CITY OF YELLOWKNIFE

Corporate and Community Energy Action Plan

2015-2025

1 Executive Summary

The City of Yellowknife's Corporate and Community Energy Action Plan (the Energy Plan) is the second installment of the City of Yellowknife's Energy Action Plan, building on the 2004-2014 Community Energy Plan and covering the ten year period of 2015 to 2025.

The purpose of the Energy Plan is to:

- Endorse the proposed energy roadmap that will support both the community and the municipality in reaching energy targets.
- Provide the necessary information for City Council to approve energy initiatives that are financially justifiable and environmentally responsible.
- List and review the current energy-efficient capital projects and initiatives implemented by the City.
- Fulfill the reporting requirements of Milestones 2 and 3 of the Partners for Climate Protection Program at both the corporate and community level.
- Highlight and celebrate the City's ongoing work towards a carbon neutral, zero waste city with reduced greenhouse gases (GHG) emissions.

Moving forward with the city's long term aspirational targets of 100% renewable energy by 2050 (as per CEP Action Plan; 2006), the Energy Plan recommends and outlines potential technological initiatives and tools for both infrastructure and cultural change. Council input and support is integral to attaining corporate and community energy targets by 2025.

The Community Energy Planning Committee is a committee of Council made up of members from the energy industry, bureaucrats from the various orders of government within the city chosen from their respective departments that deal with both energy and the environment, individuals that represent advocacy groups that deal with the environment and energy, the general public and elected officials from the City of Yellowknife. A group that has coupled their collective knowledge with the expressed energy concerns of the general public to craft the following ambitious energy targets for 2025.

City of Yellowknife Corporate Targets

- Keep annual energy costs below the average of the preceding 5 years;
- Increase the share of renewable energy use from 50% to 70% by 2025;
- 50% reduction of GHG emissions by 2025, using 2009 as the baseline year.

Community Targets

- 30% reduction of GHG emissions by 2025, using 2009 as the baseline year;
- Increase the share of renewable energy use from 18% to 30% by 2025.

Matching energy targets with the city's most recent GHG emissions inventory (Sustainable Solutions Group Inc, 2015) demonstrates that City Corporate would need to reduce its annual GHG emissions by approximately 1,500 tonnes of carbon dioxide equivalent (tCO_2e) by 2025. The community (Yellowknife as a whole) would need to reduce its annual GHG emissions by approximately 55,000 tonnes of CO_2e by 2025.

From 2011 to 2015, the City's average annual energy expenses were $4.5 M. The use of five year rolling average is in place to measure and effectively compare annual energy costs while attempting to normalize the fluctuations due to future changes in fuel prices. Our target is to keep our annual emission cost below the preceding five year average by 10% to 20%.

These targets coupled with the renewable energy targets listed above are the core of the Energy Plan's strategy.

The Energy Plan also lists four energy principles that summarize the action items' consideration of the energy concerns of the public as well as input from the Community Energy Planning (CEP) Committee. The four principles are; a focus on heating, a diversified energy profile, cost-effective strategies and long-term adaptability. These principles are reflected to varying degrees throughout the proposed action items.

A list of corporate and community actions are presented in the Energy Plan. The corporate targets list capital projects that will position the City as a climate leader and aid in reaching set energy goals. Several capital projects have already been approved by Council and the goal is to have them all approved and continually monitored by City administration. It is to be understood that this plan is meant to be read as a "living" document; proposed recommendations are not set in stone but will continually adapt to better address changes in budget, climate, technology and social values. This aligns with the CEP 2006's founding recommendation of "long-term planning that includes life-cycle analysis of environmental, social and economic factors" (CEP, 2006).

The action items under the community scope all aim to reduce GHG emissions linked to different sectors. These sectors are transportation, heating and electricity, waste management, and future innovation/legislation changes.

Through policy change that encourages sustainable transportation, more energy efficient vehicles and environment considerate driving behaviours, the plan seeks to reduce emission in the transportation sector by 18,500 tCO_2e in 2025. This tonnage represents 34% of the necessary GHG reduction needed to bring the community's 2013 annual emissions down tothe2009 baseline year levels.

The main goal for the heating and electricity sector is to push the nascent Energy Savings Program forward as well as the continual monitoring and implementation of the energy efficient construction practices resulting from the ERS 80 By-Law for new buildings.

The GHG reduction potential tied to a strong waste management plan shows the possibility of reducing emissions by approximately 9,185 tonnes (17% of targeted reductions). Full organics collection expansion and the creation of by-laws that would make both organics and cardboard a controlled waste are proposed. Commissioning a waste study, followed by the distribution of public surveys and the announcement of clear waste diversion targets are proposed.

The last section of the community scope recognizes that breakthroughs in green and energy-efficient technologies as well as potential policy changes at the territorial and national level will have an effect on our ability to attain our targets. Proposed feasibility studies and pilot projects related to integrated resource management, wind power and Electronically Commutated Motor (ECM) circulator pumps are proposed. As well, the Energy Plan proposes that the City help communicate and support territorial policy change around carbon pricing and extended producer responsibility.

The Energy Plan includes the following:

- ***An assessment*** of the energy and climate challenges and opportunities that Yellowknife must address;
- ***A summary of recommended actions at both the corporate and community levels***
  - These recommended actions are categorized by sector: Transportation, Heating and Electricity, Waste, Future Innovation and Legislation Changes.
  - Supporting action items are also listed in every section that tie the action items to timelines and (when the necessary data is available) cost.
- ***A Responsibilities Table*** that re-categorizes the action items by themes (policy and compliance, communications and IT, municipal infrastructure, etc.) that will help decision makers delegate tasks in accordance to expertise and jurisdiction.
- ***A ten year action plan spreadsheet (2015-2025)*** that will serve as a compass to assist Yellowknife decision-makers in keeping true to energy transition commitments.

The Energy Plan recognizes the complexities of creating and implementing a resilient energy strategy that all stakeholders can agree to. In order to achieve the energy targets, the City will demonstrate municipal leadership as it aims to ensure that its sustainable operations management sets an example for the rest of the community.

The total recommended budget is approximately $8.27M over 10 years. The budget for certain projects has already been approved and the proposed expenditures will continue to be assessed through the 10 year period. This recommended budget is understood to be a guideline and would be reviewed, re-assessed and discussed with Council on an annually basis during budget deliberations.

Once the Energy Plan is reviewed and approved by Council, it will be submitted to the Federation of Canadian Municipalities' Partners for Climate Protection (FCM-PCP) as part of the city's funding requirements and memorandum of understanding regarding our partnership.

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3 Introduction

3.1 Purpose

The Corporate and Community Energy Action Plan (Energy Plan) is a guide that will contribute to making Yellowknife an energy-smart and sustainable city. The recommended actions therein should:

- Increase energy efficiency and energy conservation in all sectors;
- Guide the transition towards a decreased dependency on fossil fuels and an increased use of renewable energy sources;
- Consider the level of financial viability of proposed projects;
- Contribute to a clearer sense of direction when it comes to public and private energy use and engagement.

3.2 Mandate

In 2012, City Council put forward an objective to "*Develop Smart and Sustainable Approaches to Energy, Water and Sewer, Waste Management and Building Systems"* and identified, as an action item, the renewal of the Community Energy Plan beyond 2014. In 2013, Council set aside budget for this renewal following a recommendation by the CEP Committee. The current Energy Plan is the result of this work and will serve as a second ten year strategy to address Yellowknife's energy costs, energy security, and GHG emissions.

3.3 Scope

In order to be successful, the Energy Plan requires commitment from both the corporate and community sectors and has goals and action items for both.

Corporate Scope: The Energy Plan defines the actions and investments the City can make to impact its own energy use and GHG emissions, meeting many of the sustainable goals and objectives set out by Council as well as the energy-specific goals of the CEP Committee.

Community Scope: The Energy Plan sets out to position the City, in its capacity as a local government, to have an impact on the community's energy use and greenhouse gas emissions. Through communication, education and collaboration with both private and public stakeholders, the Energy Plan places the City as an active stakeholder and decision maker regarding all things sustainable and energy-efficient.

Together, these scopes help the City standardize its energy transition and GHG reduction efforts in a way that complies with national regulatory bodies.

3.4 Compliance with National and International Frameworks

Making sure that the Energy Plan's assessment of the city's current and projected energy use is presented in a standardized matter is integral to the process of making comparisons with other municipalities and collaborating on the national and international level. The City's latest GHG Emissions

Inventory (SSG Inc., 2015) is compliant with the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC), a globally recognized standard for monitoring energy demands and emissions.

> *"The Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) is a joint project by ICLEI-Local Governments for Sustainability (ICLEI), the World Resources Institute (WRI) and C40 Cities Climate Leadership Group (C40), with additional collaboration by the World Bank, UNEP, and UN-Habitat. As a global reporting standard, the GPC enables cities and communities to consistently measure and report GHG emissions and develop climate action plans and low-emission urban development strategies."*

Furthermore, the Energy Plan recommends that the City embark with other energy-concerned municipalities by registering with the Compact of Mayors (CoM) Program. Aligning the city's efforts with the CoM compliance requirements (which include submitting inventories to a third party registry as well as adding an adaptation plan to our current Energy Plan) will reinforce our actions and involve a more rigorous accountability framework. Given our compliance to the GPC and our updated emissions inventory report, the City will need to submit to the CoM by 2018, or within two years of committing to the program.

This planning process aligns with the FCM's Milestone Program, and also makes the City of Yellowknife one of the still active participants having already completed the five milestones (as discussed in Section 4.1).

Key partners and standardization bodies:

Partners for Climate Protection (Federation of Canadian Municipalities)
Compact of Mayors: "The world's largest cooperative effort among mayors and city officials to pledge to reduce greenhouse gas emissions, track progress and prepare for the impacts of climate change." [1]
GPC: An internationally accepted standard for GHG and energy accounting at the community level. GPC will allow the City to accurately compare our efforts with other municipalities. Our energy partners require us to report using the GPC method.
Carbonn and Carbon Disclosure Project: Two of the third-party registries that the City will have to submit data and GHG inventory to in order to comply with the regulations of the Compact of Mayors

In summary, aligning Yellowknife's energy actions with the above partners and regulatory bodies demonstrates to residents and potential investors that the city is a dedicated climate leader.

[1] www.compactofmayors.org

4 Context

4.1 Yellowknife joins the Partners for Climate Protection Program

In 1997 the City of Yellowknife joined the Partners for Climate Protection (PCP) Program in an effort to do its part in addressing the effects of climate change. This program, sponsored by FCM includes five major milestones:

1. Creating an Energy and Greenhouse Gas Emissions Inventory
2. Setting emission reduction targets
3. Developing a Local Action Plan
4. Implementing the Local Action Plan
5. Monitoring progress and reporting results

The City adopted its first Community Energy Plan in 2006 and completed the fifth and final milestone of this program in 2012. In so doing, the City surpassed the proposed GHG reduction target recommended by the PCP.

Adopted 2006 Energy Targets:

☑ City: 20% reduction of GHG level from the 2004 baseline by 2014

☑ Community: 6% reduction of GHG level from the 2004 baseline by 2014.

4.2 2013 Energy Inventory Results

Recalibrating the SSG data to reflect our northern reality, Yellowknife's estimated GHG emissions in 2013 was approximately 305,000 tonnes of CO_2e or approximately 15 tonnes per person. Yellowknife's energy demand was 5,000,000 GJ and an estimated $165M was spent on energy consumption.

The City itself emitted approximately 3,185 tonnes of CO_2e in 2013 (SSG Inc, 2015). Energy demands were approximately 100,000 GJ with an associated cost of $4.6M. These numbers represent significant decreases from both the City corporate and community's benchmark figures (CEP, 2006). The energy targets set by the first Community Energy Plan have been reached and now the CEP committee has crafted more ambitious targets to reach our vision of an energy efficient Yellowknife.

The first Community Energy Plan documents Yellowknife's notable history of spearheading mitigation initiatives to address climate change. Given the northern realities of the city which include a relatively small and remote population, Yellowknifers are particularly affected by extreme temperatures and therefore a resilient and adaptable energy plan can be a strategic tool in securing the economic and environmental well-being of the city. Transportation is quite carbon dependent and accounts for 16% of our energy consumption. The energy needed to heat buildings represents approximately 69% of the community's energy consumption. Electricity use represents 15% of the city's total energy consumption. The high cost of electricity is an important factor in determining how best to proceed with an energy plan.

Figure 1: Community Energy Demand Break-Down

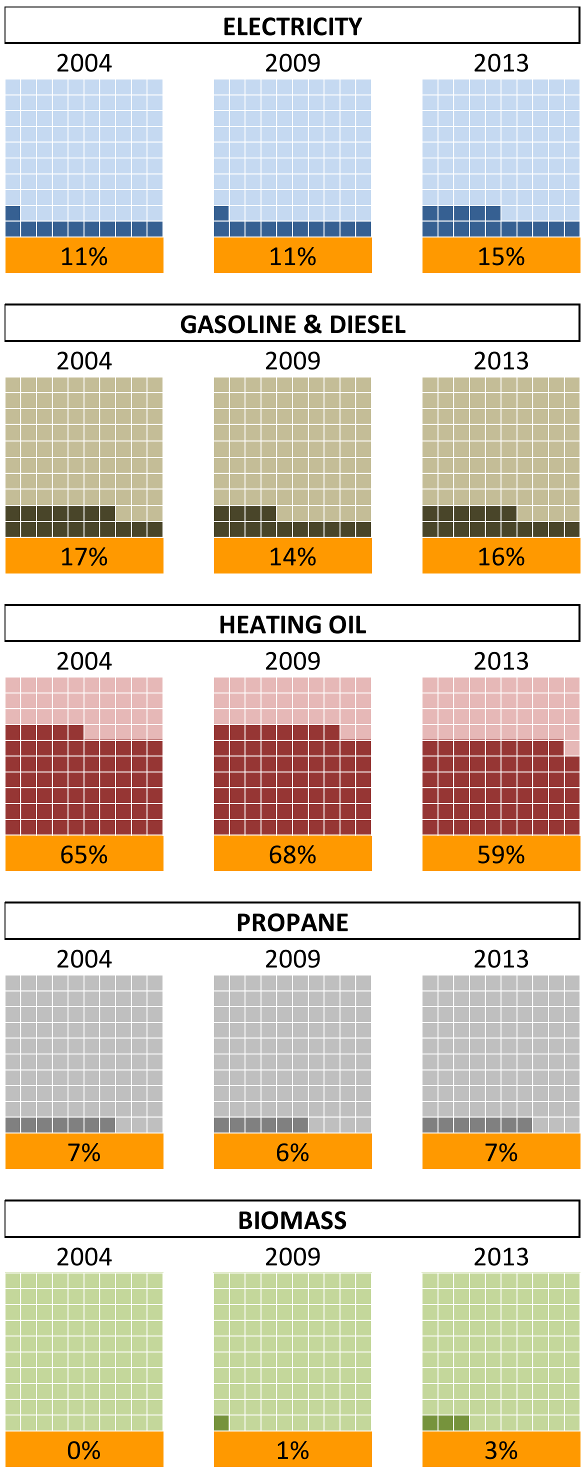


Figure 1 breaks down the community energy demand for three different years in relation to energy source. In all three years, energy derived from heating oil equates to approximately two thirds of the community's annual demands.

Evaluating and implementing more energy efficient ways of heating buildings is key to reaching set targets.

Total Annual Energy Demand		
2004	5,582,424	GJ
2009	5,543,587	GJ
2013	4,957,126	GJ

Figure 2: Community Energy Costs Break-Down

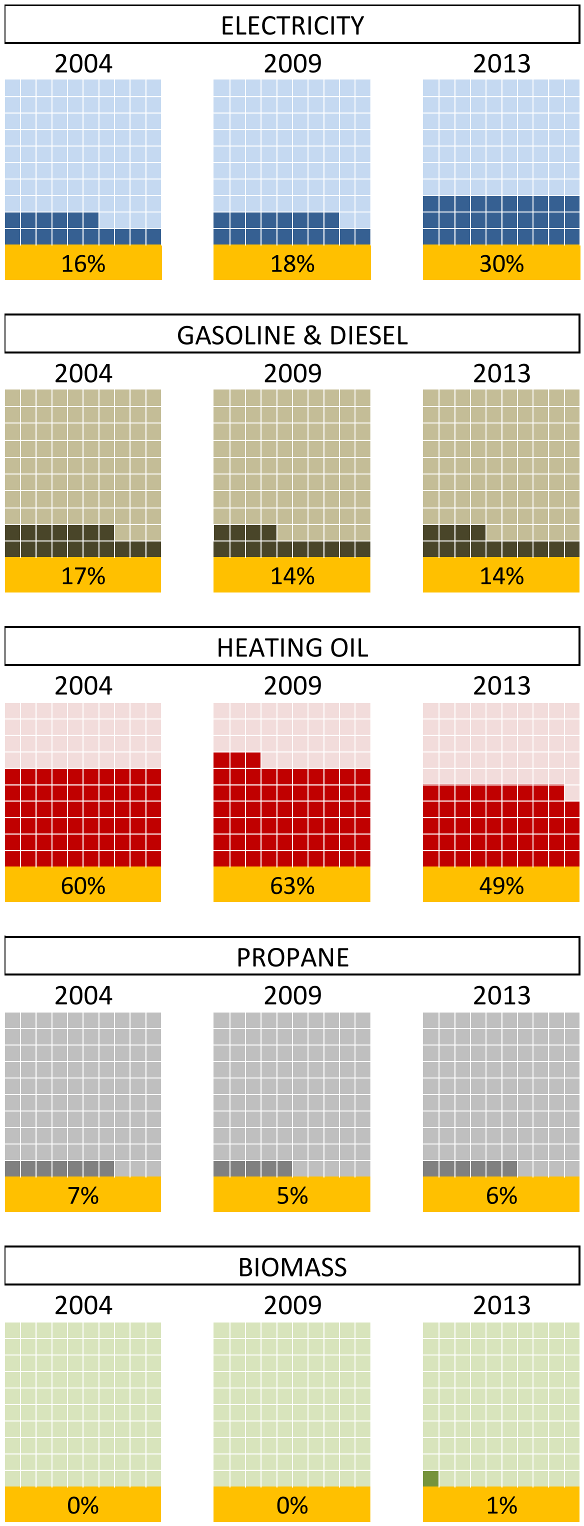


Figure 2 shows trends in energy cost for three years. There is an upward trend in electricity spending. This trend can possibly reflect the increasing cost of hydro-electricity for Northerners.

Total Annual Estimated Energy Costs	
2004	$ 155 M
2009	$ 185 M
2013	$ 161 M

4.3 Energy Risk Factors for Yellowknife

The Energy Plan considers the main energy risk factors that Yellowknife is susceptible to. Some key factors are listed below:

- Climate change and resulting changes in precipitation patterns could reduce the regularity of hydropower. This would increase both the cost of electricity, due to the use of diesel, and raise GHG emission levels;
- Exposure to global petroleum price shocks or other market risks;
- Extended power outages;
- Short term logistical disruptions in the distribution of imported fuels (oil, pellets, propane).

As with financial planning, one of the safest ways to improve energy security is to increase the diversification of energy sources. All actions proposed in this plan directly or indirectly increase the level of diversification.

4.4 Public Consultation

As approved by Council, the CEP renewal process proposed to use consultation as the level of public involvement in the planning process. This was supplemented by collaboration with the CEP Committee. (City of Yellowknife, 2013)

A public survey was conducted to consult the citizens of Yellowknife and complete the second milestone (*Milestone 2 – Setting Emission Reduction Targets).* The main objective of the public survey was to determine what Yellowknifers believe should be the objectives and priorities of energy planning. The secondary objective was to determine how various potential initiatives would be perceived. The figures below show the results of the survey.

Figure 3 – Average score given to proposed objectives, 4 being "very important", and 1 being "not important".

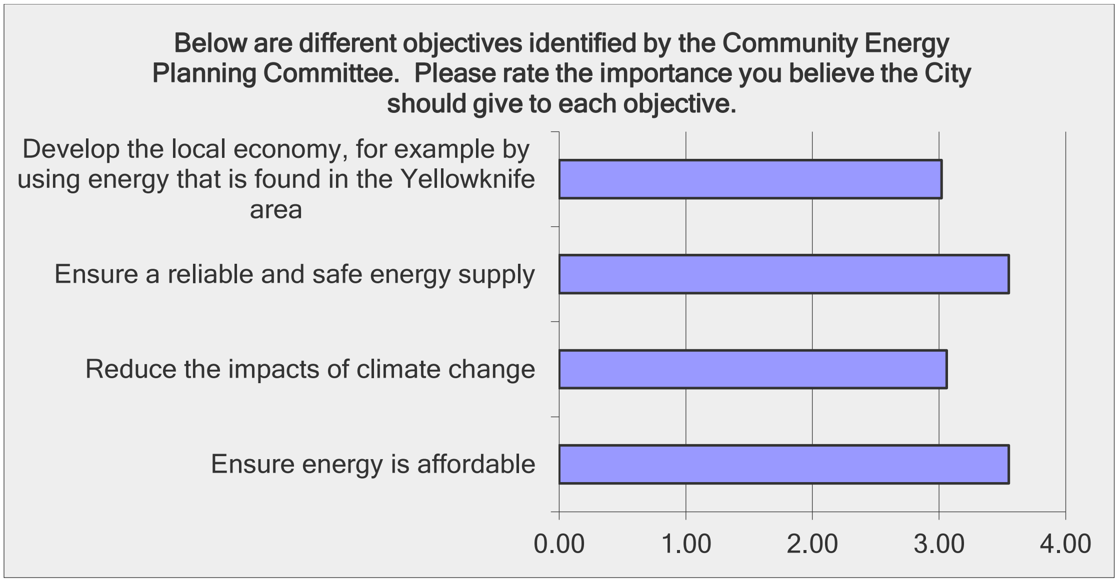
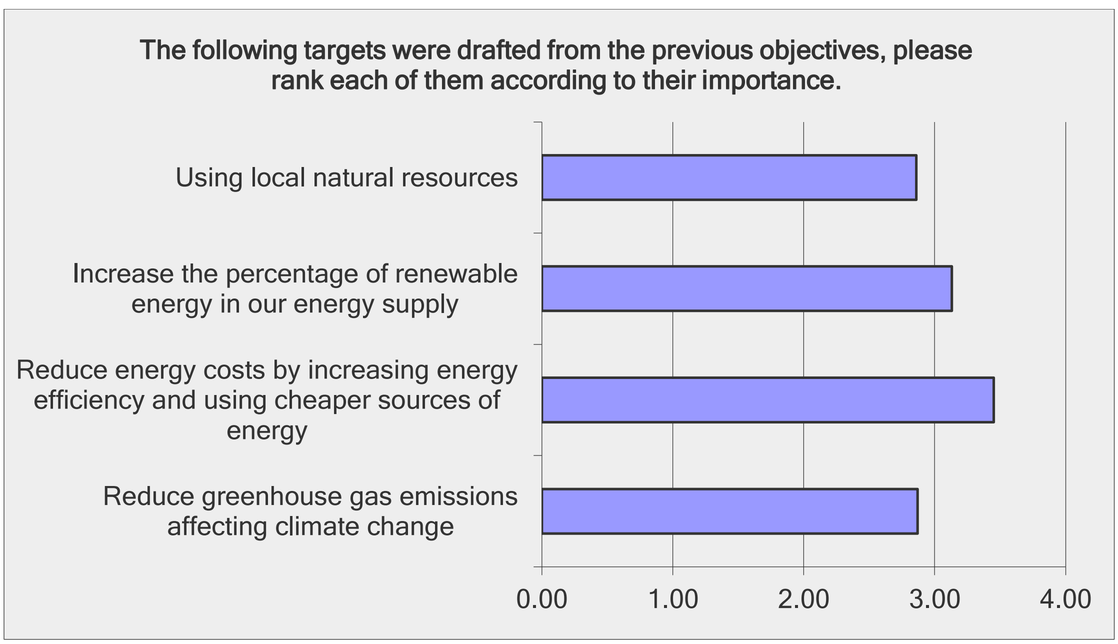


Figure 4 - Average score given to proposed targets, 4 being "very important", and 1 being "not important".



The full results of the CEP public survey can be found in Appendix B.

In short, the public consultation overlaps with the Energy Principles (listed in the following section) and together influenced how the Energy Plan's targets were set. The public's reasonable concerns around energy costs and securing renewable and reliable sources of energy are to be reflected in current and future targets.

5 Four Principles to steer us to our destination

The Energy Plan is influenced by the numerous studies and consultations that have happened in past years with regards to climate change and energy efficiency. The Energy Plan highlights four principles that encompass the collective vision of past deliberations. Action items in the Energy Plan should comply with one or more of the principles listed below.

Principle 1: Cost-effective strategies.

FACT: In 2013, the community spent approximately $140M on energy.

In order to reach the set goal of energy costs remaining below 2014 levels, action items need to make financial sense. Proposed projects will be examined to ensure that the return on investment (ROI) meets the City's financial goals.

Principle 2: Focus on heating

FACT: In 2009, the community emitted approximately 357,000 tonnes of CO_2e. In order to reach the Energy Plan's community target, collective efforts must be made to reduce annual emissions by approximately 107,000 tonnes by the year 2025. In other words, the goal is to be emitting no more than 250 000 tonnes of CO_2e in 2025.

Previous studies and public consultations have demonstrated that energy use for the heating of buildings accounted for a large portion of the city's GHG emissions and community concern. The Energy Plan puts particular emphasis on addressing energy efficiency and heating while the task of GHG emission reduction falls more on the transportation sector.

Principle 3: A diversified energy profile

FACT: Hydro-electricity is currently the city's main source of electrical energy and is s supplemented by diesel-backed generators.

Energy security is important. Irregular water levels and the rising cost of electricity in the north presents the need for a diversified energy profile. Many targets and action items brought forward in the Energy Plan will demonstrate residents' expectation of a resilient energy framework that will both be reliable and reduce the community's dependence on fossil fuels.

Principle 4: Ongoing adaptability to regulatory and technological changes

FACT: Technology and Legislation changes will undoubtedly happen within the next ten years. The Energy Plan must be able to adapt to these changes.

Principle 4 is included to account for the emergence of new technologies, new policies and other factors that may need to be integrated into the City's energy planning in the next decade. The Energy Plan is a "living document" and this fourth principle allows for the required flexibility in future energy planning.

6 Setting the Targets

In 2013, the City decided to continue its sustainability endeavours and develop an energy plan for the next ten years.

6.1 Yellowknife's Long-Term Energy Vision:

100% Renewable Energy by 2050

Current renewable energy use represents 18% of the community's energy mix even though some forms of renewable energy have been demonstrated to be cheaper and more sustainable than conventional fossil fuels. Fossil fuels are a finite resource, and their supply will eventually be exhausted. As the extraction of gas becomes more resource-demanding and as alternative energy sources become common place, there will eventually be more financial incentive to invest in alternative energy. Energy derived from wood pellets is an example where the use of renewable energy has already become less expensive than the use of non-renewable energy in the city.

6.2 Yellowknife's Short-term Energy Targets

Staying true to the ambitious commitment to be climate leaders, the CEP committee has considered the climate concerns of the public as well as the guidelines of its national partners and have settled on the following targets to guide energy efforts through to 2025. The Intergovernmental Panel on Climate Change (IPCC) recommends using 2010 as baseline year for climate action targets. The previous Energy Plan included a GHG inventory for the year 2009. The climate action target for the new Energy Plan used 2009 to be able to better compare with the previous inventory.

Community Targets

- 30% reduction in GHG emissions by 2025 when compared to the community's 2009 GHG levels;
- Increase the share of renewable energy use from 18% to 30% by 2025.

City of Yellowknife Corporate Targets

- Keep annual energy costs below the average of the preceding 5 years;
- Increase the share of renewable energy use from 50% to 70% by 2025;
- 50% reduction in GHG emissions by 2025 when compared to corporate's 2009 GHG levels.

Action Plans

Action items in this plan have been divided into action areas. However, as energy use impacts all economic activities, some item overlap may exist between areas. This means that action items may be repeated between the different action areas.

Cost of living was identified as a major issue in surveys commissioned by the City. All capital projects proposed are expected to reduce energy costs directly, while communication actions and policy work are expected to reduce costs indirectly.

As a general guideline, the target return on investment for the City's capital projects was set at 8.75% which matches the targets used by the British Columbia and Alberta Utility Commissions.

The next sections are divided into scopes; Corporate and Community. The Corporate section reflects infrastructure changes and capital projects that the City can implement. The Community section lists action items that if championed by the City, can lead to a significant culture shift in the community and in turn a considerable reduction in GHG emissions and improvement of energy efficiency.

Table 1: Summary of GHG Emissions Corporate and Community Energy Plan

CORPORATE CAPITAL PROJECTS Target: Reduce Municipal Emissions* by 50% (1,500 tCO2e)		
Baseline GHG emissions (2009)	3353 tonnes	
Potential GHG Reductions	2017 tonnes	
Percentage of Targeted Reductions	120%	
Action	**Reduction (Tonnes)**	**Percentage of Target**
Centralized Biomass Boiler (Multiplex)	829	47%
Pumphouse 1/Water Treatment Plant Heating System	340	19%
Interior LED & Daylight Harvesting	170	10%
Exterior LED Lighting	12	1%
Building Envelope Upgrades	14	1%
City Hall Centralized Boiler	130	7%
Solar Panels at City Facilities	482	27%
Air Source Heat Pumps	40	2%
Replacement of Existing Pellet Boilers	-	-
Hybrid/Electric Vehicles	TBD	TBD
City Fleet Monitoring and Improvement	TBD	TBD

COMMUNITY GHG REDUCTION GOAL Target: Reduce Community GHG Emissions* by 30% (55,000 tCO2e)			
TRANSPORTATION			
	Potential GHG Reductions	18476 tonnes	
	Percentage of Targeted Reductions	34%	
Action	**Target**	**Reduction (Tonnes)**	**Percentage of Target**
Reduce residential VKT by 20%	Spearhead programs and awareness campaigns in all areas of active transportation and public transit	8305	15%
Right sizing vehicles	Change vehicle mix. Decrease amount of trucks by 20%, increasing mid-sized vehicles by 5%, increasing compact vehicles by 15%	4358	8%
Create infrastructure for Electric cars as well as supporting policy	1% of light cars electrified	1016	2%
Businesses to include HEV to fleets	Switching 10 taxis (or cars with similar VKT) to HEV.	4797	9%
HEATING AND ELECTRICITY			
	Potential GHG Reductions	18188 tonnes	
	Percentage of Targeted Reductions	33%	
Action	**Target**	**Reduction (Tonnes)**	**Percentage of Target**
Support 1250 homes in adopting LIC (25% of detached and single households)	Average GHG savings is 3.75 tCO2/home Wood pellet stove installation, improve building envelopes, etc.	4688	9%
Ensure that new buildings abide by the City's Building By-law	100 new homes built in next 10 years under the City's Building by-law (135 tCO2e savings per home). By-law may be potentially updated to result in even more energy-efficient buildings	13500	25%
WASTE			
	Potential GHG Reductions	9185 tonnes	
	Percentage of Targeted Reductions	17%	
Action	**Target**	**Reduction (Tonnes)**	**Percentage of Target**
Full residential organics pick-up	Full City Organics collection aiming for 80% diversion rate by end of 2025	4160	8%
Full separation of Cardboard from waste streams	100% of cardboard is diverted by 2025	5025	9%
FUTURE INNOVATION AND LEGISLATION CHANGES			
	Aspirational percentage of Targeted Reductions	16%	
Action	**Target**		
Assess wind measurements at potential site			
Pre-feasibility study for ECM pumps	Feasibility study to see how best to promote usage in residential and ICI sectors and to assess the potential energy savings		
Explore integrated resource management models	Collect sufficient data on waste to energy technologies and boiler retrofitting for the northern context		
Promote education around carbon pricing	Regularly inform ICI and residential sectors on carbon pricing developments		

* Yellowknife is powered by a mix of hydro and diesel generated electricity that fluctuates from year to year. These variations have a direct effect on annual GHG savings

Corporate Action Plan

Photo credit: Pat Kane

7 Corporate Capital Projects

Table 2: Energy action items and GHG reduction targets for City Corporate

	Baseline GHG emissions (2009)	**3353 tonnes**	
	Potential GHG Reductions	**2017 tonnes**	
	Percentage of Targeted Reductions	**120%**	
projects	**Action**	**Reduction (Tonnes)**	**Percentage of Target**
	Centralized Biomass Boiler (Multiplex)	829	47%
	Pumphouse 1/Water Treatment Plant Heating System	340	19%
	Interior LED & Daylight Harvesting	170	10%
	Exterior LED Lighting	12	1%
	Building Envelope Upgrades	14	1%
	City Hall Centralized Boiler	130	7%
	Solar Panels at City Facilities	482	27%
	Air Source Heat Pumps	40	2%
	Replacement of Existing Pellet Boilers	-	-
	Hybrid/Electric Vehicles	TBD	TBD
	City Fleet Monitoring and Improvement	TBD	TBD

Projects proposed in this section should be read as a bank of potential projects for Council to consider during the ten year action plan. This bank of capital projects is divided into two groups. Items in the Stage 1 group are projects that the City can pragmatically implement within the next five years. There is a high level of confidence in the projected GHG reductions associated to stage 1 projects. The corresponding ROIs are reasonable. These projects demonstrate clear potential to attract external funding that will in turn positively affect their ROI. Table 3 includes additional columns that present projects' simple payback period as well as the change in ROI and payback period if the project were to get 30% of its cost externally funded. Another column considers the ROI of projects if a carbon tax of \$15/ tCO_2e were to be implemented. Recognizing that external funding and carbon tax rate are not yet set by regulatory bodies, the Energy Plan assumes funding discounts and carbon tax rates to allow decision makers to get a clearer idea of the future viability of the proposed capital projects.

Stage 2 projects demonstrate strong GHG reduction potential but require further analysis. These are ideal projects to investigate or revisit throughout the Energy Plan's timeline. Stage 2 projects, although not as detailed as Stage 1 projects, are pivotal to keep on the docket as new technologies emerge and market trends change. The total estimated budget required to complete the projects proposed is approximately \$9.0M. These projects also have the important goal of demonstrating the City's leadership role in the overall energy transition of Yellowknife. Projects are not only expected to be cost-effective but to provide an example to the public of how a northern city can successfully adopt climate considerate measures.

City administration will provide Council with annual reports on the status of implemented Stage 1 projects capitals as well as updates on proposed changes to Stage 2 projects. City administration will bring forward proposed projects to Council on an annual basis for consideration during the annual budget deliberations.

Table 3: List of Corporate Capital Projects

Item	Project	Investment	Annual Savings	R.O.I	ROI w. 30% anticipated funding	ROI w. 30% funding and carbon tax ($15/tonne)	payback period	payback period w/ anticipated funding	Annual GHG Reduction (tCO2e)
			STAGE 1 CAPITAL PROJECTS (2017-2020)						
7.1	Centralized Biomass (MPLEX)	$ 2,150,000.00	$ 140,000.00	6.5%	9.3%	10.1%	15	11	829
7.2	Pumphouse 1/Water Treatment Plant Boiler	$ 600,000.00	$ 100,000.00	16.7%	23.8%	25.0%	6	4	340
7.3	Interior LEDs & Daylight Harvesting	$ 470,000.00	$ 55,000.00	11.7%	16.7%	17.5%	9	6	170
7.4	Exterior LED Lighting	$ 50,000.00	$ 9,000.00	18.0%	25.7%	26.2%	6	4	12
7.5	Baling Facility Building Envelope Upgrades	$ 50,000.00	$ 5,000.00	10.0%	14.3%	14.9%	10	7	14
	STAGE 1 TOTAL	**$ 3,320,000.00**	**$ 309,000.00**						**1365**
			STAGE 2 CAPITAL PROJECTS (2020-2025)						
7.6	City Hall Centralized Boiler	$ 130,000.00	$ 20,000.00	15%	to	24.1%	7	5	130
7.7	Solar Power at City Facilities	$ 500,000.00	$ 35,000.00	7%	to	12.1%	14	10	482
7.8	Replacement of Existing Pellet Boilers	$ 1,300,000.00							
7.9	Electric Vehicle(s)	$ 75,000.00							
7.10	City Fleet Monitoring and Improvement	$ 75,000.00							
7.11	Waste to Energy Pilot projects*	$ 3,000,000.00							
	STAGE 2 TOTAL	**$ 4,950,000.00**	**$ 673,000.00**						**612**
	STAGE 1 & STAGE 2 TOTAL	**$ 8,270,000.00**	**$ 982,000.00**						**1977**

The proposed investment of $3M for WtE is in fact a range between $1.5M and $3M. A clearer assessment of the technology and cost of WtE is forthcoming.
The carbon tax of $15/tonne is used to give the reader an idea of how carbon pricing affects capital projects. The NWT has yet to implement a carbon tax.

7.1 Centralized Boiler System at Multiplex

In 2015, the City had a centralized boiler system designed for seven facilities in proximity to the Multiplex. A review of the project in 2016 determined that phase 3 of the project was not beneficial for the required cost and the scope of the project was reduced to include five facilities. Along with the Multiplex, the other facilities to be connected are: the Fieldhouse, Fire Hall, Public Works Garage, and Community Services Warehouse (Stantec, 2013).

The anticipated annual gross savings (given oil prices at $0.90 per litre) are $140,000 and would reduce the City's greenhouse gas emissions by approximately 800 tonnes per year.

Action: Install the Multiplex's Centralized Boiler System in 2017[2]

7.2 Pumphouse 1 Biomass Boiler

In 2016-17 the City completed the installation of a biomass boiler in Pumphouse #1 replacing the old existing boiler. This project was completed in the spring of 2017 and is anticipated to save the City approximately $60,000 per year and reduce greenhouse gas emissions by up to 500 tonnes per year.

There is potential for this project to be expanded in the future to include the heating of the City's Water Treatment Plant. This would require a heat transfer pipe between the two buildings and a second biomass boiler to be installed. Currently, this expansion is on hold until the heating requirements of the Water Treatment Plant are fully established and a feasibility study can be completed.

Action: Project completed in 2017

[2] City Council approved $2,150,000 in the 2016 and 2017 Capital Budgets for this project.

7.3 Interior LEDs and Daylight Harvesting

Tests conducted by the City in 2015 demonstrated that electricity savings of 25-35% can be achieved by replacing standard T8 fluorescent tubes with LED tubes[3]. In rooms with exterior windows, the use of daylight harvesting with automated dimmers would increase savings by up to 40%. Without daylight harvesting, at current power rates, annual savings would be approximately $3.84 per tube. At an approximate cost of $25.00 per tube the simple rate of return is 15%. This estimate does not include the savings realized with the longer lifespan of LED tubes, the increasing cost of electricity, the reduction of lighting outputs in areas that had excesses, or the costs avoided by no longer having to manage the disposal of mercury in fluorescent tubes.

