**5.40**	**3.54**	**2.71**	**2.12**	**1.03**
Oil and Natural Gas	-	3.77	2.71	2.15	5.40	3.54	X	X	X
INDUSTRIAL PROCESSES	**1.38**	**2.09**	**0.71**	**0.61**	**0.99**	**0.75**	**0.49**	**0.56**	**0.56**
SOLVENT & OTHER PRODUCT USE	**0.18**	**0.22**	**0.24**	**0.21**	**0.16**	**0.21**	**0.20**	**0.17**	**0.31**
WASTE	**10**	**12**	**14**	**14**	**14**	**15**	**15**	**16**	**16**
a. Solid Waste Disposal on Land	**7.6**	**9.3**	**11**	**11**	**12**	**12**	**12**	**13**	**13**
b. Wastewater Handling	**2.9**	**3.2**	**2.9**	**2.8**	**2.8**	**3.0**	**3.1**	**3.1**	**3.1**

Source: Summary of GHG Emissions for Yukon: Environment Canada. National Inventory Report 1990–2006. Greenhouse Gas Sources and Sinks for Canada. 2008.

Notes: (1) **-** : Indicates no emissions. (2) X: Indicates confidential data. (3) kt CO2 eq: Kilotons of CO2 equivalent (4) Emission totals in chart may not add up due to rounding protocol.

18.0 Appendix E Historical Whitehorse Residential Heating Cost



Source Yukon Housing Corporation (YHC, 2009)