an initiative by

ECOLOGY NORTH

THE NORTHERN BUILDING RETROFIT ECONOMY

AMBITIOUS, ACHIEVABLE BUILDING SECTOR GREENHOUSE GAS EMISSIONS REDUCTIONS, WITH NET POSITIVE RETURNS, IMPROVED QUALITY OF LIFE, & JOB CREATION

APRIL 2019

an initiative by

for

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THE NORTHERN BUILDING RETROFIT ECONOMY

Building Energy Improvements in the Northwest Territories

Ambitious, achievable building sector greenhouse gas emissions reductions, with net positive returns, improved quality of life, & job creation

Contents

© **Ecology North.** Ecology North gratefully acknowledges: project direction by **William Gagnon**, building engineer, LEED AP BD+C, LEED AP ND, LFA, ECO Canada EPt; research and primary writing by **Eric Chisholm**, CEM, LEED AP and **David**

Thompson, M.Sc., LL.M.; professional copy-editing, design and layout by Ecology North.

0. Executive Summary

The Government of the Northwest Territories has worked to improve the energy efficiency of buildings through funding retrofit programs, and to develop renewable energy to replace expensive imported diesel.

It has an enormous opportunity to expand this work.

Doing so will reduce energy costs for building owners - costs that are about twice as high as in southern Canada, and that add to an already-high cost of living across the Territories.

9%
ROI

This paper describes an ambitious but achievable program of accelerated energy efficiency retrofits, switching to low-carbon fuels, and developing renewable energy resources. This program would reduce local air pollution from the burning of fossil fuels, and would reduce GHG emissions by 121,000 tonnes of CO2e by 2030, taking the territories further toward its emissions reductions goals. It would save building owners a cumulative total of $120 million in utility bills by 2030 - a 9% return on investment - helping to reduce the cost of living.

$120M
savings by 2030
in utility bills

INSTALLING ENERGY EFFICIENCY AND ONSITE RENEWABLE ENERGY PRODUCTION

This program also would grow businesses and employment in insulating and weatherproofing, installing energy efficient doors, windows, heater and appliances, installing and maintaining solar panels, and the like. The additional spending would multiply throughout the economy, generating 87 jobs and $11.8 million in GDP gains in each year that the program operates.

NET BENEFITS

The program would have net financial benefits, rather than costs; future energy savings would more than pay for the initial investment. As soon as any borrowing costs are paid down, building owners would spend their energy cost savings in various areas of the economy. That spending would generate additional jobs and GDP growth.

0. Executive Summary (continued)

123 JOBS

123 JOBS FOR THE NORTHWEST TERRITORIES

In 2030, the upgrade activities plus the spending of energy cost savings would generate 123 jobs and $15.4 million in GDP, raising Territorial tax revenues by $1.5 million without increasing tax rates. All these amounts would increase over following years.

START NOW

START NOW

Elements of the program are already proven in the NWT, thanks for the work of the Arctic Energy Alliance, among others. There is no need to perfect the program before expanding it. The sooner the work is accelerated, the sooner energy consumption, local air pollution and GHG emissions drop, people save money, businesses grow, jobs are created, tax revenues rise, and the public costs of unemployment fall.

The program should focus initially on upgrades that improve housing for lower income people, as they would benefit the most from the savings and from more comfortable housing. Also, because lower income people tend to spend available dollars more quickly than wealthy people, the energy savings they receive will more quickly generate economic activity, jobs, and tax revenues. In housing where government pays for energy use, government will realize the savings, immediately and indefinitely into the future.

START WITH THE LOWEST HANGING FRUITS

The largest GHG reductions ("best bang for the buck") will come from improving houses that are currently heated with fossil fuels, so these should be prioritized over households heated with electricity or renewable fuels.

Ecology North et al. applaud the government for its efforts to date on energy efficiency, renewable energy and climate change mitigation, and looks forward to the next chapter and the outcomes it will deliver - for building owner, workers, businesses and the broader economy.

1. INTRODUCTION

1. Introduction

Energy costs for the average home or building in the NWT are about twice as high as in southern Canada, adding to an already-high cost of living.

The Government of the Northwest Territories has worked to reduce energy costs by funding energy efficiency retrofit programs and the development of renewable energy to replace expensive imported diesel.

This paper points out that these efforts are a good start, and that much more can be done. A program of accelerated energy efficiency retrofits, switching to low-carbon fuels, and developing renewable energy resources can dramatically cut energy costs for residents and businesses - saving homeowners thousands of dollars per year.

It can also help the government achieve its climate change emission reduction goals, while reducing local air pollution. It can also create hundreds of jobs, grow business and expand the economy by millions of dollars in GDP.

And of course all of that means generating more tax revenues, without having to increase tax rates.

The next section of this paper provides information about current climate emissions trends and goals. The third section presents a scenario for such a program - a scenario that is ambitious but achievable.

The fourth section presents the economic benefits of such a program. The fifth section provides a brief summary and some conclusions.

2. GHG EMISSIONS TRENDS & REDUCTIONS NEEDED

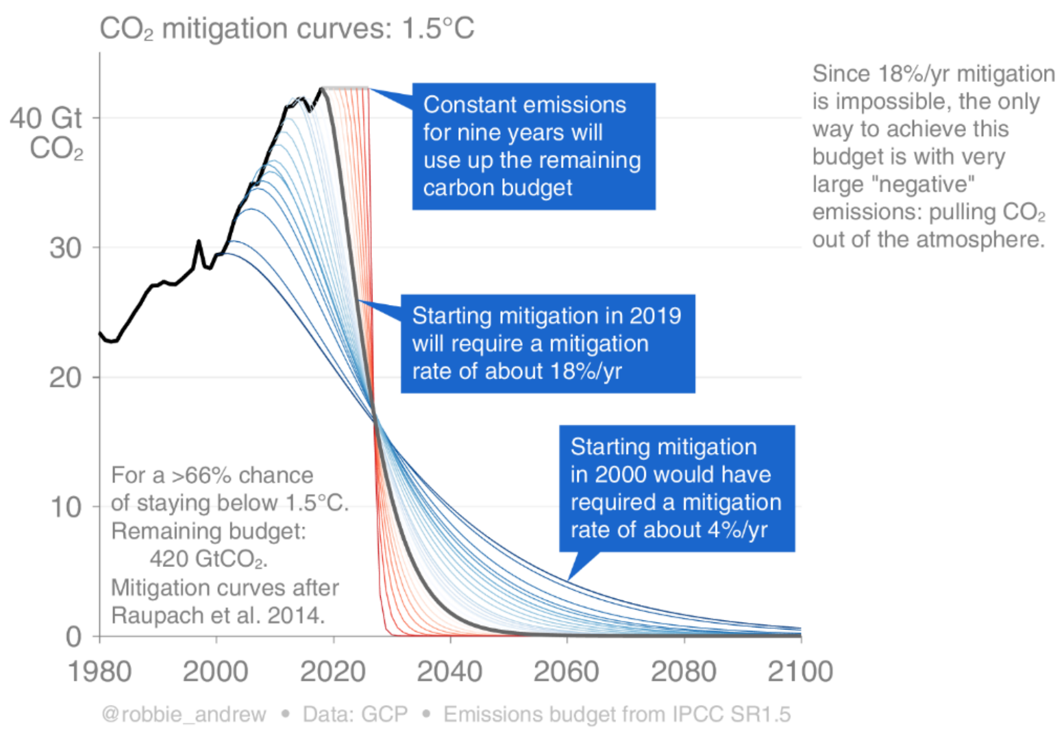
2. GHG emissions trends and reductions needed

2.1 Trends and targets

On December 9, 2016, leaders of the Northwest Territories adopted the Pan-Canadian Framework on Clean Growth and Climate Change (PCF) alongside all but two of Canada's First Ministers. Manitoba joined later and Saskatchewan did not. This positioned the Northwest Territories (and all of Canada) to meet a Paris Agreement greenhouse gas (GHG) emissions reduction target of 30% below 2005 levels by 2030.[1]

The deadline is now 11 years away while carbon emissions remains above the committed target for both Northwest Territories and for all of Canada. With every year that passes without significant progress, meeting the target becomes significantly more difficult and therefore more costly to achieve (see figure 1 below).

Figure 1 Emissions budget and pathways from IPCC SR1.5[2]

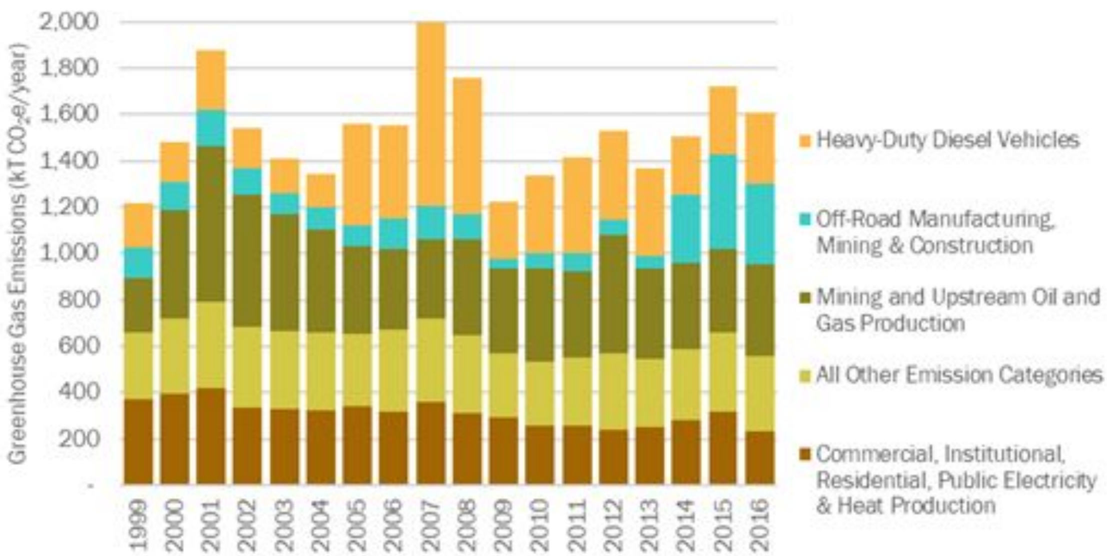


[1] "Pan-Canadian Framework on Clean Growth and Climate Change ...." 21 Dec. 2018, canada.ca. Accessed 15 Apr. 2019.
[2] "Carbon Budget - Global Carbon Project." 5 Dec. 2018, globalcarbonproject.org. Accessed 15 Apr. 2019.