The City currently manages approximately 28,500 square feet of indoor space for sports facilities, offices, and garages. To estimate the potential value of switching to LED lighting indoors, this report assumes the average illumination levels were 400 lux and that the current average lighting efficiency is 40 lumens per watt. These assumptions take into account measurements that have been taken in the various facilities. Lighting costs are estimated to be $34,800 per year. It is estimated that general lighting levels could be reduced by 25%, and that the new LED lights would be 40% more efficient, for a total savings of $19,140 per year on energy alone. Giving the long-lasting nature of LED lights, savings in maintenance are also expected.

The cost of retrofits would vary greatly and would depend on the type and location of existing lighting in the facility. The City will initiate a complete retrofit by starting with the lowest cost options. The first priority should be the direct replacement of fluorescents with LED tubes in facilities with lighting that has not been upgraded in the last few years. City Hall, the main pool area, and all three arena ice surfaces have already been upgraded in some way in the last three years.

Yellowknife is estimated to have more than five million square feet of commercial space and a complete LED retrofit could yield a significant impact for the community as a whole.

Action: Replace the City's interior lighting with LED lighting.

7.4 Exterior LED Lighting Installation

The City formally initiated the replacement of all exterior lighting with LEDs in 2012, with the acceleration of the LED street lighting program and the retrofit of City Hall, Multiplex, Fieldhouse, Baling Facility, Pool, Community Arena and Curling Club. Public Works facilities remain to be retrofitted. Buildings that were retrofitted with LEDs were able to reduce the wattage on lamps by 50% while either maintaining or exceeding previous lighting levels.

Action: Complete the retrofit of all exterior lighting with LED lighting by 2020

[3] Most current LED tube technologies require "instant-start" ballasts or require a rewire of the fixture to run on line voltage. Electricians should be hired to install LED tubes if the user is unfamiliar with how to identify fluorescent ballasts.

7.5 Building Envelope Upgrade of the Baling Facility Roof

The Baling Facility's roof has deteriorated greatly due to birds pecking at the insulation from the inside, largely exposing bare exterior metal cladding to the heated indoor space. Replacement of the insulation is proposed, and savings have been estimated by assuming the effective insulation factor would rise from R10 to R30, and the insulation would now be protected by metal cladding.

Action: Repair the Baling Facility roof and increase the roof's insulation value in 2017

7.6 City Hall Centralized Boiler System

City Hall uses approximately 55,000 litres of heating oil per year. At current fuel rates, maintaining a stand-alone biomass boiler would not be viable, however, savings would be realized by pairing a central boiler with other potential clients (e.g. RCMP, DND). There is no capital budget allocated for this project as this plan recommends leasing of municipal land to a third party operator as compensation for installing and operating a biomass boiler shared by multiple clients. This recommendation anticipates that the City would receive heat at a cost that would include the operator's capital cost, but at a lower cost when compared to oil.

An initial investment can go towards a study that would recommend an appropriate regulatory structure for district energy usage amongst City Hall and adjacent buildings. This study can in turn be used as a template for other district energy systems both at the corporate and community/private levels.

Additional revenues could be generated by this model through franchise fees on the heat sold to other customers serviced by the boiler.

Action: Complete design for a centralized boiler system near City Hall by 2020

7.7 Solar Power at City Facilities

The availability of hydroelectricity continues to fluctuate due to climate change (e.g. varying water levels, forest fires, etc.). Therefore, the integration of solar power into the City's energy framework is a solid step towards a diversified and more resilient electricity profile.

Although solar panels are expensive and, when compared with hydro-electricity, do not result in a dramatic GHG reduction, the Energy Plan considers them a worthwhile addition to the pool of stage 2 projects. Market trends and regulatory changes may render solar panel procurement and installation more viable in the future and as such, the City wants to be prepared for that possibility.

The City's first solar project was completed in 2014 with the installation of a 3kW pilot project at the Baling Facility. The City expects this project to break even, given current commercial rates. In 2016, the City's first commercial sized (25 kW) solar panel system was installed at the Fieldhouse. This system will serve as a case study for larger installations, as current returns on investment are modest at approximately 5%, not considering external funding grants or rebates.

It is important to understand the limits of the net metering program, which is the solar energy system that the City must abide by. The solar panels are what are known as grid-tied systems, where solar energy is converted and then fed into the hydro-grid as opposed to having the solar energy directly used by the building. The net metering program's maximum allowed capacity is 5 kW. Being limited by the net metering program's maximum of 5 kW, the City would have to install larger systems on a load displacement basis, on facilities that have a large minimum demand.

Action: Install more solar panels on facilities where economically viable

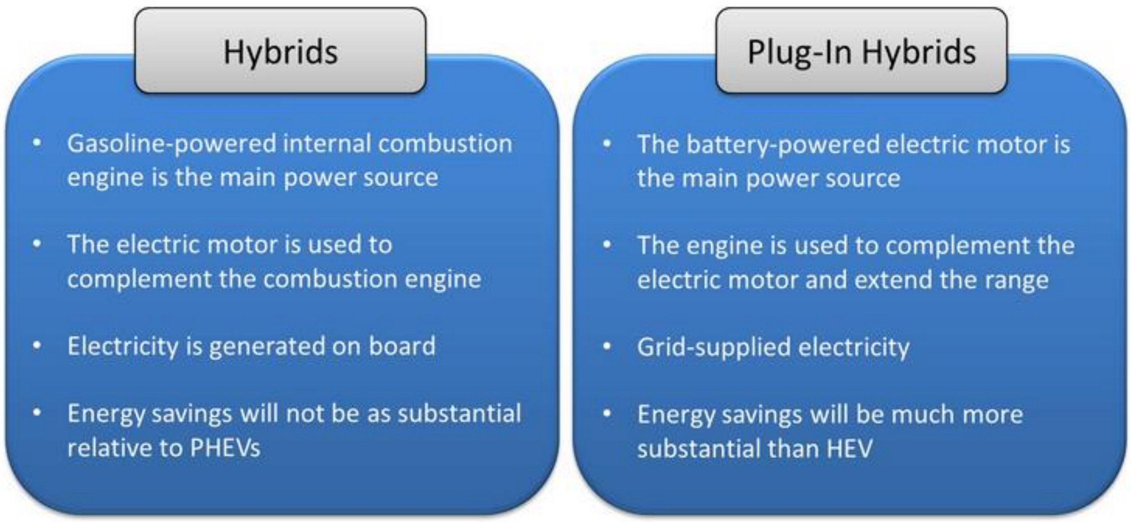
7.8 Replace Existing Pellet Boilers

In 2010, the City introduced two wood pellet boilers, one at the Ruth Inch Memorial Pool and the other at the Baling Facility. The life expectancy of those two boilers is fifteen years. Biomass is still expected to be the least expensive source of on-demand heat when the existing boilers will need replacement. This reality may eventually change due to reductions in costs of energy storage, the development of district heating systems, or changes in the facilities serviced by the boilers. All available technologies should be reviewed at the time replacements are due. Biomass, especially from locally harvested wood chips, could be proposed at that time; an investment of $720,000 is predicted for the Pool and $500,000 for the Baling Facility. These numbers are based on the installation cost of the existing boilers, adjusted for inflation up to the year of replacement.

Action: Replace existing pellet boilers with the best available technology by 2025

7.9 Replace hybrid vehicles with plug-in hybrids or electric vehicles

When the City's two hybrid vehicles are due for renewal, it is anticipated that prices for electric vehicles will have decreased enough to make their purchase financially viable. This anticipation is an educated guess based on the City producing power, the price of oil rising, vehicle models' production volumes increasing, and battery storage costs continuing their trend downward.



http://www.fleetcarma.com/hybrids-what-is-the-difference-between-traditional-and-plug-in/

Action: Replace three hybrid vehicles with plug-in hybrids or electric vehicles by 2025

7.10 City Fleet

An energy focused review of our municipal fleet should also be done on a regular basis. A fleet review was last completed in 2006 (Aboriginal Engineering, 2006) and could be updated to consider actions that were recommended in the last review and new technologies, like electric vehicles.

Action: Implement an annual municipal fleet energy report

Tasks and Responsibilities:

	Action Item	Corporate	Community	2016	17	18	19	20	21	22	23	24	25	Action Item Target
1	**Municipal Leadership**													
7.1	Install the first and second phase of centralized boiler system at Multiplex in 2017	•												80% reduction in heating oil use; 20% reduction in heating cost
7.2	Complete the installation of piping for PH1/WTP heating system	•												15% heating oil reduction for WTP; 85% heating oil reduction for PHA1, annual saving approx. $100,000
7.3	Approval to replace all of the City's facilities interior lighting with LED lighting	•												100% LED lights by 2020
7.4	Complete exterior LED lighting	•												
7.5	Improve the insulation value of the Baling Facility's roof when repaired	•												Insulate by 2020
7.6	Complete design for a centralized boiler system near City Hall that would be shared with potential clients	•	•											Design out for tender by 2020
7.7	Install more solar panels on facilities where it is economically viable	•												Aim to increase the amount of solar power produced at City facilities
7.8	Monitor the performance of the two heat pumps currently in operation	•												Monitoring report due by 2019, followed by decision for future installations
7.9	Replace existing pellet boilers with the best available technology	•												Cost/benefit analysis report done to address potential boiler retrofitting; boilers replaced by 2025
7.10	Replace hybrid vehicles with plug-in electric vehicles	•												Comparison analysis for 3 types o vehicles done by 2022, purchase o new cars based on decision by 2024
7.11	Implement an annual municipal fleet energy report													Define criteria in 2017, begin energy monitoring in 2018

Community Energy Targets:

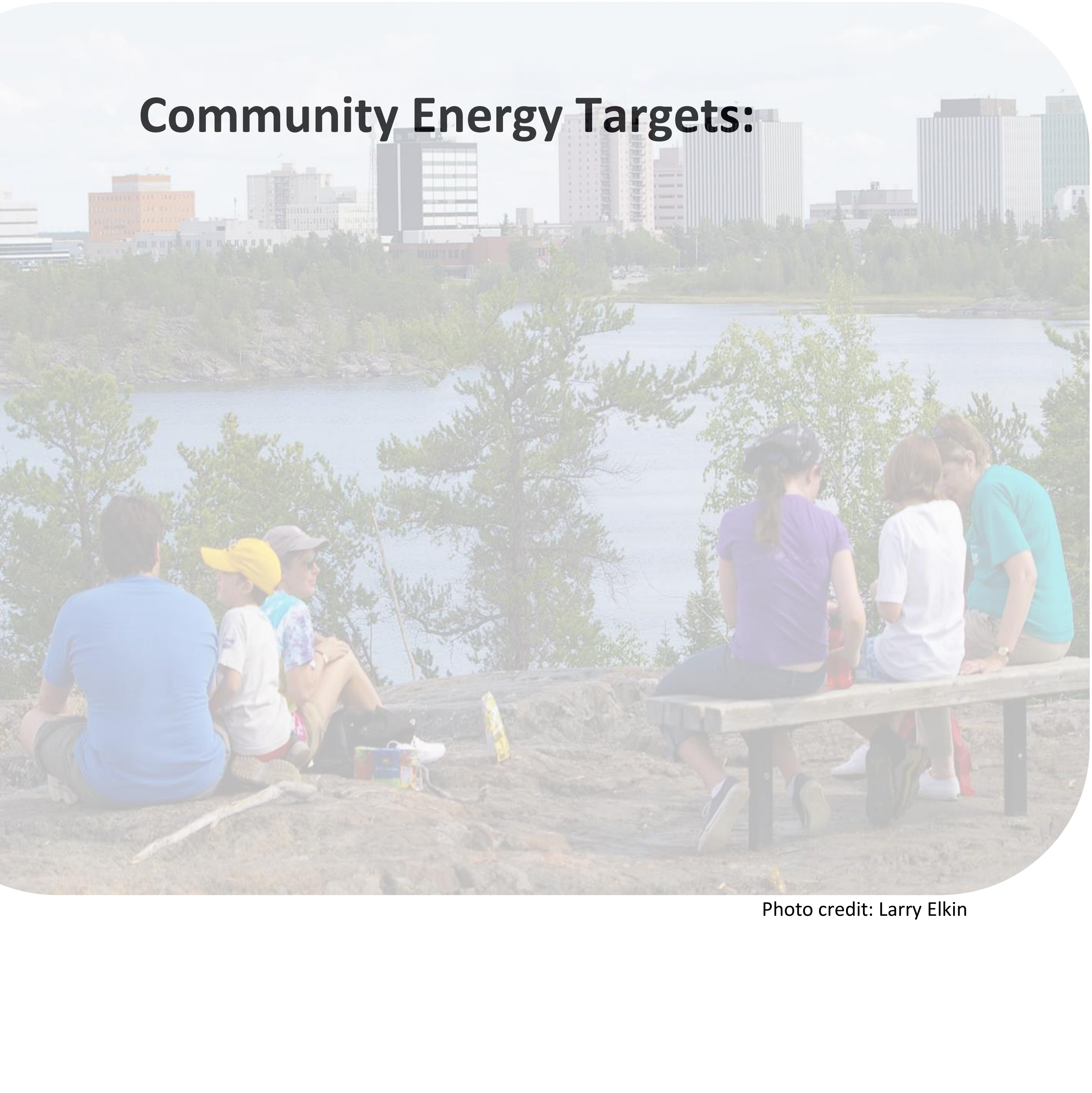


Photo credit: Larry Elkin

8 Transportation

The 2013 energy inventory estimated that 53% of the city's GHG emissions came from transportation. At the moment, few technological, cost effective solutions exist as alternatives to the use of fossil fuels in the transportation sector. Therefore, much of the endeavour to reduce GHG emissions in the transportation sector will come from a community cultural shift influenced by the actions and policies of the City and Council.

Table 4: Community action items and GHG reduction targets for the transportation sector

TRANSPORTATION				
		Potential GHG Reductions	**18476 tonnes**	
		Percentage of Targeted Reductions	**34%**	
	Action	**Target**	**Reduction (Tonnes)**	**Percentage of Target**
	Reduce residential VKT by 20%	Spearhead programs and awareness campaigns in all areas of active transportation and public transit	8305	15%
	Right sizing vehicles	Change vehicle mix. Decrease amount of trucks by 20%, increasing mid-sized vehicles by 5%, increasing compact vehicles by 15%	4358	8%
	Create infrastructure for Electric cars as well as supporting policy	1% of light cars electrified	1016	2%
	Businesses to include HEV to fleets	Switching 10 taxis (or cars with similar VKT) to HEV.	4797	9%

8.1 Reducing Vehicle Kilometres traveled by 20%

A twenty per cent reduction of vehicle kilometres travelled has the resulting GHG reduction potential of approximately 8,305 tCO_2e, translating to 15% of our Community reduction target goal. With this sub-target at the forefront, City Council has an indicator to monitor transportation sector reductions. Council can pass a motion directing City administration to push forward with a communication plan that promotes sustainable transportation and considers the goals of the Public Works Department in order to galvanize a culture shift across Yellowknife (See table 5: Transportation Tasks and Responsibilities.)

Example: CarShare

The CarShare project is being spearheaded by a developer (Cloudworks) and local environmental non-profit organization, Ecology North. The co-op would provide cars that would be available for all members at an hourly rate. This would have the result of reducing the numbers of vehicles on the road, parking issues in the downtown area, and reduce GHG emissions. The co-op believes that it is feasible to expand operations to ten vehicles relatively quickly, should government partners encourage car-sharing as a potential solution for fleet management reduction.

8.2 Changing Yellowknife's Vehicle Mix

Economic and social instruments can be put in place to see the vehicle mix of Yellowknife shift from a strong inclination towards large trucks to one that values the use of fuel-efficient compact cars. Approximately 4358 tCO_2e is reduced by shifting the Yellowknife vehicle mix from 70% large truck to

50%. Although the City has little jurisdiction in consumer choice, Council can give the go-ahead to do the necessary groundwork to educate buyers and sellers that smaller and more energy efficient cars are a worthwhile investment.

8.3 Reinforcing the City's Anti-Idling By-Law

Revisiting and revamping the city's Anti-Idling By-law is an important action. Finding ways to better enforce the by-law should be explored. A reduction in community idling not only helps the city reach the GHG emission targets, but has direct benefits to the well-being of residents.

8.4 Electric Vehicles

Electric vehicles will have a significant impact on Yellowknife's energy profile if adopted. There are indications that adoption rates could be higher in Yellowknife, as other cold climate markets are seeing higher adoption rates. For example, 23% of new vehicles sold in Norway are now electric. (Ayre, 2015)

If just 1% of Yellowknife's light vehicles were electrified, it estimated that over a million kilometres would be travelled using electricity in a year. The potential energy demand resulting in community use of electric cars will have an impact on power generation and distribution infrastructure, and would require further analysis.

There is an opportunity here for the city to encourage fast-charging EV stations. Yellowknifers are already familiar with the concept of winter plug-ins and the City can easily communicate EV and fast charging vehicles as the next step. Coupling the solar investments can partially offset the boost in the grid caused by electric vehicles. The City can invest in the deployment of public charging stations or support ways for EV drivers to create service networks.

The City can promote measures for businesses to change some of their fleet to low-emitting vehicles. If, for example, a local taxi service company were to trade in 10% of its cabs for Hybrid vehicles, the community's annual GHG will drop significantly. Having privileged parking and other city infrastructure changes would encourage businesses and residents to make the switch. The City can also use positive social instruments (e.g. public acknowledgement) to highlight businesses that have included fuel-efficient driving training into their employee orientation. Natural Resources Canada and Stantec offer interactive online courses on both fuel-efficient driving and professional driver improvement (www.solutions.ca/elearning.html)

8.5 Sustainable Transportation Communications Plan

A revamped Energy Communication Plan is paramount to getting the message out to the community about the need for public engagement in reaching community energy targets. The City should use all available resources to help disseminate information about how residents and businesses can access energy-efficient technologies and adopt climate-conscious activities, especially in the realm of sustainable transportation. A portion of the CEP's communication budget could be used to promote the use of active transportation. To measure the effectiveness of this campaign, annual surveys can be used to measure indicators like the number of commuters driving to work.

Table 5: List of tasks for the Transportation Sector

Transportation		Corporate	Community	2016	17	18	19	20	21	22	23	24	25
8.1	**Reducing residential VKT by 20%**												
	Promote active transportation with the support of the Communications Department	•		■	■	■	■	■	■	■	■	■	■
	Create and disseminate baseline survey to collect data on YK work commute to establish the foundation of future targets		•		■	■							
	Implement bi-annual campaign to collect transportation data from commuters		•			■		■		■		■	
	Continue to improve and promote public transit	•		■	■	■	■	■	■	■	■	■	■
8.2	**Changing Yellowknife's Vehicle Mix**												
	Investigate was to make the purchase of compact and mid-sized cars more appealing for residents		•			■	■	■	■				
	Highlight the benefits of buying small to residents		•	■	■	■	■	■	■	■	■	■	■
	Initiate dialogue with car dealers to increase amount of small cars available for purchase		•			■	■	■	■				
8.3	**Reinforcing the City's Anti-Idling By-law**												
	Compare and calibrate bylaw with those of other Canadian municipalities	•			■								
	Increase the number of "No-Idle Zones" in the city		•	■	■	■	■	■	■	■	■	■	■
	Work with the Municipal Enforcement Division (MED) to have by-law enforced	•				■	■						
8.4	**Electric, Plug-in Hybrid and Hybrid Vehicles**												
	Investigate the feasibility of installing electric vehicle public charging stations		•			■							
	Make a decision on infrastructure changes based on data from initial study	•					■	■					
8.5	**Sustainable Transportation Communications Plan**												
	Improve signage for bike lanes				■		■		■		■		■
	Include bike lanes in the City Explorer Mapping System	•				■							
	Review existing bike lanes for potential improvement for future bike lanes	•		■	■								
	Commission a transportation Study	•				■	■						

9 Heating and Electricity

Electricity represents 20% of the city's energy use, yet 33% of the energy cost. This places electricity as the most expensive source of energy for Yellowknifers (Sustainability Solutions Group, 2015). The communities on the Snare hydroelectric grid (Behchoko, Dettah, N'Dilo, and Yellowknife) have been facing significant upward pressures on the price of electricity in the last few years. These pressures can be attributed to inflation, recent rate equalization between communities, and the increased use of diesel to compensate for the lower water levels experienced in recent years. The electrical demand has stabilized since 2004 with more than 95% of the power supplied to the Snare grid coming from hydroelectricity.

Table 6: Community action items and GHG reduction targets for the heating and electricity sector

HEATING AND ELECTRICITY*				
		Potential GHG Reductions	**18188 tonnes**	
		Percentage of Targeted Reductions	**33%**	
	Action	**Target**	**Reduction (Tonnes)**	**Percentage of Target**
measurable actions	Support 1250 homes in adopting LIC (25% of detached and single households)	Average GHG savings is 3.75 tCO2/home Wood pellet stove installation, improve building envelopes, etc.	4688	9%
	Ensure that new buildings abide by the City's Building By-law	100 new homes built in next 10 years under the City's Building by-law (135 tCO2e savings per home). By-law may be potentially updated to result in even more energy-efficient buildings	13500	25%

** GHG savings were calculated using 2014 hydro-generation data. It is to be noted that due to low water levels, 2014's hydro-generation was particularly diesel-intensive.*

Addressing electricity costs in Yellowknife will require a mix of policies aimed at limiting load growth through implementing efficiency measures on the demand side, and integrating lower cost electricity sources on the supply side.

9.1 Residential Energy Savings Plan (Local Improvement Charges)

In 2015, the Pembina Institute completed a study that identified the obstacles Yellowknifers face when considering green retrofits for their homes. Some of the obstacles identified were finances, knowledge, and local capacities. The study recommended the use of various tools to address those obstacles, including the use of Local Improvement Charges to address financial concerns. The purpose of the program is to reduce the risk to lenders by guaranteeing the loan with the City's taxation authority. This program would increase the homeowner's ability to access credit and reduce their effective interest rate.

The City currently has limited jurisdiction over relevant policy changes, in particular with regards to the Cities, Towns and Villages Act. The City has requested that legislative changes be made to allow implementation of such a program, but to date these changes have not been made. Continuing to advocate for policy advancement at the senior governmental level and implementing public awareness regarding the advantages of investing in green retrofits are measures that the City can take. In ten years, having 500 homeowners (roughly 12% of single family households) join the Energy Savings Program has a GHG reduction potential of 1,876 tonnes, an equivalent to 4% of our target would be attained.

9.2 Implementation of Energuide 80 Bylaw

In the past decade, Yellowknife energy experts have worked diligently to find ways to make northern homes more energy efficient. The City worked closely with Arctic Energy Alliance and successfully implemented mandatory energy efficiency regulations. In 2012, Council amended By-Law No. 4469, making it mandatory for new residential homes to be designed and built to achieve a minimum Energuide rating of 80 (EGNH80). Commercial and industrial buildings must comply with stricter regulations by scoring “25% higher than the minimum requirements of the National Model Energy Code of Canada for Buildings 1997.” Amendments to the by-law also addressed additions, alterations, and repairs to existing houses by implementing either minimum higher R value insulation for all components or providing energy evaluations performed by Certified Energy Advisors.

Although the adoption of EGNH80 standards into City by-law was a success, , The Energy Plan aims to push the envelope even further by advocating for higher, better standards (consumption based rating GJ/year versus 0-100 scale rating system).

An Arctic Energy Alliance study showed that 91 houses built in Yellowknife from 2010 to 2015 saved 125,000 kWh of electricity and 7,900 GJ of fuel for participant residents when compared to the 1990-2007 energy performance average. Making a conservative assumption that 100 homes will be built in the next ten years, one can extrapolate the energy savings and GHG reductions that the new Energuide system will demand. In this direction, the City may explore improvements to its Building Bylaw in order to better monitor and implement energy efficiency regulations. This will involve continued dialogue with Natural Resources Canada as well as local industry experts.

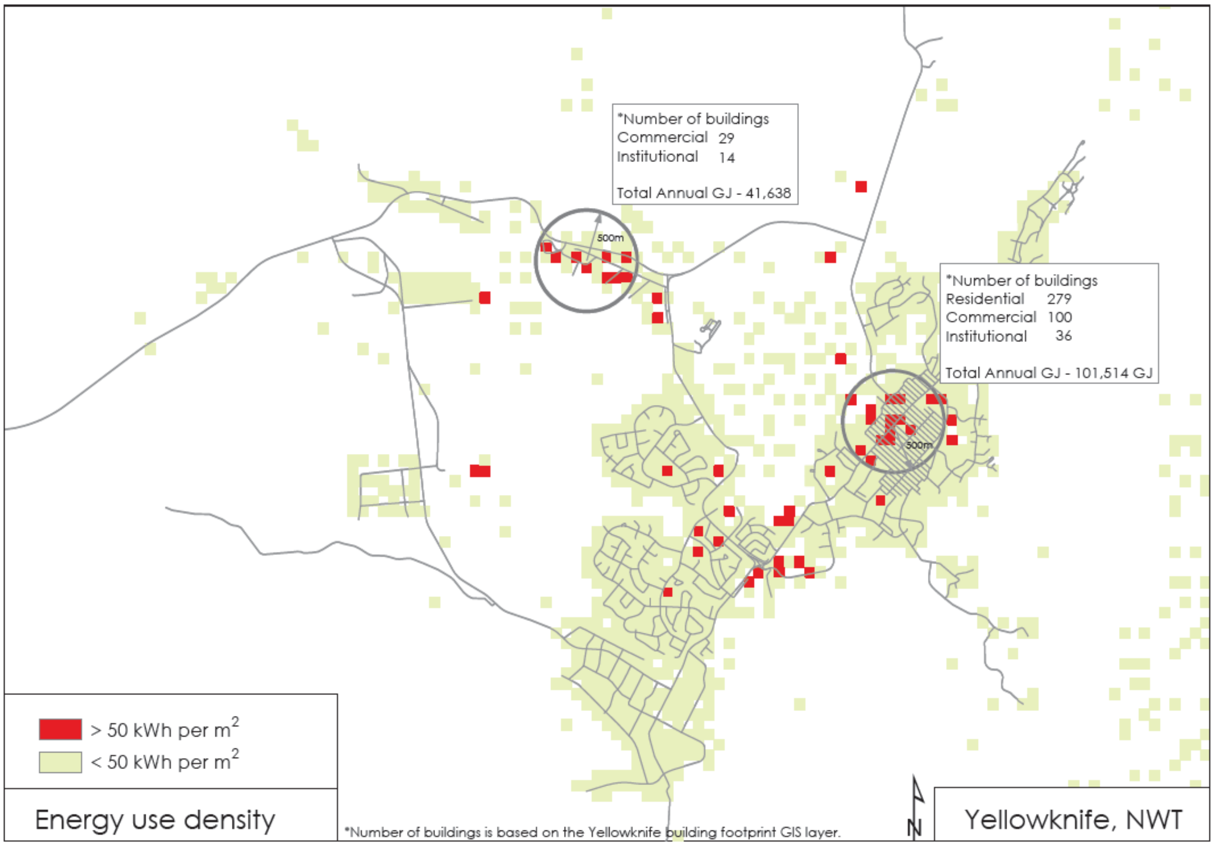
9.3 Develop a District Heating Development Policy

Communities like Portland and Vancouver have district energy policies that define the process for private sector investment in district heating systems. As private interest grows in Yellowknife, the need for a responsible development policy also increases. Such a policy would serve to reduce uncertainties related to access to information and the permitting process.

The City’s latest energy inventory identified three locations within the city that would have the heat load densities to make the construction of a district heating system feasible. These locations are identified in Figure 4 and include the City’s centralized boiler system at the Multiplex. Currently, wood is the cheapest available heat source in the city. This plan would see private partners invited to develop a utility type service in one of the downtown locations. Other locations, like the Multiplex area, would be serviced directly by the City, as the buildings in the area are mainly municipally owned and the airport area is under territorial jurisdiction. For locations that are outside the three areas identified, wood boilers, stoves or furnaces for one or two buildings may be a preferred option.

The City has confirmed potential locations for district heating systems during the creation of the 2015 energy inventory. Figure 4 identifies downtown and the airport as potential sites.

Figure 4 - Calculated Heat Energy Density Map



9.4 Solar Panels for Residents

Distributed power generation, through the installation of solar panels at the building level, has the advantage of using existing interconnection infrastructure without needing the addition of new substations or transformers, optimizing the use of existing capital.

This fact substantiates the promotion of residential solar energy use. For commercial installations, solar panels may still be financially attractive (even at the lower commercial power rate per kWh) if the size of the system is large enough to attract economies of scale; likely larger than the 5 kW limit on net metering installations. This sizing requirement would limit the installation of solar panels for commercial users to sites that have a high and consistent minimum demand during summer days. Many buildings in the city have this kind of minimum demand.

Table 7: List of tasks for the Heating and Electricity Sector

Heating and Electricity	Corporate	Community	2016	17	18	19	20	21	22	23	24	25
9.1 Residential Energy Savings Plan (Local Improvement Charges												
Communicate the benefits of energy efficient home retrofitting		•										
Monitor the process of LIC bylaw changes at the territorial level (MACA's CTV Act)	•	•										
9.2 Implementation of Energuide 80 bylaw												
Monitor, report and share information on the increasing number of buildings built in accordance with the new bylaw	•	•										
Increase by-law requirements (e.g.; increase to minimum rating of 85) so that both energy efficiency and reduced GHG emissions are prioritized		•										
9.3 Develop a District Heating Development Policy												
Organize an initial workshop to discuss challenges and opportunities of developing a utility-type service	•	•										
9.4 Solar Panels for Residents												
Inform residents of the realities of solar power in the North through the CEP communications plan and the green retrofit program		•										
Produce a solar potential map for roofs using the LIDAR data collected in 2015	•											
Promote dark sky compliant fixtures in the communications plan												

10 Waste Management

Table 8: Community action items and GHG reduction targets for the solid waste sector

WASTE				
		Potential GHG Reductions	**9185 tonnes**	
		Percentage of Targeted Reductions	**17%**	
	Action	**Target**	**Reduction (Tonnes)**	**Percentage of Target**
	Full residential organics pick-up	Full City Organics collection aiming for 80% diversion rate by end of 2025	4160	8%
	Full separation of Cardboard from waste streams	100% of cardboard is diverted by 2025	5025	9%

10.1 Waste Management Study

A review of the city's waste management efforts would greatly improve the community's understanding of how waste contributes to emissions and energy costs. Creating waste diversion targets that dovetail with the overarching GHG targets will add to the thorough analysis of the city's energy profile.

The 2017 City budget includes funding to commission a waste study and audit by an external consultant. The study, along with public consultation, will help set new targets for waste reduction and diversion of municipal solid waste. Since 2012, the City has assisted the community in better managing their waste; programs like the Centralized Compost Program and the Bottle Container Recycling Program (funded by the GNWT) have responded to the public's request for stronger by-product stewardship.

Council can support these and other waste management initiatives by making tangible amendments to solid waste by-laws. Enacting disposal bans on cardboard and organics is a practical action that will produce solid results. Detailing how the City plans to support residents and businesses through the process will lead to a sense of community agency over waste management and an overall acceptance of the goals the city is aiming to meet. It is imperative to gather the concerns of residents and businesses in this planning through a distributed waste survey.

The Whitehorse Solid Waste Action Plan (SWAP) can serve as a guide in setting up ambitious goals and tasks to achieve targets.

Table 8: List of tasks for the Waste sector

Waste Management														
			Corporate	Community	2016	17	18	19	20	21	22	23	24	25
10.1	**Waste Management Study**													
		Commission waste audit and waste management strategic plan	•											
		Implement cardboard ban by 2022	•	•										
		Implement organics ban by year 2022	•	•										
		Provide multi-family units (MFUs) with information on how best to separate waste. By 2020, City aims to ensure that all MFUs have proper means to sort residential	•	•										

11 Future Innovation and Territorial Legislation

New technology continues to be introduced into the energy market, providing municipalities with the latest in energy-efficient and low-carbon solutions. Similarly, national and territorial political landscape is continually evolving to better respond to the energy realities of its citizens. The Plan recognizes this sense of emergence that comes with sustainably planning ahead and aims to give space to the technological and political advancements sure to happen in the next ten years.

Table 10: Community action items and GHG reduction targets for the future innovation/legislation sector

FUTURE INNOVATION AND LEGISLATION CHANGES		
		Aspirational percentage of Targeted Reductions **16%**
measurable actions	**Action**	**Target**
	Assess wind measurements at potential site	
	Pre-feasibility study for ECM pumps	Feasibility study to see how best to promote usage in residential and ICI sectors and to assess the potential energy savings
	Explore integrated resource management models	Collect sufficient data on waste to energy technologies and boiler retroffiting for the northern context
	Promote education around carbon pricing	Regularly inform ICI and residential sectors on carbon pricing developments

11.1 Wind

A 2008 pre-feasibility study on wind energy in the Yellowknife region, completed by the Aurora Research Institute, found that wind was competitive with diesel generation at heights of more than 90 meters for some identified sites; given current interest rates and fuel rates.

Similar to solar installations, the cost of wind power generation has decreased in recent years. Wind also has the added benefit of having its annual production more spread-out during the year, unlike solar panels which produce very little power during winter months in Yellowknife.

If Yellowknife found itself in a situation of permanent hydroelectricity shortage either due to precipitation changes or increases to electrical consumption, the City could evaluate the feasibility of community scale wind turbines. Locations such as the water treatment plant, Pumphouse #2 at Yellowknife River, and the Solid Waste Facility are identified as potential sites for wind turbines.

Large wind projects require wind measurements on specific sites to assess the potential for long term generation. Wind measurement towers can cost up to $60,000 to install; at this cost, it is recommended that a small scale wind turbine of the same hub height as a wind measurement tower be installed instead. Potential available sites would, however, be limited within the city limits due to the proximity of the airport.

11.2 Electronically Commutated Motor (ECM) circulator pumps

ECM circulator pumps have been lauded as an effective way of improving a building's energy profile. ECM pumps are able to automatically control the speed of a boiler pump to optimize its response to energy demand. Feasibility studies should be conducted to see how effective ECM boilers would be in Yellowknife and how best to introduce them as an energy efficient instrument.

11.3 Integrated Resource Management

Integrated resource management means considering the entire economic system and all flows of energy, goods, and waste. Two studies were commissioned in 2013 to determine the feasibility of using part of the solid waste stream and sewage as energy sources. The 2015 Community Energy Inventory also identified GHG emissions sources and reductions that are not directly related to energy (Ministry of Community Development, 2009).

11.3.1 Organic Waste Biodigester

Following the prefeasibility study on biodigestion completed in 2013, biodigestion was determined to be a sensible alternative to the landfilling of food waste and that it would still enable the recovery of nutrients for composting. Once contamination levels of the nascent organics collection levels have subsided, the city can consider an organic waste biodigester pilot project at the solid waste facility. Alternatively, the City can suggest guidelines for any private or public entity willing to implement a small scale biodigester independently and share findings with the City. Waste to Energy (WTE) technologies, such as the biodigester project, are becoming attractive solutions to waste management and energy demands. The Energy Plan will make sure to stay attuned to any developments in the WTE market and industry so that the city can adapt to potential opportunities.

11.3.2 Use of Paper Waste in Centralized Boiler Systems

A study completed in 2013 revealed that biomass and paper products represented approximately 8,000 tonnes of the City's waste produced. Combustion tests revealed that waste paper contains similar amounts of energy to wood, but that this type of fuel would be challenging to burn efficiently without specialized boilers. See appendix F for a full study on the subject. Council can consider approving a cost-benefit analysis to assess the viability of retrofitting an operating boiler. If the study makes the case for paper feedstocks, the City can then investigate measures to introduce the technology to businesses and residents.

11.4 Carbon pricing

As the territorial government considers a carbon pricing policy that is stringent but keeps the territory economically competitive, the City can assist the public in understanding the policy changes and how it will affect them. With revenue recycling (in the form of tax reductions and retrofitting rebates) as a strong incentive, the City can make the paths to finding information easier for residents with a good communication line between territorial and federal officials and the public. Carbon pricing and, in particular a revenue neutral carbon tax, makes alternative energy sources more affordable than traditional fossil fuels.

Table 11: List of Tasks in preparation for Future Innovation and Legislation Changes

Future Innovation and Legislation Changes	Corporate	Community	2016	17	18	19	20	21	22	23	24	25
Assess wind measurements at an appropriate site using a smal wind turbine to determine feasibility	•											
Feasibility study and pilot project implementation for ECM ciculatory pumps	•											
Feasibility study for waste to energy infrastructure	•											
Cost benefit analysis of biomass retroffiting for paper feedstock	•											
Continually informing public on developments regarding carbon pricing policies	•											

Table 12: Actions Assigned to Groups

	MUNICIPAL INFRASTRUCTURE
Capital Projects	Install the centralized boiler system at Multiplex in 2017
Capital Projects	Improve the insulation of the Baling Facility's roof
Capital Projects	Include monitoring capabilities in all new pellet boilers and continue monitoring facilities
Capital Projects	Use waste heat from arenas
Capital Projects	Approval to replace all of the City's facilities interior lightingwith LED lighting
Capital Projects	Approval to replace all of the City's facilities interior lighting with LED lighting
Capital Projects	Complete exterior lighting replacement with LED lighting
Waste Management	City documents internal waste and recycling progress
Capital Projects	Monitor the performance of the two heat pumps currently operation
Capital Projects	Replace hybrid vehicles with plug-in electric vehicles.
Capital Projects	Complete the installation of piping for PH1/WTP heating system

	COMMUNICATIONS/ I.T.
Heating and Electricity	Communicate energy efficiency opportunities with Yellowknifers
Transportation	Promote the use of active transportation using a portion of the CEP communications budget
Transportation	Implement bi-annual campaign to collect transportation data from commuters
Transportation	Promote alternative travel means to commuters
Transportation	Continue to improve and promote public transit
Transportation	Improve signage for bike lanes
Transportation	Include bike lanes in the City Explorer Mapping System
Transportation	Put the City's bus schedule on Google Transit

	REPORTS AND STUDIES
Capital Projects	Produce annual reports to the CEP Committee and every four years provide GHG inventory to FCM and other partners
Capital Projects	Draft a communication plan for the CEP initiatives within the next three years
Capital Projects	Complete design for the centralized boiler system near City Hall, shared with potential clients
Transportation	Investigate the feasibility of installing electric vehicle public charging stations
Transportation	Create and disseminate baseline survey on YK commuting to work stats to establish the foundation of future targets
Capital Projects	Study the feasibility of water and sewer efficiency measures and their impact on energy and GHG emissions
Capital Projects	Implement City Fleet Review
Transportation	Review existing bike lanes for potential improvement of future lanes
Transportation	Commission a transportation study

	POLICY DEV & COMPLIANCE
Heating and Electricity	Monitor and advocate for changes in the Cities, Towns and Villages Act to allow for green LICs
Heating and Electricity	Support private partners to act upon the development of a district heating policy
Heating and Electricity	Develop policies and programs to promote community investment in RE or EE projects. Example: financing green projects, creation of district heating policy, etc.)
Waste Management	Implementation of cardboard and organics public education and eventual disposal ban
Capital Projects	City signs on to the Compact of Mayors

	FUTURE INNOVATION & LEGISLATION CHANGES
Future Innovation and Legislation Changes	Promote and educate public on carbon pricing
Future Innovation and Legislation Changes	Use mixed waste in biomass boilers
Future Innovation and Legislation Changes	Use municipal waste to produce energy for City facilities
Future Innovation and Legislation Changes	Assess wind measurements at a potential site using a small wind turbine to determine feasibility
Future Innovation and Legislation Changes	Reduce peaks in electrical loads by providing Yellowknifers with real-time informaton about power production and use

Colour Code

Capital Projects	**Transportation**
Heating and Electricity	**Waste Management**
Future Innovation and Legislation Changes	

Note: Items are listed from high to low priority.

