Yukon Greenhouse Gas Emission Mitigation Analysis

Phase I

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Introduction

This report presents an analysis of potential greenhouse gas emission mitigation measures that could potentially be applied in the Yukon context. The analysis will be used to inform Yukon government officials and partners in the development of an Integrated Yukon Strategy on Climate Change, Energy and the Green Economy.

The analysis was informed by a review and analysis of existing literature and data. The report begins with an overview of the current greenhouse gas emission context for the Yukon. The next section presents a comprehensive listing of greenhouse gas mitigation measures and programs undertaken by other governments together with a preliminary assessment of the practicality of implementing the measures in Yukon. The effectiveness of greenhouse gas mitigation measures and programs undertaken by other governments, categorized from three different perspectives are next discussed. The report concludes with an assessment of mitigation measures that could lead to economic development opportunities for Yukon businesses.

The Greenhouse Gas Emission Context in Yukon

The table below outlines the six different types of greenhouse gases listed in the Kyoto protocol: carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, perfluorocarbons and hydrofluorocarbons. The Kyoto protocol is an international treaty under which signatories, including Canada, have agreed to reduce emissions of greenhouse gases contributing to global warming and climate change. The table also describes the point sources of emissions for each type of greenhouse gas.

To account for differences among the six gases to contribute to global warming, the Global Warming Potential (GWP) of each greenhouse gas is calculated by the Intergovernmental Panel on Climate Change. By calculating the GWP, the potential of different greenhouse gases to trap heat in the atmosphere and contribute to global warming may be directly compared. The global warming potential for each gas is stated relative to the global warming potential of carbon dioxide (CO_2) over a specified time horizon. The resulting carbon dioxide equivalent (CO_2e) value is calculated by multiplying the volume of the gas by its associated global warming potential.

Types of Greenhouse Gases, Sources and Global Warming Potential

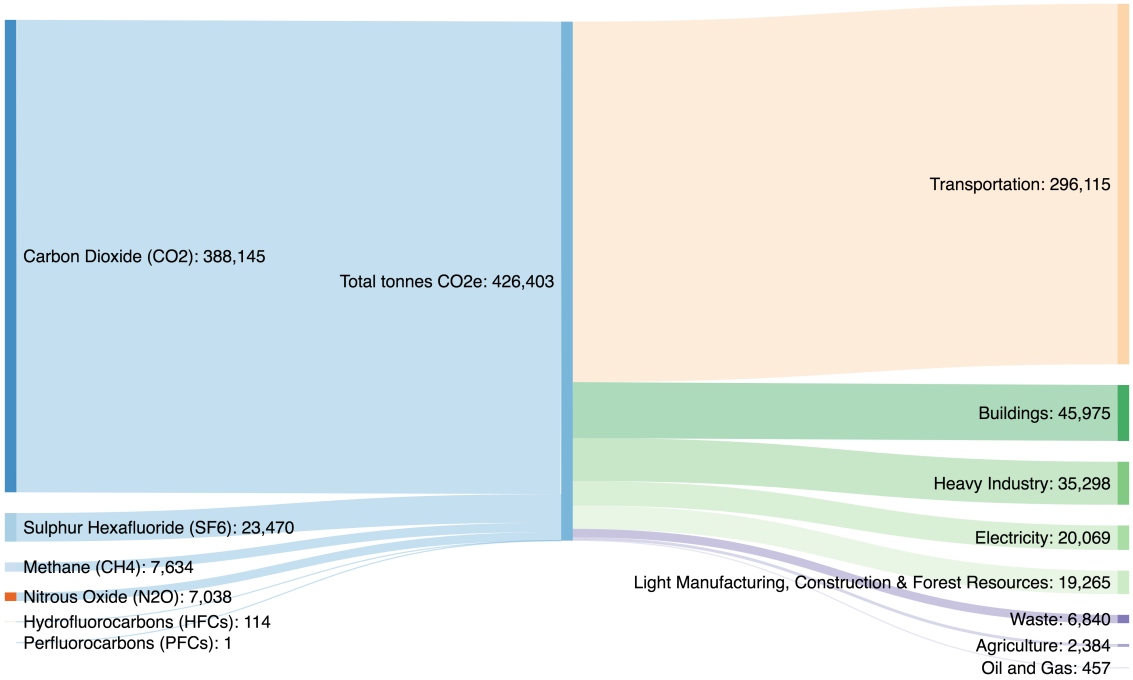
carbon dioxide (CO_2)	GWP = 1
Carbon dioxide emissions result from burning fossil fuels and biomass to produce energy, building heating and cooling, land-use changes such as deforestation and the manufacture of cement. Carbon dioxide is also released naturally into the air by plant and animal respiration, decay of plant and soil organic matter, and outgassing from water surfaces.	
methane (CH_4)	GWP = 25
Methane is released from industrial processes, fossil fuel extraction, coal mines, incomplete fossil fuel combustion, and garbage decomposition in landfills. Methane is also produced naturally during the decomposition of plant or organic matter in the absence of oxygen, as well as released from wetlands through the digestive processes of certain insects and ruminant animals.	
nitrous oxide (N_2O)	GWP = 298
Nitrous oxide is most commonly produced via the heating of ammonium nitrate and through use as an anesthetic in dentistry and surgery and as a propellant in aerosol cans. Other sources of nitrous oxide emissions include the industrial production of nylon and nitric acid, combustion of fossil fuels and biomass, soil cultivation practices, and the use of commercial and organic fertilizers. Nitrous oxide is also released naturally from oceans, by bacteria in soils, and from animal wastes.	
sulphur hexafluoride (SF_6)	GWP = 22,800
Sulphur hexafluoride is used primarily in the electricity industry as insulating gas for high voltage equipment. Sulphur hexafluoride is also used as cover gas in the magnesium industry to prevent oxidation (combustion) of molten magnesium. In lesser amounts, sulphur hexafluoride is used in the electronic industry in manufacturing of semiconductors.	
perfluorocarbons (PFCs)	GWP = 7,390 to 17,340
Perfluorocarbons are a class of human-made chemicals composed of carbon and fluorine only. PFCs are used to manufacturing semiconductors found in computers, cell phones and electronic devices. PFCs are also used as solvents in the electronics industry, and as refrigerants of some specialized refrigeration systems and are emitted as a by-product during aluminum production.	
hydrofluorocarbons (HFCs)	GWP = 12 to 14,800
Hydrofluorocarbons (HFCs) are a class of human-made chemical compounds that contain only fluorine, carbon and hydrogen. HFCs are commonly used in refrigeration, fire-extinguishing, semi-conductor manufacturing and foam blowing.	
Sources: https://www.canada.ca/en/environment-climate-change/services/management-toxic-substances/list-canadian-environmental-protection-act.html and https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/quantification-guidance/global-warming-potentials.html	