In late 2018 the Intergovernmental Panel on Climate Change (IPCC) released a Special Report[3] stating that Paris Agreement ambitions are insufficient to limit global warming to 1.5 °C, and that global human-caused emissions of carbon dioxide (CO_2) must fall by about 45 percent from 2010 levels by 2030, reaching 'net zero' around 2050. Northwest Territories has not yet committed to a new target based on this global update.

Counter to the above stated target (and global need), as of 2016, Northwest Territories' greenhouse gas emissions have increased by 20%, mostly due to mining, construction, and off-road transport related to manufacturing, mining and construction[1] (see figure 2 below). Now a total 65% reduction from 2010 levels is needed for Northwest Territories to support the IPCC 2030 target.

Figure 2 Greenhouse Gas Sources by Year, Northwest Territories



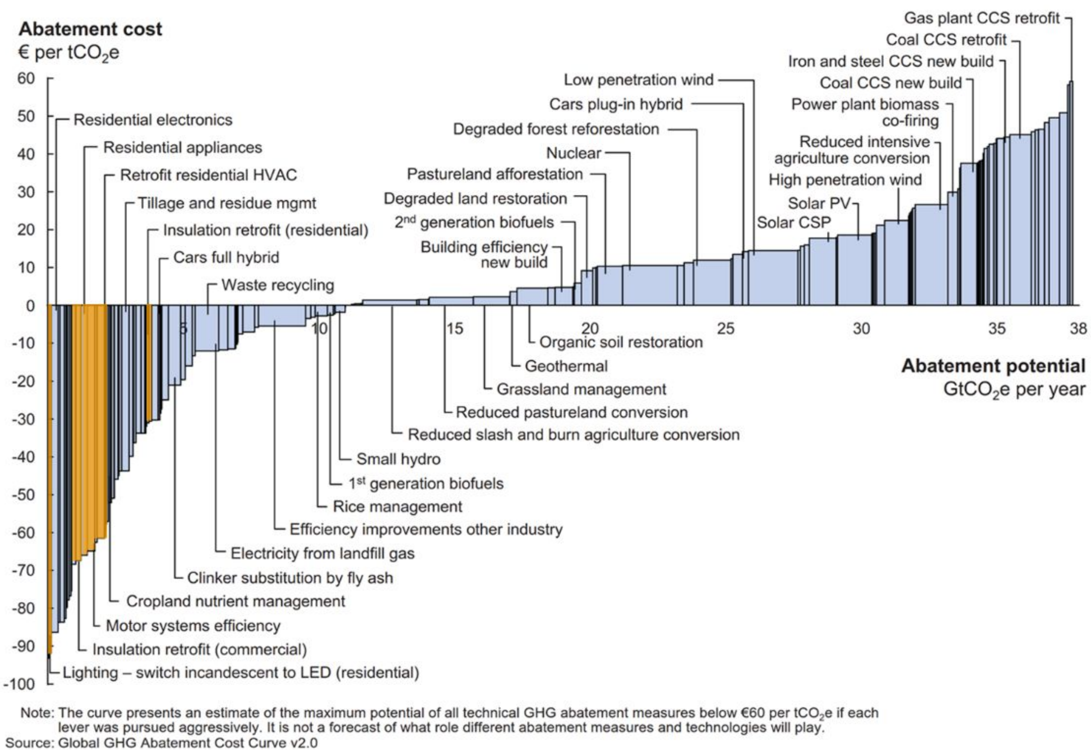
[3] "Global Warming of 1.5 °C - IPCC." ipcc.ch/sr15. Accessed 15 Apr. 2019.

2.2 The Role of Buildings

Buildings and electricity production are the most cost-effective opportunity to reduce greenhouse gas emissions, and are responsible for 14% of greenhouse gas emissions in Northwest Territories (see figure 3 below).

The Pan-Canadian Framework's second annual Synthesis Report released in late 2018[1] affirms that the buildings sector is a significant focus. Nearly half of provincial and territorial projects approved under the Low Carbon Economy Fund (with a value of $1.1 billion) are for energy efficiency retrofits in the residential and commercial buildings sector.

Figure 3 Global GHG abatement cost curve beyond business-as-usual – 2030

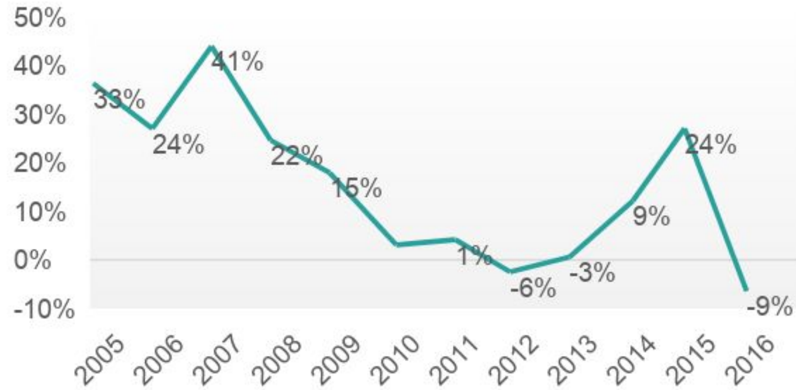


The buildings sector cannot reasonably reduce emissions enough to offset the mining sector's increase since 2010. But taking responsibility for an intra-sectoral 45% reduction is fair.

Intra-sectoral NWT buildings sector emissions have seen large swings since 2010. Emissions were 24% higher in 2015, then 9% lower in 2016 (see figure 3). From 2011-2016 emissions averaged 3% higher than the 2010 baseline, indicating that any sector progress since 2010 has not been stable or measurable.

This report describes the effort needed to reduce buildings sector emissions by 45% from latest available (2016) levels by 2030. This target represents the NWT buildings sector action consistent with limiting global warming to 1.5C (2018 IPCC Special Report), taking no credit for the unstable sector emissions changes since 2010.

Figure 3 Change in Greenhouse Gas Emissions by year, Northwest Territories Building Sector[4]



2.3 How Will Buildings Sector Emissions Change If We Do Nothing?

All else being equal, greenhouse gas emissions in the buildings sector will rise by 2030 as housing stock grows alongside population.

Northwest Territories population has increased by 3.6 percent in the past ten years. New space will be needed for a growing population to live, work, and play. Based on historic population and housing density trends provided by Statistics Canada this will require building an additional 1,000 homes and commercial spaces by 2030, increasing Northwest Territories annual emissions by a further 10,000 tonnes of greenhouse gas.

2.4 Northwest Territories Taking Action on Electricity Emissions

The Government of Northwest Territories (GNWT) has committed to take action on emissions related to electricity use.
The Government's 2030 Energy Strategy released in April 2018 sets a direction to reach an overarching 2030 vision including:

1. Reducing GHG emissions from electricity generation in diesel-powered communities by an average of 25%;
2. Increasing the share of renewable energy used for space heating to 40%; and
3. Increasing residential, commercial, and government building energy efficiency by 15%[5].

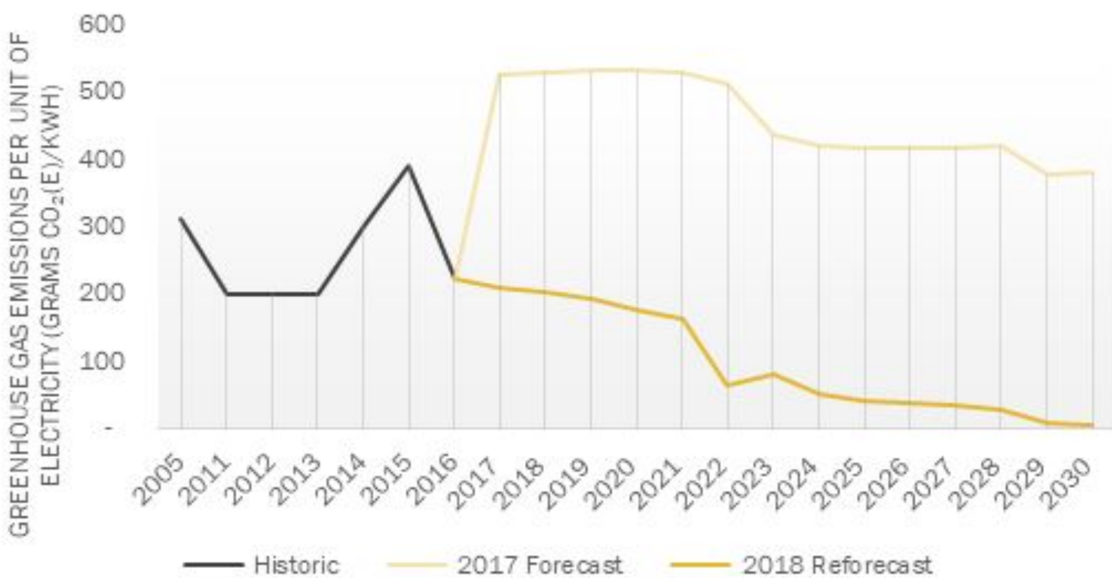
Renewable solutions to meet this target include solar, wind, transmission lines to diesel-powered communities, and energy storage.
Accomplishments in 2018 include the commissioning of a variable speed generator and solar array in Aklavik, feasibility and design work for megawatt-scale wind in Inuvik, and wind monitoring for smaller-scale wind in two communities.[1]
Canada's $220 million Clean Energy for Rural and Remote Communities Program may further support Northwest Territories communities seeking to reduce their reliance on diesel fuel for heat and power.

[4] Environment and Climate Change Canada, "National Inventory Report 2018" Table A11-2 GHG Emissions for stationary combustion from Commercial and Institutional, Residential, and Public Electricity and Heat Production
[5] "2030 Energy Strategy | Infrastructure." inf.gov.nt.ca. Accessed 15 Apr. 2019.

2.5 The future of Electricity Emissions

The Government of Canada's National Energy Board (NEB) annually publishes Energy Supply and Demand Projections to 2040 for each territory and province, including the generation from each fuel source (hydro, solar, oil, etc.). The 2017 edition predicted that a significant portion of electricity generation would come from oil and natural gas fired generation until 2040. The 2018 re-forecast presents a significant change in direction, predicting that oil and natural gas use will nearly disappear by 2030, citing the Northwest Territories 2030 Energy Strategy plan which lays out a decline in fossil fuel power. A forecast of emissions intensity of Northwest Territories electricity production to 2030 using both the 2017 and re-forecasted 2018 projections is shown in figure 4 below.