12 Assignment of Tasks

For quick reference, the previous table groups the proposed action items. Municipal Infrastructure items will be primarily under the jurisdiction of the City's Public Works Department whereas the IT and Communication departments will steer the helm for all things in the COM/IT section.

The majority of reports and studies will be conducted or commissioned by the Sustainability division of the Public Works Department in conjunction with the CEP committee. Such is the case for the visioning section. Policies and Compliance will be a collective effort by all City administration with the guiding support of Council on behalf of the public.

12.1 Policy Development

Where and when possible, the City can enable the transition to a carbon-neutral Yellowknife through crafting policies that will make the groundwork easier for the residential and ICI sectors. Having a legislation network of by-laws will help the city guide the community (both public and private) in reaching energy targets. The policy-focused action items are presented as recommendations for Council consideration. By 2025, the CEP is encouraging the City to make notable strides in policy change, with specific attention to the development of a district heating policy as well a financing program for individual and community green projects.

12.2 Reports and Studies

Attaining community targets will require investments from the private sector and the community at large. For example, individuals and businesses may choose to undertake energy retrofits on their own or they may take advantage of the retrofit program described in the policy development section. Larger community sized projects may require the support and assistance of municipal government.

Despite the City's limited jurisdiction around subsidies and taxation, it can nevertheless play a pivotal role by funding feasibility studies and facilitating action by third parties. This plan outlines key reports and studies that, through providing location-specific, evidence based research, can serve as a tool for the energy-conscious community of Yellowknife.

- General CEP Annual Reports for CEP committee, FCM and other partners
- Community Energy Communication Plan
- Waste Audit and Waste Management Strategic Plan
- GHG and Energy Inventory 2020
- Transportation Study

13 Proposed Three Year Capital Budget

The budget required to meet the timelines put forward in this plan can be financed using multiple mechanisms. The City has been investing approximately $500,000 per year since 2006 on sustainable energy initiatives. City Council has already approved funding for the centralized biomass project at the Multiplex which will help achieve greater savings in the long run. It is proposed that the City invest $1.6M over three years (2018-2020) in capital funding to complete other biomass projects and savings projects in the heating sector.

14 Conclusion

The Energy Plan, once approved by Council and reviewed by national partners, will serve as the guide to lead Yellowknife into a low-carbon and energy efficient future. The Plan, like the people of Yellowknife, is adaptive yet ambitious. The cultural shift needed to veer the community away from its fossil fuel-heavy habits will require a collaborative effort from all stakeholders.

City Corporate is committed to being a climate leader. The Energy Plan requires that the City administration stay accountable in their energy transition efforts; diligent monitoring and communicating both successes and challenges to stakeholders is pivotal. The City administration will provide necessary updates to the Community Energy Planning Committee, City Council and the public to make sure that efforts are on the agreed upon trajectory. As opportunities to improve the City's energy transition arise, measures will be taken to make certain that initiatives are in line with set principles. The implementation of biomass as a heating source for corporate buildings is but one example of the City's commitment to reduce their emissions to 19,000 tCO_2e in 2025.

In turn, the City's climate leadership and analysis will help commercial and residential sectors in better understanding how their decisions and actions affect a sustainable Yellowknife. Decreasing community emissions by 30% while remaining sensitive to energy needs and costs is paramount. By being responsive to the community's concerns and by building capacity for the necessary political and logistical infrastructure improvements, the City can work collaboratively with members of the community to ensure that Yellowknife stays below the 250,000 tCO_2e threshold in 2025.

As 2025 draws near, Yellowknife is dedicated to work towards a low-carbon, energy efficient future and will continue to push the envelope of sustainability in the North.

Glossary and Definitions

Carpooling	Sharing a vehicle ride with another commuter
Carsharing	Sharing ownership of a vehicle
CEP	Community Energy Plan or Planning
City (with capital C)	The Municipal Corporation of the City of Yellowknife
city (with lower case c)	The community of Yellowknife as a whole
Compact of Mayors (COM)	"Launched at the 2014 United Nations Climate Summit, the Compact of Mayors is the world's largest coalition of city leaders addressing climate change by pledging to reduce their greenhouse gas emissions, tracking their progress and preparing for the impacts of climate change."[4] Joining the COM is proposed in this plan.
Conference of Parties (COP)	The governing body of the United Nation's Framework Convention on Climate Change. COP meetings are where global greenhouse gas emissions reduction targets are set.
DHW	Domestic Hot Water
ESCO	Energy Service Contract (or Company) - An agreement between an energy user and an energy provider where part of the construction cost of providing the energy is included in the sale price of the energy. Most electric utilities function in this manner.
Energuide Rating System (ERS)	A national energy efficiency program that provides information to homeowners about a home's energy performance. The program is currently updating its methods of calculating and sharing data.
FCM	Federation of Canadian Municipalities. The FCM oversees the Partner's for Climate Protection Program.
GHG	Greenhouse Gases: All gases affect the amount of heat the earth's atmosphere can hold. The emissions of gases like methane and CO_2 will increase this heat captured at different intensity. This is why emissions are usually measured and standardised as "Tonnes of CO_2 Equivalents" (tCO_2e).
GNWT	Government of the Northwest Territories

ICLEI	International Council for Local Environmental Initiatives, the organization at the origin of the five milestone process for Community Energy Planning used by the FCM.
IPCC	Intergovernmental Panel on Climate Change
kW	Kilowatt, a unit of power
kWh	Kilowatt-hour, a unit of energy commonly used to measure electricity consumption. (equal to 3.6 MJ)
LIC	Local Improvement Charge
MJ	Megajoule, the standard metric unit of energy used throughout this document
NWT	Northwest Territories
PCP	Partners for Climate Protection. An FCM program guiding municipalities through the community energy planning process.
PV	Photovoltaic (Electric Solar Panel)
ROI	Return on Investment
VKT	Vehicle Kilometres Travelled

Appendix A: References

Aboriginal Engineering (2006). *City of Yellowknife Fleet Review.* Yellowknife: Aboriginal Engineering

Arctic Energy Alliance. (2006*). Review of Energy Management Opportunities in City of Yellowknife Facilities.* Yellowknife: AEA

City of Kelowna. (2012). *Community Climate Action Plan: Working towards a 33% reduction in greenhouse gases.* Kelowna: City of Kelowna.

City of Yellowknife. (2006). *Yellowknife Community Energy Plan (2006*): City of Yellowknife.

City of Yellowknife (2012). Council Goals and Objectives 2013-2016

City of Whitehorse, (2013). Solid Waste Action Plan; Details and Implementation: City of Whitehorse.

Compact of Mayors. (2014). *Compact of Mayors: Definition of Compliance*. New York.

Ecology North. (2015).*Carbon Pricing in the NWT: Discussion Paper*. Yellowknife; Ecology North

Global protocol for Community Scale GHG Inventories website

Ko Energy. (2013). *Liquid and Humid Organic Waste Utilization Study*. Yellowknife. Ko Energy.

Morgan, S., Lothian, N., & Thibault, B. (2015). *Loans for Heat.* Yellowknife; Pembina Institute.

Pinard, J.-P., Maissan, J. F., & Seccombe-Hett.P. (2008). *Yellowknife Wind Energy Pre-Feasibility Report.* Inuvik: Aurora Research Institute.

Stantec. (2013). *Collection & Utilization of Municipal Sourced Biomass*. Yellowknife: Stantec.

Sustainability Solutions Group. (2015). City of Yellowknife Community Energy Inventory. Vancouver: Sustainability Solutions Group.

Thirunavukarsu, A. (2015). *Energy Profile of New Housing*, Yellowknife 2010-2015, powerpoint presentation. Yellowknife; Arctic Energy Alliance.

Appendix B: Public Engagement Results and Response

Question 1

Please select all the following that apply to you.		
Answer Options	**Response Percent**	**Response Count**
I live in Yellowknife	97.9%	141
I conduct business in Yellowknife	33.3%	48
I own a residence in Yellowknife	63.2%	91
I am a student	2.8%	4
I am retired	4.9%	7
I am unemployed	2.8%	4
I am employed	86.1%	124
	answered question	**144**
	skipped question	**1**

Question 2

Below are different objectives identified by the Community Energy Planning Committee. Please rate the importance you believe the City should give to each objective.						
Answer Options	Not important at all	Somewhat important	Important	Very important	Rating Average	Response Count
Ensure energy is affordable	0	15	34	92	3.55	141
Reduce the impacts of climate change	9	32	40	59	3.06	140
Ensure a reliable and safe energy supply	0	5	53	83	3.55	141
Develop the local economy, for example by using	10	35	38	58	3.02	141
What other objective would you support?						46
					answered question	141
					skipped question	4

Question 3

The following targets were drafted from the previous objectives, please rank each of them according to their importance.						
Answer Options	Not important at all	Somewhat important	Important	Very important	Rating Average	Response Count
Reduce greenhouse gas emissions affecting climate	11	42	38	46	2.87	137
Reduce energy costs by increasing energy efficiency	2	17	36	82	3.45	137
Increase the percentage of renewable energy in our	11	24	38	64	3.13	137
Using local natural resources	15	35	40	46	2.86	136
What other target would you support?						26
					answered question	137
					skipped question	8

Question 4

How concerned are you about climate change?		
Answer Options	**Response Percent**	**Response Count**
Extremely concerned	25.7%	35
Very concerned	22.8%	31
Moderately concerned	30.1%	41
Slightly concerned	16.2%	22

Not at all concerned	5.1%	7
	answered question	**136**
	skipped question	**9**

Question 5

Should the City invest in using renewable energy?		
Answer Options	**Response Percent**	**Response Count**
No	4.5%	6
Yes, but only if it means reducing costs	53.8%	71
Yes, even if it is more expensive	41.7%	55
Comments?		28
	answered question	**132**
	skipped question	**13**

Question 6

What type of transportation do you most often use in your day to day activities?		
Answer Options	**Response Percent**	**Response Count**
Active transportation (walk, bike, canoe, etc)	37.0%	50
Public transit	3.0%	4
Ride sharing	4.4%	6
Private vehicle	55.6%	75
Other (please specify)		9
	answered question	**135**
	skipped question	**10**

Question 7

Is there something you would like to do to reduce your energy costs, but haven't got around to it yet?		
Answer Options	**Response Percent**	**Response Count**
Yes	57.5%	77
No	42.5%	57
If yes, please specify		69
	answered question	**134**
	skipped question	**11**

Question 8

What is preventing you from doing the things that would reduce your energy costs?		
Answer Options	**Response Percent**	**Response Count**
No time	22.4%	24
No funds	57.9%	62
Not sure what to do exactly	29.9%	32
Not sure about the impact on my property's value and if I'm going to stay in my home long enough to see the benefits	33.6%	36
The savings would not be worth the added maintenance work	14.0%	15
Other (please specify)		35
	answered question	**107**
	skipped question	**38**

Question 9

Do you feel your energy costs are having a negative impact on your quality of life?		
Answer Options	**Response Percent**	**Response Count**
Energy costs have no impact	5.3%	7
Energy costs have little impact, they don't prevent me from doing the things I want to do	43.9%	58
Energy costs are forcing me to change the way I live	50.8%	67
	answered question	**132**
	skipped question	**13**

Question 10

Would you support an energy project more if it created local jobs?		
Answer Options	**Response Percent**	**Response Count**
Yes	81.7%	107
No	18.3%	24
	answered question	**131**
	skipped question	**14**

Question 11

Below are different energy sources that are, or may become available in Yellowknife; please rate each source according to your overall current impression of it. 5 being very positive, 1 very negative.							
Answer Options	1 - Negative	2	3 - Neutral	4	5 - Positive	Rating Average	Response Count
Wind	13	6	23	33	58	3.88	133
Solar	8	4	12	33	77	4.25	134
Wood	9	11	35	40	38	3.65	133
Oil (Diesel, Gasoline, Heating oil)	54	38	27	7	7	2.06	133
Propane	28	30	50	18	6	2.58	132
Waste to energy	8	4	28	44	48	3.91	132
Hydroelectricity	7	5	21	46	54	4.02	133
Natural Gas	24	23	34	28	23	3.02	132
Geothermal	18	15	19	30	50	3.60	132
What other forms of energy would you be in favor of?							25
						answered question	134
						skipped question	11

Question 12

Would you consider using an electric vehicle in Yellowknife if they were readily available?		
Answer Options	**Response Percent**	**Response Count**
Yes	60.6%	80
No	39.4%	52
If not, please specify why.		53
	answered question	**132**
	skipped question	**13**

"Why not nuclear?"

Nuclear energy is considered by many as a valuable immediate solution to the climate change crisis.

Although designs for affordable small nuclear reactors or nuclear "batteries" exist, they are not approved for use in Canada and are not commercially available at the moment. We don't expect that reactor models suitable in size for Yellowknife will be approved and be made commercially available in Canada within the next 10 years and the City of Yellowknife does not have the resources to bring this technology to market.

"Geothermal is too expensive" "Why not Geothermal?" "Use the mines for Geothermal"

Geothermal energy can be very effective in locations that have the volcanic resource, like Iceland. The City of Yellowknife had three geothermal energy evaluations completed for Con Mine. Each evaluation revised the amount of heat available to lower amounts, down to a point where the capital costs of extracting that heat made geothermal energy in Yellowknife unaffordable. This is why the last designs for Yellowknife's district heating system relied on wood (biomass) rather than geothermal energy.

Residential sized geothermal heat pumps also exist but require deep boreholes or extensive shallow trenches. These types of application would be very limited within city limits and return on investments would be higher with air sourced heat pumps.

“Why did you choose these objectives? How long did it take to identify these objectives?”

Potential objectives of energy plans are fairly similar from plan to plan. The goal of asking what Yellowknifers would support is to prioritize our projects and understand how to best communicate the benefits of an initiative.

“If cheaper sources of energy are available and you're not using them, something is wrong don't you think?”

Switching to cheaper sources of energy takes money and time. This is why the City of Yellowknife has been investing $500,000 per year since 2006 on reducing energy costs. So far, the return on investment has been approximately 22% per year and there is still much to be done. Investing more than $500,000 per year and switching faster would require choosing to postpone other projects.

“Hydro is the only effective source of energy in the North”

Hydro is generally very effective for power generation. Yet, we are currently facing a shortage and electricity use and price has increased significantly in the last ten years. We believe that to meet this shortfall, a mix of energy efficiency and diversified power generation will provide the best results.

Also, energy is not only about electricity, we also need to address our heating and transportation issues.

“Electric vehicles don’t work in the cold” Electricity is too expensive for electric cars” “As we are using diesel for power generation, electric vehicles would pollute more than normal vehicles”

We believe the current price of electric vehicles is too high for them to be cost effective in Yellowknife, considering the short distances the average vehicle travels per year. However, they do work in the cold, even if at a reduced range; the vast majority of trips within Yellowknife could still be covered. As they use so much less energy per kilometer, they still provide a lower cost and reduced pollution per kilometer traveled, even with our current power price. We expect the economics to continue to improve.

Appendix C: Yellowknife Community Energy Inventory Report (Sustainable Solutions Group, Inc. 2015)

City of Yellowknife

Community and Corporate Energy and Greenhouse Gas Emissions Inventory

April 6, 2015

SSG SUSTAINABILITY SOLUTIONS GROUP

Acknowledgements

Many people made valuable contributions to the Greenhouse Gas Inventory. The on-the-ground experience and insights provided by those who live in Yellowknife and work for the City ensured a robust and relevant inventory. Sustainability Solutions Group team members would like to thank the following individuals for their contributions:

Community Energy Planning Committee Members & support staff:

Aleta Fowler, CanNor
Clem Hand, Manager of Corporate Services and Risk Assessment
Craig Scott, Ecology North
Dan Wong, Yellowknife City Council
Dave Nightingale, GNWT Dept. of Industry, Tourism and Investment
Dwayne Wohlgemuth, Public at Large
Jason McAvoy, Yellowknife Chamber of Commerce
Jay Pickett, NWT Power Corporation
Jim Sparling, GNWT Dept. of Environment and Natural Resources
John Hazenberg, Public at Large
Kevin Lailey, Northland Utilities (Yellowknife)
Louie Azzolini, Arctic Energy Alliance's Community Energy Planning Section
Mark Heyck, Mayor of Yellowknife

Data provision and/or focus group participation:

Catalyna Correa, GNWT Dept. of Environment and Natural Resources
Duane Morgan, Northland Utilities (Yellowknife)
Lori Burrill, Northland Utilities (Yellowknife)
Milan Nguyen, City of Yellowknife

Project coordination: Remi Gervais, City of Yellowknife

We would like to pay tribute to Doug Ritchie, a member of the project consulting team and a respected, well-recognized, and long-time environmental advocate in the North. Sadly, Doug passed away January 10th, 2015. Many environmental, community and First Nations successes in Yellowknife and the North are a result of his resolute efforts.

Cover photo: Obtained under a creative commons license from Scott Lough on www.flickr.com. Image was cropped and colour masked.

The preparation of this plan was carried out with assistance from the Green Municipal Fund, a Fund financed by the Government of Canada and administered by the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the authors, and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them.

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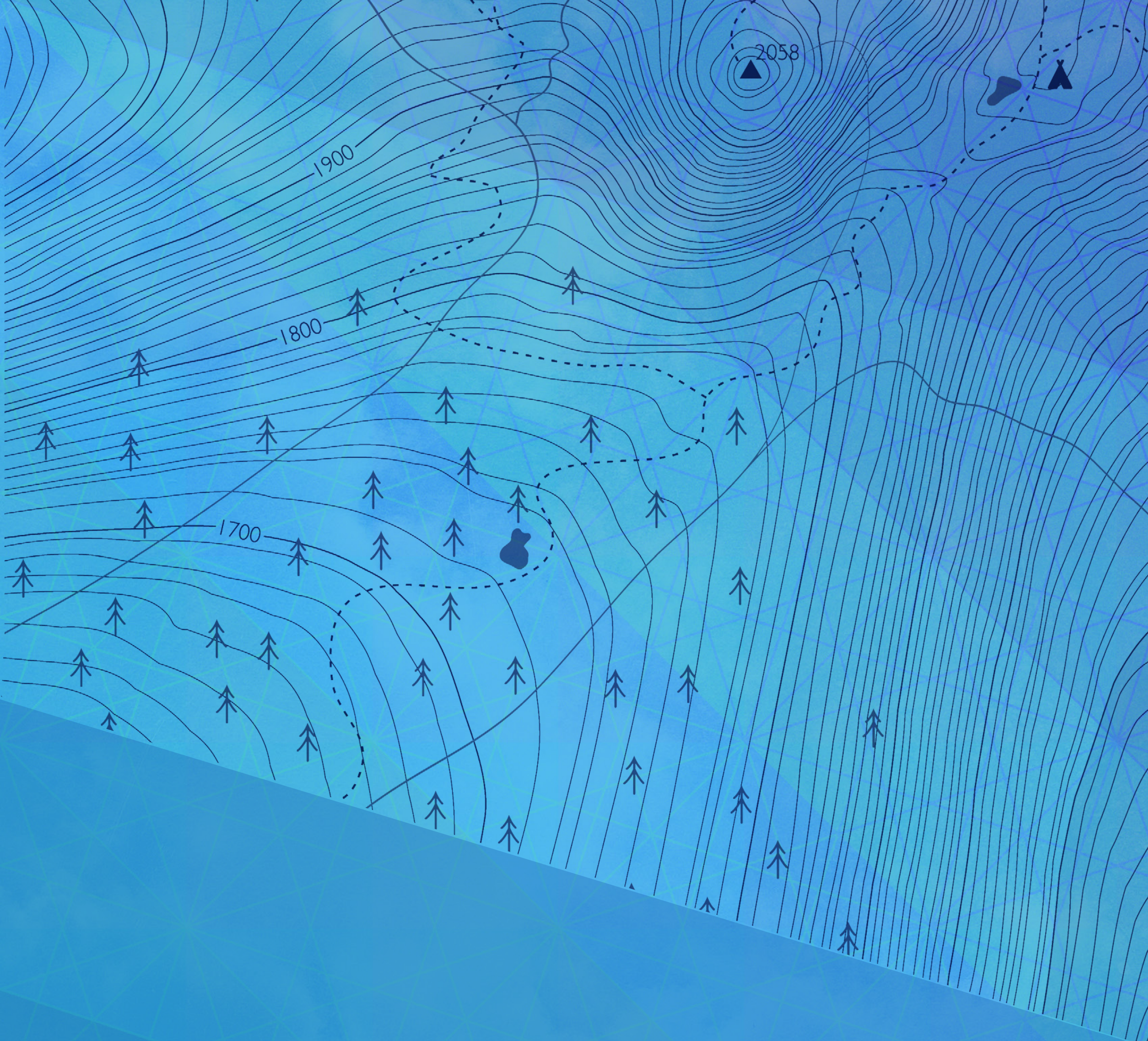


1 Introduction

1.1 Climate Change and Greenhouse Gas Emissions

1.1.1 General Climate Context

The Earth's climate is determined by its ability to both trap and reflect heat from the sun and to circulate it through the atmosphere and the oceans. Increases in greenhouse gases alters the Earth's ability to naturally regulate the climate. When this capacity is altered, the Earth's climate can change. The term "climate change" refers to a change in the average state of the climate.

Scientific evidence shows that the climate is changing. The overwhelming majority of scientists agree that this is due to rising concentrations of heat-trapping greenhouse gases in the atmosphere caused by human activities.[20] The scientific community has also concluded that some climate change is inevitable even if action is taken to reduce greenhouse gas emissions.

Annual climate data has shown noticeable temperature highs and lows, but over longer periods of time there has been a discernible warming trend across the globe. The global average temperature over the first decade of the 21st century was significantly warmer than any preceding decade on record over the past 160 years.[21]

1.1.2 Yellowknife Climate Context

The local impacts of climate change are becoming apparent. During the past 50 years, climate in the NWT has warmed at a rate four to five times faster than the global average.[22] While annual average air temperatures in the NWT have increased by 2 to 2.7°C, global temperatures have increased by 0.5°C.[23] Inuvik has warmed the fastest, however, all other NWT communities, including Yellowknife, are experiencing similar warming trends.[24] Arctic ice coverage has also been declining. Arctic ice coverage in July has been decreasing by 6.8% per decade since 1979.[25]

The Intergovernmental Panel on Climate Change (IPCC) and the Arctic Council have concluded that warming trends already evident in the North will accelerate unless global greenhouse gas emissions are reduced.[26] Climate scientists believe that near-term emissions reductions (especially reductions in fugitive methane emissions) are vital; the value of early emission reductions is greater than those that may be achieved several decades in the future.[27] Therefore, along with all other jurisdictions in the world, it is important that Yellowknife act to conserve energy, reduce greenhouse gas emissions, and adapt to the expected effects of climate change.

20 Intergovernmental Panel on Climate Change (2007). *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. IPCC, Geneva, Switzerland.

21 Hadley Centre (2011). *Evidence: the state of the climate*. UK Met Office. Available at: http://www.metoffice.gov.uk/media/pdf/m/6/evidence.pdf

22 Northwest Territories (2011). *A Greenhouse Gas Strategy for the Northwest Territories 2011-2015*.

23 Ibid.

24 Ibid.

25 Ibid.

26 Ibid.

27 Cox, P. et al. 2010. *Methane radiative forcing controls the allowable CO2 emissions for climate stabilization*. Current Opinion in Environmental Sustainability. Volume 2. Issue 5, Pages 404-408.

1.2 The Role of Cities and Local Government

The role of cities in reducing GHG emissions is gaining increasing prominence highlighted by: the work of the C40, a global network of large cities committed to helping address climate change;[28] the first IPCC chapter on human settlements;[29] and a new reporting mechanism, the Non-State Actor Zone for Climate Action,[30] launched in December under the United Nations Framework Convention on Climate Change (UNFCC). As the IPCC reports, "Addressing climate change has become part of the policy landscape in many cities, and municipal authorities have begun to implement policies to reduce GHG emissions within their administrative boundaries."[31]

The world is rapidly urbanizing and urban areas account for between 71% and 76% of CO2 emissions.[32] Increasing urbanization requires massive investments in infrastructure, which, depending on the approaches selected, will either impede or enhance society's ability to reduce GHG emissions.

Local governments are highly engaged in addressing climate change in Canada and around the world. The Federation of Canadian Municipalities' Partners for Climate Protection program has involved more than 250 municipalities, representing 80% of the total population, in a 5-step program that includes developing a GHG inventory and culminates in the implementation of actions to reduce GHG emissions.

In addition to voluntary efforts by municipalities, some jurisdictions have legal requirements to achieve emissions reductions. In other contexts, funding requirements are tied to particular emissions reductions, creating an impetus for increasingly accurate GHG accounting.[33] Some nearby jurisdictions have passed laws requiring municipal plans to include GHG emissions targets (e.g.: California, Washington and BC). This reflects a growing awareness that urban density and land-use patterns affect many GHG emission factors, such as:

- Automobile and service vehicle distances travelled;
- Modes of travel chosen;
- Building typology; and
- Possibilities for community energy systems.

There is currently no legislation in the Northwest Territories requiring municipalities to plan for and/or reduce GHG emissions. However, the City of Yellowknife recognizes the impacts associated with climate change, and has voluntarily committed to taking action.

28 Arup. (2011). *Climate action in megacities: C40 cities baseline and opportunites*.

29 Seto, K., & Dhakal, S. (2014). *Chapter 12: Human Settlements, Infrastructure, and Spatial Planning*. Climate Change 2014: Mitigation of Climate Change, 923–1000. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Human+Settlements,+Infrastructure,+and+Spatial+Planning#1

30 See http://climateaction.unfccc.int/

31 Seto, K., & Dhakal, S. (2014).

32 Ibid.

33 DeShazo, J. R., & Matute, J. (2010). *Toward accurate and valid measurement of greenhouse gas emissions for local governments (pp. 1–40)*.

1.3 The Role of Yellowknife

1.3.1 About Yellowknife

Yellowknife is a growing northern community, and the largest in the Northwest Territories. The Territorial capital, it is a hub for mining, industry, transportation, communications, education, health, tourism, commerce, and government activity in the territory.[34] The city has grown steadily over the last few years, seeing an population increase of 3% between 2004 and 2013. With a population of 20,300 in 2013, the city is expected to continue to grow, reaching 22,667 by 2031.[35]

With this growth and associated economic activity come increased sustainability challenges and opportunities.

1.3.2 Yellowknife's commitment

The City of Yellowknife recognizes the need to conserve energy, reduce greenhouse gas emissions, and adapt to expected climate change effects. The City voluntarily joined the Federation of Canadian Municipalities' Partners for Climate Protection (PCP) program in 1997, and have taken up various initiatives since.

The City of Yellowknife completed its first energy and emissions baseline in 2006. The Yellowknife Community Energy Plan (CEP) was implemented that same year, setting out goals and initiatives to increase energy efficiency and renewable energy use, and to reduce GHG emissions. The CEP set targets for a 20% reduction in emissions from City operations and a 6% reduction in emissions from the entire community over the period of 2004 to 2014. In 2009, an updated energy and emissions inventory was completed to measure progress and report results, at which point the City was reportedly in a position to surpass their initial targets.

1.3.3 Efforts to date

Yellowknife has several greenhouse gas emissions reduction initiatives. In 2008, it became a requirement for all new single-family, two-family and multi-family residential buildings to achieve a minimum score of 80 on the EnerGuide for New Houses rating system. In 2009, energy performance standards for all new commercial, institutional and industrial buildings came into effect, requiring a 25% performance improvement over minimum National Model Energy Code of Canada for Buildings 1997 requirements.

Major efforts have been made by the Government of the Northwest Territories (GNWT), the City of Yellowknife and private businesses to increase the use of wood pellets instead of fuel oil for space heating purposes, and a number of buildings have been converted to facilitate wood pellet heating.

District energy system development efforts are ongoing. If implemented, the system would be a major contributor towards decreasing Yellowknife's emissions.

1.3.4 Purpose of this report

In 2014, the City of Yellowknife completed the fifth milestone of the PCP program. Within the renewal process of the Community Energy Plan and PCP, the City sought to complete an updated inventory of Yellowknife's energy use and greenhouse gas emissions. This inventory, completed in 2014, and the results thereof are the subject of this report. This inventory will assist the City in measuring progress up to 2014 and in setting new targets for 2015 to 2025.

34 See http://www.thecanadianencyclopedia.ca/en/article/yellowknife-nwt/

35 See http://www.statsnwt.ca/population/community-projections/

1.4 Inventory Protocols and Calculation Tools

1.4.1 Municipal accounting of emissions

There are different philosophies that frame a city's GHG emissions reporting approach.[36] The 'geographic' approach seeks to account for all the emissions within the physical boundary of a city. The 'geographic plus supply chain' approach accounts for specified upstream emissions. A 'consumption-based' inventory accounts for emissions associated with all of the goods and services consumed by the residents of a city. The predominant approach is the 'geographic plus' method, which generally includes upstream emissions as a result of energy consumption.

In addition to different philosophical approaches, cities elect to use one of several reporting frameworks specific to a region or a country. As a result, most existing city-level inventories are not comparable and there are significant data gaps.[37] A consensus around a standard approach addresses one of the major sources of uncertainty around community-scale GHG emissions.[38]

1.4.2 Protocols

1.4.2.1 Community

The 2014 community emissions inventory has been completed using the Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories (GPC).

Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories (GPC)

Over the past two years the World Resources Institute, C40 Cities Climate Leadership Group (C40), and ICLEI: Local Governments for Sustainability have been collaborating with UN agencies and the Greenhouse Gas Protocol to develop a Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories (GPC). It was officially released in December, 2014.

The Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories represents a global standard for tracking municipal emissions that is consistent with the United Nations Framework Convention on Climate Change approach for national inventories. As the current best practice in City GHG reporting, the GPC is used here as the framework for City of Yellowknife's GHG inventory.

About the GPC inventory methodology

The GPC sets out requirements and provides guidance for calculating and reporting city-wide GHG emissions, consistent with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

The GPC requires cities to measure and disclose a comprehensive inventory of GHG emissions and to total these emissions using two distinct but complementary approaches. One captures emissions from both production and consumption activities taking place within the city boundary, including some emissions released outside the city boundary. The other categorizes all emissions into "scopes," depending on where they physically occur (Figure 1).

The GPC requires cities to report their emissions by gas, scope, sector and subsector:

- **Gas:** emissions are reported in metric tonnes and expressed by gas (CO2, CH4, N2O, HFCs, PFCs, SF6, and NF3) and by CO2 equivalent (CO2e).
- **Scope**: emissions are grouped into three categories based on where they occur:
  - Scope 1: GHG emissions from sources located within the city boundary;
  - Scope 2: GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary; and

36 Keirstead, J., Jennings, M., & Sivakumar, A. (2012). *A review of urban energy system models: Approaches, challenges and opportunities*. Renewable and Sustainable Energy Reviews, 16(6), 3847–3866. doi:10.1016/j.rser.2012.02.047

37 Sovacool, B. K., & Brown, M. A. (2010). *Twelve metropolitan carbon footprints: A preliminary comparative global assessment*. Energy Policy, 38(9), 4856–4869. doi:10.1016/j.enpol.2009.10.001

38 Seto, K., & Dhakal, S. (2014).

- Scope 3: All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary.

- **Sector** - GHG emissions from city activities are classified into six main sectors:
  - Stationary energy
  - Transportation
  - Waste
  - Industrial processes and product use (IPPU)
  - Agriculture, forestry, and other land use (AFOLU)
  - Any other emissions occurring outside the geographic boundary as a result of city activities.

The GPC requires cities to add up emissions using two distinct but complementary approaches:

- **Scopes framework:** This sums all emissions by scope 1, 2 and 3. Scope 1 (or territorial emissions) allows for the separate accounting of all GHG emissions produced within the geographic boundary of the city, consistent with national-level GHG reporting.
- **City-induced framework:** This sums GHG emissions attributable to activities taking place within the geographic boundary of the city. It covers selected scope 1, 2 and 3 emission sources representing the key emitting sources occurring in almost all cities, and for which standardized methods are generally available.

The city-induced framework gives cities the option of selecting between two reporting levels: BASIC or BASIC+. The BASIC level covers scope 1 and scope 2 emissions from stationary energy and transportation, as well as scope 1 and scope 3 emissions from waste. BASIC+ involves more challenging data collection and calculation processes, and includes emissions from IPPU and AFOLU and trans-boundary transportation. Therefore, where these sources are significant and relevant for a city, the city should aim to report according to BASIC+. The sources covered in BASIC+ also align with sources required for national reporting in IPCC guidelines.

GPC also requires that a city define an inventory boundary, identifying the geographic area, time span, gases, and emission sources.

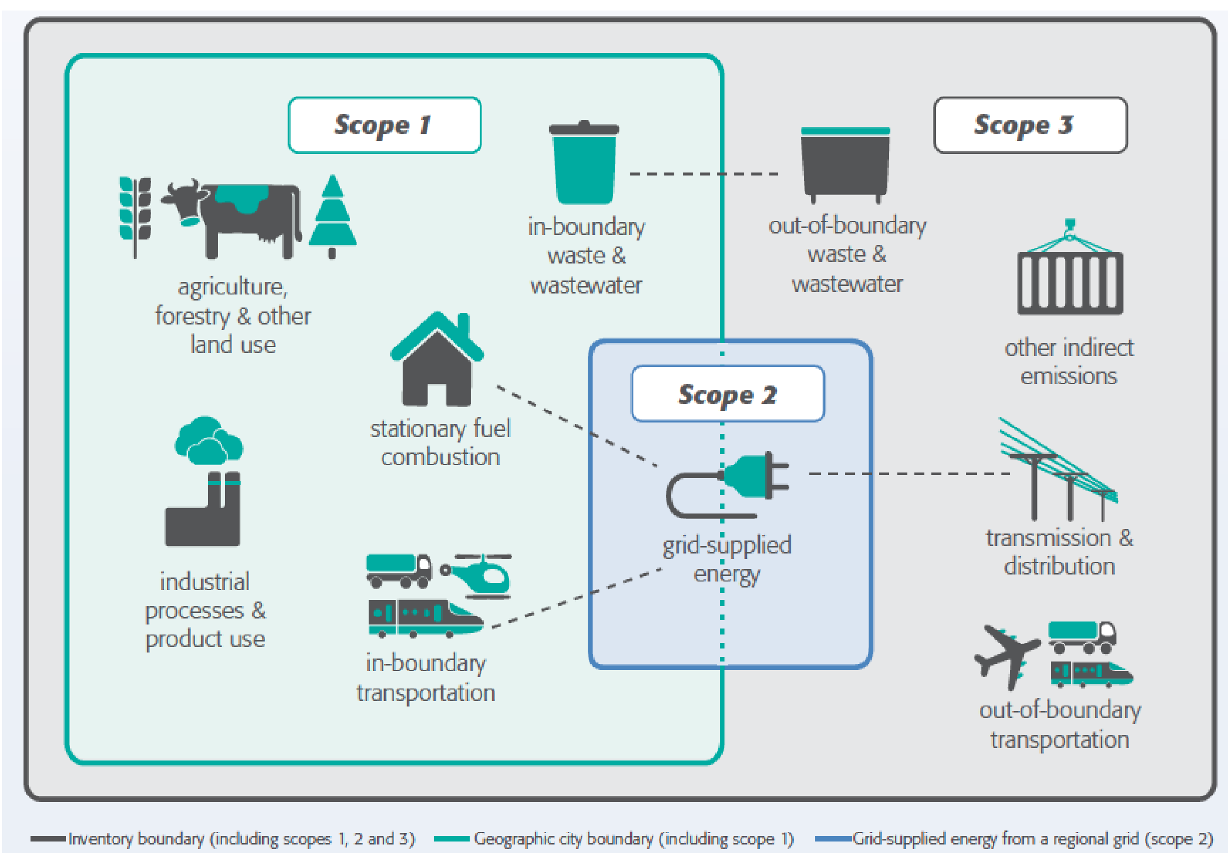


Figure 1. Sources and boundaries of city GHG emissions.

1.4.2.2 Corporate

Yellowknife's 2014 corporate emissions inventory has been completed in accordance with the Partners for Climate Protection (PCP) Program.

Partners for Climate Protection Program

Now with over 250 municipalities taking part, the Partners for Climate Protection Program was created in 1994 by the Federation of Canadian Municipalities (FCM) and ICLEI - Local Governments for Sustainability. Local government councils and boards voluntarily opt into the program and agree to commit to five milestones which guide them through successful tracking and implementation of GHG reduction measures.

Participating local governments receive services, tools, guidance, and connection to a network of local governments who have undergone initiatives using the same framework nationally, as well as the similar Cities for Climate Protection Program (CCP) internationally. Several documents have been published that outline the requirements of this program and provide guidance on its implementation. These are listed in Appendix 6 of this document.

In brief, the 5 Program Milestones are as follows (as indicated in the PCP document *Developing Inventories for GHG Emissions and Energy Consumption*):

- **Milestone One : Create a GHG inventory and forecast.**

  Complete GHG and energy use inventories and forecasts for both local government operations and the community.

- **Milestone Two : Set an emissions reduction target.**

  Suggested PCP targets are 20% reduction in GHG emissions from local government operations and a 6% reduction from the community, both within 10 years of making the commitment.

- **Milestone Three : Develop a local action plan.**

  The plan should set out how emissions and energy use in local government operations and the community will be reduced. It should include: "a summary of baseline emissions forecasts and targets; a set of existing and proposed emissions reduction actions; implementation strategies, including the resources involved; and input from stakeholders."