The Sankey diagram on the following page illustrates greenhouse gas emissions in the Yukon by type of gas and the allocation of greenhouse gas emissions across economic sectors in 2016. The emissions data, for which 2016 are the most recent available, are published by Environment and Climate Change Canada in the *National Inventory Report 1990-2016.* The data are published in terms of tonnes of carbon dioxide equivalent, which as noted earlier, allows for direct comparisons for between the six different types of greenhouse gases.

As shown in the Sankey diagram, a total of 426,403 tonnes of CO_2e were emitted in Yukon in 2016. Ninety-one percent of Yukon emissions, 388,145 tonnes, were in the form of carbon dioxide. The next largest source of greenhouse gas emissions in the Yukon in 2016 was sulphur hexafluoride, with emissions of 23,470 tonnes, representing 5.5% of total Yukon emissions in 2016. The remaining 4.5% of greenhouse gas emissions, were attributable to methane (7,634 tonnes), nitrous oxide (7,038 tonnes), perfluorocarbons (114 tonnes) and hydrofluorocarbons (1 tonne).

On the basis of the Environment and Climate Change Canada data, 69% of total greenhouse gases emitted in Yukon in 2016 were attributable to the transportation sector. Buildings accounted for 11% (45,975 tonnes of Co_2e) and heavy industry 8% (35,298 tonnes) of total greenhouse gas emissions. The electricity and light manufacturing-construction-forest resources sector each accounted for 5% of total greenhouse gas emissions (20,069 tonnes and 19,265 tonnes, respectively). The remaining 12% of greenhouse gas emissions, were attributable to the waste sector (6,840 tonnes), agriculture (2,384 tonnes) and oil and gas (457 tonnes).

Yukon Greenhouse Gas Emissions by Type and Allocation by Economic Sector - 2016 tonnes of carbon dioxide equivalent (CO_2e)



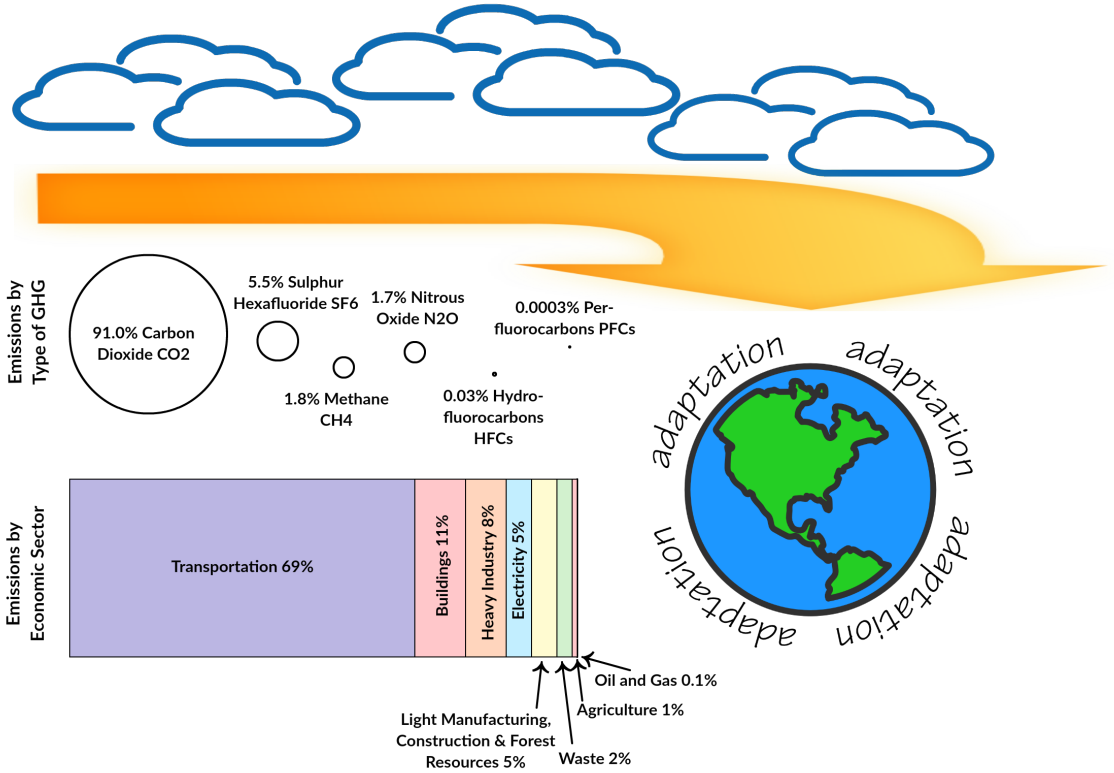
Data Source: Environment and Climate Change Canada. *National Inventory Report 1990-2016*. National and Provincial/Territorial Greenhouse Gas Emission Tables. 2018.

According to the Environment and Climate Change Canada data, within the Yukon's transportation sector, passenger transport accounted for 48.6% of total greenhouse gas emissions in Yukon in 2016. Passenger transport includes cars, light trucks, motorcycles, bus, rail and domestic aviation. Freight transport (which includes heavy duty trucks, rail, air cargo and marine) accounted for 47.8% of total greenhouse gas emissions. The remaining 3.7% of emissions within the Yukon's transportation sector were attributable to recreational, commercial and residential activities.

The diagram below provides an alternate presentation of same greenhouse gas emissions data shown in the Sankey diagram above. The diagram also highlights the distinction between the two main policy responses to confronting the effects of climate change: mitigation and adaptation. The focus of this paper is on mitigation.