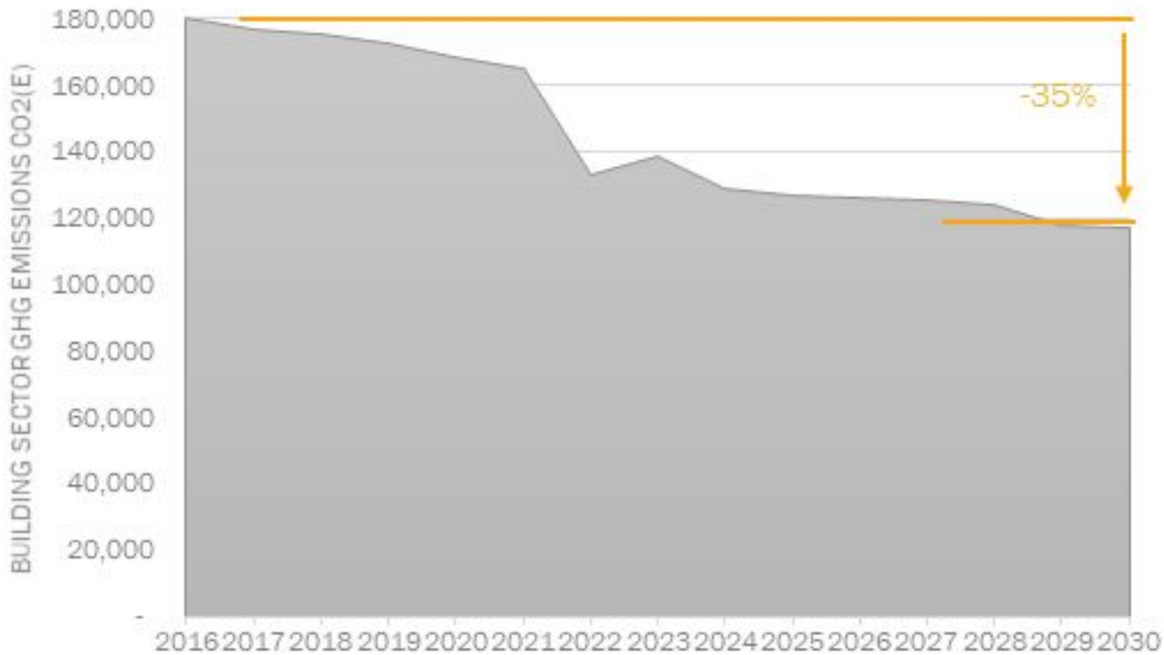
Figure 4 Northwest Territories Electricity Grid Emissions Intensity Forecast



As the territory's electricity grid shifts away from fossil fuels, building carbon emissions will decrease. By 2030 the combination of population growth and electricity grid decarbonization will result in an annual 70,000 tonne reduction in greenhouse gas emissions from buildings and the electricity they consume. This represents a 35% reduction to buildings sector carbon emissions by 2030. The remaining 65% of buildings sector carbon emissions from oil, natural gas and propane heating will continue unchanged.

Even if the NWT electric grid is successfully decarbonized on-schedule, further action is required for Northwest Territories buildings to reduce their emissions by 45% by 2030. If the NWT grid does not decarbonize at the scale or pace predicted by NEB, even greater action is required by buildings.

Figure 5 Annual Greenhouse Gas Emissions Change, Business as Usual Scenario



3. BUILDING ACTION TO REDUCE EMISSIONS

3. Building Action to Reduce Emissions

The Northwest Territories buildings must take four actions:

1. **Undertake Standard Efficiency Retrofits** to improve operational performance;
2. **Undertake Deep Retrofits** to high performance standards, focusing on carbon reduction;
3. **Incorporate Solar** or other on-site renewable energy systems in buildings; and
4. **Switch to Low-Carbon Fuel Sources** in buildings.

These actions build on the framework set out by the Canada Green Building Council (CaGBC) in “Building Solutions to Climate Change”, 2016[6] which include all but the first action. Undertaking Standard Efficiency Retrofits is added here to replace the CaGBC framework’s “Recommissioning” action which is better suited to large commercial-scale buildings and only useful to a limited number of buildings in Northwest Territories which tend toward a smaller scale.

None of these four actions alone will be enough to achieve the greenhouse gas emissions targets needed from NWT’s buildings sector, but together they represent an opportunity that is both achievable and impactful. These activities and their potential benefit to Northwest Territories buildings is as follows:

3.1 Undertake Standard Efficiency Retrofits

Standard Efficiency Retrofits are actions that improve building efficiency without requiring major building renewal. Examples include energy-efficient appliances, LED lighting, smart thermostats, weatherstripping (air sealing), and adding attic insulation.

Arctic Energy Alliance (AEA)[7], with over 20 years of experience and local knowledge, provides valuable resources on these actions specific to the Northwest Territories. The AEA website includes tips, case studies and resources related to deep retrofits, renewable energy and wood pellet heating.

Undertaking Standard Efficiency Retrofits at two percent of households and commercial buildings each year would result in 4,000 Tonnes of avoided annual Greenhouse Gas emissions and $6 Million per year of reduced utility bills by 2030 – a 23% return on investment. By 2030, 27,000 Tonnes of Greenhouse Gas emissions would have been prevented, and $35 Million would have been saved.

A two percent annual conservation activity across a population is considered challenging. For comparison, between 2007 and 2012, the federal EcoEnergy Retrofit Program (2007-2012) documented a 0.3% annual conservation program uptake in the NWT which included a combination of Standard Efficiency Retrofit, Deep Retrofit and Fuel Switching. An example of aggressive conservation program action was seen in the LiveSmart BC residential incentive program, which, in the second quarter of 2009, documented a 3% annualized conservation program uptake.[8] The program included a combination of retrofits and electrification.

[6] "Building Solutions to Climate Change - Canada Green Building Council." cagbc.org. Accessed 15 Apr. 2019.
[7] "Arctic Energy Alliance • Reducing The Use and Cost of Energy." aea.nt.ca. Accessed 15 Apr. 2019.
[8] "Deep Emissions Reduction in the Existing Building Stock ...." 11 Apr. 2017, pembina.org. Accessed 15 Apr. 2019.

3.2 Undertake Deep Retrofits

Deep retrofits involve major system replacements and equipment upgrades, often requiring significant upfront investment. For this reason, deep retrofits are typically carried out during building renewal events such as envelope replacement, major equipment replacement, new ownership or occupancy.[9] Examples of deep retrofit activities suited to the northern climate include increasing wall insulation, installing high-efficiency doors and high-efficiency triple- or quadruple-pane windows with low-emissivity coatings. Additional deep retrofit activities may be appropriate for commercial buildings and larger multi-unit residences.

The federal EcoEnergy Retrofit Program (2007-2012) highlights deep retrofit opportunities in the Northwest Territories. The program provided homeowners with grants of up to $5,000 for eligible energy efficiency measures. 961 NWT homeowners completed initial EnerGuide assessments, and 211 followed through with energy efficiency upgrades. Owners of older houses (over 25 years old) were almost twice as likely to follow through with upgrades, preferring upgraded draftproofing, windows/doors and walls over space heating improvements. These older homes saved an average 49 GJ of energy per house per year, corresponding to about $3,949 per year in savings (2014 equivalent) if the house is heated with electricity, or $1,634 per year in savings if the house is heated with oil.[10]

Undertaking Deep Efficiency Retrofits at 0.5% of households and commercial buildings each year would result in 3,300 Tonnes of avoided annual Greenhouse Gas emissions and $5 Million per year of reduced utility bills by 2030 – a 4% return on investment. By 2030, 21,000 Tonnes of Greenhouse Gas emissions would have been prevented, and $28 Million would have been saved.

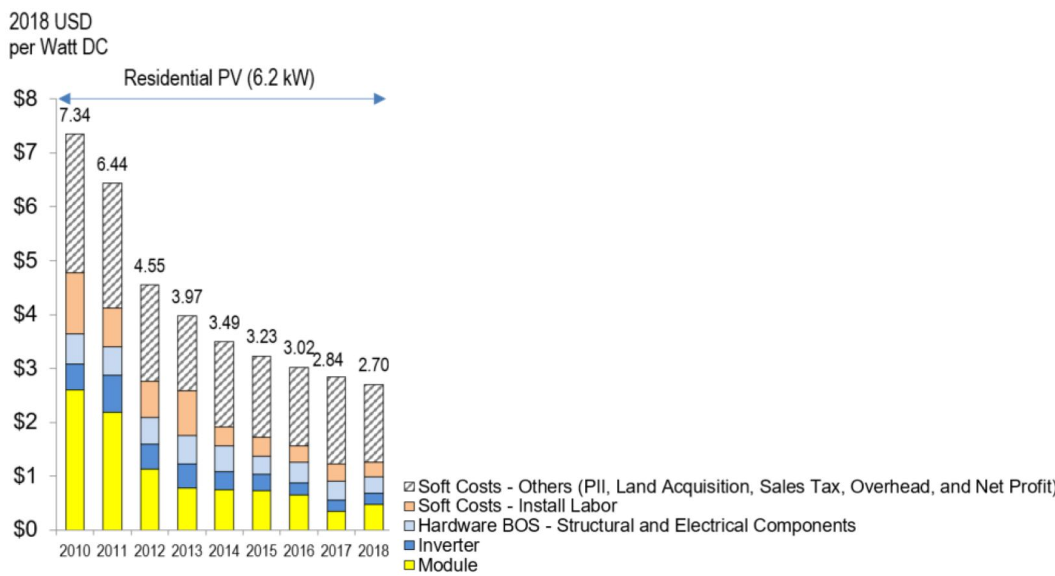
3.3 Incorporate Solar or other on-site renewable energy systems

The GNWT 2030 Energy Strategy notes that the NWT has long daylight hours in the spring and summer, and can harness solar power for up to 8 months of the year. The Strategy also notes that in the past, small wind turbines were ill-suited to the NWT's cold climate while now wind turbines features make them more robust and reliable for cold climate use. Small wind turbines have the potential to annually produce more electricity than solar, which is limited in the winter.[5]

Undertaking renewable energy installations at 0.5% of households and commercial buildings each year would result in 1,000 Tonnes of avoided annual Greenhouse Gas emissions and $5 Million per year of reduced utility bills by 2030 – a 7% return on investment (or better if the recent downward trend in solar power cost continues, see figure 6). By 2030, 9,000 Tonnes of Greenhouse Gas emissions would have been prevented, and $32 Million would have been saved.