- **Milestone Four : Implement the local action plan.**

  Establish a close working relationship with community partners to carry through on commitments and maximize the benefits from GHG reductions.

- **Milestone Five : Monitor progress and report results.**

  Maintain local government and community support by monitoring, verifying and reporting GHG reductions.

About the PCP inventory methodology

Municipalities can complete the five milestones in any order that they choose, and also have the option of completing and submitting corporate and community deliverables separately. Upon completion and endorsement of a milestone by municipal council, members submit their materials to the FCM for technical review and approval by the FCM. The corporate portion of this inventory covers Milestone One for the City of Yelowknife's corporate activities. The community portion of this inventory follows GPC methodology, which is more comprehensive than the PCP requirements for community GHG accounting.

Corporate inventories address the greenhouse gas emissions resulting from the internal operations of local governments, whereas community inventories address the emissions resulting from activities of the businesses and individuals within the government's geopolitical boundaries. Community inventories include emissions from the institutional, commercial, industrial (ICI), transportation, and residential waste sectors. Corporate inventories include emissions from municipal government facilities and operations, including buildings, street lighting, water and wastewater treatment, the municipal fleet, and corporate solid waste.

For a given year, data is collected on: electricity and fossil fuel energy use; transportation (vehicle kilometres travelled, fuel amounts and types consumed); and waste amounts and types disposed of. The inventory covers 3 main greenhouse gases: carbon dioxide (CO2), nitrous oxide (N2O), and methane (CH4), all expressed in equivalents of CO2 (CO2e).

Inventories are required: to be assembled for corporate and community emissions, to cover the base year and other inventory years, and to be divided out by the sectors indicated for each. Emissions coefficients are required to be noted, a 10-year forecast must be assembled, and percent changes from prior years should be indicated and discussed.

1.4.3 Inventory calculation tools

Both the GPC and PCP outline principles and rules for compiling community and corporate GHG emissions inventories respectively, but neither require specific tools or software to be used to produce emissions data. Where relevant, the GPC and PCP recommend using methodologies aligned with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

To calculate the 2014 community and corporate emissions for Yellowknife, a tool called GHGProof was used.

1.4.3.1 GHGProof

GHGProof is an open-source tool developed by Sustainability Solutions Group to calculate community and corporate emissions. It was designed to help local and regional governments explore and analyze the impacts of land-use planning on greenhouse gas emissions and public and private energy costs. It can also be used to help communities set targets, develop strategies to achieve targets, evaluate development proposals and design their community plans. GHGProof is fully transparent and open source for not-for-profit purposes.

GHGProof is designed to be a simple model that calculates emission inventory baselines, and forecasts future emissions based on different land-use scenarios. GHGProof has been customized into two separate versions for calculating community and corporate inventories: **GHGProof Community** and **GHGProof Corporate.**

All the calculations embedded in GHGProof are based on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

GHGProof Community

GHGProof Community is a model that uses standard GIS analysis and excel-based spreadsheets, and covers the following sectors:

- Residential buildings;
- Commercial buildings;
- Industrial buildings;
- Transportation;
- Solid waste (landfill emissions);
- Liquid waste; and
- Forestry and agriculture.

The model results, outputted as tonnes of carbon dioxide equivalent (tC02e), are calculated automatically based on the inputs and assumptions provided.

The total GHG for a community is defined as the sum of the GHG from each aspect:

$$GHG_{community} = GHG_{transport} + GHG_{energygen} + GHG_{waste} + GHG_{agriculture} + GHG_{forest} + GHG_{landconvert}$$

Where:

$GHG_{transport}$ is the movement of goods and people.

$GHG_{energygen}$ is the generation of heat and electricity.

GHG_{waste} is liquid and solid waste produced by the community.

$GHG_{agriculture}$ is the production of food.

GHG_{forest} is the area of forest land.

$GHG_{landconvert}$ is the area of land in natural or modified conditions.

Outputs from GHGProof Community are shown in Table 1.

GHGProof Corporate

GHGProof Corporate is a simple tool that uses excel-based spreadsheets and covers the following sectors:

- Buildings;
- Lighting;
- Wastewater & potable water;
- Fleet; and
- Solid waste.

The model results, outputted as tonnes of carbon dioxide equivalent (tC02e), are calculated automatically based on the inputs and assumptions provided.

The total GHG for corporate operations is defined as the sum of the GHG from each aspects:

$$GHG_{corporate} = GHG_{transport} + GHG_{energy} + GHG_{waste}$$

Where:

$GHG_{transport}$ is the operations of corporate fleet vehicles and equipment.

GHG_{energy} is the use and delivery of heat and electricity to carry out corporate services.

GHG_{waste} is the handling and treatment of all liquid waste; handling of solid waste for the community; and handling and generation of solid waste from corporate activities.

Outputs from GHGProof Corporate are shown in Table 2.

Table 1. Outputs from GHGProof Community.

GHG/Energy Outputs	Other outputs	Economic outputs
GHG emissions by sector • Energy use by type • Fuel mix • Per capita GHG emissions • Per capita energy use	• VKT • Mode split • Waste diversion • District energy feasibility • Average fuel efficiency of fleet • Fuel mix for electricity generation	• Employment • Household energy costs by sector and fuel • Commercial/industrial energy costs by sector and fuel • Social cost of carbon • Public transit costs

Table 2. Outputs from GHGProof Corporate.

GHG/Energy Outputs	Economic outputs
• GHG emissions by sector • Energy use by type	• GHG emissions by sector • Energy use by type • Municipal energy costs by sector and fuel • Energy cost intensity by building • Social cost of carbon

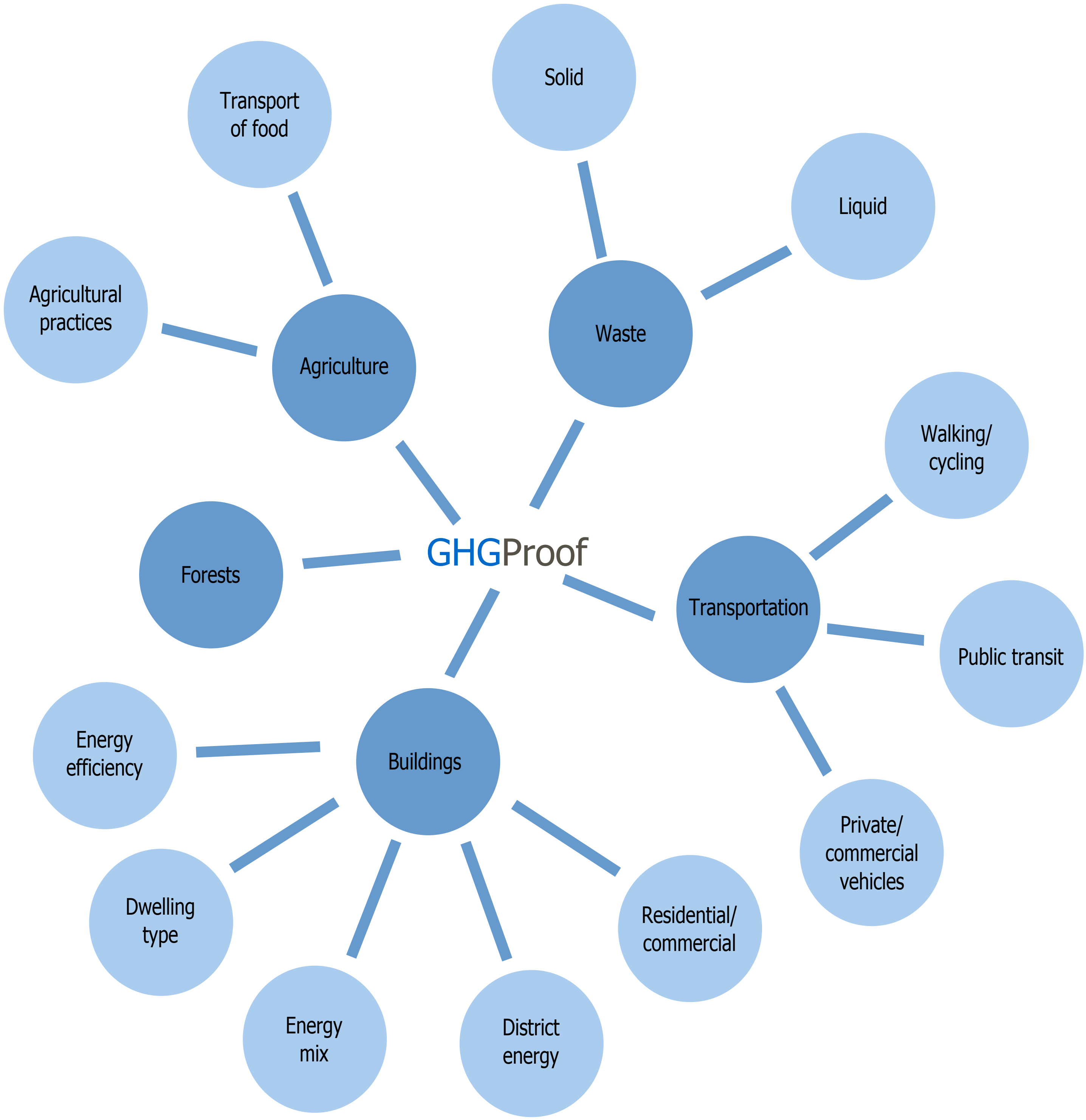
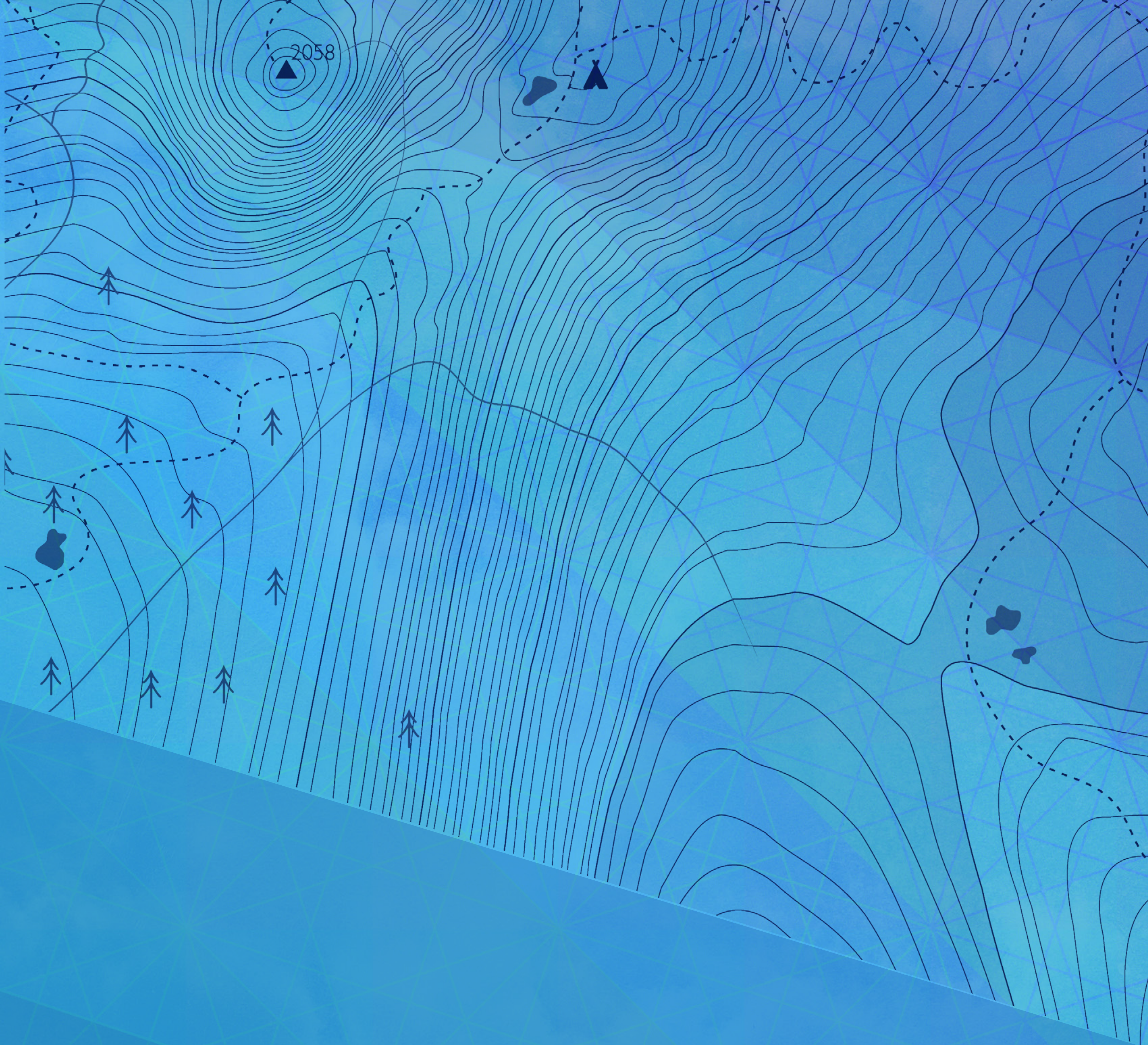


Figure 2. Scope of GHGProof.



2 Inventory Description

2.1 Introduction

This 2014 inventory report includes an assessment of the greenhouse gas emissions and energy use for the community of Yellowknife for 2013, and the corporate operations and activities of the City of Yellowknife for 2012 and 2013. The previous community and corporate inventories completed in 2006 are shown for comparison. It is an update of the 2009 inventory and will assist the City in measuring progress up to 2014 and in setting new targets for 2015 to 2025.

Estimates for energy use and greenhouse gas emissions are forecasted to 2031. Forecasts are based on a "business-as-usual" case using available information regarding potential land-uses, current policies and, projected population and macroeconomic trends.

The geographic boundary for this assessment consists of the municipal borders of the City of Yellowknife.

The inventory modelling and analysis work was carried out in the second half of 2014, and this inventory report was published in early 2015.

2.2 Inventory Attributes

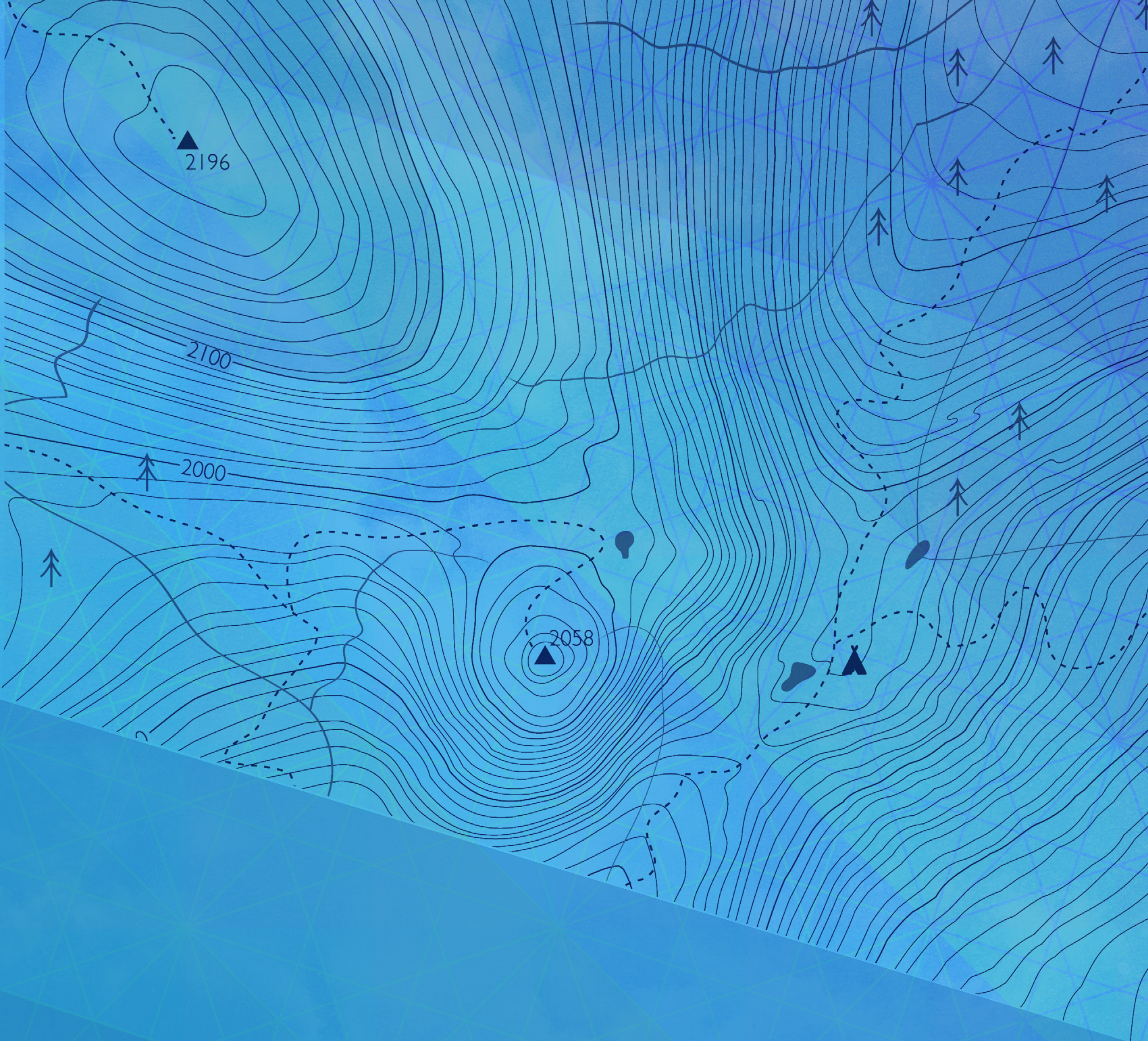
Table 3 summarizes the community and corporate inventory attributes.

Table 3. Community and corporate inventory attributes.

	Community	Corporate
Geographic boundary	The municipal borders of the City of Yellowknife.	
Time Span	• Milestones, GHG emissions and energy use inventory calculated for 2013 ("2014 Inventory") • Comparison to 2004 inventory. Note that sufficient data was not available to run the model backwards to 2004. • Forecast business-as-usual for 2014-2031.	
Gases	• The inventory addresses carbon dioxide (CO2), methane (CH4) and nitrous oxide (N20). • Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF6) and nitrogen triflouride (NF3) are not included. • Emissions for gases included in this inventory are expressed in CO2 equivalents (CO2e), per the assumptions in Table 4.	
Emissions accounted for	Refer to Appendix 1 for a detailed list of what emissions have been included in the community inventory.	Refer to Appendix 2 for a detailed list of what emissions have been included in the corporate inventory.
Data assumptions and emissions factors	Refer to Appendix 3 for a detailed list of data assumptions and emissions factors used to calculate the community inventory.	Refer to Appendix 4 for a detailed list of data assumptions and emissions factors used to calculate the corporate inventory.
Protocol	Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories (GPC)	Partners for Climate Protection Program
Calculation Tools	GHGProof Community	GHGProof Corporate

Table 4. CO2 equivalents for greenhouse gases.

Gas	CO2 equivalents
CO2	1
CH4	28
N20	265



3 Methodology

3.1 Community Inventory Methodology

3.1.1 Data collection

A detailed data request for the City of Yellowknife outlined all the data needs of the project. In certain cases, data was also requested from the Territorial Government and from Northland Utilities, the company which distributes electricity in the City of Yellowknife.

3.1.2 Data and assumptions

Based on the data provided, a list was compiled indicating where data was available and where assumptions would be required. This was reviewed, revised and approved by the Community Energy Planning Committee. A complete list of the data and assumptions used in the modelling is available in Appendix 3.

3.1.3 Scenario planning

The scope of the project included a business as usual scenario, projecting planned land-use to 2031. The number of additional households was calculated using population projections from the NWT Bureau of Statistics. The probable locations of the dwellings were identified in a workshop with Community Energy Planning Committee members. Similarly, likely future commercial space growth in new and existing commercial areas was identified.

Since Corporate GHGProof is based on actual usage data, the business as usual scenario for the corporate inventory was calculated based on per capita results from 2013 and multiplying these by the population projections for 2031.

3.1.4 GIS analysis

GIS analysis was used to identify floor space of residential and commercial buildings, likelihood of walking and cycling in future scenarios, and the average trip length of vehicles. The City of Yellowknife provided parcel data for planning purposes and floor area from tax data. These two datasets were merged in GIS to identify buildings by type and to identify the floor area associated with each building.

Each non-residential building was then assigned a trip generation number based on the type of building and the area of that building. Trip generation numbers are averages calculated for all of North America drawing on thousands of studies[20]. For example, a library generates 56 trips per thousand square feet and so each library was then assigned a certain number of trips based on its floor area and so on for each type of building. A GIS technique called heat mapping was then used to identify the major aggregations of trips generated (Figure 3).

20 See the Institute of Transportation Engineers Trip Generation Manual, 8th Edition.

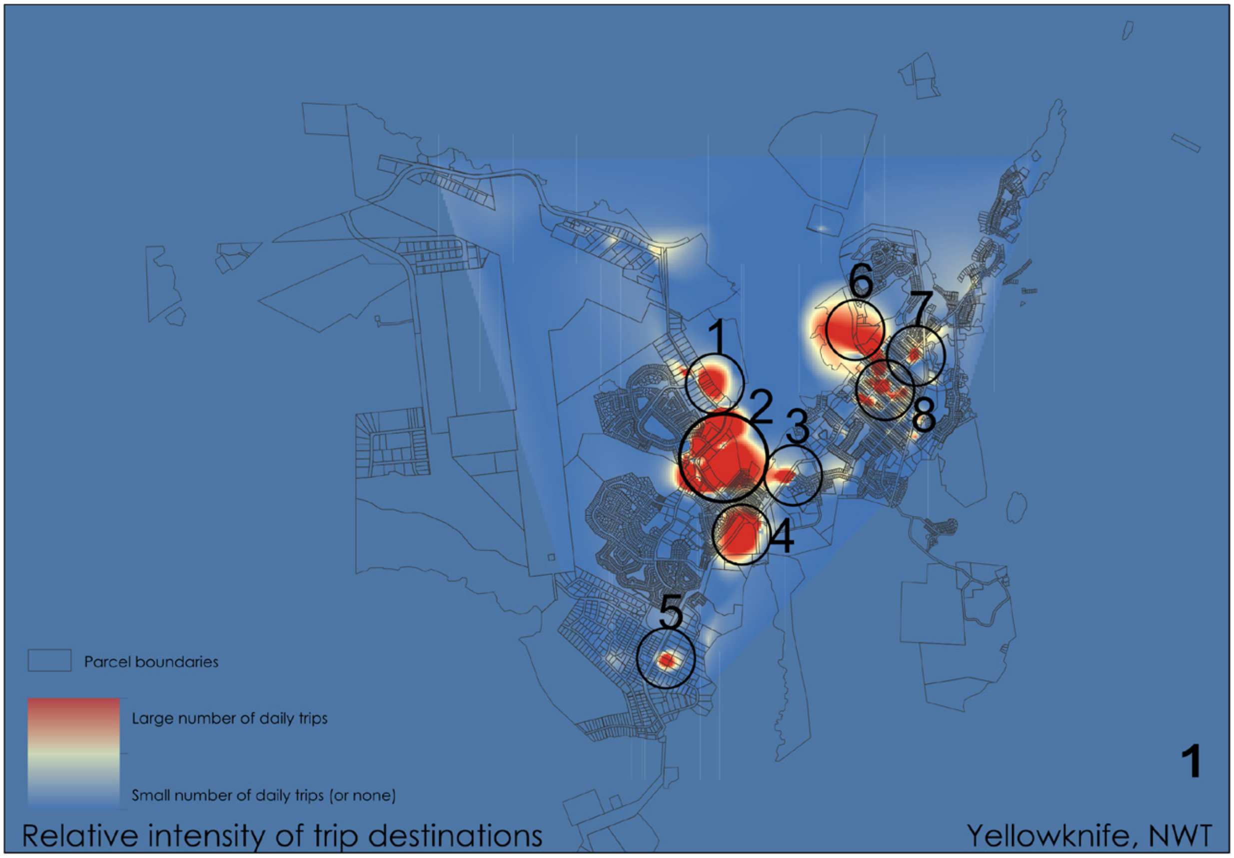


Figure 3. Aggregations of trips identified using a heat map.

As a by-product of this analysis, the aggregated trip generation data provides insight into locations that are likely most viable for transit service; in other words these are the areas people frequent most often relative to other potential destinations.

The average distance from each dwelling to each of these aggregations was then calculated along roads, again in GIS. This analysis was completed in the current scenario (2013) and for the future scenario (2031) using the Business as Usual land-use projections described in 5.3. The resulting trip lengths are a measure of how the spatial distribution of the community changes are a result of new development (Figure 4).

In order to understand the spatial distribution of energy consumption in the City, energy intensity numbers were assigned to floor areas for various buildings types. A heat map was then generated to highlight areas of concentrated energy demand (Figure 5). This map provides an indication of potential target areas for district energy, energy retrofits or renewable energy generation. Note that the way in which the GIS platform averages the results may provide some distortion.

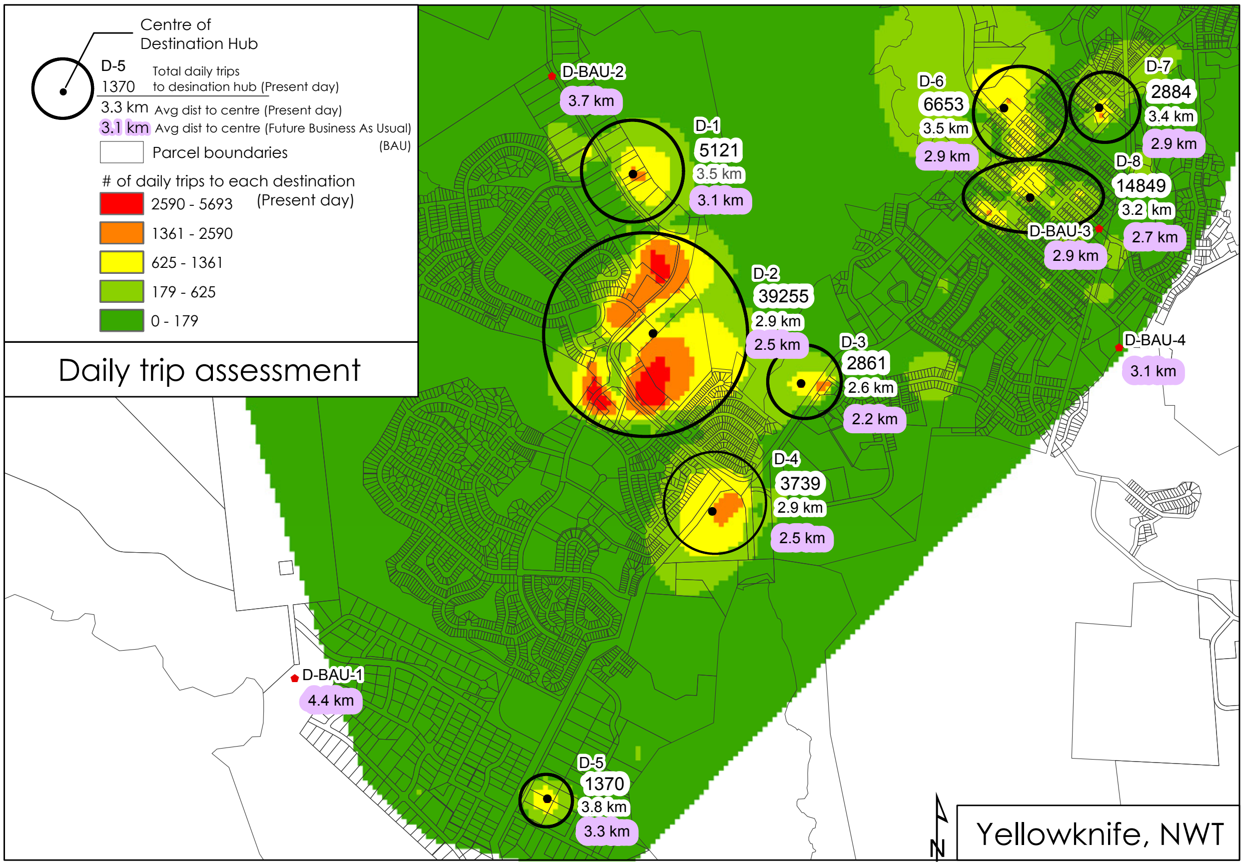


Figure 4. Trip generation for key destination aggregations and average distance from dwellings to those aggregations.

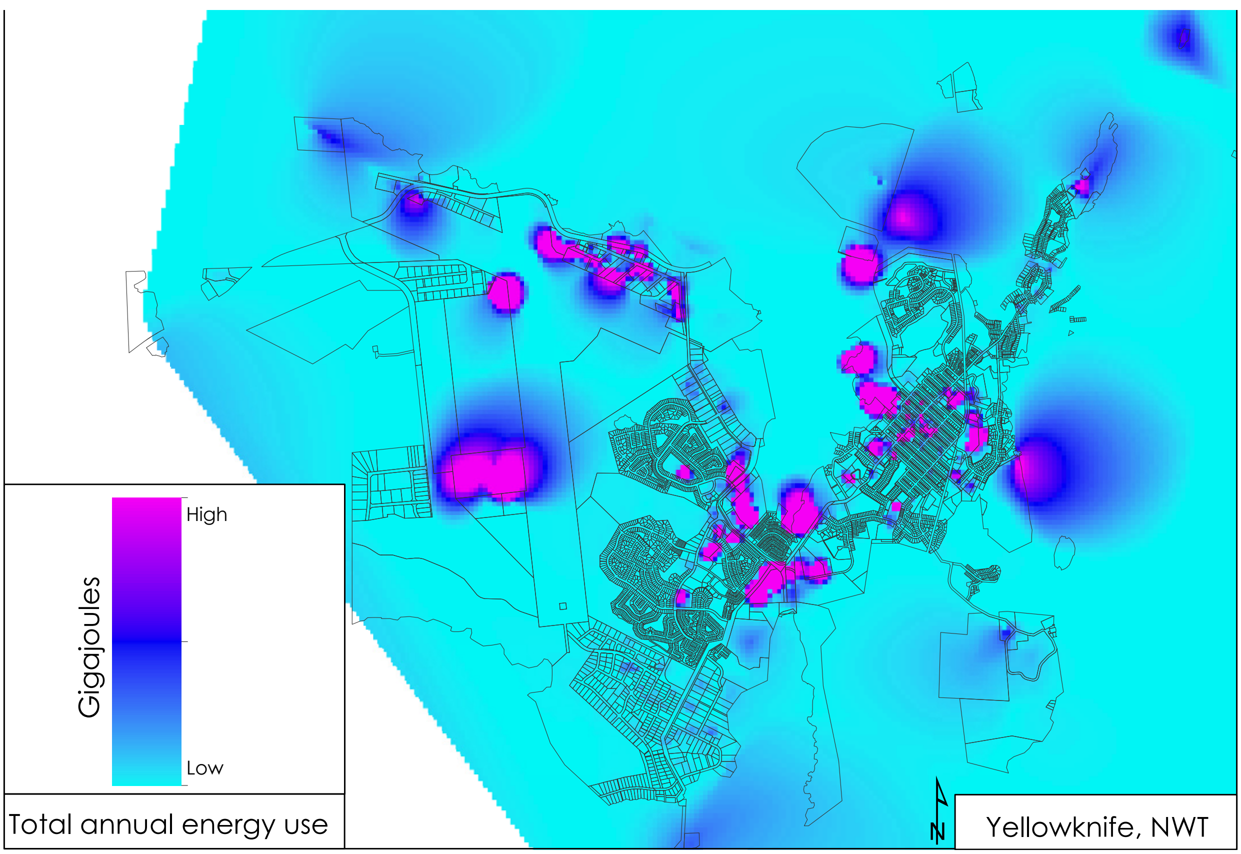


Figure 5. Spatial distribution of energy consumption in the City of Yellowknife.

Further analysis was conducted to identify district energy potential. Areas exceeding a 50 kWh/m2/yr threshold were identified.[21] In this case a grid was created with cells of 100m by 100m and the energy consumption was calculated for each cell (Figure 6). Red cells indicate areas that exceed the threshold. Concentrations of red cells are thus the most likely areas for future district energy systems.

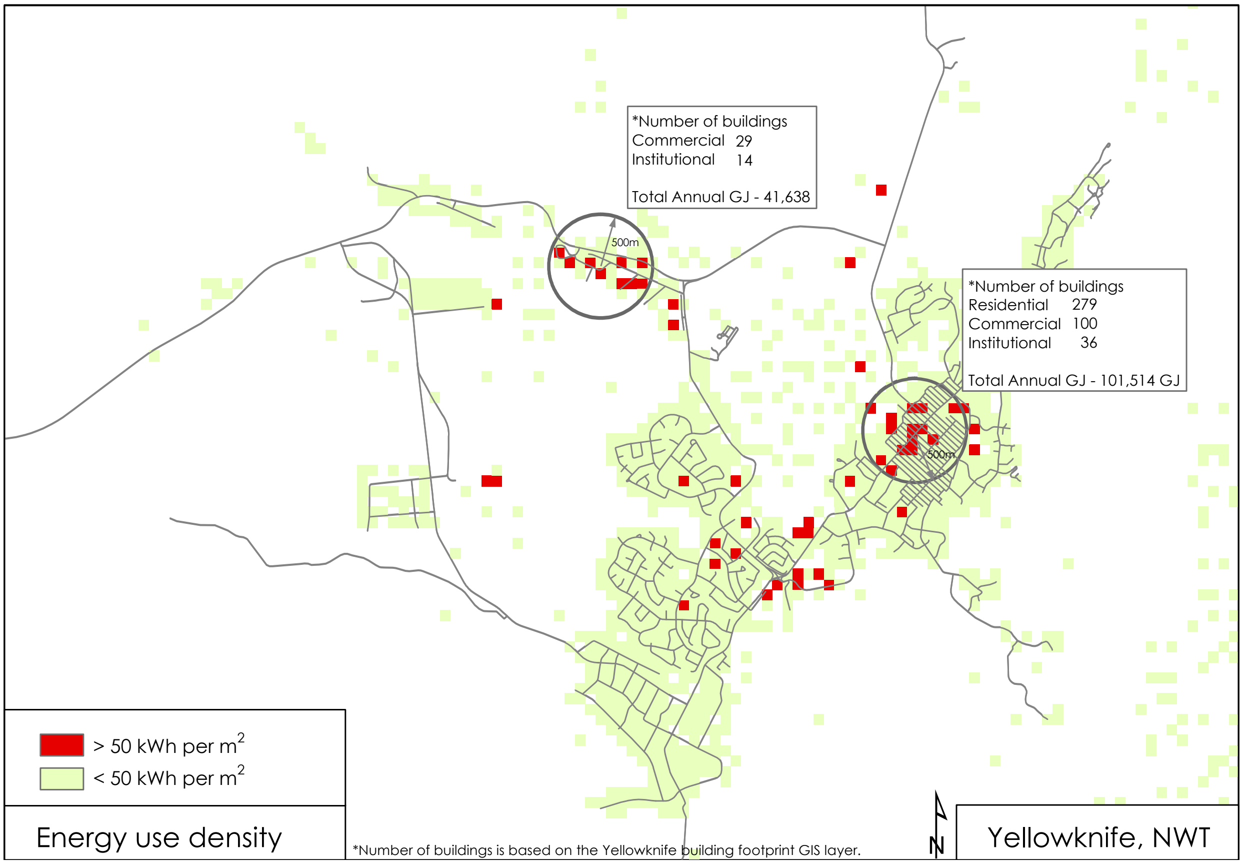


Figure 6. Potential areas for district energy according to 2013 heat demand.

3.1.5 Scenario Modelling

GIS analysis provided modelling inputs including average trip length, floor area of buildings, number of buildings by type, and number of dwellings within walking distance of destinations. These inputs were combined with data extracted from other reports and from other agencies to develop a model of GHG emissions, energy and energy costs year over year until 2049 using GHGProof.

The excel-based GHGProof Community model has been provided to the City of Yellowknife as a stand-alone entity that accompanies this report. A summary of the assumptions and data are available in Appendix 3.

3.1.5.1 Transportation

Transportation emissions included analysis of private and commercial vehicle trips within Yellowknife, private vehicle trips to Edmonton, community resupply (commercial trips) from Edmonton, and idling.

Private vehicle emissions were calculated by identifying trip length from GIS, number of daily trips and mode split from the Smart Growth Development Plan Transportation Improvement Study, number of households from demographic projections, and the average fuel efficiency of the fleet. Half of households were assumed to make one annual vehicular trip to Edmonton. Results were calibrated by assigning a per capita portion of total on-road diesel and gasoline sales to the City of Yellowknife. Commercial transportation emissions were calculated by assuming the additional fuel used beyond

21 Note that this is conservative as Zinko et al.(2008) found that district energy in Europe is feasible at heat density as low as 10-30 kwh/m2/yr. Zinko et al.(2008) District heating distribution in areas with low heat demand density. The 11th International Symposium on District Heating and Cooling.

residential purposes was for commercial purposes. Idling emissions assumed 75% of the vehicles idled one hour per day for 275 days of the year. Community resupply was allocated on a per capita basis to Yellowknife at 78,000 tonnes and 28 tonnes of freight per truck was assumed. The sources for these assumptions are provided in Appendix 3.

3.1.5.2 Buildings

Data for buildings including type and floor area was derived from GIS. Residential dwelling mix was sourced from the Census. The Comprehensive Energy Use Database from Natural Resources Canada reports on energy use intensity for residential dwellings by type. This information, combined with dwelling size, was used to construct a bottom-up model of dwelling energy use, which was then calibrated against total electricity use provided by Northland Utilities. Accurate data for heating oil, propane or biomass was not available.

A similar approach was used for commercial buildings, in which energy intensities were assigned according to building type and the total was calibrated against electricity use. Natural Resources Canada also provides energy mix for commercial buildings, so total energy consumption for other fuel types was calculated using the actual electricity data provided by Northland Utilities.

For the Business as Usual projection, additional residential dwellings and commercial space were added to accommodate the population projections and energy consumption was assigned to those buildings. Assumptions were made around a shifting fuel mix, increased energy efficiency and a rate of building retrofit.

3.1.5.3 Waste

Solid and liquid waste data was provided by the City of Yellowknife. Projections for solid waste incorporated a slightly increasing diversion rate and the use of landfill gas capture beginning in 2025. A first order decay method was used to calculate GHG emissions according to the Intergovernmental Panel on Climate Change Guidelines.

Emissions from liquid waste were calculated on a per capita basis according to the level of treatment.