> *Mitigation* addresses the root causes and involves reducing the magnitude of climate change itself through efforts to reduce or prevent emissions of greenhouse gases.
>
> *Adaptation* seeks to lower the risks posed to human civilization by the consequences of climate change without necessarily dealing with the underlying causes of climate change.

Yukon Greenhouse Gas Emissions by Economic Sector and by Type of GHG - 2016



Data Source: Environment and Climate Change Canada. *National Inventory Report 1990-2016.* National and Provincial/Territorial Greenhouse Gas Emission Tables. 2018.

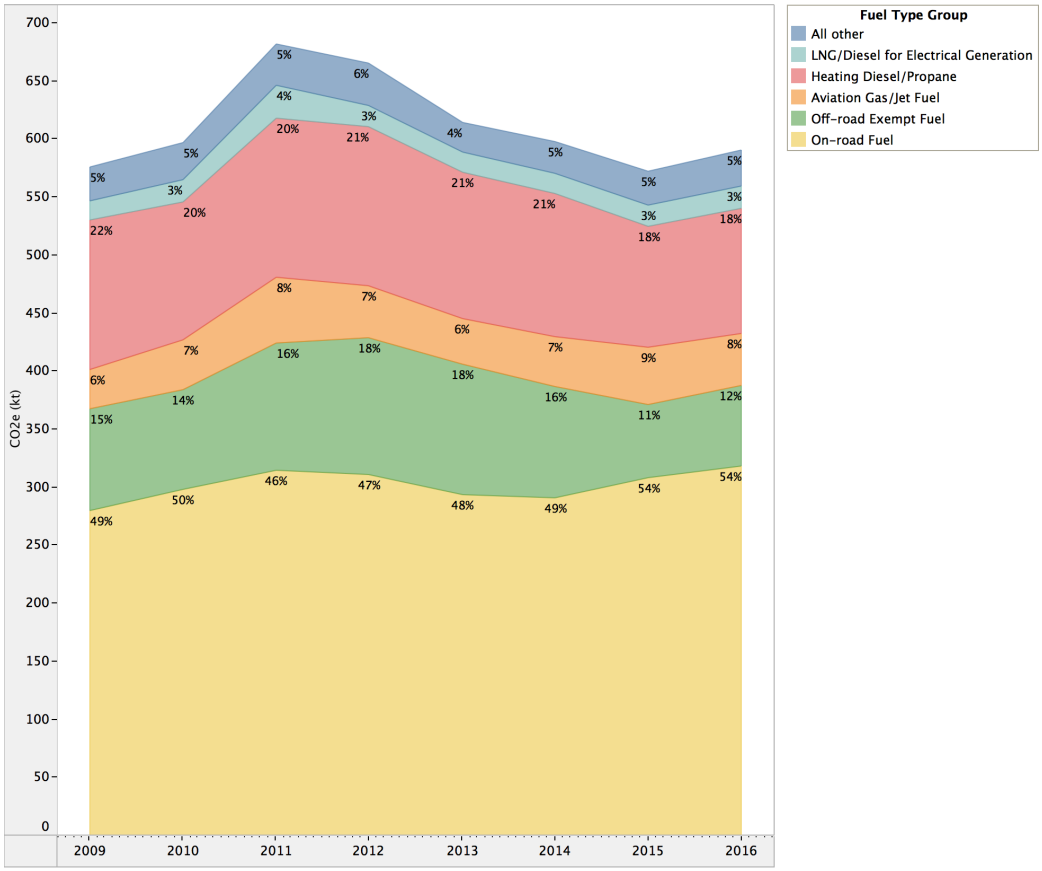
Previous research efforts undertaken by Environment Yukon, notably *Yukon Greenhouse Gas Emissions: The transportation sector* (Research Northwest and Forest Pearson, 2013 and 2015), have established that greenhouse gas emissions in the Yukon's transportation sector have been underreported in the National Inventory Reports. Environment and Climate Change Canada has, in turn, acknowledged that fuel imports from Alaska and Alberta have not been properly captured in the greenhouse gas emission calculations.

In an attempt to improve the quality of greenhouse gas emissions data for the Yukon, the Yukon Bureau of Statistics has analyzed Yukon Finance fuel tax data to estimate the volume of

carbon dioxide equivalent (CO_2e) emissions originating from fuel combustion in Yukon. The chart below illustrates Yukon's greenhouse gas emissions from petroleum-based fuels, measured as kilotons of CO_2 equivalent, over the period 2009 to 2015, by fuel type and type of use as calculated by the Yukon Bureau of Statistics. Over the eight-year period from 2009 to 2016, total Yukon greenhouse gas emissions from petroleum fuel-sourced GHG emissions peaked in 2011 at 681 kt CO_2e, declined between 2012 and 2015 before increasing to590 kt CO_2e in 2016.

In 2016, consumption of gasoline and diesel for on- road transportation uses accounted for approximately half (54%) of total petroleum fuel-sourced GHG emissions in Yukon. Twelve percent of total petroleum fuel-sourced GHG emissions in Yukon were attributable to off-road consumption of gasoline and diesel. Heating uses of diesel and propane were associated with 18% of total petroleum fuel-sourced GHG emissions. Consumption of aviation fuels (avgas and jet fuel) accounted for 8% of total petroleum fuel-sourced emissions. Three percent of Yukon's total petroleum fuel-sourced GHG emissions resulted from the generation of electricity with liquefied natural gas (LNG) and diesel.

Yukon GHG Emissions by Petroleum Fuel Type
Kilotons of CO2 equivalent 2009 to 2016
Source: Yukon Bureau of Statistics



Note: The 'All other' category includes Industrial Processes and Product Use, Agriculture and Waste as defined in the Government of Canada's *National Inventory Report*.

Practicality Assessment of Greenhouse Gas Emission Mitigation Measures

The list of greenhouse gas mitigation measures that have been undertaken by other governments which follows on the pages below was developed though a review of reports, studies and articles. The list is intended to be comprehensive as it includes measures attempted by all levels of government and in different provinces, territories and countries. A total of 118 measures were identified and are listed in the table.

The right-hand column in the table presents a preliminary assessment of the practicality of the Yukon Government implementing the measure. Measures identified as practical for implementation in Yukon are notated in green: . A 'Yukon check-mark' (✔) indicates that the measure has already been implemented in Yukon.