[9] "A ROADMAP FOR RETROFITS IN CANADA: - Canada Green Building ...." cagbc.org. Accessed 15 Apr. 2019.
[10] "Corporate and Community Energy Action Plan ... - City of Yellowknife." yellowknife.ca. Accessed 15 Apr. 2019.

Figure 6 U.S. Solar Photovoltaic System Cost Benchmark[11]



3.4 Switch to Low-Carbon Fuel Sources

Existing buildings can reduce carbon emissions by switching oil and propane furnaces, boilers, and other combustion appliances to low-carbon fuels like renewable biomass, low carbon district heating/cooling systems, and high efficiency electricity-based heat pump systems.[9]

The GNWT 2030 Energy Strategy sets a target of increasing the share of heating met by renewable energy to 40% by 2030 over 2016 levels by focusing on high-efficiency electric heat pump heating and heating with wood pellets which are generally a less expensive heating source than heating with oil or propane, and considered to be a renewable resource when harvested sustainably or sourced from waste.

Relevant actions in the GNWT Strategy include

- expanding the wood-pellet supply chain with local production,
- supporting the early adoption of wood-pellet boilers in communities, Yellowknife schools and larger commercial buildings,
- installing biomass and electric heat pump heating in government buildings,
- providing incentives to switch to wood fuel for heat, and
- promoting a reduced hydroelectric rate that is less than the cost to heat with oil for South Slave communities[5].

Switching to low-carbon fuel sources at 1% of households and commercial buildings each year would result in 10,000 Tonnes of avoided annual Greenhouse Gas emissions and $4 Million per year of reduced utility bills by 2030 – a 20% return on investment. By 2030, 64,000 Tonnes of Greenhouse Gas emissions would have been prevented, and $25 Million would have been saved.

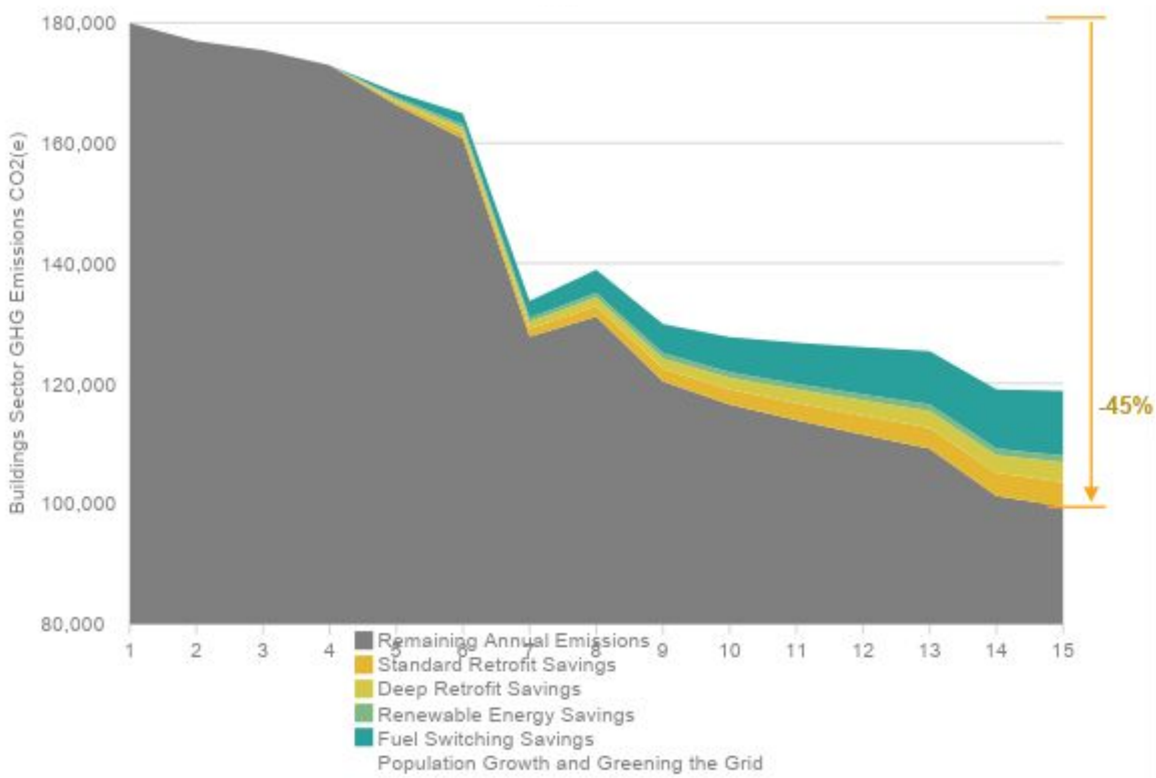
[11] U.S. Solar Photovoltaic System Cost Benchmark: Q1 2018" Ran Fu, David Feldman, and Robert Margolis, National Renewable Energy Laboratory

3.5 Combined GHG Impact of All Four Actions

Alone, none of these four actions can achieve the greenhouse gas emissions targets needed from NWT's buildings sector by 2030, but together they can. The combination of actions represents an opportunity that is both achievable and impactful in the short-term while preparing NWT to achieve the further reduction that will be needed beyond 2030.

All four actions together would result in 121,000 Tonnes of avoided annual Greenhouse Gas emissions and $120 Million of reduced utility bills by 2030 – a 9% return on investment.

Figure 7 Impact of Building Sector Actions on NWT Sector Greenhouse Gas Emissions by Year



4. ECONOMIC BENEFITS

4. Economic benefits

This upgrade program of investments in energy efficiency, renewable energy, and fuel switching will meet its goals of providing energy savings, GHG emissions reductions, and energy cost savings for home and other building owners (and occupiers[12]), as outlined above.

This program also will provide significant economic benefits - business growth, employment and territorial government revenues - starting immediately, growing over time, and continuing for decades.

Part of these benefits will come from the activities involved in carrying out the upgrade work - transporting materials and equipment, installing, repairing and maintaining, etc.

In the long run, even greater benefits will come from the energy cost savings that accrue to home owners and building owners. These owners in turn will spend that money saved, and thus generate economic activity, jobs, and revenues.

Indeed, the cost savings from energy efficiency are so great that they result in a positive net financial benefit (a negative cost) for reducing GHG emissions.[13] This is illustrated by the McKinsey curve (figure 3),[14] various GHG emission reduction methods are profiled. Carbon capture and storage (CCS - seen on the right) are the highest cost methods, while typical energy efficiency methods are at the left side of the figure, in the negative costs.

The following sections examine the economic benefits of the upgrade work, and of the energy costs savings arising from those upgrades.

4.1 Economic benefits from carrying out the upgrades

Part of the program's economic benefits will come from the activities involved in carrying out the work. Materials and equipment will be stored, transported and managed, creating new business in trucking, flying, warehousing and more. Insulation, weatherstripping, energy efficient windows, solar panels, efficient appliances, heating systems and more will need to be installed, thus providing business to firms that do this work. Some of the installations will need to be maintained and repaired over time, again engaging firms. All these sectors will create jobs, employing a range of skilled and novice workers in communities throughout the Territories. These benefits are termed the direct impacts of the program work being done.
In addition to these direct impacts, the firms carrying out this work will need to make purchases from various suppliers, creating business for those suppliers, and employment for their workers. These benefits are termed the indirect impacts of the upgrade.

[12] In this paper, "owners" is used to include renters who pay for heating or cooling.
[13] Modelling conducted in larger jurisdictions shows that energy efficiency savings are considerably larger than the benefits from the upgrade work being done, e.g.: US Environmental Protection Agency, "Quantifying the Multiple Benefits of Energy Efficiency and Renewable Energy A Guide for State and Local Governments" 2018 epa.gov esp ch.5; L Ryan and N. Campbell, "Spreading the Net: The Multiple Benefits of Energy Efficiency Improvements." International Energy Agency, 2012. ourenergypolicy.org; and Dunsky et al, "The Economic Impact of Improved Energy Efficiency in Canada: Employment And Other Economic Outcomes from the Pan-Canadian Framework's Energy Efficiency Measures" Clean Energy Canada, April 2018. cleanenergycanada.org.
[14] McKinsey & Company, "Pathways to a Low-Carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve" mckinsey.com

Furthermore, the employees of the firms that are directly and indirectly engaged will be spending money that they earn, thus creating new business for restaurants, grocery stores, other retail stores, etc. - and jobs for their workers. These benefits are termed the induced impacts of the upgrade work.

JOB CREATION & BANG-FOR-THE-BUCK

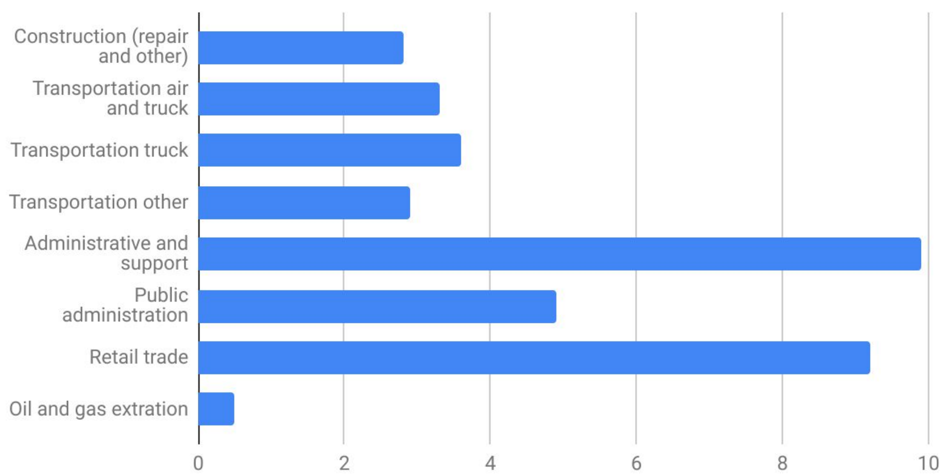
Governments and businesses often present the number of jobs that their investments are projected to generate. Investments are generally made not to create jobs, but to pursue other public policy goals or profit-making goals. Nevertheless, the jobs created are normally presented as an important benefit.

Governments publish multipliers tables, which show the relative number of jobs created by different industries for given levels of investment. These tables make it clear that some industries are more labour intensive, and some are more capital intensive.