3.1.5.4 Forest and agriculture

Forest area was provided by the City of Yellowknife (Smart Growth Plan) and emissions data (absorption by tree growth and release through soil emissions) was derived from Intergovernmental Panel on Climate Change data. Agricultural activity was retrieved from the 2011 Agricultural Census (Statistics Canada), which reported essentially no agricultural activity.

3.1.5.5 Transportation of food

Transportation of food refers to the emissions associated with transportation of food from point of cultivation to point of consumption. Increased local production and consumption results in reduced emissions. It was assumed that 90% of the population eats some locally-produced food. It was also assumed that on average 50% of the food consumed by that 90% is locally-produced.

3.1.5.6 Economic data

Fuel costs were identified from a mix of Yellowknife-specific sources and a fuel cost escalation factor was applied for future fuel use.

3.1.6 Data validation

Due to the extent of the assumptions used, a variety of strategies were employed to validate the data. Validation is a process of exploring the inputs, assumptions and results and confirming this data with additional sources or analysis. The process does not determine that the results are correct, but rather looks for and seeks to understand discrepancies or inaccuracies, with the aim of generating logically consistent results.

3.1.6.1 External data validation

A process of data validation was completed by a third party. Stephen Salter of Farallon Consultants Ltd. Farallon made recommendations including alternative approaches to solid waste calculations and the addition of trucking for resupply as a category. Farallon also conducted a sensitivity analysis which did not identify any particular variables of particular importance (Appendix 5).

3.1.6.2 Comparison with previous inventories

In order to construct an independent model, no data from the previous two inventories was used. This enabled a direct comparison between the past inventories and the model results (Table 5). Major discrepancies were identified including that the previous inventories estimated emissions from buildings to be three times higher than the GHGProof results and GHGProof calculated emissions to be almost twice as high for transportation as the previous inventories

Table 5. Comparison with previous inventories. Note that electricity totals differ from those in Appendix 8 as Table 5 does not include electricity distribution losses.

Attributes	2004 GHG Inventory	Calculated numbers	2009 GHG Inventory	Calculated numbers	Calculated numbers
	2004	2006	2009	2009	2013
Electricity (GJ)	604,356	468,681	626,746	588,538	680,409
Fuel oil (GJ)	3,621,165	947,666	3,762,272	1,244,907	975,566
Propane (GJ)	376,186	117,551	315,123	140,234	155,628
Biomass (GJ)	23,280	67,063	59,204	88,683	193,803
Gasoline (GJ)	403,883	598,962	309,316	607,621	615,674
Diesel (GJ)	553,554	801,636	470,926	814,945	850,972
Total	5,584,428	3,003,564	5,545,596	3,486,937	
Electricity ($)	$27,775,147	$29,438,362	$39,571,000	$37,568,731	$46,729,149
Fuel oil ($)	$56,141,939	$29,339,727	$88,246,000	$39,561,139	$32,099,390
Propane ($)	$731,119	$3,445,216	$8,668,000	$4,333,900	$4,890,964
Biomass ($)	$280,125	$670,633	$2,555,000	$930,774	$2,169,533
Gasoline ($)	$10,776,250	$48,077,898	$12,248,000	$50,307,793	$24,581,989
Diesel ($)	$11,596,770		$14,595,000		$29,331,867
Total	$107,301,350	$110,971,836	$165,883,000	$132,702,336	
Residential (tCO2e)	125,588	26,129	130,717	25,623	21,021
Commercial (tCO2e)	104,991	50,047	169,622	73,531	62,166
Institutional (tCO2e)	42,323				
Transportation (tCO2e)	62,238	102,218	54,119	102,844	104,816
Total	335,140	178,394	354,458	201,998	188,003

As a result of the discrepancies, a detailed analysis o f the methods underlying the previous inventories was undertaken, Table 6 illustrates the different methodological approaches to the inventory of the previous two inventories in comparison with this inventory. Both the 2004 and 2009 inventories relied on similar data and a similar approach.

Table 6. Comparison of methodologies

Key sectors	2004 Inventory/2009 inventory	GHGProof analysis	Key differences
Residential	Dwelling numbers were identified from various sources and floor areas were assumed for each dwelling type. Fuel supply was estimated from collecting data from suppliers. Electricity data was from Northland Utilities.	Number of dwellings and floor area identified from GIS. Energy model based on floor area was developed and calibrated with electricity consumption data from Northland Utilities. Fuel supply assumptions were based on the NRCan Residential Energy Use survey.	Previous inventories estimate non-electricity fuel use from supplier data and floor area estimates from an unknown source. GHGProof used floor area from GIS and energy intensity factors to calculate total fuel use, which was then calibrated against electricity consumption.
Commercial and institutional buildings	Floor space was estimated by building type from City permits and energy intensity factors were used from Natural Resources Canada. Energy supply assumptions are not identified.	Floor area of commercial buildings was identified using GIS going forward and energy model was created by assigning an energy intensity factor for different types of commercial buildings. Energy supply was developed using electricity data and NRCan reports.	In GHGProof, energy consumption is driven by floor space which is calibrated against electricity consumption according to the share of energy consumption indicated by NRCan for NWT and BC. Assumptions on energy supply for previous inventories are not clear.
Transportation	Emissions were estimated using fuel efficiency (Canadian averages from Statistics Canada) and VKT (NWT averages from Statistics Canada) with vehicle counts from NWT registry.	Uses similar sources for fuel efficiency and vehicle counts as inputs into a transportation model. GIS model was developed to represent travel distances in Yellowknife. Model was calibrated against fuel sales for residential and commercial vehicles. Also models walking and cycling mode share based on proximity and accounts for idling in commercial and residential vehicles.	Previous inventories used a standard assumption for VKT. GHGProof calculated VKT using a transportation model. GHGProof also accounts for commercial vehicles, idling and private and commercial trips to Edmonton.
Waste	Not included	Solid waste and waste water data was provided by the City. Solid waste emissions were calculated using a first order decay method specific to the climate of Yellowknife	
Agriculture and forestry	Not included	GIS analysis completed to identify forest area. Agricultural data provided by the agricultural census.	

While there are a number of differences indicated in Table 6, the most signficant quantitative difference between the two previous inventories and the current invenotry is associated with energy consumption of residential and commercial buildings.

Previous inventories used a different classification of building types, whereas this inventory uses the Statistics Canada classes of residential dwellings. One difference is the assumption of the size of dwelling types and in the previous inventories the basis of this assumption is unclear. The GHGProof inventory derived floor area from analysis of the city of Yellowknife's GIS data. These differences are illustrated in Table 7.

Table 7. Comparison with previous inventories.

Building category	Area (m2)	Source
2004 and 2009 Inventory		
Single detached	150	Unknown
Single attached	125	
Apartments	90	
Mobile homes	120	
GHGProof		
Detached	190	GIS analysis
Row houses	125	
Apartments <5 storeys	108	
Apartments >5 storeys	108	
Mobile Homes	97	

Floor area discrepancies, however, do not explain the significance of the difference, which can be attributed to assumptions on total energy consumption. Previous inventories relied on data from suppliers to estimate total energy consumption, although it is not clear how these calculations were undertaken. GHGProof includes a residential energy model that calculates an energy supply mix for each year , which is driven by floor area (from GIS) and energy use intensity (from NRCan's Comprehensive Energy Use Databbase), a bottom-up model. This was then calibrated against actual electricity consumption from Northland Utilities. If the previous inventories used energy supply data, they would be classified as a top-down model.

Table 8. Comparison with previous inventories.

Attribute	2004 Inventory	GHGProof	2009 Inventory	
Year	2004	2006	2009	Units
Residential				
Energy	1,404,000	952,328	2,061,849	m2
Area	781,290	999,823	842,280	GJ
EUI (GJ/m2)	1.80	0.95	2.45	GJ/m2
Commercial				
Energy	2,554,060	952,308	2,808,980	m2
Area	366,695	366,695	445,162	GJ
EUI (GJ/m2)	7.0	2.6	6.3	GJ/m2

An analysis of the energy use intensity for the different approaches was completed to provide additional insight, revealing that energy use intensity factors for both commercial and residential buildings in the previous two inventories are unexpectedly high. Another possible explanation for these high numbers is that the previous two inventories underestimated floor area. Further validation was undertaken using the National Inventory Report to investigate this possibility.

National Inventory Report

In order to ensure the modelling results were in the ballpark of appropriate totals, we considered the total emissions as reported by Environment Canada in the National Inventory Report, a top down approach (Table 9). Given that Yellowknife represents 46% of the total population of the Northwest Territories, it was possible to ensure that the totals were within an expected range.

Residential buildings represent less than the per capita proportion of emissions for residential buildings because electricity production is particularly low in carbon in Yellowknife relative to other areas in the NWT. Commercial buildings are higher because of the concentration of services and as a result buildings in Yellowknife Agriculture is higher than the National Inventory Report because we assumed a small base level of agricultural activity. Liquid waste is also high because the primary liquid waste treatment is in Yellowknife.

3.1.6.3 Other studies

A bottom-up approach was also used to validate the results. Recognising the significant discrepancy related to buildings with previous inventories, energy use for buildings was compared with the results of the Urban Archetypes project of Natural Resources Canada.[22] The Urban Archetypes project provides dwelling-level energy and GHG emissions for buildings and transportation in Whitehorse. This comparison provided assurance that the modelled results were in an appropriate range.

Table 9. Comparison of results with National Inventory Report for Northwest Territories.

		2009	2010	2011	2012
Buildings					
Yellowknife	Residential	25.6	25.0	24.5	22.5
NWT	Residential	119.0	93.4	101.0	93.7
	%	22%	27%	24%	24%
Buildings					
Yellowknife	Commercial & Institutional	73.5	72.7	71.4	64.8
NWT	Commercial & Institutional	110.0	100.0	102.0	107.0
	%	67%	73%	70%	61%
Transportation					
Yellowknife	Road transportation	102.8	109.4	116.1	112.5
NWT	Road transportation	210.0	186.0	240.0	227.0
	%	49%	59%	48%	50%
Agriculture					
Yellowknife	Agriculture	5.4	5.4	5.3	5.4
NWT	Agriculture	0.0	0.0	0.0	0.0
	%	0%	0%	0%	0%
Solid waste					
Yellowknife	Solid waste disposal on land	1.6	1.7	1.7	1.8
NWT	Solid waste disposal on land	2.6	2.7	2.8	2.8
	%	62%	61%	61%	63%
Liquid waste					
Liquid waste	Wastewater handling	2.4	2.4	2.4	2.5
NWT	Wastewater handling	2.6	2.6	2.6	2.6
	%	94%	94%	94%	95%

3.1.6.4 Conclusion

While these additional steps provided a higher level of comfort in the results, it is important to note that the GHGProof model also relies extensively on assumptions and in order to achieve more accurate outcomes, reliable data collection processes need to be introduced. Major data gaps include residential and commercial fuel use by type for buildings (excluding electricity), mode split, vehicle fleet composition and vehicle kilometres travelled (VKT).

22 Described in detail here: http://www.nrcan.gc.ca/energy/efficiency/communities-infrastructure/research/4531

3.2 Corporate Inventory Methodology

The methodology used for the corporate inventory was less comprehensive than that used for the community inventory, since: fewer inputs were required, it was based on actual usage data for each emissions sector requiring fewer calculations, and it did not use any GIS or spatial calculations.

3.2.1 Data collection

A corporate data request was made, outlining the data required to undertake the corporate GHG inventory. Corporate data was provided by the City for the years 2012 and 2013.

3.2.2 Data and assumptions

Based on the data provided, a list was compiled indicating where data was available and where assumptions would be required. A complete list of the data and assumptions used in the modelling is available in Appendix 2.

3.2.3 Calculations

The excel-based GHGProof Corporate model has been provided to the City of Yellowknife as a stand-alone entity that accompanies this report. A summary of the assumptions and data are available in Appendix 4.

3.2.3.1 Buildings

Building utility bills were provided for: electricity, heating oil, propane, diesel, and wood pellet usages. Actual amounts paid by the city were provided, and building addresses and square footages were also recorded. Buildings were assigned usage categories that were reviewed by the City.

Amounts of energy used in GJ were calculated using standard conversion factors applied to the litres of fuel used and kwH of electricity used for each building. Wood pellet usage was provided in tonnes, and a factor for conversion to GJ of energy used was taken from the NWT Wood Pellet Public Report Jan 14 2010.

Electricity emissions were calculated using an emissions factor derived from the proportional mix of hydro and diesel electricity used by Northland Utilities for each inventory year, as well as a distribution loss factor of 4.8%. Other fuels' emissions factors were also applied (as per Appendix 4) to calculate each building's total emissions.

Buildings' electricity, energy, and spending were totalled for their usage categories, and for the types of energy used.

3.2.3.2 Vehicles

Vehicle fuel usage and spending was recorded for gasoline, diesel, and propane purchased by the City for each inventory year (2012 and 2013). These were recorded by cardlocks rather than on a per-vehicle basis. Usage categories for the cardlocks were provided by the City and recorded, to get a general idea of the breakdown of the City's vehicle operations requirements.

Some vehicles using the cardlocks included: fire trucks, administration vehicles, roads and traffic operations vehicles, and snowmobiles. Waste collection and transport was not included in the inventory since these services were contracted out to a private company, Kavanaugh Waste Management.

Fuel usage assumptions factors were taken from 2014 BC Best Practices for Quantifying Greenhouse Gas Emissions. Gasoline usage was assigned the emissions factor for light duty cars, diesel usage was assigned the emissions factor for light duty trucks, and propane usage was assigned the emissions factor for light duty cars.

3.2.3.3 Streetlights

Utility bills for City lighting were collected, which included energy used and energy paid by the City for each. Lighting covered in the records provided by the City included: street lights, traffic lights, crosswalks, park lighting, plug loads, seasonal/holiday lights, and others. Addresses were recorded when provided, as well as billing service ID codes. See accompanying GHGProof Corporate model for the full table of inputs.

The same energy and emissions factors were applied to streetlights as for building energy usage. These included the energy mix-specific factors from Northland utilities for 2012 and 2013, as well as a 4.8 % distribution loss factor.

Each input for the rest of the inventory was assigned a usage category, which, for this section, fell under either 'Roads & Traffic Operations', 'Arts, Recreation, Parks & Cultural'.

3.2.3.4 Solid Waste

No records had been collected by the City on solid waste generated from its operations or of bins required to store it. Staff numbers for 2012 (202) and 2013 (203) were obtained from a city report, and a yearly per-staff waste generation amount of 114 kg was applied which was derived from a national study on government office waste generation. Refer to Appendix 4 sources for these reports.

An emissions factor of 1.645 tCO2e per tonne of waste for the gas produced from solid waste decomposition at the landfill was applied, which was taken from the Environment Canada National Inventory Report 1990-2011 Greenhouse Gas Sources and Sinks in Canada, also found in Appendix 4.

Emissions from solid waste off-gassing were assigned to 'Administration & Governance'.

3.2.3.5 Water Utilities

Electrical utility bills, diesel bills, and heating oil bills were collected for the City's lift and pump stations. Addresses and service/billing/tank numbers were also recorded. Emissions and energy factors were applied in the same manner as for buildings, including energy distribution losses.

Wastewater treatment for the City is taken care of by a natural lagoon, for which off-gassing was not accounted for. This was covered in the community portion of the inventory.

3.2.4 Comparisons with previous inventories

The emissions factor for electricity was adjusted from the 2009 inventory after having collected the energy mix details for this and subsequent years from Northlands Utilities. A number was not obtained for 2004, so the emissions for this year were not adjusted. 2009 emissions were adjusted from 924,000 kgCO2e to approximately 154,000 kgCO2e.

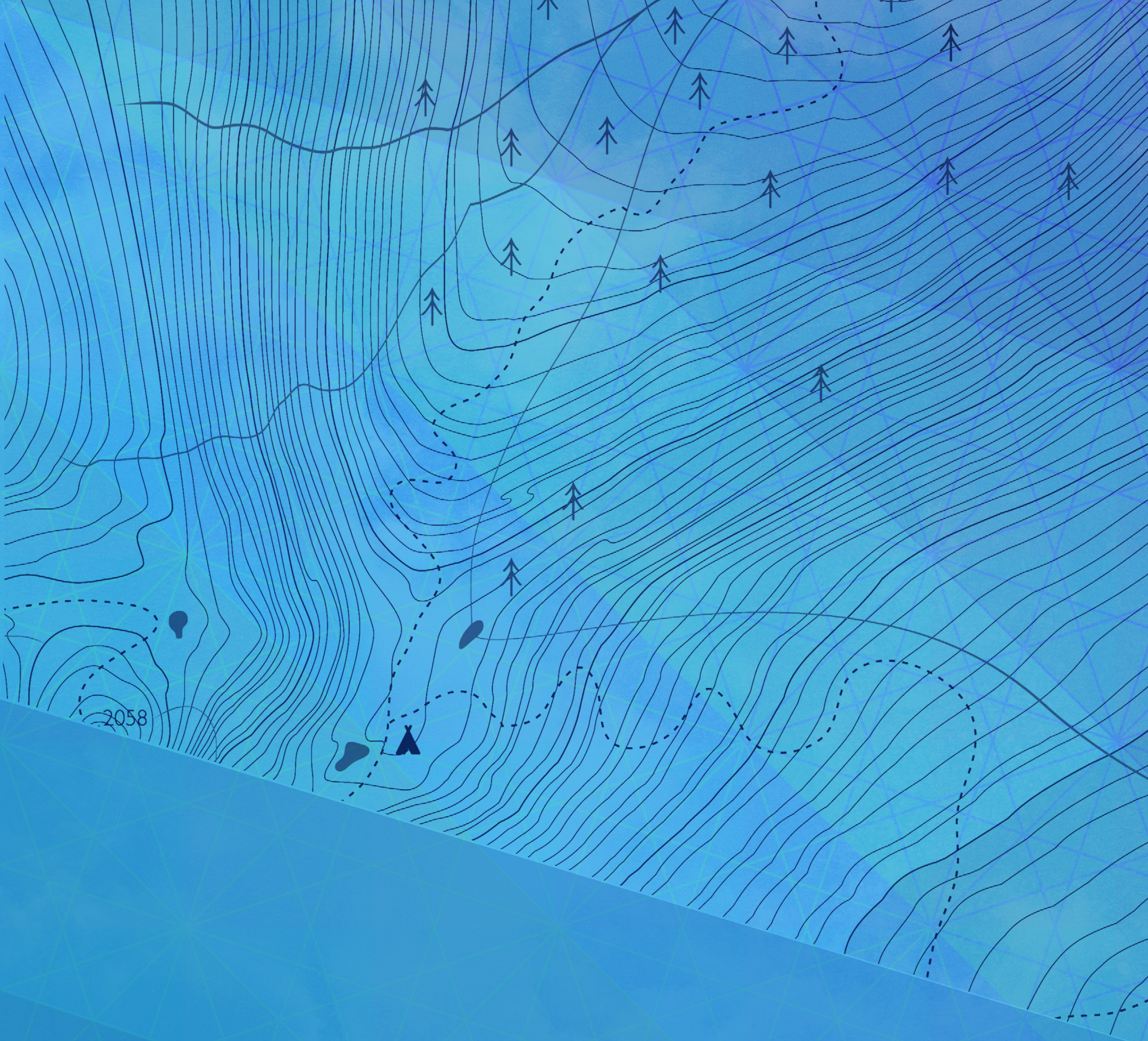
Fuel and energy spending amounts were adjusted based on inflation rates between 2004 and 2009 to 2013 (www.bankofcanada.ca/rates/related/inflation-calculator).

3.2.5 Data validation

Results were reviewed internally, by a consulting engineer, as well as by the City of Yellowknife once the inventory was assembled.

3.2.6 Forecast

The Business as Usual forecast was completed to 2031 using 2013 per capita corporate consumption and extrapolating based on population projections. This is a very coarse estimate since, for example, it does not account for the energy and emissions used in new building construction and infrastructure, or for fluctuations in energy mix for electricity production, which has varied largely over the years.



4 Inventory Results

4.1 Community Energy and Emissions Inventory

The results consist of two parts; a revised GHG inventory for 2013 and forward and reverse modelling results going back to 2006 and forward to 2031 respectively. Note that further results are available in the GHGProof Community model to 2049 but these were not included in this discussion due to the required scope of the project.

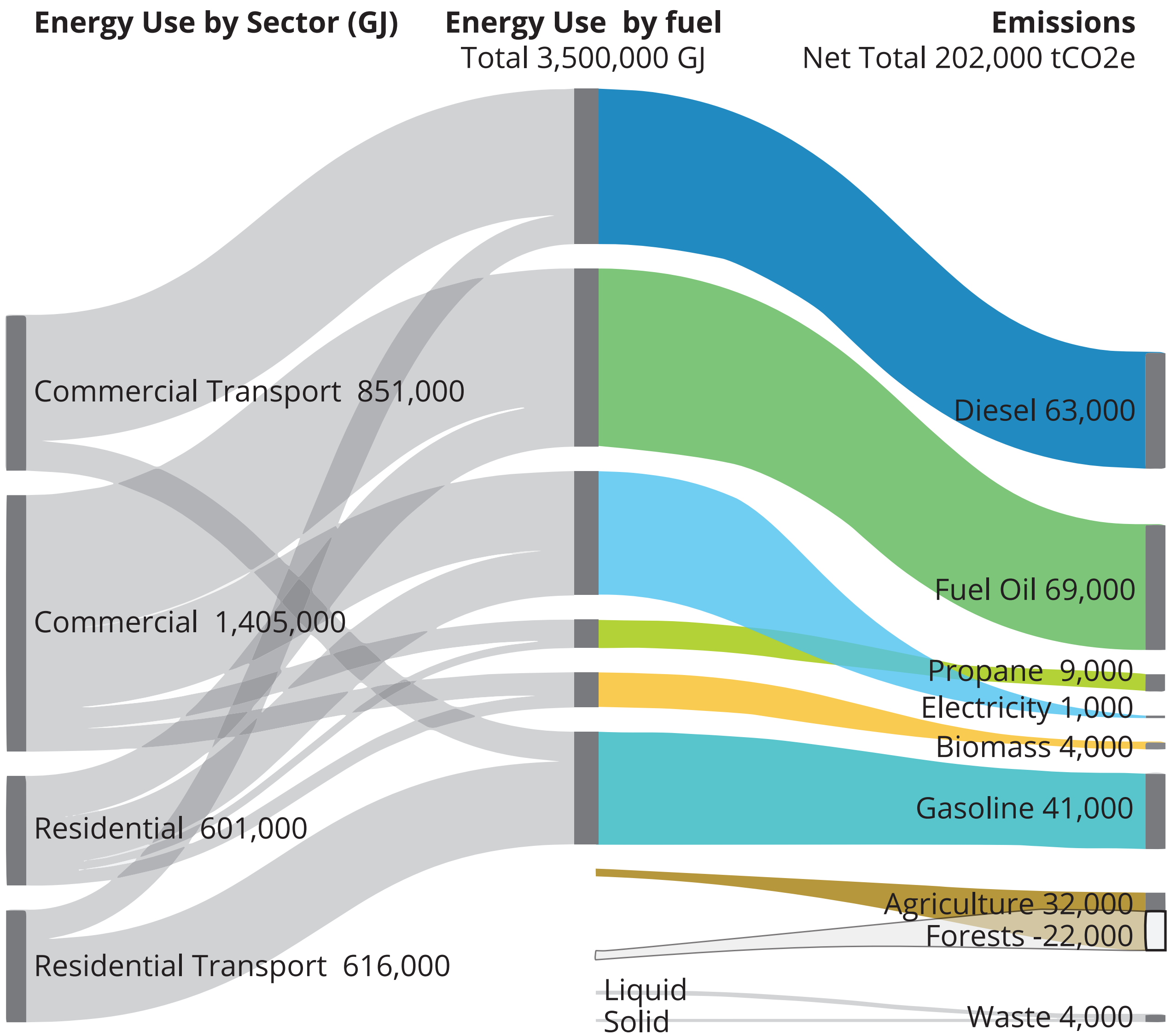


Figure 7. Diagram of Yellowknife's overall community energy use and emissions.

4.1.1 Detailed table of results

Table 1010 consists of the results presented according to the Global Protocol for Cities format for the year 2013. Refer to Appendix 7 for the detailed breakdown of these results. Further discussion on the results follows.

Table 10. Yellowknife community emissions results for 2013.

GHG Emissions Source	Total by Scope (tCO2e) 2013				Total by city-induced reporting level (tCO2e)		tCO2e by Sector 2013
	Scope 1	Scope 2	Scope 3	Other Scope 3	BASIC	BASIC+	
STATIONARY ENERGY SOURCES	83,187	-	57	-	83,187	83,244	83,244
TRANSPORTATION	97,490	-	7,325	-	97,490	104,816	104,816
WASTE	4,276	-	-	-	4,276	4,276	4,276
IPPU	-	-	-	-	-	-	-
AGRICULTURE, FORESTRY AND LAND USE (AFOLU)	-21,936	-	-	-	-	-21,936	-21,936
OTHER INDIRECT EMISSIONS	-	-	-	31,606	-	-	31,606
Total	**163,018**	**-**	**7,383**	**31,606**	**184,953**	**170,401**	**202,007**

Light green	Sources required for BASIC reporting
Light blue	Sources required for BASIC+ reporting (incl. BASIC)
Light orange	Sources included in Other Scope 3
Light grey	Non-applicable sources

4.1.2 Discussion

Table 11. Community energy and emissions overview.

	GJ	$	tCO2e
Buildings			
Residential buildings	600,539	$ 27,129,417	21,021
Electricity	251,162	$ 17,249,294	443
Fuel oil	234,659	$ 7,721,077	16,497
Propane	43,239	$ 1,358,875	2,633
Biomass	71,479	$ 800,171	1,448
Commercial buildings	1,404,868	$ 58,759,619	62,166
Electricity	429,247	$ 29,479,855	758
Fuel oil	740,907	$ 24,378,313	52,086
Propane	112,389	$ 3,532,089	6,845
Biomass	122,324	$ 1,369,362	2,478
Grid loss (electricity)	1,299		57
Buildings total	2,006,706	$ 85,889,036	83,244
Transportation			
Residential transportation	615,754	$ 23,702,905	41,523
Gasoline	454,181	$ 18,133,727	30,440
Diesel	161,572	$ 5,569,178	11,082.88
Commercial transportation	850,893	$ 30,210,951	63,293
Gasoline	161,493	$ 6,448,262	10,890
Diesel	689,400	$ 23,762,689	52,403
Transportation total	1,466,646	$ 53,913,856	104,816
Waste			
Solid			1,801
Liquid			2,476
Waste total			4,276
Land-use			
Agriculture (transportation)			31,606
Forests			-21,936
Land-use total			9,671
Total	3,473,352	$ 139,802,892	202,007

4.1.2.1 Energy

Electricity in Yellowknife is primarily derived from hydroelectric generation, with supplementary diesel generation accounting for between 2% and 3% of total generation. A drought in 2014 reduced the water storage for hydro and diesel generation increased to 23%, with a significant impact on GHG emissions resulting for electricity consumption. Going forward, lower emissions for electricity are projected as solar and potentially wind power supplement hydro while displacing diesel generation.

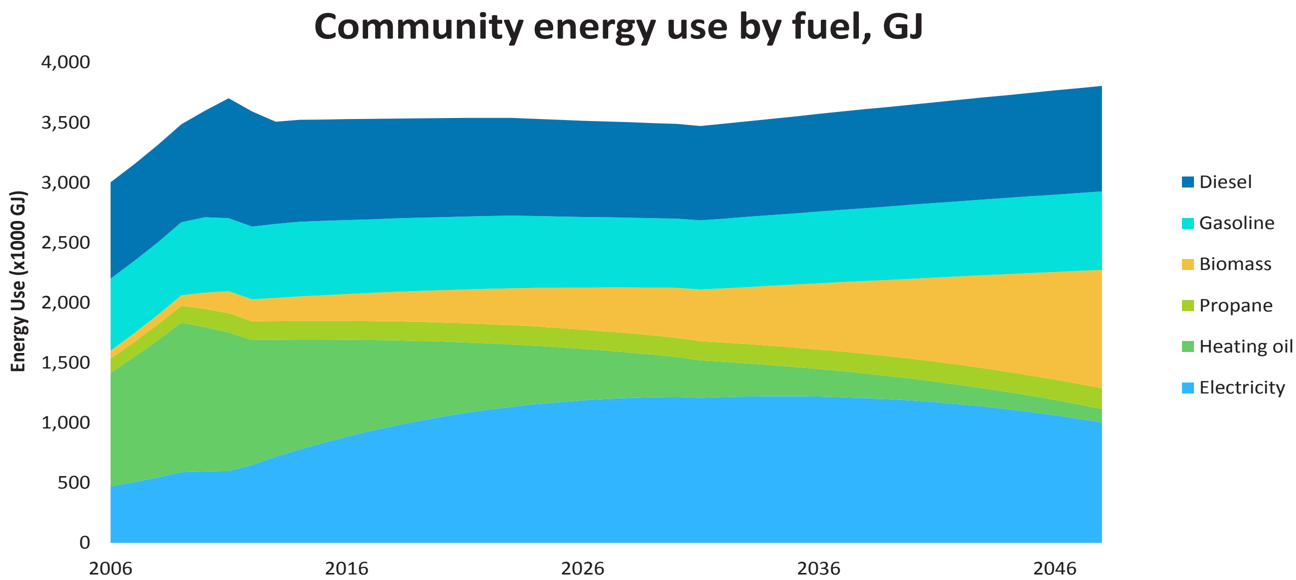


Figure 8. Historical and projected energy consumption by type.

Figure 8 illustrates the historical and projected energy mix. Heating with biomass is also projected to continue to increase along the historical trend, displacing the use of fuel oil. Gasoline and diesel use continue to decline, particularly on a per capita basis as federal fuel efficiency regulations increase the efficiency of the fleet over time. It is also anticipated that as heat pumps become more efficient in cold weather conditions, electricity will capture an increasing share of the heating demand.

4.1.2.2 Transportation

Mode split in 2031 will be consistent with that experienced in Yellowknife in current years with 82% of trips using vehicles compared with 81% in 2006 (Figure 9). Note that the 'other' consists of modes such as skiing, snowmobiling and canoeing.

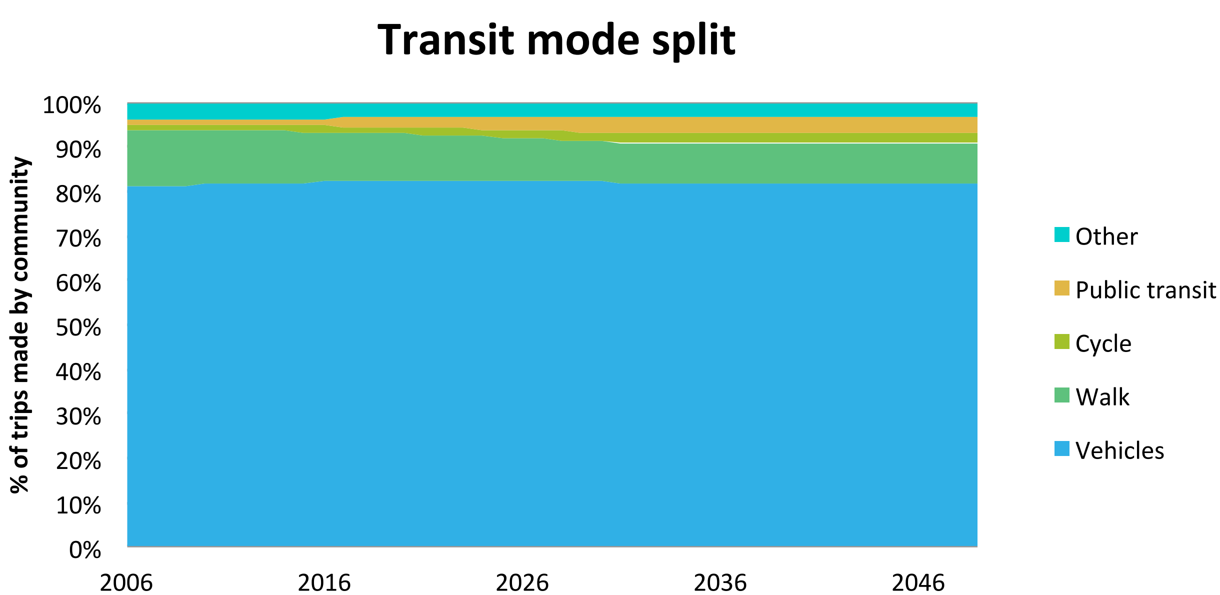


Figure 9. Mode split for Yellowknife.

Walking trips will lose ground to transit and cycling, falling from 13% to 9% in the Business as Usual scenario. The average fuel efficiency of the fleet will increase from 8 km/litre to 13.6 km/litre by 2031. Average trip length will also decline from 3.5 km to 3.09 km between 2006 and 2031, translating into reduced VKT per household. However as the population increases, total VKT increases (Figure 10).

Note that VKT has not always climbed—there is a small decline in 2013-2014. The rate of increase is initially offset in part as the average trip length decreases until 2030. After 2030 however, the model holds trip length constant and the rate of increase in VKT directly parallels the population increase.

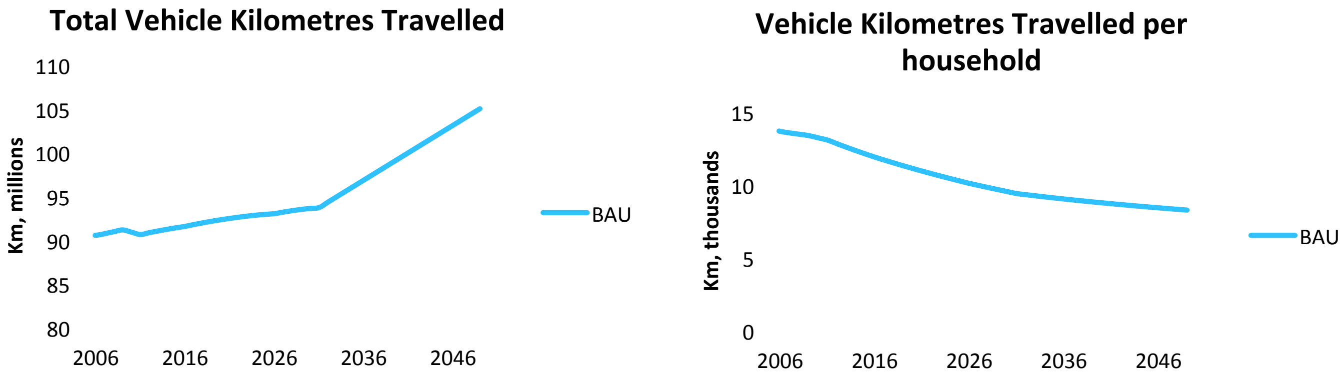


Figure 10. Total VKT and VKT per household.

4.1.2.3 GHG emissions

GHG emissions showed a steady increase from 2006 to 2011 at which point they decreased, when increased emissions by transportation were more than offset by reductions from the building sector, partly from a shift toward cleaner fuels and partly because of decreased energy demand, most likely for heating. Overall, the trend is driven primarily by reduced emissions from buildings as there is a shift towards cleaner fuels and more efficient buildings (Figure 11).

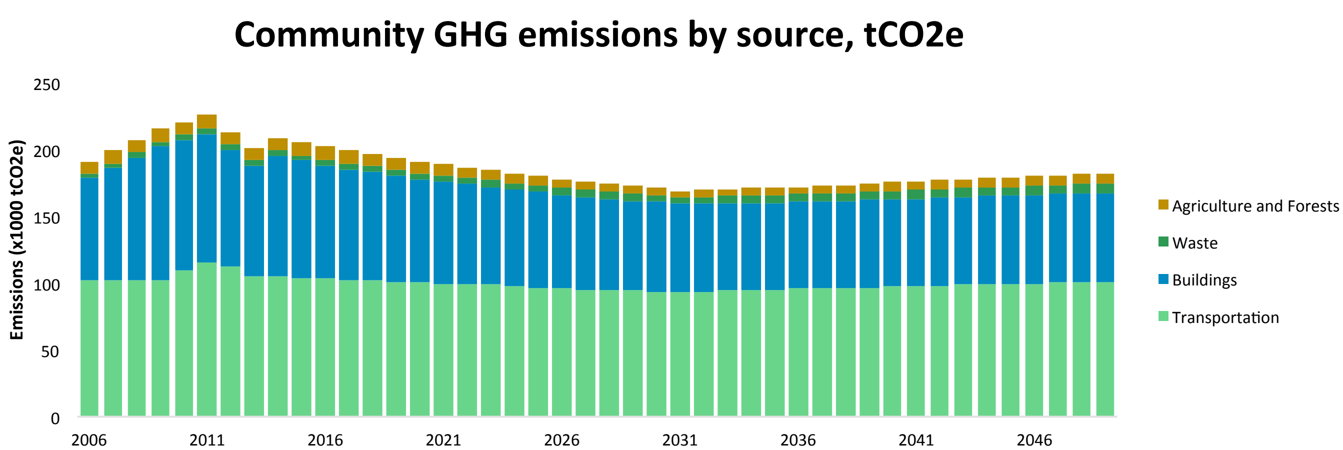


Figure 11. GHG emissions trends.

Figure 12 provides more detail on historical emissions by sector, further illustrating that the drop was primarily due to a decrease in emissions by residential buildings, reversing an overall increasing trend from 2006 to 2010.

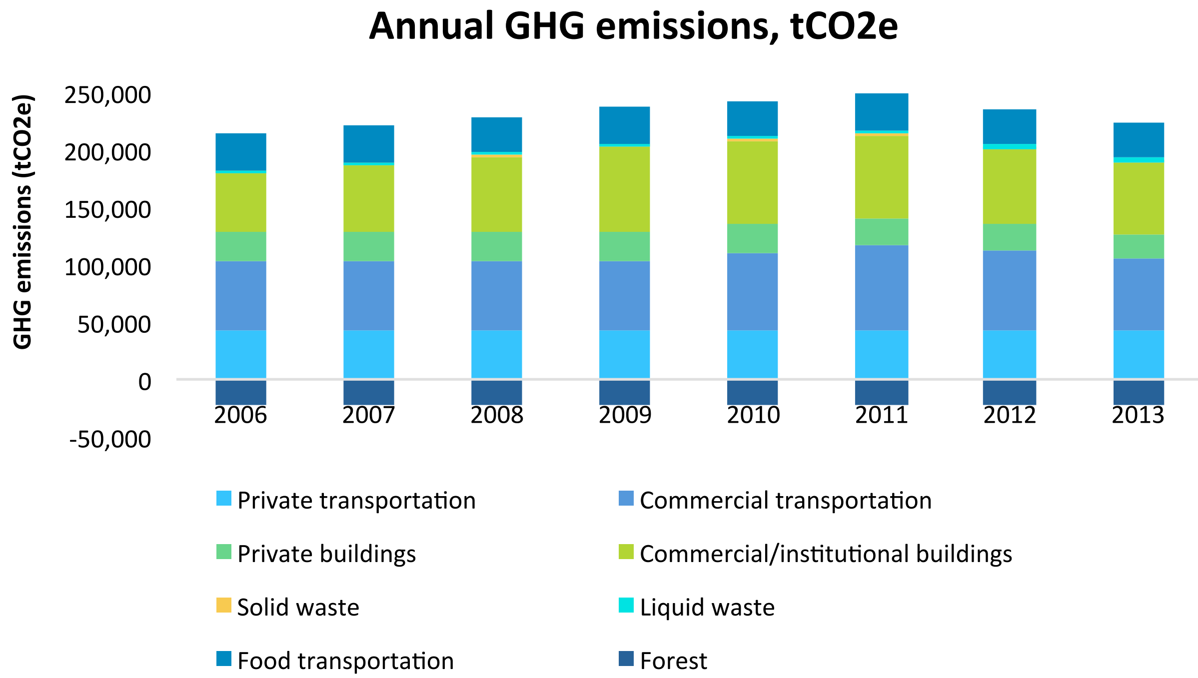


Figure 12. Historical GHG emissions by year and source.