Measures identified as not practical for implementation in Yukon are notated in red: . Measures were noted as not practical for implementation according to one of three reasons:

- FJ federal jurisdiction, governments in Yukon (territorial, First Nation, municipal) do not have authority to implement measure.
- LC limited Yukon capacity to undertake and/or implement.
- SS industry or activity not currently at sufficient scale to warrant measure design and implementation.

Cross-sector Measures	Practicality Assessment
C1. Carbon Tax	
introduce a tax on each tonne of carbon dioxide emitted from the combustion of petroleum-based fuels (coal, natural gas, gasoline, diesel, heating fuel, aviation gas).	
C2. Cap and Trade Program	
introduce a cap and trade program with a fixed number of pollution permits for a fixed volume of carbon dioxide emissions and allow the trading of permits to establish a price for carbon.	
C3. Research and Development	
fund basic and applied R&D focused on reducing the capital costs of less carbon intensive equipment, vehicles, buildings, etc.	LC
fund basic and applied R&D focused on reducing the volume of petroleum-based fuel required to operate combustion engines and devices.	LC
C4. Government Leadership	
implement green (zero-emission) government vehicle fleets.	
transition government buildings to net-zero.	✔
implement green procurement practices for the purchase of products and services that minimize adverse environmental impacts without compromising quality or price competitiveness.	✔

A high-level indication of effectiveness is also provided in the sector-specific sections of the table presented below as the sectors have been ordered by the ranking of a sectors' contribution to Yukon's overall greenhouse gas emissions. Thus, the transportation sector, which according to Environment and Climate Change Canada's 2018 *National Inventory Report*, accounts for 69% of total greenhouse gas emissions, appears first in the table.

Transportation [69% of Total Yukon CO_2e]	Practicality Assessment
T1: Passenger Vehicle Emission Regulations and Incentives	
reduce emissions from passenger vehicles through incentives to: - purchase zero emission vehicles (e.g., electric cars) - scrap older high-emission vehicles	
run awareness campaigns to reduce vehicle idling in winter.	✓
impose emissions standards for light duty vehicles that ramp up over time.	FJ
introduce zero emission standards for vehicle fleets.	
T2: Expanded Availability and Use of Lower-carbon Vehicle Fuels	
increase the supply and distribution of lower-carbon vehicle fuels (e.g., ethanol) throughout Canada's 13 provinces and territories by imposing standards for the composition of carbon-based fuels (e.g., 10% ethanol).	FJ
assist private firms to convert truck engines to be compatible with lower carbon fuels (e.g., rebates for new engines).	
require municipal governments to make public transit vehicles (e.g. buses) compatible with low carbon fuels.	
switch public transit vehicles from petroleum fuel-powered to electric-powered.	
require a minimum number of electric vehicle charging stations per municipality.	
T3: Energy Efficiency in the Aviation, Rail, Marine and Off-road Industrial Sectors	
introduce measures to encourage the replacement of turbo-prop powered airplanes with jet-powered airplanes.	FJ
offer incentives for using more energy-efficient boat engines.	SS
minimum efficiency regulations for new planes, trains, boats, off-road vehicles and off-road equipment.	FJ
introduce energy efficiency targets for off-road vehicles and equipment currently in use.	FJ
introduce retrofit incentives for off-road vehicles and equipment currently in use.	
T4: Heavy Duty Vehicle and Engine Emission Regulations and Incentives	
implement the federal heavy duty vehicle greenhouse gas regulations.	FJ
introduce incentives to encourage replacement of less fuel-efficient engines with higher-efficiency engines in road construction equipment.	
introduce regulations requiring GHG-reducing technologies be used in heavy duty vehicles currently in use.	
introduce regulations with upper limits on greenhouse gas emissions from heavy duty vehicles.	FJ
offer incentives to scrap older high-emission heavy duty vehicles.	
offer incentives for retrofits of heavy duty vehicles currently in use.	
require truck stops to install heavy duty vehicle charging stations.	
provide funding for electrified truck highway pilot projects.	LC
T5: Fuel Efficiency of On-road Vehicles	
improved enforcement of speed limits to reduce average speeds and fuel consumption.	
regulations requiring truck speed limiters.	FJ
funding for intelligent transportation systems which enable users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks.	LC
regulations requiring truck speed limiters.	FJ
increase the quantum of paved roads.	
outreach and education programs to encourage fuel-efficient driving behaviors.	
T6. Freight Efficiency	
incentives for information technology-enabled freight logistics and supply chain systems.	
funding to support shifts towards more efficient modes of transportation (e.g., from highway truck to rail).	LC
weight-based per kilometer charges for heavy goods vehicles.	✓

T7: Change Transportation Usage Patterns	
use incentives to shift vehicle drivers and passengers to public transit.	
use incentives to shift vehicle drivers and passengers to human-powered transportation modes such as walking and bicycles.	
require urban planning that encourages human-powered transportation	
reduce the number of vehicle-kilometres travelled by building high- occupancy vehicle lanes and high-occupancy toll lanes.	SS
offer employees incentives for car sharing.	
require employers to implement transportation demand management measures (e.g., charge all employees for parking and rebate parking fees to employees that do not use parking spaces).	
provide funding for high frequency and high performance rail systems.	SS
T8: Reduce Congestion and Vehicle-kilometers Travelled	
implement road use pricing based on vehicle kilometres traveled.	
institute pay-as-you-drive (PAYD) insurance policies that cost more the higher the number of kilometres driven.	
reduce transportation-related GHG emissions in municipalities through smart growth oriented development patterns.	
implement congestion pricing in large cities.	SS
introduce variable vehicle registration pricing based on number of cylinders, vehicle weight or vehicle emission rating.	
vehicle excise taxation at time of purchase based on vehicle emission rating.	FJ
introduce financial incentives to accelerate private sector vehicle fleet turnover.	
T9. Increased Availability and Use of Low Carbon Fuels in the Domestic Marine, Rail and Aviation Sectors	
introduce low carbon fuel standard for marine and rail.	FJ
introduce low carbon fuel framework for aviation.	FJ
Buildings [11% of Total Yukon CO_2e]	**Practicality Assessment**
B1. New Housing	
modify building codes to require new houses to be built to net-zero ready standard (i.e., new houses poised to achieve net zero with installation of renewable energy system post-construction).	
B2. Existing Housing	
financial incentives to reduce low rise housing energy use via voluntary shallow retrofits (e.g., LED lights, weather stripping).	✓
financial incentives to reduce low rise housing energy use via voluntary deep retrofits (e.g., upgrades to building envelope and HVAC systems).	✓
introduce regulations and loan programs to reduce energy use by requiring moderate retrofits at time of home sale or permit application.	
B3. New Commercial-Institutional Buildings	
modify building codes to require new commercial and industrial buildings to be built to net-zero ready standard (i.e., buildings poised to achieve net zero with installation of renewable energy system post-construction).	
B4. Existing Commercial-Institutional Buildings	
introduce financial incentives for retrofitting to reduce emissions in existing buildings.	✓
introduce information programs to reduce emissions in existing buildings.	
introduce energy disclosure regulations to reduce emissions in existing buildings.	
B5. Equipment Efficiency	
introduce financial incentives and retrofitting requirements to improve the energy efficiency of equipment and appliances in existing buildings.	✓
increase minimum efficiency standards for additional equipment product categories, such as home appliances, consumer electronics and lighting.	FJ