The problem with capital intensive industries, particularly in a small economy like the NWT, is that the capital items generally are imported. Thus the indirect impacts of a capital intensive industry, like oil and gas extraction, tend to be lower; the money leaves the jurisdiction and its benefits are felt elsewhere.

The industries typically employed in the program outlined in this paper generally create several times as many jobs per dollar invested as oil and gas extraction does (see figure 8). Also, these jobs tend to be spread out across communities instead of being concentrated in few areas.

Figure 8 Selected employment multipliers[15] : Jobs create per $M invested, person-years of employment



The jobs and new business activity created by the upgrade spending will be spread throughout the Territory, in all communities where work is undertaken.

[15] NWT Bureau of Statistics, "NWT Economic Multipliers - Overview and Results" September 2018. statsnwt.ca.

All of the above activity - direct, indirect, and induced - create taxable transactions. Governments will receive revenues from sales taxes, corporate income taxes, personal income taxes and other taxes.
These economic benefits - business activity, jobs and tax revenues - begin to flow immediately, in the year when the upgrade work is commenced.

The upgrade spending of $21.9 million per year described above, will directly and indirectly generate roughly 87 jobs (person-years of employment, or PYE) and $11.8 million in GDP each year above baseline levels.

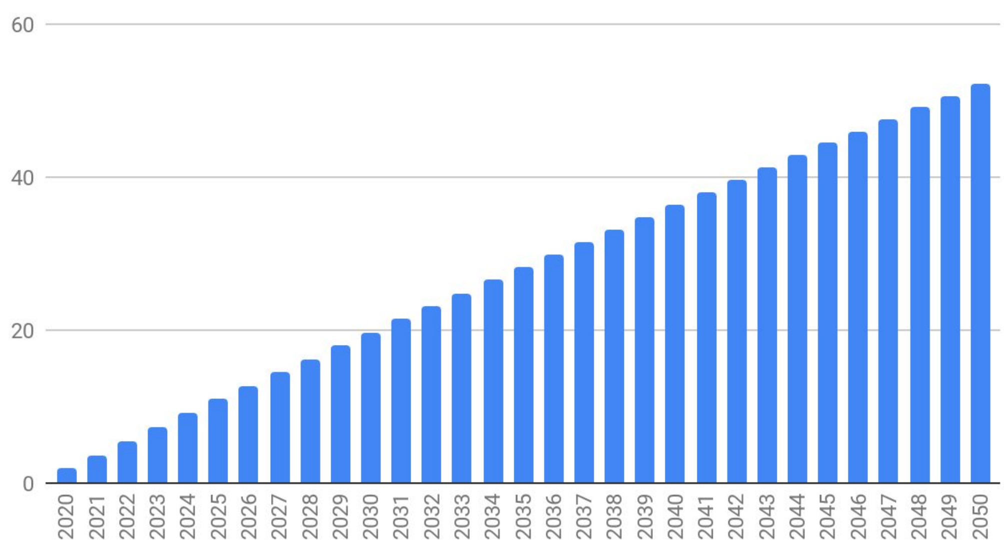
In addition to the direct and indirect impacts, there will also be induced impacts - increases to GDP and employment caused by workers spending their incomes.[16] In order to provide conservative estimates, these induced impacts are not included in this report.

In addition to the above, building owners will save money on energy, and spend those savings elsewhere in the economy, generating more economic benefits, as discussed in the next section.

4.2 Economic benefits from spending energy cost savings

Soon after upgrade work begins, homeowners and other building owners will begin to see a reduction in their energy spending. On average, each household will save thousands of dollars per year on energy costs. Across the Territories, the savings are in the millions, and grow each year the program is in operation (figure 9).

Figure 9 Energy cost savings (annual, Territory-wide, $M)



These savings can go back into paying down the costs of initial energy upgrade improvements, if the owners borrowed to finance those investments. The savings on energy costs can pay off some of those investment costs (e.g. standard energy efficiency retrofit, or SR) in as little as four years, and possibly sooner. Others will take longer to pay off.

[16] Lower income people in particular - out of necessity - tend to spend any available dollars (they have a higher "marginal propensity" to consume).

Once owners start the additional spending - on a variety of activities and goods - this spending will generate business activity and create jobs in a wide range of sectors, as well as boosting government tax revenues.

The savings and their benefits grow every year that the program continues. For the program described above, annual energy cost savings would begin in 2020, at $1.85 million per year, and grow annually by that amount. By 2030, annual energy cost savings would be $19.7 million per year, and the spending of those dollars would directly and indirectly generate roughly 36 jobs and $3.6 million in GDP per year - in addition to those created by the upgrading.[17] This does not include induced impacts, which would make the benefits greater.

By 2042 the number of direct and indirect jobs generated by spending the energy cost savings would exceed those created by upgrade work. By 2044, the GDP impacts of savings exceed those of upgrade work.

These numbers would increase in future years, as more and more buildings were improved, and energy cost savings are spent. Even when the upgrade work comes to an end, the savings would continue indefinitely, generating local business, jobs and tax revenues.

DEMYSTIFYING THE "REBOUND EFFECT"

When people and businesses save money from reduced energy costs, they spend it in a variety of areas, some of which consume energy and result in GHG and other emissions. This has led to some claims that energy efficiency is futile, as people and businesses will simply use the savings to consume more energy, and perpetuate GHG emissions.

That claim is not accurate. While the "rebound effect" is real, the magnitude is actually quite small due to a number of factors. First, households and businesses spend on a wide variety of priorities, not just on energy. For example, consider a household with an overall $100,000 budget and an energy budget envelope of $5,000, or 5% of its budget. It invests in upgrades that reduce its bill by $4,000. The members of the household are likely to allocate the $4,000 annual savings to any number of areas across the budget - e.g. groceries, entertainment, or dining out - and not just to energy.

These other areas will have some energy costs. For instance, dining out may involve driving the car, and preparing the food and running the restaurant require some energy. However, this would be a fraction of the costs for the evening.

Finally, not all the energy used in these other areas might be from fossil fuels. In our dining out example, the restaurant may run on electricity, as might some of the food chain operations.

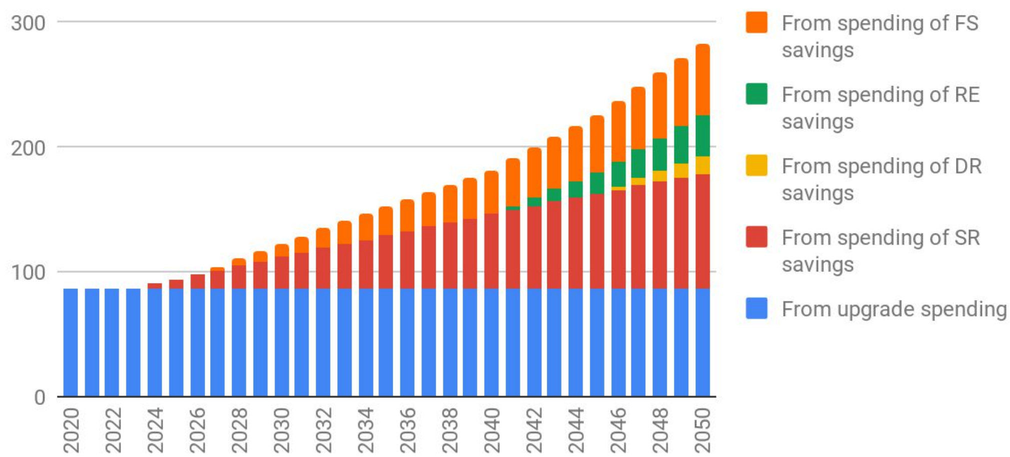
While the rebound effect is real, it is a small percentage of overall energy cost savings, and should not deter or delay the pursuit of energy cost reductions.

[17] The economic benefits associated with the spending of dollars saved due to reduced energy costs would be offset by reduced economic activity associated with delivery of that energy. This offset would be small - on the order of 10%-15% of overall savings. Only about half of program energy cost savings are related to fossil heating fuels (the remainder is electricity, which will find markets in high efficiency heat pump upgrades, as well as industrial uses and electric vehicles). Of that half, for heating oil and propane, the majority of the cost is in the imported product itself, and only a fraction is spent in the NWT on trucking and retailing. The rampdown of demand for fuel products will be gradual, and firms currently involved in trucking fossil heating fuel products will have ample time to expand into other products, including the growing market in energy upgrade products.

4.3 Total benefits - upgrades + savings

The upgrade spending, and the spending of energy cost savings, together in 2030 generate roughly 123 jobs and $15.4 million in GDP per year above baseline levels.

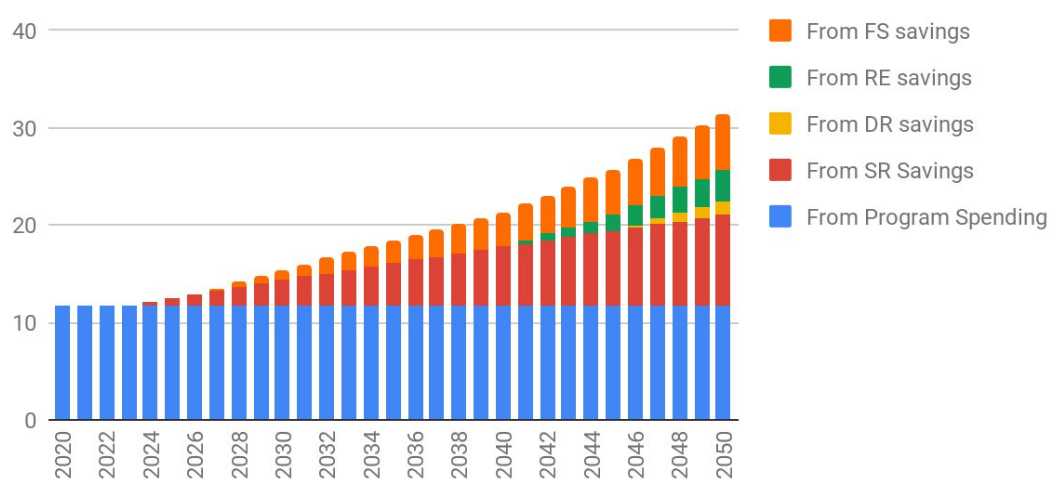
Figure 10 Jobs impact due to upgrades + spending of energy cost savings. FTEs - direct and indirect impacts (omitting induced impact)



As can be seen in Figure 10 above, the jobs created by the upgrade work start immediately, and continue for as long as the program is operated.