4.1.2.4 Energy costs

Energy costs are calculated for the business as usual scenario by projecting energy costs out into the future with a small escalation factor, assuming energy costs will increase over time. As the energy mix and total energy demand change, the total community expenditures on energy change. In terms of total community costs, energy costs increase from $143 million in 2013 to $178 million in 2013, an increase of almost 25%, primarily as a result of population increases. Household energy costs decline from $19,800 to $17,800 over the same period as a result of efficiencies and a reliance on cheaper energy sources such as biomass (Figure 13).

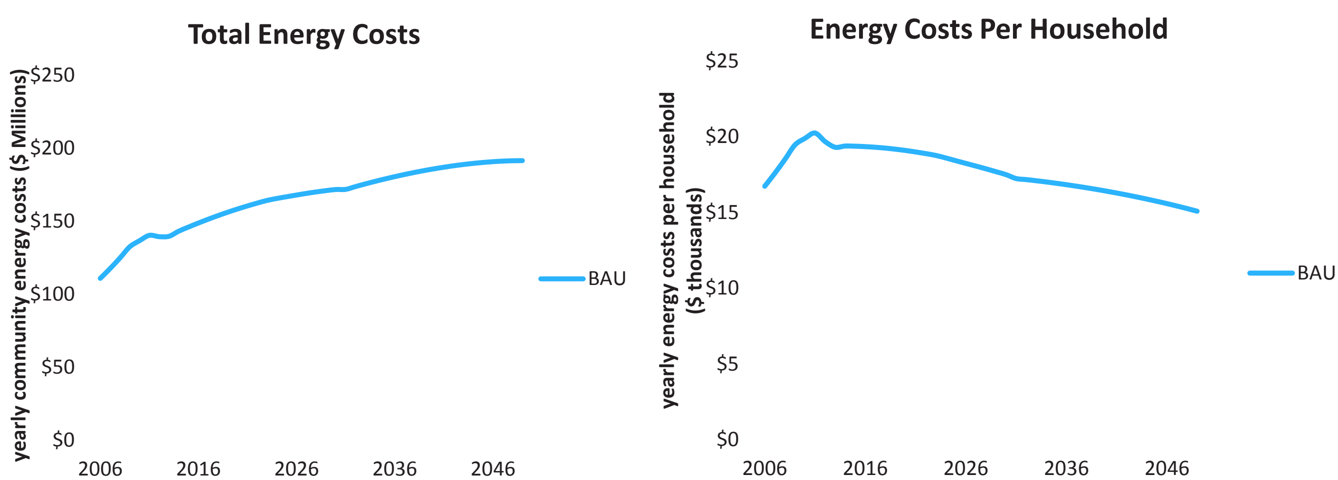


Figure 13. Energy costs.

4.1.2.5 Social cost of carbon

The complexity of the climate system makes it difficult to ascribe a value to future damages brought about by climate change. One economic strategy for expressing these damages is the Social Cost of Carbon (SCC)—an estimate of the monetized damages associated with an increase in GHG emissions each year, including impacts on agriculture, human health, and property damage from the increased risk of floods. SCC is typically presented as a range of values, to capture the uncertainty of the estimate, and to incorporate discounting rates, which are used in economic analysis to recognize that people value dollars in hand more than dollars in the future. The SCC increases over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change.

The SCC graphs in Figure 14 show the four standard discount rate estimates. By 2031, the annual damages resulting from emissions in Yellowknife are estimated to be between $2.5 million (5% discount rate) and $20 million (3% discount rate, 95th percentile). These costs reflect the damage caused by climate change anywhere in the world as a result of Yellowknife's GHG emissions. There is no correlation between where the emissions are released and the damage incurred. Yellowknife can use the SCC as a policy tool, requiring that it be calculated and incorporated into the economic decision-making for major projects. This helps to ensure that the economic analysis reflects the damage resulting from climate change and provides an economic case for selecting lower carbon options.

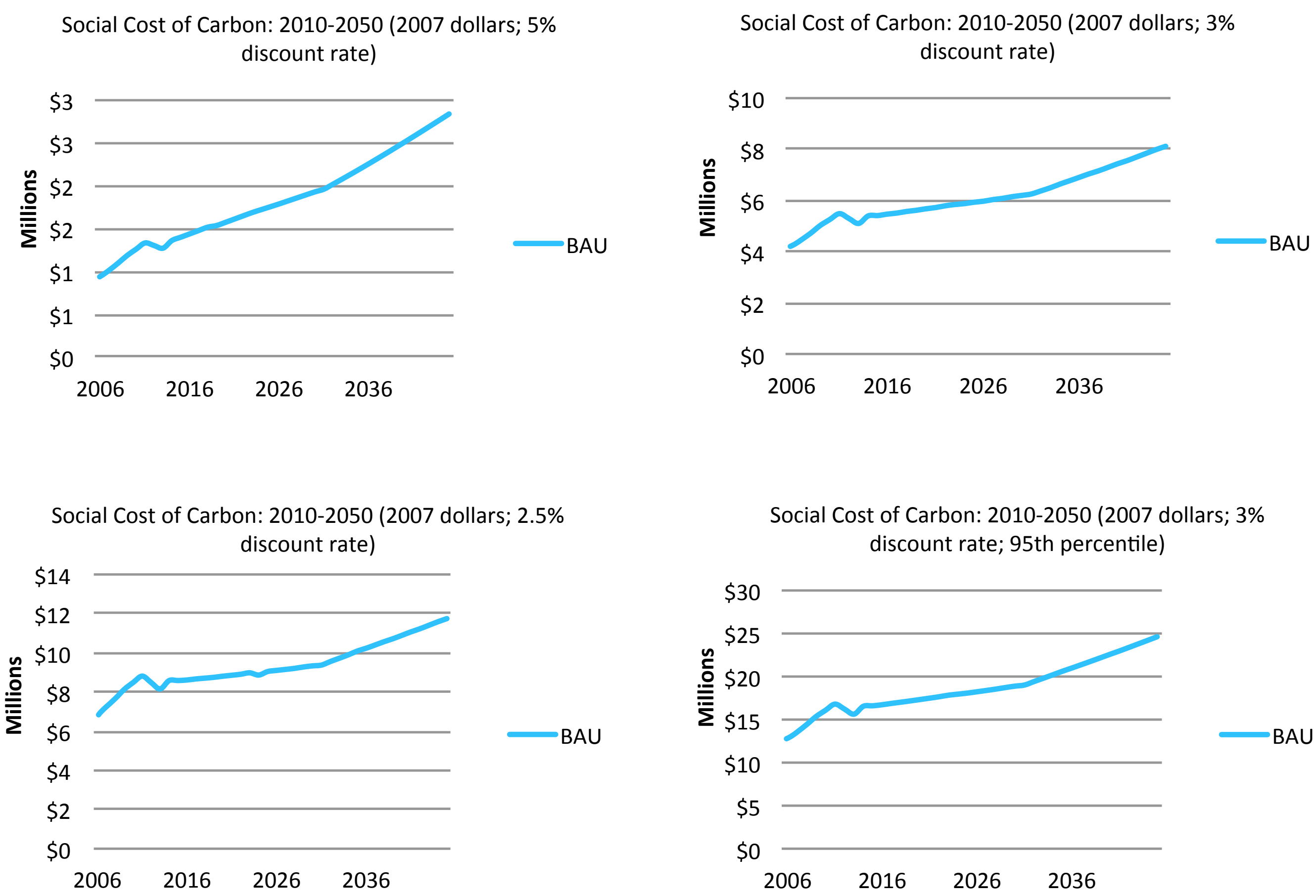


Figure 14. Social Cost of Carbon.

4.1.3 Future modelling work

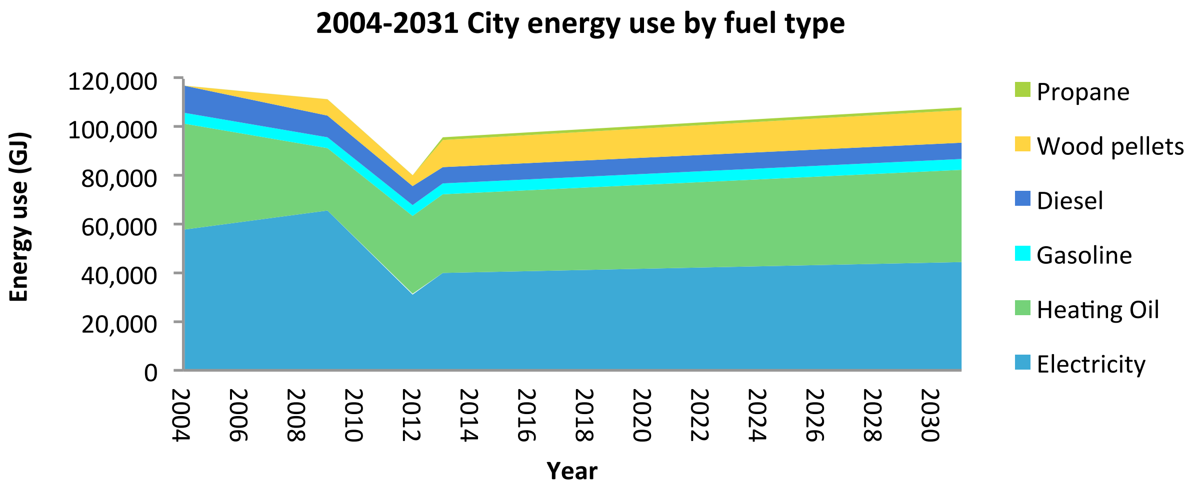
The GHGProof Community model has been provided to the City of Yellowknife to enable exploration of strategies and action against the Business as Usual projection.

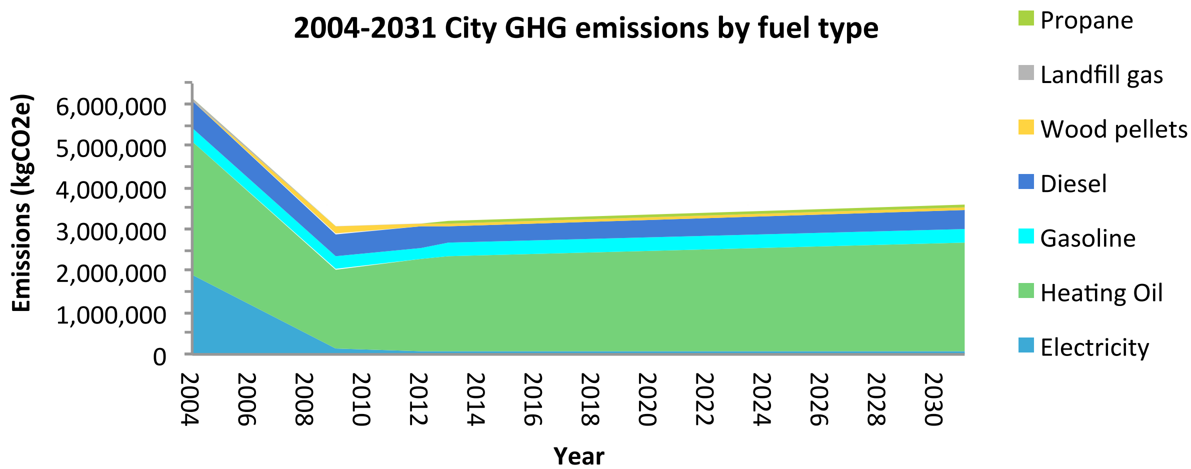
4.2 Corporate Energy and Emissions Inventory

The business as usual forecast to 2031 shows an increase in emissions from approximately 3,200 to 3,600 tons of CO2e. This is based on a slight projected population increase from 20,300 people to 22,850 people in 2031. Actual projections will vary with the change in energy mix for electricity generation, the implementation of energy reductions measures, as well as with infrastructure changes and investments such as the construction of new buildings, roads, and water utilities. Filling in gaps to the corporate inventory's robustness will also alter projections, for example, by tracking actual waste and recycling from corporate activities rather than accounting for this based on staff numbers, and tracking actual fleet vehicle mileage and fuel usage.

Results of the current inventory show that the greatest opportunity for emissions reductions could be realized by mitigating heating oil usage. Projected emissions could be reduced by the continued implementation of a wood pellet heating program, as well as conducting an assessment and undertaking of opportunities for municipal building and water utility station upgrades.

Both energy use and emissions from corporate activities decreased from 2004 to 2013. This was largely due to reductions in electricity usage. Emissions were shown to decrease significantly from 2004 to 2009, however, the emissions factor for electricity generation for that year was not adjusted for the diesel versus hydro energy mix.





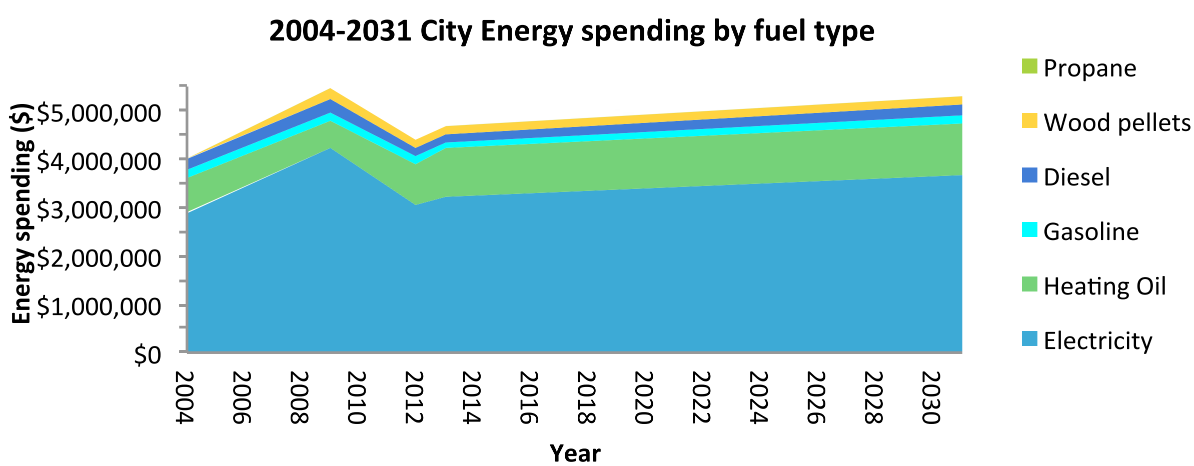


Figure 15. Corporate energy use, emissions and spending by fuel type from 2004 to 2013, and projected onwards to 2031.

Figure 16 and Table 12 show the proportional and aggregate changes in emissions by source for the years 2012 and 2013. Note that the uncertainty for emissions calculations is approximately 8% of the totals for each year. Detailed calculations of these are included in the accompanying GHGProof Corporate model. Previous inventories tracked these exclusively by fuel type and are thus not included for comparison. Buildings and streetlights accounted for the increase in emissions from 2012 to 2013. Figure 16 shows that the most notable emissions increases were seen from Ruth Inch Memorial Pool, the Community Arena, and the Fieldhouse. Also shown is that the Community arena and Ruth Inch Memorial Pool emissions increases were mitigated by increased wood pellet usage at these facilities in 2013, as well as for the Baling Facility and Curling Club. Aggregate corporate emissions for 2013 were approximately 3,200 tCO2e, amounting to a reduction of 48% from 2004 corporate emissions and greatly surpassing its target of a 20% reduction for 2014.

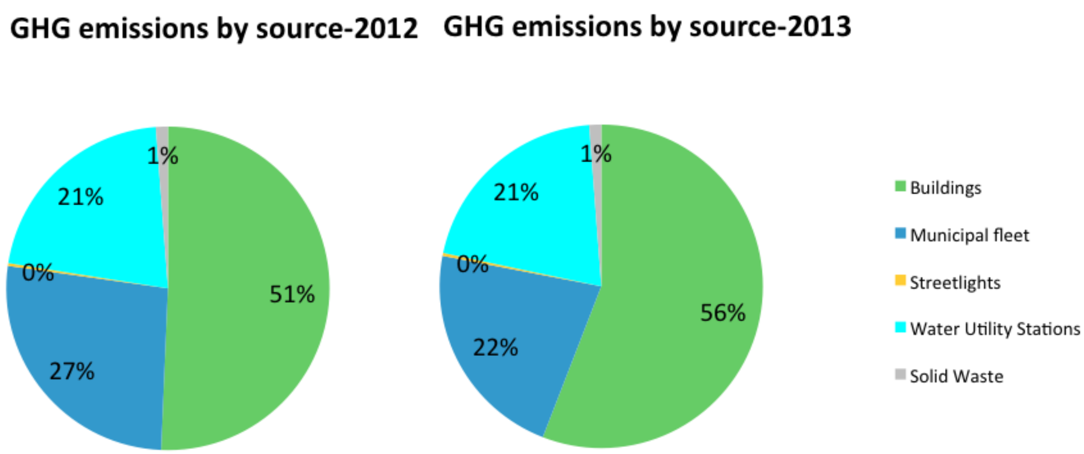
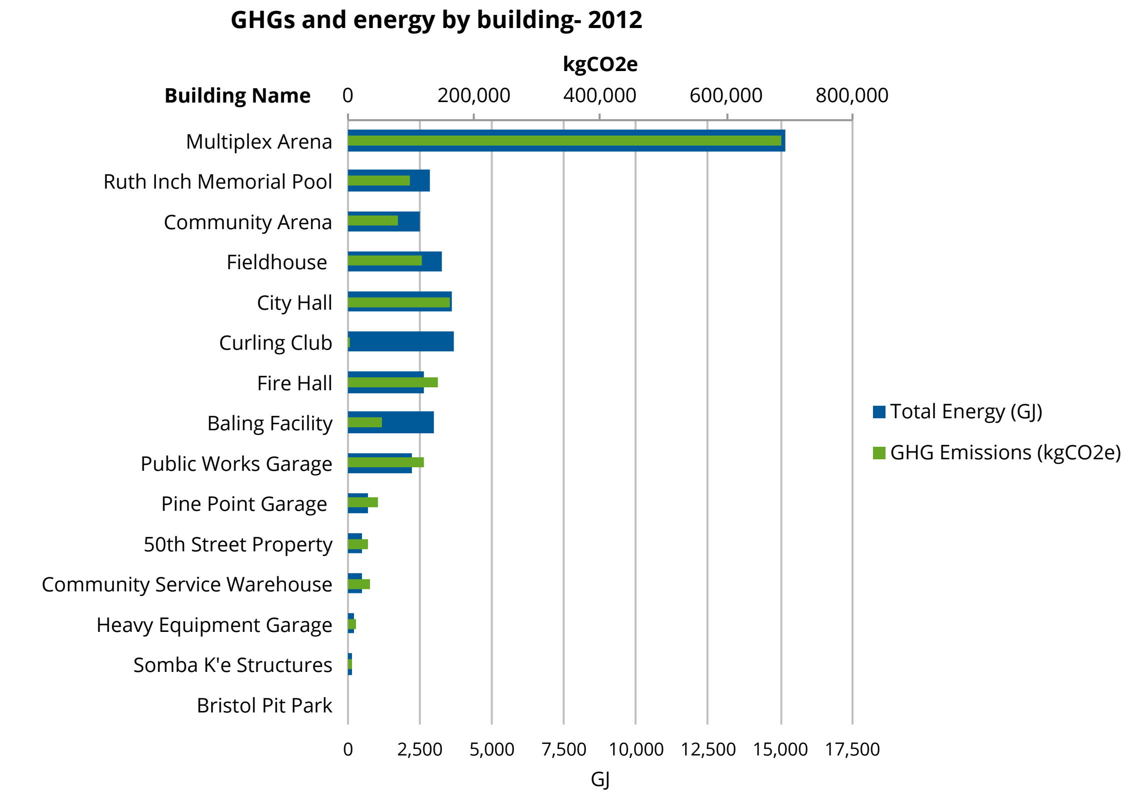


Figure 16. Proportional GHG emissions by source for 2012 and 2013.

Table 12. Aggregate GHG emissions by source for 2012 and 2013

	Annual GHG emissions (kgCO2e)		
Source	**2012**	**2013**	**% change**
Buildings	1,615,836	1,801,968	12
Municipal fleet	834,365	704,638	-16
Streetlights	8,861	9,667	9
Water Utility Stations	678,924	660,548	-3
Solid Waste	37,883	38,071	0
Total	**3,142,679**	**3,184,534**	**1**



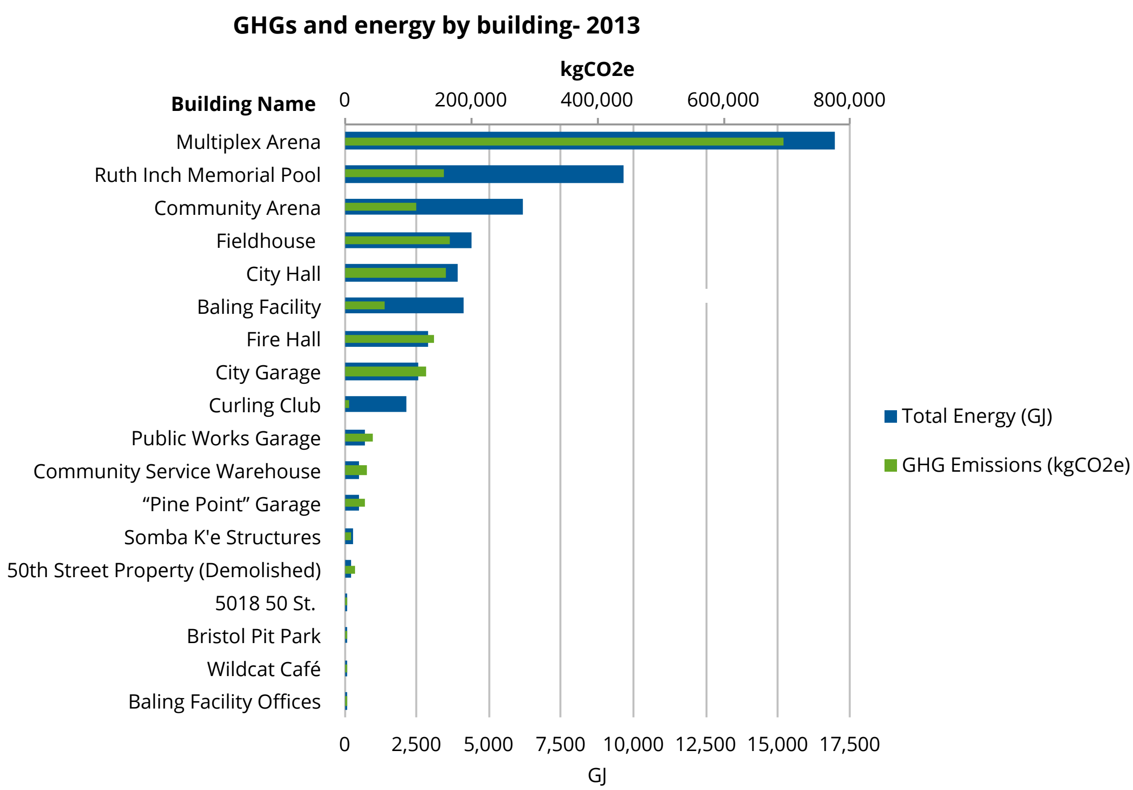


Figure 17. 2012 and 2013 emissions and energy usage by building.

Figure 18 shows the breakdown of fuel usage by source and the emissions, energy, and spending associated with each. Decrease in fleet emissions can be shown from less diesel fuel usage in 2013, whereas an increase in building emissions is observed from greater heating oil demands.

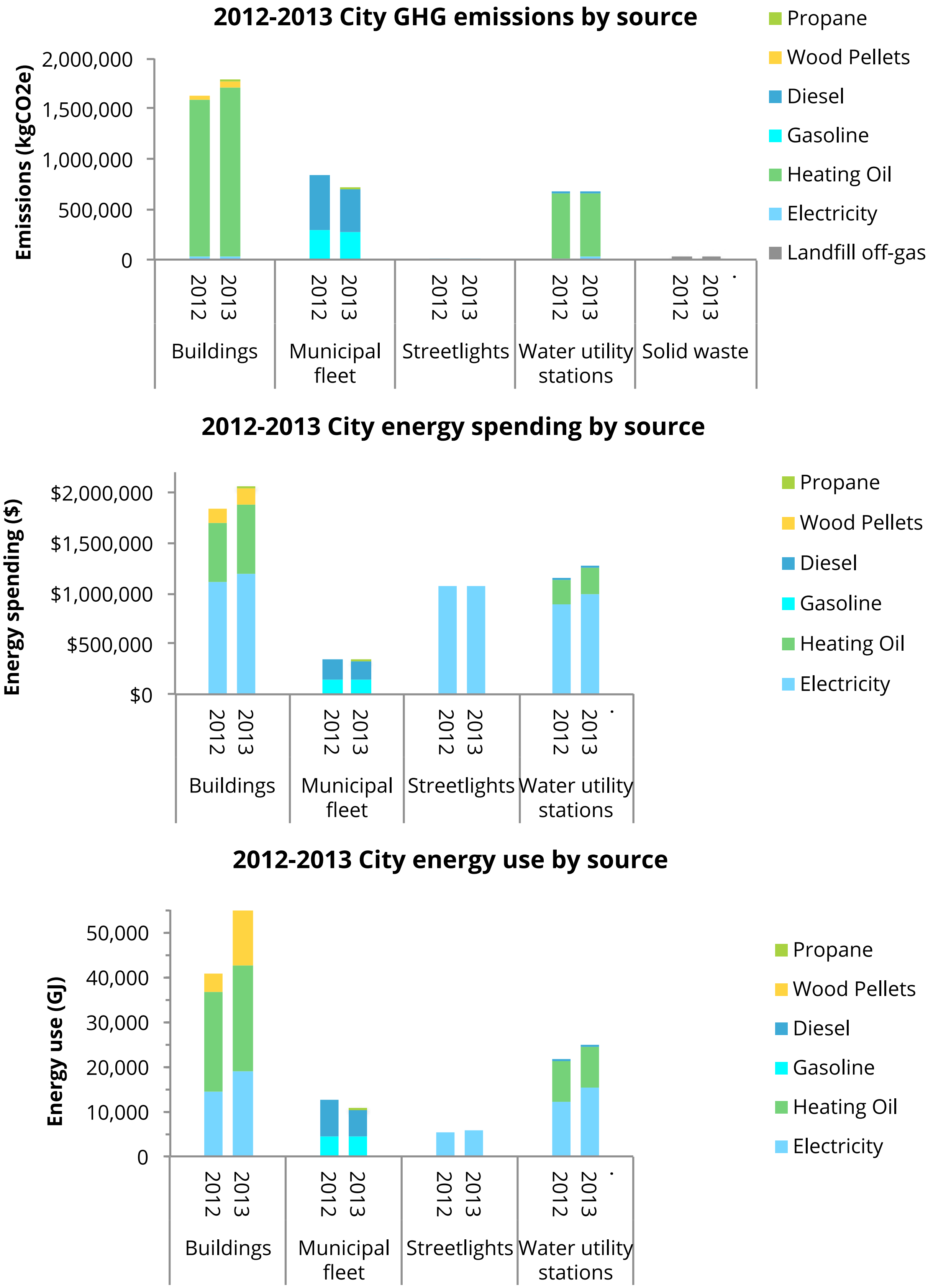
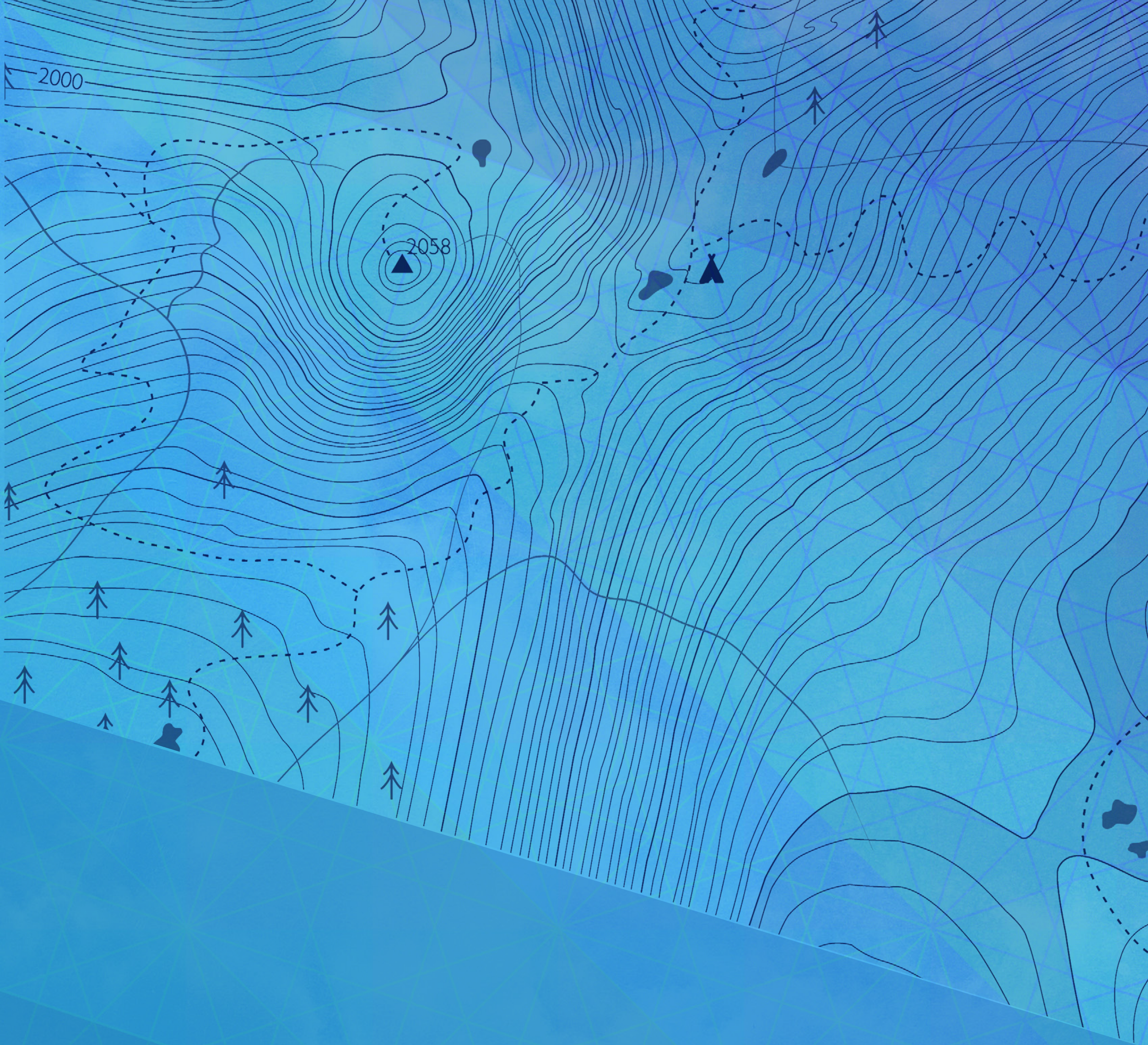


Figure 18. Corporate emissions, energy usage, and spending for 2012 and 2013.



5 Conclusions

This report describes the preparation of a GHG inventory for the community and corporate emissions for calendar year of 2013 according to the GHGProtocol City standards and PCP program respectively. The project involved developing a ground-up GHG and energy model for the City of Yellowknife based on land-use and other assumptions to develop a business as usual scenario.

With a continued focus on fuel-switching, particularly away from heating oil to biomass, total community emissions are likely to continue to fall despite an increasing population. Regulations such as the federal fuel efficiency standards for both private and commercial vehicles will also contribute to this reduction.

However, these reductions are not in line with UN calls for 80%+ reduction of GHG emissions by 2050. The imperative for significant reductions is further enhanced by the extremely high cost of energy and the impact of climate change on the North. Another risk to consider is the issue of energy security, which, for example, can impact the GHG intensity of electricity, when reduced water volumes require increased use of diesel generators, as has occurred in the past.

Finally there is a consideration related to data quality. Due to the considerable uncertainty of data related to transportation-fuel use and energy use for heating buildings, it will continue to be difficult to accurately track GHG emissions and energy use in the future. While GHGProof provides a consistent approach, there are still issues with underlying data uncertainty. Any efforts or strategies that can be undertaken to reduce this data uncertainty will result in clearer guidance to the City moving forward. A collaborative effort with North West Territories focusing on accurate data could help address these gaps. Specifically this could include annual data sharing on the following:

- Number of registered vehicles by vehicle class
- Fuel sales for the City of Yellowknife
- Electricity generation by fuel type
- Electricity consumption by building category
- Energuide audit data for residential and commercial buildings
- Survey of building-related energy consumption and costs by the NWT Bureau of Statistics.

In order to improve its data, the City of Yellowknife should merge GIS and database records for planning and tax purposes to ensure consistent categorization and labelling of buildings and re-assess its floor area and age of building data. An annual transportation survey should be completed to identify mode split, key destinations and average vehicle kilometres travelled.

Appendices

Appendix 1 Community Inventory—Emissions Accounted For

GPC ref No.	Scope	GHG Emissions Source	Inclusion	Data quality		Comments
				Activity data	Emissions factor	
I		**STATIONARY ENERGY SOURCES**				
I.1		**Residential buildings**				
I.1.1	1	Emissions from in-boundary fuel combustion	Yes	Low	High	In addition to the local combustion of heating oil, propane and biomass, electricity generation also occurs within the geographic scope of Yellowknife
I.1.2	2	Emissions from consumption of grid-supplied energy	No			All emissions from electricity are assumed to be within the boundary of the City of Yellowknife.
I.1.3	3	Transmission and distribution losses from grid-supplied energy	Yes	Medium	High	Assumes distribution losses of 4.9%.
I.2		**Commercial and institutional buildings/facilities**				
I.2.1	1	Emissions from in-boundary fuel combustion	Yes	Low	High	See comment for I.1.1
I.2.2	2	Emissions from consumption of grid-supplied energy	N/a			Not relevant
I.2.3	3	Transmission and distribution losses from grid-supplied energy	Yes	Medium	High	Assumes distribution losses of 4.9%.
I.3		**Manufacturing industry and construction**				
I.3.1	1	Emissions from in-boundary fuel combustion	Yes			Included in I.2.1
I.3.2	2	Emissions from consumption of grid-supplied energy	N/a			Not relevant
I.3.3	3	Transmission and distribution losses from grid-supplied energy	Yes			Included in I.2.3
I.4		**Energy industries**				
I.4.1	1	Emissions from in-boundary production of energy used in auxiliary operations	No			No relevant industries were identified.
I.4.2	2	Emissions from consumption of grid-supplied energy	No			No relevant industries were identified.
I.4.3	3	Transmission and distribution losses from grid-supplied energy	No			No relevant industries were identified.
I.4.4	1	Emissions from in-boundary production of grid-supplied energy	Yes			Included in I.1.1 and I.2.1
I.5		**Agriculture, forestry and fishing activities**				
I.5.1	1	Emissions from in-boundary fuel combustion	N/a			There are limited agriculture, forestry and fishing activities within the city boundary
I.5.2	2	Emissions from consumption of grid-supplied energy	N/a			Not relevant
I.5.3	3	Transmission and distribution losses from grid-supplied energy	No			Not relevant
I.6		**Non-specified sources**				
I.6.1	1	Emissions from in-boundary fuel combustion	N/a			Not relevant
I.6.2	2	Emissions from consumption of grid-supplied energy	N/a			Not relevant
I.6.3	3	Transmission and distribution losses from grid-supplied energy	N/a			Not relevant
I.7		**Fugitive emissions from mining, processing, storage, and transportation of coal**				
I.7.1	1	In-boundary fugitive emissions	N/a			There are no mining activities in the city boundary.
I.8		**Fugitive emissions from oil and natural gas systems**				
I.8.1	1	In-boundary fugitive emissions	N/a			There are no oil or gas systems in the city boundary.