support the adoption of minimum efficiency standards through market transformation initiatives and incentives.	
introduce minimum standards and labelling (EnerGuide and ENERGY STAR) for space and water heating equipment.	FJ
support the introduction of minimum standards and labelling with incentives.	
B6. Renewable Power and Fuel Switching	
introduce incentive or loan programs for 5 kW solar photovoltaic systems.	✓
introduce incentive or loan programs to reduce emissions by fuel switching of space and water heating from oil/propane to less GHG intensive alternatives.	
B7. Demand Response Opportunities and Behaviour Change	
impose regulations requiring electricity and natural gas utilities to offer enhanced billing to facilitate reduced energy use.	
introduce regulations and incentives to reduce peak electricity demand through time of use rates or by providing utilities control over household thermostat settings.	
introduce financial incentives or rebates to install adaptive thermostats in existing homes.	
B8. Urban Form and Spatial Planning	
reduce heating-related GHG emissions in municipalities through smart growth oriented development patterns.	✓
reduce overall urban emissions through tree planting, green roofs and permeable surfaces.	
Heavy Industry [8% of Total Yukon CO_2e]	**Practicality Assessment**
HI1. Install Combined Heat and Power	
issue tax credits for installation of combined heat and power units that burn biomass instead of fuel oil (e.g., Volter CHP Plant).	
HI2. Transition to Electric Mechanical Drive Systems	
require all new mechanical drive systems in industrial facilities to be powered by electricity rather than carbon-based fuels.	
implement incentives to encourage replacement of existing carbon-based fuel drive systems.	
HI3. Mandate or Use Incentives to Promote Energy Efficiency	
introduce financial incentives such as grants, tax measures and low interest loans to accelerate the use of computerized energy management systems that improve energy efficiency.	
impose regulations that require emissions standards for new and/or existing facilities to achieve a benchmarked improvement.	
HI5. Fuel Switching to Lower Carbon Alternatives	
encourage industrial firms to substitute lower-carbon fuels for heavy fuel oils used in industrial equipment (e.g., substitute "renewable natural gas" for traditional natural gas in industrial applications).	
require natural gas producers to include 5-10% renewable content in natural gas supplied to all sectors.	SS
HI7. Implement Carbon Abatement and Sequestration Technology	
encourage the installation of carbon capture and sequestration technologies in large-scale industrial processes to limit carbon emissions.	SS
HI8. Impose Emission Intensity Regulations	
impose strict emission intensity regulations in selected industrial sectors in an attempt to drive and advance transformative changes in emission-reducing technologies.	SS

Electricity [5% of Total Yukon CO_2e]	Practicality Assessment
E1. Emissions Intensity Performance Standard for Petroleum Fuel-fired Electricity Generation	
for all large petroleum fuel-fired electricity generating units, set performance standard to be equivalent to level of highly efficient combined cycle natural gas (365 tCO2e/GWh, with compliance flexibilities).	
for all large petroleum fuel-fired electricity generating units, set performance standard at a level of 300 tCO2e/GWh in 2020, increasing in stringency to 250 tCO2e/GWh in 2025 with compliance flexibilities.	
for all large coal and natural gas fired units that operate as baseload starting in 2030, set at a level of 250 tCO2e / GWh for coal-fired units and 375 tCO2e /GWh for natural gas-fired units with no flexibilities.	SS
E2. Accelerated Phase-out of Coal-Fired Electricity	
phase-out of unabated coal-fired units completed by 2030.	SS
E3. Non-Emitting Portfolio Standard for Electricity Generation	
an overall portfolio (basket) of electricity generation sources that do not emit greenhouse gases featuring the lesser of 90% non-emitting supply in 2030 or a 20-percentage point increase from the 2014 portion of non-emitting supply by 2030.	✓
an overall portfolio (basket) of electricity generation sources that do not emit greenhouse gases featuring the lesser of 97% non-emitting supply in 2030 or a 30-percentage point increase from the 2014 portion of non-emitting supply by 2030.	
E4. Construction of New Non-Emitting Electricity Generating Facilities	
subsidize the construction of new non-emitting generation capacity to displace diesel-fueled electricity.	✓
facilitate independent power production to enable independent, non-utility producers to sell renewable-source electricity to public utilities.	✓
enable individuals and businesses to instal micro-generation equipment and sell surplus into electricity transmission system.	✓
E6. Interjurisdictional Transfers of Non-Emitting Electricity	
increased use and interties of existing high-voltage transmission capacity connected to non-emitting generation sources.	
increase existing transmission line intertie capacities.	
subsidize the construction of new transmission capacities where none currently exist.	
Forest Resources, Light Manufacturing, Construction [5% of Total Yukon CO_2e]	**Practicality Assessment**
F1. Substitute Domestic Wood Materials for More Emissions-Intensive Building Products	
encourage the adoption of wood-intensive building designs and building codes.	
F2. New Forests	
implement a program to plant vast quantities (e.g., one billion) new trees of fast and slow-growing species to increase the span of forest-based carbon sinks.	
F3. Forest Rehabilitation	
support rehabilitation of Crown lands affected by natural disturbances where such efforts are not currently required to increase the span of forest-based carbon sinks.	
F4. Change in Forest Management Practices	
introduce regionally-appropriate changes to forest management practices that expand the effectiveness of forest-based carbon sinks.	