The jobs generated by building owners spending their energy cost savings commence after the borrowing costs are paid off. SR costs are paid off first (in four years), and FS savings are next (seven years), followed by RE (20 years) and DR (25 years).

Figure 11 GDP impact due to upgrades + spending of energy cost savings ($M). $GDP - direct and indirect impact (omitting induced impact)



As with the jobs impact, the GDP impact of upgrade work starts immediately, while the GDP impact from energy cost savings is delayed (while investment borrowing costs are paid off), but rises over time.

The above charts illustrate a scenario of upgrades continuing over time. New technologies develop over time (e.g. the recent advent of LED bulbs). Building practices, expectations and standards also improve over time. Such trends tend to reinforce and drive further improvements.

However, even if upgrades and their economic impacts were to come to an abrupt end, and never resume, the economic impacts generated by the energy cost savings would continue indefinitely. Moreover, the economic impacts of those upgrades done to date would continue to *increase* in the years after the upgrades ended, as the borrowing costs were paid off over time.

4.4 Government fiscal impact

The employment and GDP increases from the upgrade work and from the spending of energy cost savings will have a positive fiscal impact for the Territorial government.

In 2030, the above level of economic activity will generate on the order of $1.5 million in additional tax revenues for the Government of the Northwest Territories. Of course, as with the jobs and GDP impact, this number will increase further in subsequent years.

The Government will also see fiscal improvements due to significant spending reductions, including heating fuel costs that the government currently supports, and financial support and programs for people who were unemployed but who have become employed through the upgrade spending or the spending of energy cost savings.

5. SUMMARY & CONCLUSIONS

5. Summary and conclusions

The government of the Northwest Territories has an enormous opportunity to expand its efforts to enhance energy efficiency and develop renewable energy.

It can reap significant rewards. An ambitious but achievable program can reduce GHG emissions by 121,000 tonnes of CO2e by 2030, taking the territories further toward its emissions reductions goals. And it can save building owners a cumulative total of $120 million in utility bills, helping reduce the cost of living.

Doing so will generate 87 jobs and $11.8 million in GDP gains each year the program operates. As building owners spend their energy cost savings, that spending will generate additional jobs and GDP growth. By 2030, the program + cost savings generate 123 jobs and $15.4 million in GDP, helping raise tax revenues by $1.5 million - amounts that increase over following years.

This paper has focussed on the opportunities as noted above. Flowing from those opportunities are a number of conclusions about rolling out the energy upgrade program.

START IMMEDIATELY. The sooner the work is accelerated, the sooner energy consumption drops, local air pollution drops, GHG emissions drop, people save money, businesses grow, jobs are created, tax revenues rise and the costs of supporting fuel and unemployment fall. There is no need to perfect the program before launching it; it can be tweaked over time, and no doubt it will be as various technologies are improved.

PRIORITIZE UPGRADE ACTIVITIES THAT BENEFIT LOWER-INCOME PEOPLE. The government should focus initially on upgrades that improve housing for lower income people, as they would benefit the most from the savings and from more comfortable housing. Also, because lower income people tend to spend available dollars more quickly than wealthy people, the energy savings they receive will more quickly generate economic activity, jobs, and tax revenues. In housing where government pays for energy use, government will realize the savings, immediately and indefinitely into the future.

PRIORITIZE HOUSEHOLDS THAT USE FOSSIL FUEL FOR HEATING. The largest GHG reductions (“bang for the buck”) will come from houses that are currently heated with fossil fuels, so these should be prioritized over households heated with electricity or renewable fuels.

Ecology North applauds the government for its efforts on energy efficiency, renewable energy and climate change mitigation, and looks forward to the next chapter and the outcomes it will deliver - for building owner, workers, businesses and the broader economy.

6. APPENDICES

6. Appendix - Methods, Assumptions and Limitations

6.1 Retrofit scenario

The forecast calculation begins with a baseline of 2016 selected to align with the latest available carbon emissions, energy use, and census data for NWT. Building sector presence is defined as the gross floor area of residential and commercial buildings that exist in the Northwest Territories.

Gross floor area is categorized into building use (single-family residential, multi-family residential and commercial), age (32+ years old and under 32 years old), and energy use (oil heating, natural gas/coal/propane heating, electric resistance heating, heat pump heating, wood heating, and non-heating energy use).

Annual population growth is calculated. Annual gross floor area is adjusted according to population growth, assuming that floor area changes in proportion to population.

For each category, considering the building characteristics and heating system efficiency, a baseline energy intensity (energy per unit of gross floor area) is assigned. The category total baseline energy use is then calculated as the product of presence (floor area) and energy intensity.

Each activity is assigned an energy savings where implemented, as a percent of total heating or non-heating energy use. Sector savings is the product of percent savings where implemented and total floor area where it is implemented. Fuel switching activity additionally reassigns energy use between energy use (e.g. oil heating energy use is removed, and wood heating energy use is added).

Greenhouse gas emissions intensity for each fuel (fuel oil, natural gas & propane, electricity, wood) is taken from sources noted in the table below. Greenhouse gas emissions is calculated as the product of fuel emissions intensity and fuel energy use for the sector.

Utility costs are calculated as the product of energy consumed and energy rate (cost per unit of energy consumed). All costs are represented in present dollars. Utility costs are assumed to escalate at the same rate as inflation.

The cost to implement each activity is the product of activity unit cost (per unit of floor area) and volume of floor area where the activity is implemented. Activity unit costs are derived from sources noted in the table below.

Scenarios are defined by the ‘uptake’ percent of floor area taking each action annually. Uptake is only applied to applicable categories (e.g.: fuel switching is not applied to buildings that already have heat pump heating or wood heating). Activity uptake is assumed to start in 2020.

Table 1 Scenario assumptions

Category	Value	Source
Annual Fuel Cost Escalation above CPI	0%	Assumed
Cost of Electricity	$0.30/kWh	Arctic Energy Alliance "Fuel Cost Library – Fall 2018" [ref]
Cost of Fuel Oil	$1.23/L	Arctic Energy Alliance "Fuel Cost Library – Fall 2018" [ref]
Cost of Firewood	$325/cord	Arctic Energy Alliance "Fuel Cost Library – Fall 2018" [ref]
Cost of Natural Gas or Propane	$0.24/m^3	nwtpublicutilitiesboard.ca Government of Northwest Territories, "Energy Prices and Costs in the NWT, May 2016"
Fuel Content and Unit Conversions		energystar.gov
Carbon Content - Natural Gas	180 g CO2e/ekWh	Canada National Inventory Report Part 2 Annex 6.1
Carbon Content - Propane	220 g CO2e/ekWh	Canada National Inventory Report Part 2 Annex 6.1
Carbon Content - Light Fuel Oil (Diesel)	256 g CO2e/ekWh	Canada National Inventory Report Part 2 Annex 6.1
Carbon Content - Heavy Fuel Oil	269 g CO2e/ekWh	Canada National Inventory Report Part 2 Annex 6.1
NWT Population – 10-year average population growth	+0.361%/year	Calculated using January 2009-2018 values from Statistics Canada
Cost of New Construction in NWT	$200/ft^2	homelesshub.ca
Number of Residential Buildings in NWT, 2016	14,970	Statistics Canada, 2016 Census Data Tables, Household and dwelling characteristics
Number of commercial buildings in NWT, 2016	1,819 [12.2 for every 100 households]	Natural Resources Canada, "Remote Communities Energy Database"
Average size of commercial building in NWT	[200% of average residential]	Assumed
Heating System Efficiency	Heating Oil 76% Natural Gas/Propane 69% Electric Resistance 100% Heat Pump 190% Wood 50%	Natural Resources Canada Comprehensive Energy Use Database, Table R26
Share of Buildings by Heating System	Heating Oil 51.5% Natural Gas/Propane 32.5% Electric Resistance 8.0% Heat Pump 0% Wood 8.1%	Natural Resources Canada Comprehensive Energy Use Database, Table R8
Share of Buildings by Construction Year	28% before 1983, 72% after 1983	Natural Resources Canada Comprehensive Energy Use Database, Table R15
Share of Building Floor Area (m^2) by Construction Year	24% before 1983, 76% after 1983	Natural Resources Canada Comprehensive Energy Use Database, Table R18
Total Housing Stock in NWT	14,980	Statistics Canada, 2016 Census Data Tables, Household and dwelling characteristics

Total Residential Housing Area in NWT	2.45 Million m^2	Natural Resources Canada Comprehensive Energy Use Database, Table R18
Share of Buildings by Dwelling Type	81% single-family 19% multi-family	Natural Resources Canada Comprehensive Energy Use Database, Table R15
Share of Buildings Area (m^2) by Dwelling Type	86% single-family 14% multi-family	Natural Resources Canada Comprehensive Energy Use Database, Table R18
Average Energy Intensity of Buildings	280 kWh/m^2	Natural Resources Canada Comprehensive Energy Use Database, Table R2
Share of Energy Intensity for Heating Use	67%	Natural Resources Canada Comprehensive Energy Use Database, Table R2
Share of Energy Intensity for Non-Heating Use	33%	Natural Resources Canada Comprehensive Energy Use Database, Table R2
Average household size	155 m^2	Natural Resources Canada Comprehensive Energy Use Database, Table R2
Standard Retrofit Costs	$17.88/m^2	An average household cost of - $2,000 for attic insulation [national average reported by homeadvisor.com] - $200 for weather-stripping [energy.gov estimates $40 for caulking and weatherstripping, while rona.ca offers window insulating film at $8 per window or $64 for a home of 10 windows. Inflated by factor of 2 for Northern region] - $200 for smart thermostats [middle of $100 to $300 range homedepot.ca] - $376 for LEDs based on an average $8 per bulb and 45 bulbs per home [CBS News Green Light Bulb Buying Guide]
Deep Retrofit Costs	$302.63/m^2	An average household cost of $35,000 for reinsulation [a middle value from City of Yellowknife, "Corporate and Community Energy Action Plan 2015-2025"], plus $12,000 for high-performance quadruple pane windows based on - Home window area is 10% of its floor area, lower for Northern Canada than the 15% U.S. estimate referenced in "ENERGY STAR for Windows, Doors, Skylights Version 6.0 Criteria Revision Review of Cost Effectiveness Analysis"; - Average window cost in Northern Canada of $50/ft^2 ["Picking Windows & Glazing Units for Optimal Energy Efficiency in the North", RDH, Feb 2016]; and - Marginal cost for high-performance (triple or quadruple pane) windows of $100, lower than the $165.29 per window indicated in the ENERGY STAR document referenced above, since triple glazed windows are already common in Northern Canada as noted by RDH in the reference presentation above.
On-Site Generation	$424.05/m^2	An average household cost of $65,819 for total net annual non-heating energy use offset based on - A 9 kW installation to offset yearly non-heating energy use of the average household; and - An installed solar power system cost of $4.32/kW, which is 150% of the $2.88/kW CAD average stated in "Trends 2018 in Photovoltaic Applications", International Energy Agency 2018. The escalated value is in-line with values used by City of Yellowknife, "Corporate and Community Energy Action Plan 2015-2025". - Considerations like improving solar power economics, or integrating battery storage technology may increase or decrease this cost and should be explored further as they relate to Northern Canada households.
Fuel Switching	$64.43/m^2	An average household cost of $10,000 based on one of a biomass heater or air source heat pump, selected based on the most common referenced cost from two Northern Canada sources:

		- $3,000-6,000 cost for a biomass stove or $10,000-20,000 for a biomass furnace or boiler; "Residential Wood Pellet Heating: A Practical Guide for Homeowners" Arctic Energy Alliance 2012 - $10,000 cost of air source heat pumps, derived from values stated in Energy Solutions Centre, Yukon Energy, Mines and Resources "An Evaluation of Air Source Heat Pump Technology in Yukon", May 31, 2013.
Standard Retrofit Savings	15%	U.S. Department of Energy, Oct 7, 2016 "How Much Can You REALLY Save with Energy Efficient Improvements?" indicates average savings of - 10-20% on heating & cooling from sealing air leaks - 10% on heating & cooling from thermostat setback - 5-10% on heating & cooling from window weatherstripping - 9% on electricity from replacing a home's five most frequently used light fixtures/bulbs The average of each range was taken, then halved to be conservative and acknowledge not all savings are possible in all homes.
Deep Retrofit Savings	47%	Brennan Less & Iain Walker, 2014 "A Meta-Analysis of Single-Family Deep Energy Retrofit Performance in the U.S."
On-site Generation Savings	940 kWh/yr of electricity savings per kW of installed solar PV system	Based on a RETscreen4 energy model of a rooftop solar PV system located in Yellowknife.
Fuel Switching Savings	100% reduction in existing fuel type, alongside an increase in electricity or biomass fuel use (refer to notes column for values)	Existing electric-heat operates at 100% efficiency; replaced by heat pumps operating at 190% efficiency (47% decrease in energy use) Existing propane/gas heat operates at 69% efficiency. Replaced by heat pumps operating at 190% efficiency (64% decrease in energy use) Existing oil-heat operates at 76% efficiency. 50% replaced by biomass operating at 50% efficiency (52% increase in energy use). 50% replaced by electric heat pump operating at 190% efficiency (60% decrease in energy use)

6.2 Spending on upgrades

This paper assumes a program of upgrades as described earlier. There are many ways that governments can incentivize or mandate such upgrades,[18] but this paper focuses on the benefits of doing so.

The economic impact estimates (jobs, GDP and tax revenues) arising from upgrade spending are based on the annual upgrade spending on SR, DR, FS, and RE scenarios noted in section 3.

For jobs and GDP, weighted composite multipliers were created based on relevant industries listed in the GNWT multipliers[19] - construction (repair and other) 70%; retail 10%; transportation 10%; and administrative and support work 10% - which yields a jobs multiplier of 3.95 PYE per $ million, and a GDP multiplier of 0.539 dollars of GDP impact per dollar spent on the upgrade.

These jobs and GDP multipliers include the direct and indirect impacts of the upgrade spending - i.e. the jobs and GDP created in the industries doing the upgrade work, and the jobs and GDP created by supplier industries.

[18] E.g. PACE-type financing; on-bill utility financing; requiring all buildings to be audited and annual energy costs to be publicly available; requiring all buildings sold to meet standards; improving building codes and step codes for new builds and renovations; providing financial support for upgrades for lower income people.
[19] See NWT Bureau of Statistics, "NWT Economic Multipliers - Overview and Results" September 2018. statsnwt.ca.

Government-published multipliers are routinely relied upon by governments and by industry to estimate employment and GDP impacts of planned developments. As noted in the multipliers reports, they are rough approximations, and so are the economic impact projections in this report. This report builds in conservative assumptions in two key areas:

- **Indirect impact.** Indirect impact multipliers in the NWT tend to be significantly lower than in larger jurisdictions because of the amount of input materials that are imported, rather than being created locally. A sustained investment in upgrade activities could result in local supply industries being created. However, for the purpose of this estimate, a conservative assumption was made that there would be zero development of local supply industries despite the operation of a significant program.
- **Induced impact.** In line with the GNWT-published multipliers, the estimates in this report conservatively omit induced impacts - i.e. the jobs and GDP created when employees of the upgrade industries and supplier industries spend their money locally, on things like groceries, restaurant meals, clothing and the like.

6.3 Spending of energy cost savings

The savings realized from energy efficiency and reduced fuel costs can go back into paying off up-front borrowing costs, where there are any. Some of those costs can be paid off in as little as four years, and possibly sooner, if all the savings are applied to them.[20] Of course they don't need to be paid down as quickly as possible; owners could choose to pay them down more slowly, and immediately start spending a portion of their savings on other priorities. And some owners won't even need to borrow - they can make the investments in cash, and immediately start buying with the savings. Those who start spending early would drive up economic benefits sooner.

However, this report again takes a conservative approach, and assumes that all investors would borrow the full costs of upgrade investment, and all would pay off financing costs starting immediately and at full speed. The energy cost savings from standard retrofits (SR) are used to pay the costs of those retrofits for the first four years. After that, they are available for spending, and that spending creates a number of jobs, increasing as more upgrades are completed and paid off. The same applies to deep retrofits (DR), renewable energy (RE) and fuel switching (FS), which have longer payback times.[21] Thus the economic benefits from the savings are delayed until those investments are paid off.

Once owners start spending, they will spend on a wide range of items. Average household expenditures in Yellowknife are shown in the table below. Of course, everyone is different, and the spending for any household varies, and between communities average household spending also will vary. This report assumes spending in the proportions in Table X.[22]

Table 2 Household expenditures as percentage of current consumption[23]

Item	%

[20] As noted earlier, the payback periods for this program are as follows: Standard retrofits – 4 years, Deep Retrofits – 25 years, Renewables – 20 years, Fuel Switching – 7 years.
[21] The payback periods for this program are as follows: Standard retrofits – 4 years, Deep Retrofits – 25 years, Renewables – 20 years, Fuel Switching – 7 years.
[22] Average household spending proportions in Yellowknife are fairly similar to other Canadians' spending. A notable exception is household fuel (other than natural gas), where spending is more than ten times higher.
[23] StatCan, "Average Household Expenditure by Component: Canada and Yellowknife, 2017" 2017 Survey of Household Expenditure. statsnwt.ca

Food	12.5
Shelter	32.3
Household operations	7.5
Household furnishings and equipment	3.7
Clothing and accessories	5.2
Transportation	20.3
Health care	2.6
Personal care	1.9
Recreation	7.4
Education	1.3
Reading materials and other printed matter	.3
Tobacco products and alcoholic beverages	2.2
Games of chance	.2
Miscellaneous expenditures	2.7
	100.0

Weighted composite multipliers were created based on the above spending categories, and relevant industries listed in the GNWT multipliers, which yielded a jobs multiplier of 6.8 PYE per $ million, and a GDP multiplier of 0.681 dollars of GDP impact, per dollar saved.

The spending at the Territorial level will increase each year, as more buildings are upgraded. Those higher levels of spending due to energy cost savings are sustained indefinitely. In the long term, the economic impact of the savings is considerably larger than the impact of the upgrade spending itself.

Even if all upgrades were to come to an abrupt and permanent end, the economic impact due to spending the energy cost savings would continue, and would actually increase for several years.

Figure 12 Jobs due to upgrades + spending of energy cost savings, assuming all upgrades end abruptly and permanently in 2030. FTEs - direct and indirect impacts (omitting induced impact)

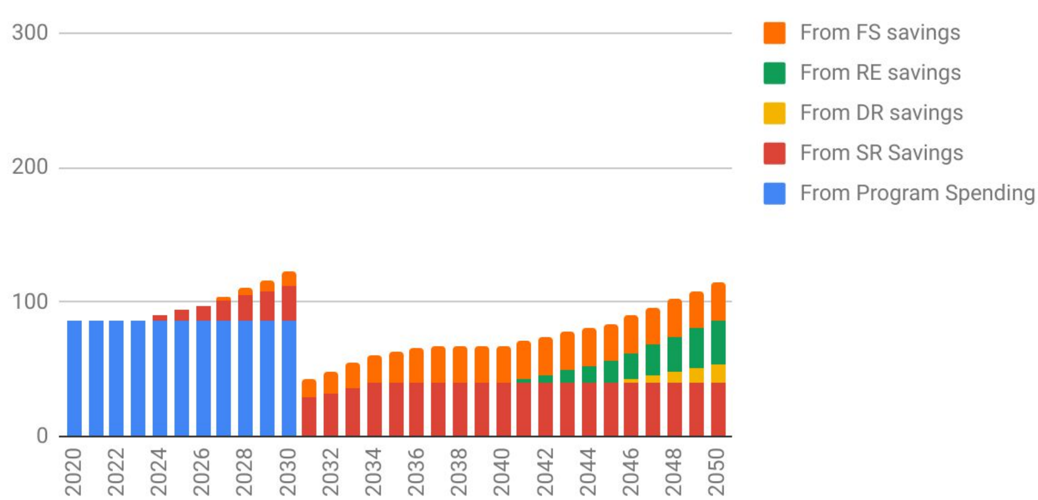


Figure 12 illustrates a scenario of all upgrades coming to an abrupt end in 2030 and never resuming. Jobs created by the spending of standard retrofit (SR) energy cost savings continue to increase for four years as the borrowing costs for the final years of upgrades completed are paid off, and then continue at the same level. Likewise for the other upgrade spending, in accordance with their payback periods. This is not a likely scenario, but merely used to illustrate the continuing nature of the benefits from energy cost savings.