Major Sector
Sources required for BASIC reporting
Sources required for BASIC+ reporting
Sources included in Other Scope 3
Sources required for territorial total but not for BASIC/BASIC+ reporting

II		**TRANSPORTATION**				
II.1		**On-road transportation**				
II.1.1	1	Emissions from in-boundary transport	Yes	Medium	Medium	A transportation model was used to develop an activity-based estimate of emissions.
II.1.2	2	Emissions from consumption of grid-supplied energy	N/a			Not relevant
II.1.3	3	Emissions from transboundary journeys	Yes	Medium	Medium	Accounts for trips to Edmonton, assuming that half the households in Yellowknife go once a year and commercial transportation to resupply Yelllowknife as calculated in the validation analysis. Also accounts for trips for community resupply.
II.2		**Railways**				
II.2.1	1	Emissions from in-boundary transport	N/a			There are no railways that service Yellowknife.
II.2.2	2	Emissions from consumption of grid-supplied energy	N/a			Not relevant
II.2.3	3	Emissions from transboundary journeys	N/a			Not relevant
II.3		**Water-borne navigation**				
II.3.1	1	Emissions from in-boundary transport	N/a			There is recreational boat traffic based out of Yellowknife. This was not included in this inventory.
II.3.2	2	Emissions from consumption of grid-supplied energy	N/a			Not relevant
II.3.3	3	Emissions from transboundary journeys	N/a			Not relevant
II.4		**Aviation**				
II.4.1	1	Emissions from in-boundary transport	N/a			There may be some localised air traffic but it is considered negligible.
II.4.2	2	Emissions from consumption of grid-supplied energy	Yes			These emissions are accounted for I.1.1
II.4.3	3	Emissions from transboundary journeys	No			The airport is an important hub for transport of people and goods into and out of Yellowknife. This analysis was not included as data on the movements of Yellowknife residents is not available.
II.5		**Off-road**				
II.5.1	1	Emissions from in-boundary transport	No			There is likely extensive off-road combustion resulting from snowmobile use for example, but no data is available.
II.5.2	2	Emissions from consumption of grid-supplied energy	N/a			Not relevant
III		**WASTE**				
		Solid waste disposal				
III.1.1	1	Emissions from waste generated and treated within the city	Yes	High	High	Methane commitment method was used.
III.1.2	3	Emissions from waste generated within but treated outside of the city	No			Specific waste streams diverted to other locations, particularly for recycling, were not assessed as data is not available.
III.1.3	1	Emissions from waste generated outside the city boundary but treated within the city	No			All emissions from solid waste are accounted for in III.1.1. Some waste+F34 may be from outside the city boundary.
		Biological treatment of waste				
III.2.1	1	Emissions from waste generated and treated within the city	N/a			Not relevant
III.2.2	3	Emissions from waste generated within but treated outside of the city	N/a			Not relevant
III.2.3	1	Emissions from waste generated outside the city boundary but treated within the city	N/a			Not relevant
		Incineration and open burning				
III.3.1	1	Emissions from waste generated and treated within the city	N/a			Not relevant
III.3.2	3	Emissions from waste generated within but treated outside of the city	N/a			Not relevant
III.3.3	1	Emissions from waste generated outside the city boundary but treated within the city	N/a			Not relevant
		Wastewater treatment and discharge				
III.4.1	1	Emissions from wastewater generated and treated within the city	Yes	Low	Low	Liquid waste is treated with a lagoon before being discharged into a series of wetlands.
III.4.2	3	Emissions from wastewater generated within but treated outside of the city	N/a			Not relevant
III.4.3	1	Emissions from wastewater generated outside the city boundary but treated within the city	N/a			Not relevant

IV.1	1	In-boundary emissions from industrial processes	No			Not relevant
IV.2	1	In-boundary emissions from product use	No			Not relevant
V		**Agriculture, Forestry and Land Use (AFOLU)**				
V.1	1	In-boundary emissions from livestock	Yes	Low	Low	There is essentially no farming activity within the city boundary.
V.1	1	In-boundary emissions from land	Yes	High	Medium	Sequestration and release of emissions are calcuated for the forest cover within the boundary of Yellowknife. Soils and land-use change were not calculated.
V.1	1	In-boundary emissions from other agriculture	No			Not relevant
VI		**Other indirect emissions**				
VI.1	3	Other indirect emissions	Yes	Low	Low	These emissions are the result of transportation of food to Yellowknife from other parts of the world.

Major Sector
Sources required for BASIC reporting
Sources required for BASIC+ reporting
Sources included in Other Scope 3
Sources required for territorial total but not for BASIC/BASIC+ reporting

Appendix 2 Corporate Inventory—Emissions accounted for

Input Category	*Data*	*Data provided by*	*Data format*	*Limitations/ Comments*
Buildings	Energy usage and spending	City of Yellowknife	Spreadsheet showing monthly kWh used per building, and actual price paid by the City for electricity.	
	Fuel usage and spending	City of Yellowknife	Spreadsheet showing monthly diesel, heating oil, and propane litres per building and actual price paid by the City for fuel.	Propane records were only found for Sept-Dec for 2013. In cases where actual fuel quantities used were not provided (but cost was), fuel quantities were calculated based on costs and fuel used from other entries (Community Arena, Curling Club, and Somba K'e Park).
	Wood pellet use and spending	City of Yellowknife	Spreadsheet of monthly usage of wood pellets (kg) and actual price paid by the City for wood pellets.	2012 data from January-June was provided in hundreds of Heating Oil Equivalents rather than kg. Conversion to kg was made by multiplying these values by 100 x 28,000 BTU/HOE x 1/947.82 MJ/BTU x 0.07 kg/MJ x 94% burner efficiency. Pellet usage for 2012 was noted to be lower due to the pellet boiler being down for repairs.
Municipal fleet	Gas and Diesel use and spending	City of Yellowknife	Spreadsheet of monthly usage of gas and diesel (l) and actual price paid by the City for gas and diesel.	Data was recorded by cardlock accounts and not by individual vehicle fuel usage. Categories of usage were assigned to cardlocks based on the vehicles that would typically use them, which were provided by the City, to estimate the fuel used for the various vehicle-related corporate activities (i.e. Fire department, roads and traffic operations, etc.). It is recommended (and required) for future inventories to record individual vehicle fuel usage in order to provide an accurate account of corporate vehicle emissions, operations, and opportunities to increase efficiencies. Waste collection and transportation fuel usage was not included, since this was contracted out to a private company, Kavanaugh Waste Management.
Streetlights	Electricity use and spending	City of Yellowknife	Spreadsheet of monthly kWh for streetlights, traffic lights, park and public space lighting, and actual price paid by the City for electricity.	
Waste	Amount generated from municipal operations	City of Yellowknife	Number of municipal staff for 2012 and 2013.	Amount of 80 kg per employee was used to determine municipal waste generation, based on a Canada Government Office Waste Survey. Recommendations for more accurate results include recording actual waste generated from municipal offices, or conducting an inventory of the size and number of waste collection bins and multiplying these by collection frequency.
Water utilities	Electricity, diesel, and heating oil usage and spending	City of Yellowknife	Spreadsheets provided by the city of monthly usage of electricity, diesel, and heating oil for lift stations, pumps, and pumphouses.	Does not include wastewater treatment plant.

Appendix 3 Community Inventory—Data and assumptions

Start year	2006		
Population			
2000	17,415	#	2006 City of Yellowknife Energy and Emissions Inventory
2001	17,772	#	Yellowknife Statistical Profile
2004	19,056	#	2006 City of Yellowknife Energy and Emissions Inventory
2006	19,522	#	Yellowknife Statistical Profile
2009	19,861	#	2009 Energy Inventory Update
2011	19,888	#	NWT Population projections
2016	20,488	#	NWT Population projections
2021	21,160	#	NWT Population projections
2026	21,839	#	NWT Population projections
2031	22,667	#	NWT Population projections
Household numbers			
2001	5,795	#	2001 Statistics Canada Census
2006	6,630	#	2006 Statistics Canada Census
2011	6,935	#	2011 Statistics Canada Census
2031	9,970	#	Projected outwards
Employment			
2011-2021	2,351	#	General Plan Employment Projections
2011-2031 additional trips	65,000	#	Calculated in trip generation spreadsheet
Transportation			
Total trips, daily	87,100	#	Smart Growth Development Plan Transportation Improvement Study, pg 76, assuming a 10% factor, see 2.1 in https://www.fhwa.dot.gov/planning/tmip/publications/other_reports/tod_modeling_procedures/ch02.cfm
Vehicles/capita			
2011	0.74	#/capita	NWT traffic collisiion report 2012
2012	0.80	#/capita	NWT traffic collisiion report 2012
2031	0.80	#/capita	Estimate
Vehicle mix			
Small passenger cars	15%		Estimate
Large passenger cars	15%		Estimate
Light trucks, vans and SUVs	70%		Estimate
VKT, Canadian average	16,443	VKT/vehicle	Transportation in Canada, 2013, pg. 23
Idling, 2011			
% of cars that idle	75%	%	Estimate
Hours/day	1	#	Estimate
Days/year	273.75	#	Estimate
Litres/hour	1	L/hour	CEP Action Areas Study: City of Yellowknife Fleet Review, pg. 22
Idling, 2031			
% of cars that idle	75%	%	Estimate
Hours/day	1	#	Estimate
Days/year	273.75	#	Estimate
Litres/hour	1	L/hour	CEP Action Areas Study: City of Yellowknife Fleet Review, pg. 22
# of dwellings, 2011			
500 m from CBD	249	#	GIS
1000 m from CBD	1164	#	GIS
500 m from transit	500	#	GIS
# of dwellings, 2031			
500 m from CBD	1498	#	GIS
1000 m from CBD	4464	#	GIS
500 m from transit	900	#	GIS
Passenger km			
2010	23,158	Passenger km/capita	Assessing emissions reductions from potential policies
2015	24,503	Passenger km/capita	Ibid
2020	26,030	Passenger km/capita	Ibid
2025	28,042	Passenger km/capita	Ibid
2030	29,917	Passenger km/capita	Ibid
Mode split, 2006			
Vehicles	81%		Smart Growth Development Plan Transportation Improvement Study Model Techno Memo, pg 20
Transit	1%		Ibid
Cycle	1%		Ibid
Other	4%		Ibid
Walk	13%		Ibid
Mode split, 2031			
Vehicles	82%		Smart Growth Development Plan Transportation Improvement Study Model Techno Memo, pg 20
Transit	4%		Ibid
Cycle	2%		Ibid
Other	3%		Ibid
Walk	9%		Ibid
Destinations, baseline			
D1	3,500	m	GIS analysis
D2	2,900	m	Ibid
D3	2,600	m	Ibid
D4	2,900	m	Ibid
D5	3,800	m	Ibid
D6	3,500	m	Ibid
D7	3,400	m	Ibid
D8	3,200	m	Ibid
Edmonton trips			
Distance	1,497	km	Google maps
Trips per year per household	1	#	Estimated

Destinations, BAU				
D1	3,100	m		GIS analysis
D2	2,500	m		Ibid
D3	2,600	m		Ibid
D4	2,500	m		Ibid
D5	3,300	m		Ibid
D6	2,900	m		Ibid
D7	2,900	m		Ibid
D8	2,700	m		Ibid
D-BO-1	4,400	m		Ibid
D-BO-2	3,700	m		Ibid
D-BO-3	2,900	m		Ibid
D-BO-4	3,100	m		Ibid
Edmonton	1,497,000	m		Google maps
Destinations, baseline trips				
D1	5,121	#		GIS analysis
D2	39,255	#		Ibid
D3	2,861	#		Ibid
D4	3,739	#		Ibid
D5	1,370	#		Ibid
D6	6,653	#		Ibid
D7	2,884	#		Ibid
D8	14,849	#		Ibid
Edmonton	-	#		Estimated, half the households go once per year
Destinations, weighed allocation of additional trips, 2(	%			
D1	8%			Estimated
D2	39%			Ibid
D3	4%			Ibid
D4	5%			Ibid
D5	8%			Ibid
D6	9%			Ibid
D7	7%			Ibid
D8	13%			Ibid
D-BO-1	2%			Ibid
D-BO-2	2%			Ibid
D-BO-3	2%			Ibid
D-BO-4	1%			Ibid
Edmonton	-	#		Estimated, half the households go once per year
Total fuel sales for NWT	*Gas*	*Diesel*		
2009	38,149	50,197	klitres	Statistics Canada Sales of Fuel Used for Road Vehicles
2010	42,959	55,958	klitres	Ibid
2011	42,415	63,585	klitres	Ibid
2012	40,751	60,227	klitres	Ibid
2013	39,618	52,852	klitres	Ibid
NWT population		*Yellowknife population factor*		
2009	43,149	0.46		Stats NWT
2010	43,278	0.46		Ibid
2011	43,501	0.46		Ibid
2012	43,639	0.46		Ibid
2013	43,841	0.46		Ibid
Fuel consumption				
	1.39	km/l		
Gasoline	18,769,839	Litres		Calculated from above
Diesel	26,035,682	Litres		Calculated from above
Gasoline share				
Residential, 2031	80%			Estimate
Commercial, 2031	22%			Estimate
Commercial				
Commercial portion of gas	25%	%		Estimate
Commercial portion of diesel	80%	%		Estimate
Per capita gas, 2031		klitres/capita		Estimate
Per capita gas, 2031		klitres/capita		Estimate
Fuel cost, 2011		$		Statistics Canada
Fuel cost escalation	101%	%/year		Assumption
Emissions factors				
Gasoline, 2006	2.50	kgCO2e/L		Environment Canada National Inventory Report 1990-2011 Greenhouse Gas Sources and Sinks in Canada
Gasoline, 2050	1.92	kgCO2e/L		Estimate
Diesel, 2006	2.70	kgCO2e/L		Environment Canada National Inventory Report 1990-2012 Greenhouse Gas Sources and Sinks in Canada, Light duty diesel vehciles
Diesel, 2050	2.70	kgCO2e/L		Ibid
Annual vehicle replacement	4%	%		Vehicle scrappage in Canada
2016 Fuel efficiency regulation	9.54	km/l		EPA Regulations and Standards for 2016
2025 Fuel efficiency regulation	15.15	km/l		EPA Regulations and Standards for 2025
% of trips within 400 m, 2006	24%	%		Access to destinations: How close is close enough?
% of trips within 400 m, 2030	24%	%		Estimate
% of 400m trips willing to walk, 2006	21%	%		Trends in walking for transportation in the United States, 1995 and 2001
% of 400m trips willing to walk, 2030	21%	%		Estimate
% of trips within 1000 m, 2006	24%	%		Access to destinations: How close is close enough?
% of trips within 1000 m, 2030	24%	%		Estimate
% of 1000m trips willing to cycle, 2006	21%	%		Ibid
% of 1000m trips willing to cycle, 2030	21%	%		Estimate
% of trips shifted to transit if <400m, 2006	15%	%		Quantifying Greenhouse Gas Emissions Mitigation Measures
% of trips shifted to transit if <400m, 2030	15%	%		Estimate
Transit efficiency, 2006	45.0	passenger km/L		A cost comparison of transportation modes
Transit efficiency, 2030	45.0	passenger km/L		Estimate
Transit emissions factor, 2006	1.7	kgCO2e/km		Getting to Carbon Neutral: A guide for Canadian Municipalities; assumes diesel buses

Transit emissions factor, 2030	1.7	kgCO2e/km		Estimate
Transit cost	0.5	$/passenger km		A cost comparison of transportation modes
Community resupply				
Total NWT for community resupply, 2009	163,000	tons		Northern Transport Systems Discussion Paper
Proportion for Yellowknife	75,027	tons	3.78	Calculated from above
Per capita total, 2031	3.5	t/capita		Estimate
Tons/truck	28.0	t/truck		Estimate
Emissions, 2006	1.020	kgCO2e/km		Calculated in the validation analysis
Emissions, 2031	1.000	kgCO2e/km		Estimated
Air traffic				
Airplane passenger traffic, 2010, Yellowknife	463,936	#		Northern Transport Systems Discussion Paper

Buildings

Emissions factors			
Electricity			
2000	125.0	kgCO2e/GJ	Environment Canada National Inventory Report 1990-2012 Greenhouse Gas Sources and Sinks in Canada
2005	136.1	kgCO2e/GJ	Ibid
2008	116.7	kgCO2e/GJ	Ibid
2009	111.1	kgCO2e/GJ	Ibid
2010	111.1	kgCO2e/GJ	Ibid
2011	94.4	kgCO2e/GJ	Ibid
2012	94.4	kgCO2e/GJ	Ibid
2050	30.0	kgCO2e/GJ	Estimate
Energy use			
Residential			
2006			
Electricity	208,754	GJ	2006 Yellowknife GHG inventory (for the year of 2004)
Fuel oil	309,683	GJ	Calculated using the proportion of electricity with NRCAN residential energy mix for NWT
Propane	41,375	GJ	Calculated using the proportion of electricity with NRCAN residential energy mix for NWT
Biomass	67,077	GJ	Calculated using the proportion of electricity with NRCAN residential energy mix for NWT
2009			
Electricity	203,612	GJ	2009 Yellowknife Inventory
Fuel oil	317,878	GJ	Calculated using the proportion of electricity with NRCAN residential energy mix for NWT
Propane	26,135	GJ	Calculated using the proportion of electricity with NRCAN residential energy mix for NWT
Biomass	60,172	GJ	Calculated using the proportion of electricity with NRCAN residential energy mix for NWT
2011			
Electricity	202,727	GJ	Northland Utilities
Fuel oil	285,606	GJ	Calculated using the proportion of electricity with NRCAN residential energy mix for NWT
Propane	42,930	GJ	Calculated using the proportion of electricity with NRCAN residential energy mix for NWT
Biomass	64,992	GJ	Calculated using the proportion of electricity with NRCAN residential energy mix for NWT
2012			
Electricity	197,143	GJ	Ibid
2013			
Electricity	199,789	GJ	Ibid
Commercial			
2011			
Electricity	367,409	GJ	Northland Utilities
2012			
Electricity	368,597	GJ	Ibid
2013			
Electricity	365,630	GJ	Ibid
Distribution losses, 2006	4.9%	%	Atco Utilities Board Submission
Distribution losses, 2031	4.5%	%	Estimate
Natural gas	64.2	kgCO2e/GJ	Environment Canada National Inventory Report 1990-2012 Greenhouse Gas Sources and Sinks in Canada
Heating Oil	70.3	kgCO2e/GJ	Environment Canada National Inventory Report 1990-2012 Greenhouse Gas Sources and Sinks in Canada
Propane	65.1	kgCO2e/GJ	Environment Canada National Inventory Report 1990-2012 Greenhouse Gas Sources and Sinks in Canada
Wood	0.0	kgCO2e/GJ	Considered biogenic source of energy
Cost of energy, 2006			
Electricity	65.9	$/GJ	Northland Utilities
Natural gas	19.3	$/GJ	Arctic Energy Alliance Brochure
Heating Oil	31.0	$/GJ	Energy North Presentation
Propane	29.3	$/GJ	Arctic Energy Alliance Brochure
Wood	10.0	$/GJ	Energy North Presentation
Cost of energy, 2050			
Electricity	$85	$/GJ	Assumption
Natural gas	$30	$/GJ	Ibid
Heating oil	$45	$/GJ	Ibid
Propane	$45	$/GJ	Ibid
Wood	$20	$/GJ	Ibid

Residential

Fuel Mix, 2011		
Electricity	33%	Comprehensive Energy Use Database Table
Natural gas	0%	
Heating oil	49%	
Propane	7%	
Biomass	11%	
Fuel Mix, 2009		
Electricity	34%	Comprehensive Energy Use Database Table
Natural gas	0%	
Heating oil	52%	
Propane	4%	
Biomass	10%	
Fuel Mix, 2011		
Electricity	34%	Comprehensive Energy Use Database Table
Natural gas	0%	Ibid

Heating oil	48%			Ibid
Propane	7%			Ibid
Biomass	11%			Ibid
Fuel Mix, 2050				
Electricity	40%			Estimate
Natural gas	0%			
Heating oil	1%			
Propane	1%			
Biomass	58%			
Detached				
2006	3,255	#	6,630	2006 Census
2011	3,560	#		2011 Census
Attached				
2006	1,220	#		2006 Census
2011	1,440	#		2011 Census
Apartments ≤ 5 stories				
2006	1,524.90	#		2006 Census
2011	1,755	#		2011 Census
Apartments > 5 stories				
2006	418	#		2006 Census
2011	150	#		2011 Census
Mobile homes				
2006	212	#		2006 Census
2011	35	#		2011 Census
Dwelling mix, 2006				
Detached	49%			2006 Census
Attached	18.4%			2006 Census
Apartments ≤ 5 stories	23%			2006 Census
Apartments > 5 stories	6.3%			2006 Census
Mobile homes	3.2%			2006 Census
Dwelling mix, 2011				
Detached	51%			2011 Census
Attached	21%			2011 Census
Apartments ≤ 5 stories	23%			2011 Census
Apartments > 5 stories	2%			2011 Census
Mobile homes	1%			2011 Census
Dwelling mix, 2031				
Detached	39%			Estimate
Attached	24%			Estimate
Apartments ≤ 5 stories	25%			Estimate
Apartments > 5 stories	8%			Estimate
Mobile homes	4%			Estimate
Detached				
2006	0.74	GJ/m2		Comprehensive Energy Use Database- Territories Table 34
2007	0.79	GJ/m2		Ibid
2008	0.81	GJ/m2		Ibid
2009	0.70	GJ/m2		Ibid
2010	0.61	GJ/m2		Ibid
2011	0.61	GJ/m2		Ibid
Average size	189.7	m2		Ibid
Average size, 2031	120.0	m2		Estimated
Attached				
2006	0.72	GJ/m2		Comprehensive Energy Use Database- Territories Table 36
2007	0.77	GJ/m2		Ibid
2008	0.80	GJ/m2		Ibid
2009	0.71	GJ/m2		Ibid
2010	0.63	GJ/m2		Ibid
2011	0.62	GJ/m2		Ibid
Average size	125.0	m2		Ibid
Average size, 2031	100.0	m2		Estimated
Apartments ≤ 5 stories				
2006	0.55	GJ/m2		Comprehensive Energy Use Database- Territories Table 38
2007	0.59	GJ/m2		Ibid
2008	0.60	GJ/m2		Ibid
2009	0.54	GJ/m2		Ibid
2010	0.49	GJ/m2		Ibid
2011	0.49	GJ/m2		Ibid
Average size	107.7	m2		Ibid
Average size, 2031	100.0	m2		Estimated
Apartments > 5 stories				
2006	0.55	GJ/m2		Comprehensive Energy Use Database- Territories Table 38
2007	0.59	GJ/m2		Ibid
2008	0.60	GJ/m2		Ibid
2009	0.54	GJ/m2		Ibid
2010	0.49	GJ/m2		Ibid
2011	0.49	GJ/m2		Ibid
Average size	107.7	m2		Ibid
Average size, 2031	100.0	m2		Estimated
Mobile homes				
2006	0.99	GJ/m2		Comprehensive Energy Use Database- Territories Table 40
2007	1.08	GJ/m2		Ibid
2008	1.12	GJ/m2		Ibid
2009	0.99	GJ/m2		Ibid
2010	0.87	GJ/m2		Ibid
2011	0.87	GJ/m2		Ibid
Average size	97.0	m2		Ibid

	Average size, 2031	100.0	m2		Estimate
Energy reduction for new buildings, 2011 onwards					
	2012	25%	%		Energy efficiency requirements in building codes, energy efficiency policies for new buildings
	2050	30%	%		Estimate
% of existing buildings upgraded per year					
	2012	1%	%		Estimate
	2050	2%	%		Estimate
Energy savings in existing buildings					
	2012	10%	%		Estimate
	2050	12%	%		Estimate
Commercial buildings					
Energy consumption, 2006					
	Electricity	238,077	GJ	45%	2006 Yellowknife GHG Inventory
Fuel Mix, 2006					
	Electricity	25%	%		
	Natural gas	0%	%		
	Heating oil	67%	%		
	Propane	8%	%		
	Biomass	0%	%		
Energy consumption, 2009					
	Electricity	356,580	GJ	45%	2009 Yellowknife GHG Inventory
Fuel Mix, 2009					
	Electricity	25%	%		
	Natural gas	0%	%		
	Heating oil	65%	%		
	Propane	8%	%		
	Biomass	2%	%		
Energy consumption, 2011					
	Electricity	367,409	GJ	45%	Northwest Power
Fuel mix, 2011					
	Electricity	25%	%		
	Natural gas	0%	%		Estimate
	Heating oil	59%	%		Estimate
	Propane	8%	%		Estimate
	Biomass	8%	%		Estimate
Fuel Mix, 2031					
	Electricity	45%	%		Estimate
	Natural gas	0%	%		Estimate
	Heating oil	7%	%		Estimate
	Propane	8%	%		Estimate
	Biomass	40%	%		Estimate
Floor space					
	Total, 2006	366,695	m2		2006 Yellowknife GHG Inventory
	Total, 2011	528,832	m2		Floor space worksheet- GIS
	Total, 2031	595,540	m2		Calculated on a per capita basis
	Energy/area	1.5	GJ/m2/yr		BOMA BEST Energy and Environment Report
Energy savings from new build					
	2012	5%	%		Estimate
	2031	15%	%		Estimate
% of existing buildings upgraded, commercial/year					
	2012	1%	%		Estimate
	2049	2%	%		Estimate
Energy savings in existing commercial buildings/year					
	2006	5%	%		Estimate
	2049	7%	%		Estimate
Community energy					
District energy in the future BAU		Yes			
Threshold		50.0	kWh/m2/yr		District heating distribution in areas with low heat demand density
Energy savings from DE					
	2006	50%	%		The Con Mine as a Heat Resource, pg. 59
	2049	60%	%		Estimate
District energy, 2006					
	Detached	10.0	#		GIS
	Row	10.0	#		GIS
	Apartments <5	10.0	#		GIS
	Apartments>5	10.0	#		GIS
Year district energy is introducted		2025			
District energy, 2031					
	Detached	243.0	#		GIS
	Row	12.0	#		GIS
	Apartments <5	12.0	#		GIS
	Apartments>5	12.0	#		GIS
Waste					
Emissions factor, solid waste		1,645.1	kgCO2e/t		Environment Canada National Inventory Report 1990-2011 Greenhouse Gas Sources and Sinks in Canada
Landfill gas capture		55%	%		Landfill Gas Management Facilities Design Guidelines
Year landfill gas is installed		2,025.0			
Solid waste					
	2010	58,477.6	tonnes		2013 Feasibility Study- Collection and utilisation of biomass
	2011	41,459.0	tonnes		2011 Waste and Recycling Material Report
	2012	25,700.0	tonnes		2012 Waste and Recycling Material Report
	2013	76,803.4	tonnes		2013 Waste and Recycling Material Report
	2013	1,910,094.4	$		2013 Waste and Recycling Material Report

2031	41,459.0	tonnes	Estimate
Diversion rate 2010			
BAU, 2011	4.5%	%	2013 Waste and Recycling Material Report
BAU, 2031	12%	%	Estimate
Liquid waste			
2012	4,438,069	m3	Liquid and Humid Organic Waste Utilization Study
Emissions factor, liquid waste, tertiary	123.2	kgCO2e/capita	2006 IPCC Guidelines for National Greenhouse Gas Inventories
Emissions factor, liquid waste, secondary	123.0	kgCO2e/capita	Ibid
Emissions factor, liquid waste, primary	123.0	kgCO2e/capita	Ibid
Emissions factor, liquid waste, septic	205.0	kgCO2e/capita	Ibid

Food miles

Include food miles	Yes		
Country food (50% or more)	10.7	% of families	Yellowknife Statistical Profile
Emissions factor, imported food	3.6	kgCo2e/kg	Fighting Global Warming at the Farmers Market
Emissions factor, local food	0.1	kgCo2e/kg	Ibid
Land/person	0.2	ha	BC's Food Self- Reliance
Weight of food/year	580.4	kg	Ibid

Agriculture

2011			
People local food	80%	%	Agricultural Census
Portion of food local	30%	%	Ibid
Agricultural land- perennial cover	1.0	#	Ibid
Agricultural land- till	1.0	#	Ibid
Agriculture no-till	1.0	#	Ibid
Beef and heifer cows	1.0	#	Ibid
Dairy cows	1.0	#	
2031			
People local food	90%	%	Estimate
Portion of food local	50%	%	Estimate
Agricultural land- perennial cover	1.0	#	Estimate
Agricultural land- till	1.0	#	Estimate
Agriculture no-till	1.0	#	Estimate
Beef and heifer cows	1.0	#	Estimate
Dairy cows	1.0	#	Estimate
Emissions factor, perennials	0.3	tCO2e/ha	2006 IPCC Guidelines for National Greenhouse Gas Inventories
Emissions factor, till	1.2	tCO2e/ha	2006 IPCC Guidelines for National Greenhouse Gas Inventories
Emissions factor, no-till	2.0	tCO2e/ha	2006 IPCC Guidelines for National Greenhouse Gas Inventories
Emissions factor, beef	1.8	tCO2e/head	Environment Canada National Inventory Report 1990-2011 Greenhouse Gas Sources and Sinks in Canada
Emissions factor, dairy	2.7	tCO2e/head	Ibid

Forest

Area, 2006	3,990.0	ha	Smart Growth Plan, Natural areas, assumes 38% forest cover	
Area, 2031	3,990.0	ha	Estimate	
Harvesting, 2006	1.0	m3		
Harvesting, 2031	1.0	m3	28980	28980
Firewood, 2006	2,000.0	m3		
Firewood, 2031	3,000.0	m3		
Absorption	9.2	tCO2e/ha	IPCC	
Emissions factor, soil	3.7	tCO2e/ha	IPCC	
Emissions, proportion	33%	tCO2e/m3	Future carbon storage in harvested wood products from Ontario's Crown forests	
Emissions factor, fuel removal	0.0	tCO2e/m3	2006 IPCC Guidelines for National Greenhouse Gas Inventories	

Economic variables

Social cost of carbon	$ 150.00	$/tCO2e	OECD Social Cost of Carbon
Carbon tax	N/A	$/tCO2e	
Renewable energy investment cost	$ 3,567.00	$/GJ	Distributed generation renewable energy estimate of costs
Residential retrofit costs	$ 10.00	$/GJ	Energy savings and economics of retrofitting single-family buildings
Commercial retrofit costs	$ 7.00	$/GJ	Energy Management Action Plan for Langara College
District energy investment costs	$ 5,528.00	$/GJ	Distributed generation renewable energy estimate of costs
Recycling-investment	$ 50.00	$/tonne	Green Communities Carbon Neutral Framework: Option 1: Household Organic Waste Composting.
Landfill gas	$ 10.00	$/tCO2e	Cost estimation model for implementing GHG emission reduction rpojects at landfills in BC
Liquid waste upgrade	$ 400.00	$/household	Affordability of wastewater treatment services in Canada
Local food consumption	$ 15,000.00	$/ha	Estimated
Agricultural practices change	$ 6.00	$/ha	Zero tillage: a greener way for Canadian farms.
Reforestation	$ 3,000.00	$/ha	The Carbon sequestration potential from afforestation in Ontario

Employment

	Direct	Indirect	Induced	
Densification	2.2	0.0	0.0	Employment effects of brownfield redevelopment
Residential retrofit costs	4.6	4.9	3.8	Climate justice, green jobs and sustainable production in BC
Comme	7.0	4.9	4.8	Ibid
Renewable energy	4.6	4.9	3.8	Ibid
Recycling-investment	6.7	3.5	3.2	Ibid
Landfill gas	6.7	3.5	3.2	Ibid
Liquid waste upgrade	6.7	3.5	3.2	Ibid
Local food consumption	0.5	0.0	0.0	Assumption
Reforestation	0.1	0.0	0.0	Assumption

Appendix 4 Corporate Inventory—Data and Assumptions

Data	*Assumption*	*Unit*	*Source*
Electricity	0.0036	GJ/kWh	Conversion factor
Electricity	0.006	kgCO2e/kWh	Electrical utility- calculated using % diesel versus hydro provision: 1.765587 kgCO2e/GJ (see community inventory for further details).
Electricity	4.8	% Distribution loss	Atco Utilities Board Submission, Distribution losses for 2006 are indicated by the source to be 4.9%. It was then estimated that these would reduce to 4.5% by 2031, and the rates for the years between were calculated accordingly.
Heating oil	0.0388	GJ/L	2014 BC Best Practices for Quantifying Greenhouse Gas Emissions
Heating oil	70.300	kgCO2e/GJ	ibid
Diesel	0.0383	GJ/L	ibid
Diesel	72.700	kgCO2e/GJ	Ibid
Propane	1.54	kgCO2e/L	ibid
Propane	0.0253	GJ/L	ibid
Propane	65.100	kgCO2e/GJ	ibid
Gasoline	0.035	GJ/L	ibid
Gasoline – Light duty car	2.227	kgCO2e/L	ibid
Diesel –Light duty truck	2.653	kgCO2e/L	ibid
City Staff			http://www.yellowknife.ca/en/city-government/resources/budget/2015_draft_budget/8_staffing_summary.pdf
Solid waste	80.000	kg/person	http://www.tpsgc-pwgsc.gc.ca/biens-property/gd-env-cnstrctn/page-10-eng.html
Solid waste	1.645	tCO2e/t	Environment Canada National Inventory Report 1990-2011 Greenhouse Gas Sources and Sinks in Canada
Wood Pellets	19.087	GJ/t	NWT Wood Pellet Public Report Jan 14 2010, section 5, approx 5% moisture content & 80% burner efficiency
Wood Pellets	0.072	tCO2e/t	NWT Wood Pellet Public Report Jan 14 2010, section 5, approx 5% moisture content & 80% burner efficiency

Appendix 5 Results of Sensitivity Analysis

Variable	Year	Current Input Value	Change in Input	New Input Value	Units	Output	Current Output Value (2012)	Change in Output	Sensitivity	Sensitive?
Emission Factor, Electricity	2009	111.1	10%	122.2	kgCO2e/GJ	Total GHGs	250,717	2.5%	0.25	No
Emission Factor, Electricity	2012	94.4	10%	103.8	kgCO2e/GJ	Total GHGs	220,087	2.5%	0.25	No
Emission Factor, Diesel	2006	3.0	10%	3.3	kgCO2e/litre	Total GHGs	252,607	2.0%	0.2	No
Total Fuel Sales for NWT, Gasoline	2012	40,751	10%	44,826	klitres/year	Total GHGs	220,087	0.5%	0.05	No
Quantity of Solid Waste Disposed	2012	25,700	10%	28,270	tonnes/year	Total GHGs	220,087	1.0%	0.1	No
Quantity of Solid Waste Disposed	2013	76,803	10%	84,483	tonnes/year	Total GHGs	220,087	2.7%	0.27	No

Appendix 6 Partners for Climate Protection Resources

PCP Website- Milestone Framework. Accessible at:

www.fcm.ca/home/programs/partners-for-climate-protection/milestone-framework.htm

PCP Website- Program Resources. Accessible at:

www.fcm.ca/home/programs/partners-for-climate-protection/program-resources.htm

Submission Requirements for Milestone Recognition. Accessible at:

www.fcm.ca/Documents/tools/PCP/Submission_Requirements_for_Milestone_Recognition_EN.pdf

Developing Inventories for Greenhouse Gas Emissions and Energy Consumption: A Guidance Document for Partners for Climate Protection in Canada. Accessible at:

www.fcm.ca/Documents/reports/PCP/Developing_Inventories_for_Greenhouse_Gas_Emissions_and_Energy_Consumption_EN.pdf

Appendix 7 Community Inventory 2013—GPC Format

GPC ref No.	Scope	GHG Emissions Source	tCO2e 2013	Total by Scope (tCO2e) 2013			
				Scope 1	Scope 2	Scope 3	Other Scope 3
I		**STATIONARY ENERGY SOURCES**		**83,187**	**-**	**57**	**-**
I.1		**Residential buildings**					
I.1.1	1	Emissions from in-boundary fuel combustion	20,869	20,869			
I.1.2	2	Emissions from consumption of grid-supplied energy	-		-		
I.1.3	3	Transmission and distribution losses from grid-supplied energy	21			21	
I.2		**Commercial and institutional buildings/facilities**					
I.2.1	1	Emissions from in-boundary fuel combustion	62,318	62,318			
I.2.2	2	Emissions from consumption of grid-supplied energy	-		-		
I.2.3	3	Transmission and distribution losses from grid-supplied energy	36			36	
I.3		**Manufacturing industry and construction**					
I.3.1	1	Emissions from in-boundary fuel combustion	-	-			
I.3.2	2	Emissions from consumption of grid-supplied energy	-		-		
I.3.3	3	Transmission and distribution losses from grid-supplied energy	-			-	
I.4		**Energy industries**					
I.4.1	1	Emissions from in-boundary production of energy used in auxiliary operations	-	-			
I.4.2	2	Emissions from consumption of grid-supplied energy	-		-		
I.4.3	3	Transmission and distribution losses from grid-supplied energy	-			-	
I.4.4	1	Emissions from in-boundary production of grid-supplied energy	-	-			
I.5		**Agriculture, forestry and fishing activities**					
I.5.1	1	Emissions from in-boundary fuel combustion	-	-			
I.5.2	2	Emissions from consumption of grid-supplied energy	-		-		
I.5.3	3	Transmission and distribution losses from grid-supplied energy	-			-	
I.6		**Non-specified sources**					
I.6.1	1	Emissions from in-boundary fuel combustion	-	-			
I.6.2	2	Emissions from consumption of grid-supplied energy	-		-		
I.6.3	3	Transmission and distribution losses from grid-supplied energy	-			-	
I.7		**Fugitive emissions from mining, processing, storage, and transportation of coal**					
I.7.1	1	In-boundary fugitive emissions	-	-			
I.8		**Fugitive emissions from oil and natural gas systems**					
I.8.1	1	In-boundary fugitive emissions	-	-			
II		**TRANSPORTATION**		**97,490**	**-**	**7,325**	**-**
II.1		**On-road transportation**					
II.1.1	1	Emissions from in-boundary transport	97,490	97,490			
II.1.2	2	Emissions from consumption of grid-supplied energy	-		-		
II.1.3	3	Emissions from transboundary journeys	7,325			7,325	
II.2		**Railways**					
II.2.1	1	Emissions from in-boundary transport	-	-			
II.2.2	2	Emissions from consumption of grid-supplied energy	-		-		
II.2.3	3	Emissions from transboundary journeys	-			-	
II.3		**Water-borne navigation**					
II.3.1	1	Emissions from in-boundary transport	-	-			
II.3.2	2	Emissions from consumption of grid-supplied energy	-		-		
II.3.3	3	Emissions from transboundary journeys	-			-	
II.4		**Aviation**					
II.4.1	1	Emissions from in-boundary transport	-	-			
II.4.2	2	Emissions from consumption of grid-supplied energy	-		-		
II.4.3	3	Emissions from transboundary journeys	-			-	
II.5		**Off-road**					
II.5.1	1	Emissions from in-boundary transport	-	-			
II.5.2	2	Emissions from consumption of grid-supplied energy	-		-		

Total by city-induced reporting level (tCO2e)		tCO2e by Sub-sector 2013	tCO2e by Sector 2013	Energy GJ 2013	Energy GJ by Source 2013						
BASIC	BASIC+				Diesel	Gasoline	Biomass	Propane	Heating Oil	Natural Gas	Electricity
83,187	**83,244**		**83,244**	**2,037,961**	**-**	**-**	**193,803**	**155,628**	**975,566**	**-**	**712,963**
		20,890		612,556	-	-	71,479	43,239	234,659	-	263,179
20,869	20,869										
-	-										
	21										
		62,354		1,425,405	-	-	122,324	112,389	740,907	-	449,785
62,318	62,318										
-	-										
	36										
		-									
-	-										
-	-										
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97,490	**104,816**		**104,816**	**1,579,126**	**998,694**	**577,609**	**-**	**-**	**-**	**-**	**2,824**
		104,816		1,579,126	998,694	577,609	-	-	-	-	2,824
97,490	97,490										
	7,325										
		-									
-	-										
-	-										
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		-									
-	-										
-	-										