Waste [2% of Total Yukon CO_2e]	Practicality Assessment
W1. Land Fill Gas Capture and Utilization	
require that an increasing percentage of methane produced in land fill waste facilities be captured and utilized.	
W2. Avoidable Food Waste	
introduce education and incentive programs to reduce increasing percentages of avoidable food waste to reduce emissions at all stages of the food production supply chain including transport.	
W3. Diversion of Organics	
introduce education and incentive programs to increase the volume of organic material diverted from land fill waste facilities.	✓
W4. Diversion of Recyclable Materials	
introduce education and incentive programs to increase the volume of recyclable materials diverted from land fill waste facilities.	✓
Agriculture [1% of Total Yukon CO_2e]	Practicality Assessment
A1. Methane Emissions from Cattle	
adjust cattle feed to incorporate higher proportions of oils and oilseeds and less grass, to reduce methane emissions.	SS
harvest cattle at younger ages (e.g., 60 days).	SS
A2. Convert Marginal Land from Annual Crop Land to Permanent Cover	
increase the percentage of cropped marginal land (classes 4, 5 and 6) converted to permanent cover.	SS
A3. Acres of Nitrogen Fixing Crops in Rotation	
increase the number of acres of nitrogen fixing crops such as soybeans, peas, lentils, beans and chickpeas.	SS
increase the number of acres of legume forage acres (note: legumes are plants that bear their seeds in pods such as beans and canola).	SS
increase the number of acres planted in legumes through forage, cover crops and intercrops.	SS
A4. Biofuel Production	
encourage the growing of low carbon fuels (e.g., corn, willow) for blending with carbon-based fuels.	SS
A5. Adoption of Zero Till Cropping Practices	
encourage the adoption of zero till cropping practices to reduce tractor operation time and conserve soil cover.	SS
A6. Capture and Destroy/ Treat Methane from Manure Storage Systems	
encourage the adoption of available technologies such as biofilter oxidation, catalytic oxidation and anaerobic digestion.	SS
A7. Precision Application of Nitrogen Fertilizers	
reduce the overall amount of nitrogen fertilizers applied by introducing financial incentives to use precision application methods on a greater number of hectares of land.	SS
Oil and Gas [0.1% of Total Yukon CO_2e]	Practicality Assessment
O1. Zero Routine Flaring in Oil Production	
require oil producers to cease routine flaring in oil production and expand zero routine flaring to other sectors.	SS
O2. Oil and Gas Sector Methane Reductions	
require firms in the oil and gas sector to establish detection and repair programs that reduce methane emissions from fugitive (i.e., unintended or irregular) equipment leaks.	SS
meet the federal policy commitment of a 40-45% reduction from 2012 levels by 2030.	SS

O3. Production Subsidy Phase-out	
terminate existing federal subsidies and tax credits for the production of petroleum-based fuels (e.g., Canadian Development Expenses corporate income tax deduction).	FJ

Effectiveness of Practical Greenhouse Gas Emission Mitigation Measures

In this section of the report, the effectiveness of greenhouse gas mitigation measures and programs undertaken by other governments are categorized from three different perspectives: sector effectiveness, mitigation effectiveness and economic sensitivity. The results of the categorization are presented in the table below. The table includes only those measures identified as "practical" in the previous section.

Sector Effectiveness	reflects the potential for greenhouse mitigation measures to have a significant impact on the overall volume of Yukon's greenhouse gas emissions (**high = sector emissions >49%**, **low = sector emissions < 50%**).
Mitigation Effectiveness	as 91% of Yukon's greenhouse gas emissions are in the form of carbon dioxide (on a CO_2 equivalent basis), the most effective greenhouse gas mitigation measures target CO_2 emissions (**high = CO_2 targeted**, **low = CO_2 not targeted**).
Economic Sensitivity	reflects the potential for the measure to have a significant impact on the economic health of Yukon businesses (**high**, **low**).

Cross-sector Measures	Sector Effectiveness	Mitigation Effectiveness	Economic Sensitivity
C1. Carbon Tax			
introduce a tax on each tonne of carbon dioxide emitted from the combustion of petroleum-based fuels (coal, natural gas, gasoline, diesel, heating fuel, aviation gas).	high	high	high
C2. Cap and Trade Program			
introduce a cap and trade program with a fixed number of pollution permits for a fixed volume of carbon dioxide emissions and allow the trading of permits to establish a price for carbon.	low	high	high
C4. Government Leadership			
implement green (zero-emission) government vehicle fleets.	high	high	low
transition government buildings to net-zero.	low	high	low
implement green procurement practices for the purchase of products and services that minimize adverse environmental impacts without compromising quality or price competitiveness.	low	low	low

Transportation [69%]	Sector Effectiveness	Mitigation Effectiveness	Economic Sensitivity
T1: Passenger Vehicle Emission Regulations and Incentives			
reduce emissions from passenger vehicles through incentives to:	high	high	low

- purchase zero emission vehicles (e.g., electric cars) - scrap older high-emission vehicles			
run awareness campaigns to reduce vehicle idling in winter.	high	high	low
introduce zero emission standards for vehicle fleets.	high	high	high
T2: Expanded Availability and Use of Lower-carbon Vehicle Fuels			
assist private firms to convert truck engines to be compatible with lower carbon fuels (e.g., rebates for new engines).	high	high	high
require municipal governments to make public transit vehicles (e.g. buses) compatible with low carbon fuels.	high	high	low
switch public transit vehicles from petroleum fuel-powered to electric-powered.	high	high	low
require a minimum number of electric vehicle charging stations per municipality.	high	high	low
T3: Energy Efficiency in the Aviation, Rail, Marine and Off-road Industrial Sectors			
introduce retrofit incentives for off-road vehicles and equipment currently in use.	high	high	high
T4: Heavy Duty Vehicle and Engine Emission Regulations and Incentives			
introduce incentives to encourage replacement of less fuel-efficient engines with higher-efficiency engines in road construction equipment.	high	high	high
introduce regulations requiring GHG-reducing technologies be used in heavy duty vehicles currently in use.	high	high	high
offer incentives to scrap older high-emission heavy duty vehicles.	high	high	high
offer incentives for retrofits of heavy duty vehicles currently in use.	high	high	high
require truck stops to install heavy duty vehicle charging stations.	high	high	high
T5: Fuel Efficiency of On-road Vehicles			
improved enforcement of speed limits to reduce average speeds and fuel consumption.	high	high	low
increase the quantum of paved roads.	high	high	low
outreach and education programs to encourage fuel-efficient driving behaviors.	high	high	low
T6. Freight Efficiency			
incentives for information technology-enabled freight logistics and supply chain systems.	high	high	high
weight-based per kilometer charges for heavy goods vehicles.	high	high	high
T7: Change Transportation Usage Patterns			
use incentives to shift vehicle drivers and passengers to public transit.	high	high	low
use incentives to shift vehicle drivers and passengers to human-powered transportation modes such as walking and bicycles.	high	high	low