6.4 Tax revenues

As noted in the text, increases in economic activity - business growth and jobs - will increase GNWT tax revenues.
Assuming no changes in current tax rates, a territorial GDP of approximately $4.8 billion per year,[24] own-source revenues of about $600 million per year[25] (approximately 80% of which can scale with GDP), an increase in GDP of $15.4 million in 2030 would increase tax revenues by an amount on the order of $1.5 million per year in that year. As with GDP and employment, revenues would be higher in subsequent years.

This report conservatively omits the reduced need for program spending and transfers to individuals when individuals move from unemployment to employment. These reductions could be more significant than the tax revenue increases to the government's overall fiscal position.

6.5 Economic benefits of reduced emissions

A major limitation of this study is that it does not attempt to quantify the economic benefits of reduced emissions from fossil-fuel based heating and electricity generation, although these are very real, and can be quite large. Reduced fossil fuel emissions can have local health benefits, and reduced GHG emissions has global benefits. There are methods to estimate the dollar value of emissions and emission reductions, but doing so is beyond the scope of this study.

6.6 Upgrade scenarios - detailed tables of values

Table 3 Population, Building Presence and Utility Grid Emissions Intensity by Year

Year	Population	# Buildings	Electric Grid GHG Intensity (g/kWh)
2016	44,507	16,790	220.00
2017	44,668	16,850	207.93
2018	44,829	16,911	201.21
2019	44,991	16,972	191.65
2020	45,153	17,033	175.77
2021	45,316	17,095	162.80
2022	45,479	17,156	63.94
2023	45,643	17,218	78.72
2024	45,808	17,280	48.72
2025	45,973	17,343	40.53
2026	46,139	17,405	36.28
2027	46,306	17,468	32.32
2028	46,473	17,531	28.75
2029	46,641	17,595	7.18
2030	46,809	17,658	5.06

Table 4 Gross Floor Area (Million ft^2) Involved in Activity by Year

[24] GNWT Bureau of Statistics (statsnwt.ca).
[25] Consolidated Statement of Operations and Accumulated Surplus for the year ended March 31, 2018. fin.gov.nt.ca.

Year	Population Growth & Greening the Grid	Standard Retrofit Savings	Deep Retrofit Savings	Renewable Energy Savings	Fuel Switching Savings	Sum of 4 Sector Actions	Sum of All
2016	-	-	-	-	-	-	33.22
2017	0.12	-	-	-	-	-	33.34
2018	0.24	-	-	-	-	-	33.46
2019	0.36	-	-	-	-	-	33.59
2020	0.48	0.67	0.17	0.09	0.15	1.09	33.71
2021	0.60	1.35	0.34	0.18	0.31	2.18	33.83
2022	0.73	2.03	0.51	0.27	0.47	3.28	33.95
2023	0.85	2.71	0.68	0.37	0.62	4.38	34.07
2024	0.97	3.40	0.85	0.46	0.78	5.48	34.20
2025	1.09	4.08	1.02	0.55	0.94	6.59	34.32
2026	1.22	4.77	1.19	0.64	1.10	7.70	34.44
2027	1.34	5.46	1.37	0.74	1.25	8.82	34.57
2028	1.47	6.16	1.54	0.83	1.41	9.94	34.69
2029	1.59	6.85	1.71	0.92	1.57	11.06	34.82
2030	1.72	7.55	1.89	1.02	1.73	12.19	34.94

Table 5 Annual Utility Cost Increase/Decrease ($Millions per year) by Year

Year	Population Growth and Greening the Grid	Standard Retrofit Savings	Deep Retrofit Savings	Renewable Energy Savings	Fuel Switching Savings	Sum of 4 Sector Actions	Sum of All
2016	$ -	$ -	$ -	$ -	$ -	$ -	$ 178
2017	$ 0.6	$ -	$ -	$ -	$ -	$ -	$ 179
2018	$ 1.3	$ -	$ -	$ -	$ -	$ -	$ 180
2019	$ 1.9	$ -	$ -	$ -	$ -	$ -	$ 180
2020	$ 2.6	$ (0.5)	$ (0.4)	$ (0.5)	$ (0.4)	$ (1.9)	$ 179
2021	$ 3.2	$ (1.1)	$ (0.8)	$ (1.0)	$ (0.8)	$ (3.7)	$ 178
2022	$ 3.9	$ (1.6)	$ (1.3)	$ (1.5)	$ (1.2)	$ (5.5)	$ 177
2023	$ 4.6	$ (2.2)	$ (1.7)	$ (1.9)	$ (1.6)	$ (7.3)	$ 176
2024	$ 5.2	$ (2.7)	$ (2.1)	$ (2.4)	$ (2.0)	$ (9.1)	$ 175
2025	$ 5.9	$ (3.2)	$ (2.5)	$ (2.9)	$ (2.3)	$ (10.9)	$ 173
2026	$ 6.5	$ (3.7)	$ (2.9)	$ (3.4)	$ (2.7)	$ (12.7)	$ 172
2027	$ 7.2	$ (4.2)	$ (3.3)	$ (3.8)	$ (3.1)	$ (14.5)	$ 171
2028	$ 7.9	$ (4.8)	$ (3.7)	$ (4.3)	$ (3.4)	$ (16.2)	$ 170
2029	$ 8.6	$ (5.3)	$ (4.1)	$ (4.8)	$ (3.8)	$ (18.0)	$ 169
2030	$ 9.2	$ (5.8)	$ (4.5)	$ (5.3)	$ (4.1)	$ (19.7)	$ 168

Table 6 Greenhouse Gas Emissions Increase/Decrease (Tons per year) by Year

Year	Population Growth and Greening the Grid	Standard Retrofit Savings	Deep Retrofit Savings	Renewable Energy Savings	Fuel Switching Savings	Sum of 4 Sector Actions	Sum of All
2016	-	-	-	-	-	-	180,153
2017	(3,211)	-	-	-	-	-	176,942
2018	(4,731)	-	-	-	-	-	175,422
2019	(7,180)	-	-	-	-	-	172,973
2020	(11,689)	(505)	(396)	(284)	(912)	(2,097)	166,366
2021	(15,264)	(994)	(778)	(547)	(1,828)	(4,147)	160,743
2022	(46,442)	(1,382)	(1,083)	(649)	(2,845)	(5,960)	127,751
2023	(41,226)	(1,781)	(1,395)	(776)	(3,834)	(7,787)	131,141
2024	(50,306)	(2,148)	(1,682)	(853)	(4,845)	(9,528)	120,319
2025	(52,447)	(2,502)	(1,960)	(918)	(5,853)	(11,233)	116,473
2026	(53,339)	(2,849)	(2,232)	(975)	(6,855)	(12,910)	113,904
2027	(54,134)	(3,188)	(2,497)	(1,027)	(7,849)	(14,561)	111,458
2028	(54,810)	(3,520)	(2,758)	(1,072)	(8,835)	(16,185)	109,158
2029	(61,140)	(3,829)	(2,999)	(1,083)	(9,833)	(17,745)	101,268
2030	(61,379)	(4,132)	(3,237)	(1,091)	(10,822)	(19,282)	99,492

Table 7 Annual Cost of Activity by Year ($Millions per year)

Year	Population Growth & Greening the Grid	Standard Retrofit Savings	Deep Retrofit Savings	Renewable Energy Savings	Fuel Switching Savings	Sum of 4 Sector Actions	Sum of All
2016	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2017	$ 48.0	$ -	$ -	$ -	$ -	$ -	$ 48.0
2018	$ 48.1	$ -	$ -	$ -	$ -	$ -	$ 48.1
2019	$ 48.3	$ -	$ -	$ -	$ -	$ -	$ 48.3
2020	$ 48.5	$ 2.2	$ 9.5	$ 7.2	$ 1.9	$ 20.7	$ 69.2
2021	$ 48.7	$ 2.2	$ 9.5	$ 7.2	$ 1.9	$ 20.8	$ 69.5
2022	$ 48.8	$ 2.3	$ 9.5	$ 7.2	$ 1.9	$ 20.9	$ 69.7
2023	$ 49.0	$ 2.3	$ 9.6	$ 7.2	$ 1.9	$ 21.0	$ 70.0
2024	$ 49.2	$ 2.3	$ 9.6	$ 7.3	$ 1.9	$ 21.0	$ 70.2
2025	$ 49.4	$ 2.3	$ 9.6	$ 7.3	$ 1.9	$ 21.1	$ 70.5
2026	$ 49.5	$ 2.3	$ 9.7	$ 7.3	$ 1.9	$ 21.2	$ 70.7
2027	$ 49.7	$ 2.3	$ 9.7	$ 7.4	$ 1.9	$ 21.3	$ 71.0
2028	$ 49.9	$ 2.3	$ 9.8	$ 7.4	$ 1.9	$ 21.3	$ 71.2
2029	$ 50.1	$ 2.3	$ 9.8	$ 7.4	$ 1.9	$ 21.4	$ 71.5
2030	$ 50.3	$ 2.3	$ 9.8	$ 7.4	$ 1.9	$ 21.5	$ 71.8

Table 8 Cumulative Cost of Activity by Year ($Millions)

Year	Population Growth and Greening the Grid	Standard Retrofit Savings	Deep Retrofit Savings	Renewable Energy Savings	Fuel Switching Savings	Sum of 4 Sector Actions	Sum of All
2016	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2017	$ 48	$ -	$ -	$ -	$ -	$ -	$ 48
2018	$ 96	$ -	$ -	$ -	$ -	$ -	$ 96
2019	$ 144	$ -	$ -	$ -	$ -	$ -	$ 144
2020	$ 193	$ 2	$ 9	$ 7	$ 2	$ 21	$ 214
2021	$ 242	$ 4	$ 19	$ 14	$ 4	$ 42	$ 283
2022	$ 290	$ 7	$ 29	$ 22	$ 6	$ 62	$ 353
2023	$ 339	$ 9	$ 38	$ 29	$ 7	$ 83	$ 423
2024	$ 389	$ 11	$ 48	$ 36	$ 9	$ 104	$ 493
2025	$ 438	$ 14	$ 57	$ 43	$ 11	$ 126	$ 563
2026	$ 487	$ 16	$ 67	$ 51	$ 13	$ 147	$ 634
2027	$ 537	$ 18	$ 77	$ 58	$ 15	$ 168	$ 705
2028	$ 587	$ 20	$ 87	$ 65	$ 17	$ 189	$ 776
2029	$ 637	$ 23	$ 96	$ 73	$ 19	$ 211	$ 848
2030	$ 687	$ 25	$ 106	$ 80	$ 21	$ 232	$ 920

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