require urban planning that encourages human-powered transportation.	high	high	low
offer employees incentives for car sharing.	high	high	high
require employers to implement transportation demand management measures (e.g., charge all employees for parking and rebate parking fees to employees that do not use parking spaces).	high	high	high
T8: Reduce Congestion and Vehicle-kilometers Travelled			
implement road use pricing based on vehicle kilometres traveled.	high	high	high
institute pay-as-you-drive (PAYD) insurance policies that cost more the higher the number of kilometres driven.	high	high	high
reduce transportation-related GHG emissions in municipalities through smart growth oriented development patterns.	high	high	low
introduce variable vehicle registration pricing based on number of cylinders, vehicle weight or vehicle emission rating.	high	high	high
introduce financial incentives to accelerate private sector vehicle fleet turnover.	high	high	high
Buildings [11%]	**Sector Effectiveness**	**Mitigation Effectiveness**	**Economic Sensitivity**
B1. New Housing			
modify building codes to require new houses to be built to net-zero ready standard (i.e., new houses poised to achieve net zero with installation of renewable energy system post-construction).	low	high	low
B2. Existing Housing			
financial incentives to reduce low rise housing energy use via voluntary shallow retrofits (e.g., LED lights, weather stripping).	low	high	low
financial incentives to reduce low rise housing energy use via voluntary deep retrofits (e.g., upgrades to building envelope and HVAC systems).	low	high	low
introduce regulations and loan programs to reduce energy use by requiring moderate retrofits at time of home sale or permit application.	low	high	low
B3. New Commercial-Institutional Buildings			
modify building codes to require new commercial and industrial buildings to be built to net-zero ready standard (i.e., buildings poised to achieve net zero with installation of renewable energy system post-construction).	low	high	high
B4. Existing Commercial-Institutional Buildings			
introduce financial incentives for retrofitting to reduce emissions in existing buildings.	low	high	high
introduce information programs to reduce emissions in existing buildings.	low	high	high
introduce energy disclosure regulations to reduce emissions in existing buildings.	low	high	high
B5. Equipment Efficiency			

introduce financial incentives and retrofitting requirements to improve the energy efficiency of equipment and appliances in existing buildings.	low	low	high
support the adoption of minimum efficiency standards through market transformation initiatives and incentives.	low	low	high
support the introduction of minimum standards and labelling with incentives.	low	high	low
B6. Renewable Power and Fuel Switching			
introduce incentive or loan programs for 5 kW solar photovoltaic systems.	low	high	low
introduce incentive or loan programs to reduce emissions by fuel switching of space and water heating from oil/propane to less GHG intensive alternatives.	low	high	high
B7. Demand Response Opportunities and Behaviour Change			
impose regulations requiring electricity and natural gas utilities to offer enhanced billing to facilitate reduced energy use.	low	low	low
introduce regulations and incentives to reduce peak electricity demand through time of use rates or by providing utilities control over household thermostat settings.	low	low	high
introduce financial incentives or rebates to install adaptive thermostats in existing homes.	low	high	low
B8. Urban Form and Spatial Planning			
reduce heating-related GHG emissions in municipalities through smart growth oriented development patterns.	low	high	low
reduce overall urban emissions through tree planting, green roofs and permeable surfaces.	low	low	low
Heavy Industry [8%]	**Sector Effectiveness**	**Mitigation Effectiveness**	**Economic Sensitivity**
HI1. Install Combined Heat and Power			
issue tax credits for installation of combined heat and power units that burn biomass instead of fuel oil (e.g., Volter CHP Plant).	low	high	high
HI2. Transition to Electric Mechanical Drive Systems			
require all new mechanical drive systems in industrial facilities to be powered by electricity rather than carbon-based fuels.	low	high	high
implement incentives to encourage replacement of existing carbon-based fuel drive systems.	low	high	high
HI3. Mandate or Use Incentives to Promote Energy Efficiency			
introduce financial incentives such as grants, tax measures and low interest loans to accelerate the use of computerized energy management systems that improve energy efficiency.	low	high	high
impose regulations that require emissions standards for new and/or existing facilities to achieve	low	high	high

a benchmarked improvement.			
HI5. Fuel Switching to Lower Carbon Alternatives			
encourage industrial firms to substitute lower-carbon fuels for heavy fuel oils used in industrial equipment (e.g., substitute "renewable natural gas" for traditional natural gas in industrial applications).	low	high	high
Electricity [5%]	**Sector Effectiveness**	**Mitigation Effectiveness**	**Economic Sensitivity**
E1. Emissions Intensity Performance Standard for Petroleum Fuel-fired Electricity Generation			
for all large petroleum fuel-fired electricity generating units, set performance standard to be equivalent to level of highly efficient combined cycle natural gas (365 tCO2e/GWh, with compliance flexibilities).	low	high	high
for all large petroleum fuel-fired electricity generating units, set performance standard at a level of 300 tCO2e/GWh in 2020, increasing in stringency to 250 tCO2e/GWh in 2025 with compliance flexibilities.	low	high	high
E3. Non-Emitting Portfolio Standard for Electricity Generation			
the lesser of 90% non-emitting supply in 2030 or a 20-percentage point increase from the 2014 portion of non-emitting supply by 2030.	low	high	high
the lesser of 97% non-emitting supply in 2030 or a 30-percentage point increase from the 2014 portion of non-emitting supply by 2030.	low	high	high
E4. Construction of New Non-Emitting Electricity Generating Facilities			
subsidize the construction of new non-emitting generation capacity to displace diesel-fueled electricity.	low	high	low
facilitate independent power production to enable independent, non-utility producers to sell renewable-source electricity to public utilities.	low	high	high
enable individuals and businesses to instal micro-generation equipment and sell surplus into electricity transmission system.	low	high	high
E6. Interjurisdictional Transfers of Non-Emitting Electricity			
increased use and interties of existing high-voltage transmission capacity connected to non-emitting generation sources.	low	high	high
increase existing transmission line intertie capacities.	low	high	high
subsidize the construction of new transmission capacities where none currently exist.	low	high	high
Forest Resources, Light Manufacturing, Construction [5%]	**Sector Effectiveness**	**Mitigation Effectiveness**	**Economic Sensitivity**
F1. Substitute Domestic Wood Materials for More			

Emissions-Intensive Building Products			
encourage the adoption of wood-intensive building designs and building codes.	low	low	high
F2. New Forests			
implement a program to plant one billion new trees (fast and slow-growing species) to increase the span of forest-based carbon sinks.	low	high	low
F3. Forest Rehabilitation			
support rehabilitation of Crown lands affected by natural disturbances where such efforts are not currently required to increase the span of forest-based carbon sinks.	low	high	low
F4. Change in Forest Management Practices			
introduce regionally-appropriate changes to forest management practices that expand the effectiveness of forest-based carbon sinks.	low	high	low
Waste [2%]	**Sector Effectiveness**	**Mitigation Effectiveness**	**Economic Sensitivity**
W1. Land Fill Gas Capture and Utilization			
require that an increasing percentage of methane produced in land fill waste facilities be captured and utilized.	low	low	low
W2. Avoidable Food Waste			
introduce education and incentive programs to reduce increasing percentages of avoidable food waste to reduce emissions at all stages of the food production supply chain including transport.	low	high	low
W3. Diversion of Organics			
introduce education and incentive programs to increase the volume of organic material diverted from land fill waste facilities.	low	low	low
W4. Diversion of Recyclable Materials			
introduce education and incentive programs to increase the volume of recyclable materials diverted from land fill waste facilities.	low	high	high
Agriculture [1%]	**Sector Effectiveness**	**Mitigation Effectiveness**	**Economic Sensitivity**
n/a	--	--	--
Oil and Gas [0.1%]	**Sector Effectiveness**	**Mitigation Effectiveness**	**Economic Sensitivity**
n/a	--	--	--

Economic Development Opportunities for Yukon Businesses

Implementation of the greenhouse gas mitigation measures identified in the report section above will bring possibilities for economic development opportunities for Yukon businesses. The Yukon's economy features a remote location, small population size and limited manufacturing capacity. As a result, significant economic development opportunities will be limited to measures and initiatives involving three types of economic opportunity factors: import substitution, labour intensity and local knowledge.

Import Substitution	involves replacing imported energy inputs with Yukon-sourced energy inputs. Example: substituting Yukon-grown biomass fuels for petroleum-based heating fuels refined in Alberta.
Labour Intensity	with limited manufacturing capacity in Yukon, capital-intensive mitigation measures will tend to benefit southern jurisdictions over Yukon. Conversely, mitigation measures which are more labour intensive will tend to benefit Yukon businesses that supply local labour.
Local Knowledge	while many mitigation measures are equally effective whether applied in southern Canada or the Yukon, the application of local knowledge in the design of place-specific mitigation measures will increase effectiveness of the measure.

The results of the analysis, grouped by economic opportunity factor, are presented below:

Import Substitution

- implement green procurement practices for the purchase of products and services that minimize adverse environmental impacts without compromising quality or price competitiveness.
- issue tax credits for installation of combined heat and power units that burn biomass instead of fuel oil (e.g., Volter CHP Plant).
- subsidize the construction of new non-emitting generation capacity to displace diesel-fueled electricity.
- facilitate independent power production to enable independent, non-utility producers to sell renewable-source electricity to public utilities
- enable individuals and businesses to instal micro-generation equipment and sell surplus into electricity transmission system.

Labour Intensity

- transition government buildings to net-zero.
- introduce retrofit incentives for off-road vehicles and equipment currently in use.
- offer incentives for retrofits of heavy duty vehicles currently in use.
- increase the quantum of paved roads.

- financial incentives to reduce low rise housing energy use via voluntary shallow retrofits (e.g., LED lights, weather stripping).
- financial incentives to reduce low rise housing energy use via voluntary deep retrofits (e.g., upgrades to building envelope and HVAC systems).
- introduce regulations and loan programs to reduce energy use by requiring moderate retrofits at time of home sale or permit application.
- introduce financial incentives for retrofitting to reduce emissions in existing buildings.
- introduce incentive or loan programs for 5 kW solar photovoltaic systems.
- introduce incentive or loan programs to reduce emissions by fuel switching of space and water heating from oil/propane to less GHG intensive alternatives.
- reduce overall urban emissions through tree planting, green roofs and permeable surfaces.
- increased use and interties of existing high-voltage transmission capacity connected to non-emitting generation sources.
- increase existing transmission line intertie capacities.
- subsidize the construction of new transmission capacities where none currently exist.
- implement a program to plant one billion new trees (fast and slow-growing species) to increase the span of forest-based carbon sinks.
- support rehabilitation of Crown lands affected by natural disturbances where such efforts are not currently required to increase the span of forest-based carbon sinks.

Local Knowledge

- require urban planning that encourages human-powered transportation.
- modify building codes to require new houses to be built to net-zero ready standard (i.e., new houses poised to achieve net zero with installation of renewable energy system post-construction).
- modify building codes to require new commercial and industrial buildings to be built to net-zero ready standard (i.e., buildings poised to achieve net zero with installation of renewable energy system post-construction).
- introduce information programs to reduce emissions in existing buildings.
- encourage the adoption of wood-intensive building designs and building codes.
- introduce regionally-appropriate changes to forest management practices that expand the effectiveness of forest-based carbon sinks.