GPC ref No.	Scope	GHG Emissions Source	tCO2e 2013	Total by Scope (tCO2e) 2013			
				Scope 1	Scope 2	Scope 3	Other Scope 3
III		**WASTE**		**4,276**	**-**	**-**	**-**
		Solid waste disposal					
III.1.1	1	Emissions from waste generated and treated within the city	1,801	1,801			
III.1.2	3	Emissions from waste generated within but treated outside of the city	-			-	
III.1.3	1	Emissions from waste generated outside the city boundary but treated within the city	-	-			
		Biological treatment of waste					
III.2.1	1	Emissions from waste generated and treated within the city	-	-			
III.2.2	3	Emissions from waste generated within but treated outside of the city	-			-	
III.2.3	1	Emissions from waste generated outside the city boundary but treated within the city	-	-			
		Incineration and open burning					
III.3.1	1	Emissions from waste generated and treated within the city	-	-			
III.3.2	3	Emissions from waste generated within but treated outside of the city	-			-	
III.3.3	1	Emissions from waste generated outside the city boundary but treated within the city	-				
		Wastewater treatment and discharge					
III.4.1	1	Emissions from wastewater generated and treated within the city	2,476	2,476			
III.4.2	3	Emissions from wastewater generated within but treated outside of the city	-			-	
III.4.3	1	Emissions from wastewater generated outside the city boundary but treated within the city	-	-			
IV		**IPPU**		**-**	**-**	**-**	**-**
IV.1	1	In-boundary emissions from industrial processes	-	-			
IV.2	1	In-boundary emissions from product use	-	-			
V		**Agriculture, Forestry and Land Use (AFOLU)**		**- 21,936**	**-**	**-**	**-**
V.1	1	In-boundary emissions from livestock	5	5			
V.1	1	In-boundary emissions from land	- 21,941	- 21,941			
V.1	1	In-boundary emissions from other agriculture	-	-			
VI		**Other indirect emissions**		**-**	**-**	**-**	**31,606**
VI.1	3	Other indirect emissions	31,606				31,606
			202,007	**163,018**	**-**	**7,383**	**31,606**

Major Sector
Sources required for BASIC reporting
Sources required for BASIC+ reporting
Sources included in Other Scope 3
Sources required for territorial total but not for BASIC/BASIC+ reporting

Total by city-induced reporting level (tCO2e)		tCO2e by Sub-sector 2013	tCO2e by Sector 2013	Energy GJ 2013	Energy GJ by Source 2013						
BASIC	BASIC+				Diesel	Gasoline	Biomass	Propane	Heating Oil	Natural Gas	Electricity
4,276	**4,276**		**4,276**								
		1,801									
1,801	1,801										
-	-										
		-									
-	-										
-	-										
		-									
-	-										
-	-										
		2,476									
2,476	2,476										
-	-										
-	**-**	-	-								
	-										
	-										
-	**- 21,936**	**- 21,936**	**- 21,936**								
	5										
	- 21,941										
	-										
-	**-**	**31,606**	**31,606**								
184,953	**170,401**	**202,007**	**202,007**	**3,617,088**	**998,694**	**577,609**	**193,803**	**155,628**	**975,566**	**-**	**715,787**

Appendix 8 Energy Costs, Energy Results, and GHG Results

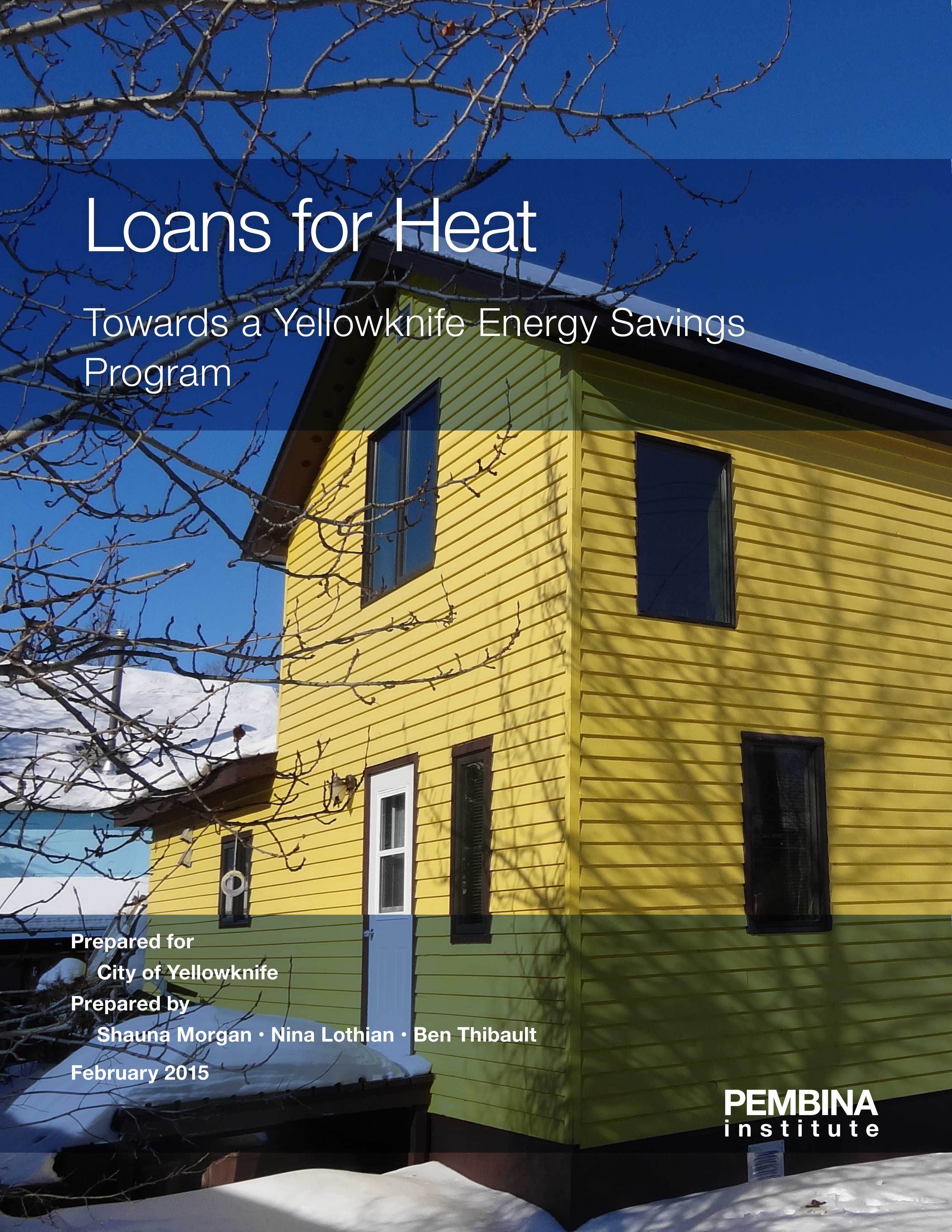
Energy Costs

	2006	2007	2008	2009	2010	2011	2012	2013	2015	2020	2025	2030
Buildings												
Residential buildings	$25,220,550	$25,204,551	$25,188,813	$25,172,429	$25,093,162	$25,015,055	$26,015,857	$27,129,417	$29,112,882	$32,806,799	$34,939,079	$35,934,490
Electricity	$13,751,733	$13,718,434	$13,685,646	$13,652,876	$13,704,382	$13,755,495	$15,522,200	$17,249,294	$20,290,157	$25,806,443	$28,856,782	$30,055,724
Fuel oil	$9,585,812	$9,757,273	$9,928,494	$10,099,133	$9,665,654	$9,233,055	$8,410,625	$7,721,077	$6,501,182	$4,204,161	$2,693,446	$1,720,109
Propane	$1,212,372	$1,071,139	$930,044	$789,045	$1,055,519	$1,322,212	$1,335,233	$1,358,875	$1,406,178	$1,522,624	$1,633,379	$1,746,626
Biomass	$670,633	$657,705	$644,628	$631,375	$667,607	$704,294	$747,799	$800,171	$915,365	$1,273,570	$1,755,471	$2,412,031
Commercial buildings	$37,673,388	$43,694,296	$50,175,673	$57,123,060	$57,696,764	$57,870,173	$56,918,104	$58,759,619	$62,182,242	$69,229,139	$74,061,017	$76,476,796
Electricity	$15,686,629	$18,227,042	$20,969,009	$23,915,855	$24,503,929	$24,935,782	$26,655,915	$29,479,855	$34,724,034	$45,558,322	$53,212,266	$57,625,756
Fuel oil	$19,753,915	$22,787,755	$26,024,426	$29,462,006	$28,873,220	$28,038,035	$25,487,456	$24,378,313	$22,288,946	$17,739,569	$14,006,325	$10,934,548
Propane	$2,232,844	$2,604,974	$3,009,010	$3,445,801	$3,544,855	$3,621,964	$3,486,894	$3,532,089	$3,622,003	$3,840,437	$4,039,616	$4,201,410
Biomass	$0	$74,525	$173,229	$299,398	$774,760	$1,274,392	$1,287,839	$1,369,362	$1,547,260	$2,090,811	$2,802,811	$3,715,081
Buildings total	$ 62,893,938	$ 68,898,847	$ 75,364,486	$ 82,295,489	$ 82,789,926	$ 82,885,229	$ 82,933,961	$ 85,889,036	$ 91,295,124	$102,035,938	$109,000,096	$112,411,285
Transportation												
Residential transportation	$21,626,624	$21,941,778	$22,260,508	$22,581,774	$22,798,559	$22,919,087	$23,280,408	$23,702,905	$23,955,302	$23,648,493	$22,996,560	$22,159,503
Gasoline	$16,598,565	$16,840,448	$17,085,075	$17,331,649	$17,539,012	$17,038,691	$17,370,300	$18,133,727	$18,475,420	$18,610,133	$18,464,645	$18,153,009
Diesel	$5,028,059	$5,101,330	$5,175,433	$5,250,125	$5,259,547	$5,880,396	$5,910,109	$5,569,178	$5,479,882	$5,038,360	$4,531,914	$4,006,494
Commercial transportation	$26,451,273	$26,870,426	$27,295,317	$27,726,018	$31,213,478	$34,646,345	$33,332,032	$30,210,951	$30,927,618	$32,866,775	$34,928,431	$37,286,206
Gasoline	$5,707,121	$5,797,557	$5,889,231	$5,982,159	$6,788,112	$6,739,048	$6,558,065	$6,448,262	$6,707,216	$7,417,061	$8,201,832	$9,109,916
Diesel	$20,744,153	$21,072,869	$21,406,086	$21,743,859	$24,425,366	$27,907,297	$26,773,967	$23,762,689	$24,220,402	$25,449,714	$26,726,599	$28,176,290
Transportation total	$48,077,898	$48,812,205	$49,555,825	$50,307,793	$54,012,037	$57,565,432	$56,612,441	$53,913,856	$54,882,920	$56,515,268	$57,924,991	$59,445,708
Total	$110,971,836	$117,711,051	$124,920,311	$132,603,282	$136,801,962	$140,450,661	$139,546,402	$139,802,892	$146,178,044	$158,551,206	$166,925,086	$171,856,993
% change		106%	113%	119%	123%	127%	126%	126%	132%	143%	150%	155%

	2006	2007	2008	2009	2010	2011	2012	2013	2015	2020	2025	2030
Buildings												
Residential buildings	626,760	620,308	613,944	607,646	601,845	596,107	596,004	600,539	609,172	627,536	640,442	651,537
Electricity	208,711	206,976	205,262	203,561	203,123	202,676	227,357	251,162	291,960	360,499	391,348	395,714
Fuel oil	309,619	312,428	315,158	317,799	301,524	285,535	257,849	234,659	194,177	120,227	73,747	45,093
Propane	41,366	36,185	31,107	26,129	34,606	42,920	42,912	43,239	43,860	45,183	46,112	46,911
Biomass	67,063	64,719	62,418	60,157	62,592	64,976	67,886	71,479	79,175	101,628	129,235	163,820
Commercial buildings	952,308	1,099,998	1,258,002	1,426,320	1,452,762	1,469,635	1,400,791	1,404,868	1,412,184	1,424,523	1,425,526	1,410,511
Electricity	238,077	274,999	314,500	356,580	363,191	367,409	390,434	429,247	499,652	636,420	721,650	758,701
Fuel oil	638,046	729,665	826,088	927,108	900,713	867,085	781,382	740,907	665,726	507,299	383,495	286,650
Propane	76,185	88,000	100,640	114,106	116,221	117,571	112,063	112,389	112,975	113,962	114,042	112,841
Biomass	0	7,333	16,773	28,526	72,638	117,571	116,912	122,324	133,831	166,842	206,339	252,320
Grid loss (electricity)	Not calculated							1,299	Not calculated			
Buildings total	1,579,068	1,720,305	1,871,946	2,033,966	2,054,607	2,065,742	1,996,795	2,006,706	2,021,356	2,052,059	2,065,968	2,062,048
Transportation												
Residential transportation	602,116	604,842	607,553	610,219	609,810	609,363	612,589	615,754	609,471	571,090	527,099	482,055
Gasoline	445,720	447,738	449,745	451,718	452,597	435,333	439,411	454,181	453,622	434,752	410,418	383,908
Diesel	156,396	157,104	157,808	158,501	157,213	174,030	173,178	161,572	155,849	136,338	116,681	98,147
Commercial transportation	798,481	803,103	807,725	812,347	905,253	998,084	950,415	850,893	853,502	861,924	870,409	882,880
Gasoline	153,242	154,129	155,016	155,903	175,155	172,167	165,885	161,493	164,668	173,257	182,291	192,646
Diesel	645,240	648,975	652,709	656,444	730,098	825,917	784,531	689,400	688,834	688,667	688,118	690,234
Transportation total	1,400,597	1,407,945	1,415,278	1,422,566	1,515,062	1,607,447	1,563,004	1,466,646	1,462,972	1,433,014	1,397,508	1,364,935
Total	2,979,665	3,128,251	3,287,224	3,456,531	3,569,669	3,673,189	3,559,799	3,473,352	3,484,329	3,485,073	3,463,476	3,426,983
% change		105%	110%	116%	120%	123%	119%	117%	117%	117%	116%	115%

	2006	2007	2008	2009	2010	2011	2012	2013	2015	2020	2025	2030
Buildings												
Residential buildings	26,129	25,958	25,790	25,623	25,044	24,473	22,500	21,021	22,857	19,905	18,477	18,023
Electricity	485	481	477	473	472	471	386	443	4,932	6,643	7,867	8,678
Fuel oil	21,766	21,964	22,156	22,341	21,197	20,073	18,127	16,497	13,651	8,452	5,184	3,170
Propane	2,519	2,204	1,894	1,591	2,108	2,614	2,613	2,633	2,671	2,752	2,808	2,857
Biomass	1,359	1,311	1,265	1,219	1,268	1,316	1,375	1,448	1,604	2,059	2,618	3,319
Commercial buildings	50,047	57,442	65,273	73,531	72,713	71,352	64,787	62,166	64,832	57,711	52,593	48,775
Electricity	553	639	731	828	844	853	662	758	8,440	11,728	14,508	16,639
Fuel oil	44,855	51,295	58,074	65,176	63,320	60,956	54,931	52,086	46,801	35,663	26,960	20,151
Propane	283	5,359	6,129	6,949	7,078	7,160	6,825	6,845	6,880	6,940	6,945	6,872
Biomass	0	149	340	578	1,472	2,382	2,369	2,478	2,711	3,380	4,180	5,112
Grid loss (electricity)								57				
Buildings total	76,176	83,400	91,064	99,154	97,757	95,825	87,287	83,244	87,689	77,616	71,070	66,798
Transportation												
Residential transportation	42,386	42,317	42,247	42,172	41,886	41,599	41,564	41,523	40,597	36,891	33,020	29,285
Gasoline	31,376	31,326	31,273	31,218	31,088	29,719	29,814	30,627	30,216	28,084	25,711	23,323
Diesel	11,009	10,992	10,973	10,954	10,799	11,881	11,750	10,895	10,381	8,807	7,309	5,963
Commercial transportation	59,832	60,112	60,392	60,671	67,526	74,532	70,889	63,293	63,361	63,682	64,019	64,659
Gasoline	10,787	10,783	10,779	10,774	12,031	11,753	11,255	10,890	10,969	11,192	11,420	11,704
Diesel	49,044	49,328	49,613	49,897	55,495	62,779	59,634	52,403	52,393	52,490	52,599	52,955
Transportation total	102,218	102,429	102,638	102,844	109,413	116,132	112,452	104,816	103,959	100,573	97,039	93,944
Waste												
Solid	1,459	1,507	1,555	1,603	1,652	1,701	1,750	1,801	1,902	1,974	2,247	2,531
Liquid	2,393	2,415	2,429	2,443	2,445	2,446	2,461	2,476	2,505	2,586	2,669	2,772
Waste total	3,853	3,922	3,984	4,046	4,096	4,147	4,211	4,276	4,407	4,560	4,916	5,304
Land-use												
Agriculture (transportation)	31,272	31,453	31,634	31,815	31,837	31,859	31,739	31,606	31,297	30,330	28,918	27,083
Forests	-21,936	-21,936	-21,936	-21,936	-21,936	-21,936	-21,936	-21,936	-21,936	-21,936	-21,936	-21,936
Land-use total	9,337	9,518	9,699	9,880	9,901	9,923	9,804	9,671	9,362	8,394	6,982	5,147
Total	191,583	199,269	207,384	215,923	221,167	226,026	213,754	202,007	205,416	191,144	180,008	171,193
% change		104%	108%	113%	115%	118%	112%	105%	107%	100%	94%	89%

Appendix D: Loans for Heat Study (Pembina Institute, 2015)



Loans for Heat

Towards a Yellowknife Energy Savings Program

Prepared for

City of Yellowknife

Prepared by

Shauna Morgan · Nina Lothian · Ben Thibault

February 2015

PEMBINA institute

The preparation of this plan was carried out with assistance from the Green Municipal Fund, a Fund financed by the Government of Canada and administered by the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the authors, and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them.

Disclaimer

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The Pembina Institute have based this report on information received or obtained, on the basis that such information is accurate and, where it is represented to The Pembina Institute as such, complete.

PEMBINA institute

About the Pembina Institute

The Pembina Institute is a national non-partisan think tank that advances clean energy solutions through research, education, consulting and advocacy. We have spent close to three decades working to reduce the environmental impacts of Canada's energy production and use in several key areas:

- driving down energy demand by encouraging energy efficiency and transportation powered with cleaner energy sources;
- promoting pragmatic policy approaches for governments to avoid dangerous climate change, such as increasing the amount of renewable energy plugged into our electricity grids;
- and — recognizing that the transition to clean energy will include fossil fuels for some time — advocating for responsible development of Canada's oilsands and shale gas resources.

For more information about the Pembina Institute, visit www.pembina.org.

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Contents

Acronyms

AEA	Arctic Energy Alliance
AFUE	annual fuel utilization efficiency
CMHC	Canada Mortgage and Housing Corporation
CO_2e per GJ	carbon dioxide equivalent per gigajoule
CTV Act	Cities, Towns and Villages Act (Northwest Territories legislation)
DHW	domestic hot water
ESCO	Energy Service Company
ESPA	Energy Service Performance Agreement
FCM	Federation of Canadian Municipalities
FIRST	Financing Initiative for Renewable and Solar Technology (LIC program in Berkeley, California)
GEERS	Guelph Energy Efficiency Retrofit Strategy (LIC program in Guelph)
GHG	greenhouse gas
GNWT	Government of the Northwest Territories
HELP	Home Energy Loan Program (LIC program in Toronto)
HVAC	heating, ventilation, and air conditioning
LIC	local improvement charge
NRCan	Natural Resources Canada (federal government agency)
NWT	Northwest Territories
PACE	Property Assessed Clean Energy Investments (name for LIC programs in the United States)
PAPER	Property Assessed Payments for Energy Retrofits (name for LIC programs in the United States)
PV	photovoltaic
ROI	return on investment
TAF	Toronto Atmospheric Fund

property tax bills. However, LICs are not currently used to enable loans for projects that benefit individual homes or properties. While the CTV Act does not explicitly prevent the use of the local improvement section for energy retrofits, as it is currently written it would create impossible complications for an effective energy efficiency financing program. Appendix A contains a description of the legislative changes that would be required to launch an LIC program for energy retrofits in Yellowknife, as well as a suggested draft amendment to the CTV Act.

The use of LICs to support residents and small business owners in implementing energy efficiency and renewable energy retrofits was the subject of a 2013 resolution passed by the NWT Association of Communities,[2] which urged the Government of the Northwest Territories (GNWT) to review the CTV Act to enable LICs for this purpose. In its December 2013 Energy Action Plan, the GNWT committed to do just that.[3]

Structure of this report

This report has five main sections, plus Appendices containing more detailed information:

Why an LIC program? —The purpose of an LIC-based Yellowknife Energy Savings Program and evidence for why there may be a need in Yellowknife.

Experience from other Canadian cities — Lessons learned from similar programs underway in Halifax, Toronto, Yukon, Guelph, Vancouver and Edmonton.

What a Yellowknife LIC program could look like — Recommended overall design for a Yellowknife Energy Savings Program (including eligible retrofits), and aspects of program delivery such as outreach, contractor engagement, and the energy audit/assessment.

Benefits, costs, and funding sources — Benefits and savings enjoyed by the City and residents from a Yellowknife Energy Savings Program (Phase 1), what the program would likely cost the City and residents, and sources of initial funding to get the program off the ground.

Conclusion — Key factors for success.

Appendices — Appendix A contains a description of the legislative changes that would be required for Yellowknife to launch an LIC program for energy retrofits, as well as a suggested draft amendment to the CTV Act. Appendix B is a detailed explanation of how predicted cost and energy savings have been calculated for Phase 1 of a Yellowknife Energy Savings Program. Appendix C includes further details on possible funding sources to help Yellowknife get its LIC program off the ground. Appendix D lists potential financing and delivery mechanisms (other than an LIC program) for municipal and commercial energy retrofit projects, including examples and lessons learned from Toronto, as well as historical examples from Yellowknife. Appendix E lists references plus a sample list of further resources and existing research on the topic.

How the research was done

This report is based on a review of literature and publicly available material, interviews with experts in Yellowknife and in other Canadian cities, and consultation with members of Yellowknife's Community Energy Planning Committee.

Types of materials reviewed:

- data about the Yellowknife context, including housing and population statistics
- data from previous energy retrofit subsidy programs carried out in Yellowknife
- relevant legislation from the NWT as well as other Canadian provinces
- studies analyzing the Local Improvement Charge program model in North America
- case studies and online materials about LIC programs implemented in other Canadian cities

Experts interviewed:

- several current and former staff with Arctic Energy Alliance
- members of the Community Energy Planning Committee, including representatives from federal and territorial government, City Council, and non-profit organizations
- staff running LIC programs in other Canadian cities
- representatives from non-profit organizations promoting innovative financing for energy retrofits in municipalities across Canada

A complete list of references is found in Appendix E.

Photo: Binnu Jeyakumar, Pembina Institute

Why an LIC program?

Purpose of an LIC program for energy retrofits

Through an LIC Program, the municipality would help homeowners access low-interest loans for energy retrofits and allow them to pay back the loans on their property tax bills. The loan would be tied to the property rather than to the property owner, so if an owner sells his or her home the responsibility for paying back the loan would pass to the new owner.

A municipality has an advantage over individuals in being able to access low-interest, long-term financing from an institution such as a bank. Through an LIC program, the municipality can pass on these lower rates to residents. The municipality can also help homeowners realize further savings by linking the LIC program with government rebate and incentive programs.

According to the GNWT Energy Action Plan (December 2013):

> Research indicates that individuals often need upfront financing to conduct energy improvements on their homes. However, many homeowners do not have access to these funds and have competing priorities with their money. Additionally, many homeowners resist making energy retrofits if they plan to move before they can recoup their costs through energy savings. A number of jurisdictions have amended their 'Local Improvement Charge' legislation to allow for the development of energy financing programs designed to address the above constraints.[4]

If property owners are strapped for cash, they are more likely to choose the lowest-cost retrofit options, making small improvements but missing out on opportunities to realize the greatest energy and cost savings in the long term. Retrofits can be a hassle, so property owners are not likely to keep going back and making more improvements; they need to get it right the first time. If an LIC loan is available, property owners will have the financial flexibility to opt for higher-cost, higher-efficiency investments that will allow them to realize maximum savings right from the start. For example, someone planning a renovation may see an opportunity to improve insulation in the walls at the same time, but with more cash on hand the property owner could do a more complete building envelope upgrade and perhaps install much higher quality windows and doors to keep the heat in for many years to come.

The risk of participants defaulting on their loans is low because the liability is tied to the property owner's tax bill and transfers with the property if it is sold. Property owners should be able to afford the loan repayments because they are realizing energy savings, which are ensured as part of the program's design, screening and assessment process. A well-designed LIC program provides a great deal of security for the municipality.

It is important to recognize that an LIC program based on property taxes is not designed to help renters who pay their own utility bills to save on energy costs. A landlord who does not pay for utilities may have little motivation to undertake energy efficiency upgrades. According to the 2006 census, approximately 46% of dwellings in Yellowknife are occupied by renters rather than owners. Alternative types of LIC programs have been successfully implemented in Canada whereby utility companies have helped residents (including renters) obtain loans for energy upgrades, and the loans are paid back via utility bills.[5] This type of LIC program was outside the scope of this report given that the City of Yellowknife does not control any utilities.

An LIC program is likely to benefit the local economy by generating business in the building contracting/ retrofit sector in particular. Another side benefit from the existence of a local LIC program for energy retrofits is increasing resident awareness of the benefits of energy efficiency in general, as a result both of program marketing and word-of-mouth success stories. Ultimately, energy retrofits support a municipality's overall security and make the community a more affordable place to live by reducing dependence on expensive imported fuel and reducing exposure to volatile global fossil fuel prices.

Is there a need in Yellowknife for an LIC program?

There are several possible barriers to homeowners undertaking energy efficiency or renewable energy retrofits on their own:

- lack of funds / capital up front
- high rate of turnover in home ownership; uncertainty about whether energy retrofits will improve resale value of home
- hassle factor; lack of motivation
- lack of awareness of technologies / opportunities

An LIC program could address each of these barriers. The latter two points (hassle factor, lack of awareness) should be considered in the design and delivery of a program, as discussed later in this report.

An LIC program would be particularly helpful for those who own relatively inefficient (often older) homes and who do not have the personal savings or access to low-interest financing that would allow them to make energy improvements.

In this section, we consider:

- How old are Yellowknife homes, and what kind of shape are they in?
- What kind of take-up has there been by Yellowknife homeowners to previous energy retrofit incentive programs, and how much energy and cost savings were they able to realize?
- What financial capacity might Yellowknifers have to pay for energy retrofits on their own, without an LIC program?
- Is there high turnover in Yellowknife home ownership, and could this prevent Yellowknifers from wanting to invest in home energy efficiency upgrades?

Age and condition of Yellowknife homes

According to the 2006 census (the most recent data available), about 40% of dwellings in Yellowknife were built before 1980. Most of these pre-1980 homes were built in the 1960s and 70s.

The census also shows that 10% of owner-occupied homes in Yellowknife are in need of major repair (340 dwellings), and 32% of owner-occupied homes are in need of minor repairs (another 1150 dwellings). This may signal opportunities for homeowners to conduct energy efficiency upgrades while they are undertaking their necessary repairs. According to an Ipsos Reid survey of Toronto residents, timing was usually the main driver of energy retrofits; if a homeowner already needs to replace an item such as a furnace, she or he is more likely to choose an upgrade that improves energy efficiency or uses renewable energy.[6]

EnerGuide is a rating system that scores Canadian homes on a scale of 1 to 100, with a rating of 100 representing a house that is airtight, well insulated, sufficiently ventilated and requiring no purchased energy. A home rated as 0 has major air leakage, no insulation and extremely high energy consumption. New homes built to minimum Canadian building code standards generally rate between 65 and 72. Homes rated 80 or higher are considered 'energy efficient'.[7] As of January 2008, the City of Yellowknife requires new homes to meet the EnerGuide 80 standard.[8] An upgrade from an EnerGuide rating of 72 to 80 represents a 40% reduction in energy use.[9]

Out of 1069 Yellowknife homes that have been audited within the past decade, only 8% met or exceeded EnerGuide 80 standard, while 40% met or exceeded EnerGuide 70 standard. EnerGuide ratings were generally related to the age of the house, with older homes receiving lower ratings. The average NWT home built around 1960 is rated about 60; a 1980 home is rated about 65; and an NWT home built in 2000 is generally rated about 70.[10]

Older homes in Yellowknife are more likely to contain renters than newer homes. Only 48% of pre-1980 dwellings in Yellowknife are occupied by owners (as opposed to renters), while 58% of post-1980 homes

Photo: Binnu Jeyakumar, Pembina Institute

are occupied by owners. Given that renters cannot participate in a property tax-based LIC program, yet older homes may benefit the most from energy retrofits, this moderately limits the potential uptake of a Yellowknife LIC program.

Previous energy retrofit incentive programs in Yellowknife

The federal EcoEnergy Retrofit Program ran from April 2007 to March 2012 and provided homeowners with grants of up to $5,000 for eligible energy efficiency measures, which included space heating, insulation (basement, attic, walls), draftproofing, and new windows and doors. The program required an energy assessment using the EnerGuide Rating System before and after work was completed. While 961 homeowners in the NWT had initial EnerGuide assessments done, only 211 followed through with energy efficiency upgrades.

The results of this program provide useful lessons for any future LIC program in Yellowknife. Unfortunately, the data available from the EcoEnergy program covers the NWT as a whole (with no breakdown specifically for Yellowknife); however, it can be assumed that a large portion of participating homeowners may have been in Yellowknife, given that Yellowknife contains about half the population of the territory.

About 47% of the houses that had assessments done were built before 1980. This roughly matches the housing profile in Yellowknife, where about 40% of the dwellings were built before 1980. However, owners of houses built before 1980 were much more likely to follow through with the upgrades: 28% vs. only 17% follow-through by owners of houses built after 1980. While houses built in the 1970s were subject to the largest number of upgrades compared to any other decade of construction, the highest rate of follow-through was with houses built in the 1960s (32%). For houses built before 1980, the three most popular upgrades were draftproofing, windows/doors and then walls. For houses built after 1980, the three most popular upgrades were draftproofing, windows/doors, and then space heating.

The 124 homes built before 1980 that went through with upgrades saved on average about 49 GJ of energy per house per year. This would correspond 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.[11] Upgraded NWT homes built before 1980 improved their EnerGuide rating score by 8 to 9 points. Another 87 homes built after 1980 improved their EnerGuide ratings by up to 6 points and saved between 8 and 34 GJ of energy per house per year.[12]

It is interesting to note that the NWT had the lowest follow-through rate in the country (percentage of those who had initial assessments done who actually followed through with upgrades), with only 20% compared to the Canadian average of 80% follow-through. This may in part be due to difficulty securing qualified contractors and/or access to financing beyond the partial grant amount.

Arctic Energy Alliance (AEA) has been administering rebates to NWT residents on behalf of the the territorial government to support energy efficiency upgrades in residential homes and businesses. The rebates awarded in Yellowknife over the past five years consistently number in the several hundreds, and the dollar amount distributed per year has exceeded $200,000 for the past four years. The heat-related retrofits (wood or pellet stoves, insulation/air sealing, and efficient furnaces and boilers) represent somewhere between 20-30% of the total number of rebates Yellowknifers have accessed. In terms of dollars they represent closer to 40-50% of the rebates. This indicates that these types of energy improvements are the more expensive of those that Yellowknife residents wish to pursue and may warrant additional financing mechanisms.

Financial capacity of Yellowknife residents

Yellowknife households on average have nearly the highest income of any municipality in Canada.[13] While home prices in Yellowknife are relatively expensive, the average household annual income covers 28% of the average home value, which is significantly higher than some other cities such as Whitehorse and Toronto (23% and 16% respectively) (see Table 1 below).

Despite the apparent wealth of Yellowknife residents, there are also many first-time homeowners, who tend to be cash-poor and highly leveraged. According to a 2014 trends report by the Canada Mortgage and Housing Corporation (CMHC), more people in Yellowknife are moving into first-time home ownership — especially lower priced condominiums and mobile homes — given low interest rates and an 18% drop in the prices of Yellowknife condos between 2012 and 2013. First-time homeowners are notorious for maxing out their mortgage limits, so they may have limited savings and limited ability to access further loans through conventional means.

The size of loan required for an energy efficiency retrofit, often less than $10,000, is typically offered by banks only as high interest unsecured loans.[15]

Turnover in home ownership

It is possible that turnover rates in Yellowknife home ownership could prevent Yellowknifers from wanting to invest in home energy efficiency upgrades.

Table 1. Comparison of Yellowknife income to home value ratio[14]

	Average annual household income	Average home price	Avg household income as % of avg home value
Yellowknife	$138,278	$493,544	28%
Whitehorse	$96,112	$417,779	23%
Toronto	$93,288	$594,112	16%

According to research by the Ontario Clean Air Alliance, homeowners generally demand a payback on energy efficiency investments in the range of one to five years, given uncertainty about future savings from the investment, difficulty accessing funds, and uncertainty about how long they will own the home.[16] This is why many LIC programs have been designed to make loans transferable, meaning they stay with the property, and homeowners can recoup their investment when they sell their house.

In fact, Yellowknife home turnover rates are not excessively high, and new studies show that LIC loan transferability is not as important to the success of a program as once thought.

According to calculations based on CMHC data, the ratio of Yellowknife housing transactions to housing stock was about 6.8% in 2012, and about 6.0% in 2013.[17] A similar estimate of the ratio of Whitehorse housing transactions to housing stock in 2006 was 5.5%,[18] and in Toronto the ratio in 2006 was 4.6%.[19]

While Yellowknife has a reputation for being a very transient city (with many residents arriving and leaving within short periods of time), it could be that many transient people are renters rather than homeowners, which would not affect participants in a property-tax-based LIC program.

Several other LIC programs in North America have been successful even when they do not tie loans to the property or to the utility bill, but rather to the individual resident, meaning the loan is not transferable. For example, Manitoba Hydro's Power Smart program and Clean Energy Works Oregon have both had substantial uptake (89,000 and 3,000 households respectively).[20] Analysis suggests that when participants are deciding whether or not to undertake energy retrofits, they are much more concerned with the interest rate being offered, rather than how long they will be staying in the house.[21]

Photo: Binnu Jeyakumar, Pembina Institute

Conclusion

The evidence above suggests that there may indeed be a need and a significant demand for an LIC program in Yellowknife, particularly amongst owners of houses built in the 1960s and 70s. This segment of the population realized the greatest energy and cost savings from retrofits conducted under the EcoEnergy program. Poor overall follow-through in the NWT with the EcoEnergy program could potentially be improved with better access to financing (beyond the $5,000 grant that was offered).

An estimated 60% of Yellowknife homes are rated below EnerGuide 70, leaving substantial room for improvement. Moreover, the significant number of owner-occupied homes in Yellowknife that are in need of major or minor repairs may signal opportunities for homeowners to conduct energy efficiency upgrades while they are undertaking their necessary repairs. It is interesting to note that amongst those who did follow through with the EcoEnergy program, building envelope improvements were most popular—not only relatively cheap upgrades such as draftproofing but also more expensive projects such as windows and doors. This indicates an appetite for energy improvements that would require financing for most people.

While Yellowknife residents have relatively high household incomes, many are first-time homeowners who are likely to have low savings and high debts, and who may find it difficult to access low-interest financing for energy retrofits.

Photo: David Dodge, Green Energy Futures

Experience from other Canadian cities

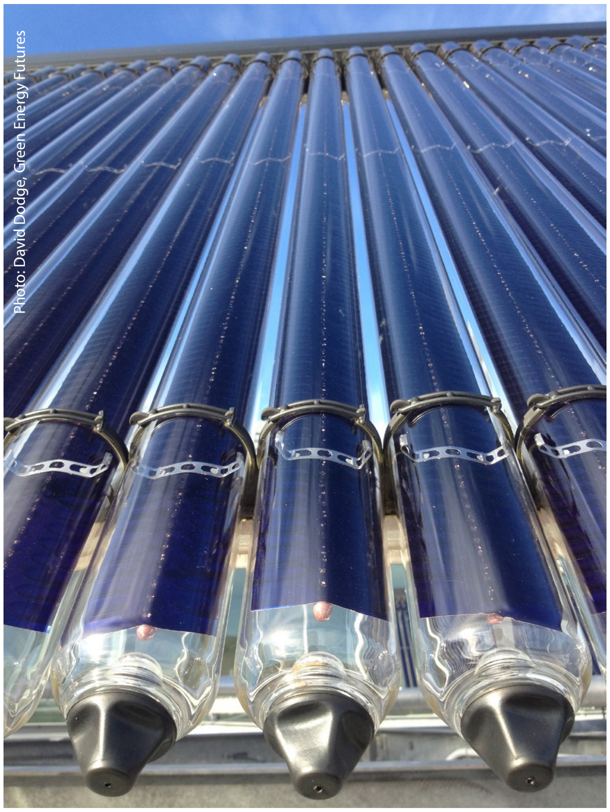
Jurisdictions across Canada, including Nova Scotia and Ontario, have begun to amend legislation to accommodate the use of local improvement charges to fund home energy upgrades. In Ontario alone, there are 22 municipalities collaborating in the design of their own local improvement energy retrofit programs.

Some jurisdictions such as the Yukon are relatively hands-off in the delivery of their LIC programs — while the program provides the loan, it is up to the homeowner to figure out which retrofit to undertake, how much the energy and cost savings will be, whether the savings will be worth the expense, and which contractor to choose. Other jurisdictions such as Halifax have taken more of a 'turnkey' approach, retaining more control over which retrofits are eligible but providing a more complete package of services along with the loan itself. For example, a turnkey-style program could provide an energy audit and perhaps even manage the relationship with the contractor on behalf of the homeowner. Many LIC programs fall somewhere on this spectrum between 'hands-off' and 'turnkey'.

Halifax

Following a provincial legislative amendment in 2010, the City of Halifax[22] launched an LIC program called Solar City in March 2013. The program offers financing for only one eligible retrofit — solar water heating. It is a direct install program that uses only contractors who have an established relationship with the program. This makes it straightforward for homeowners by having the program oversee the contract management as well as rigorous screening, assessment and third party audit of contract work. Halifax also collects all available retrofit rebate incentives on behalf of the homeowner, putting the funds towards repayment.

The program has been popular, with over 1,600 applicants for 1,000 spots. In just over a year (2013–2014), Halifax installed over 325 residential solar heating systems — more than the rest of Canada combined within that period.[23] It is worth noting that only 25% of applicants have immediately followed through with installing the solar hot water heater. Another 25% have withdrawn their applications and the remaining half find it difficult to make a decision. Of those participants who follow through with installation, about 10% choose to finance the retrofit themselves rather than getting financing through the City.[24] This indicates that while low-interest financing is important to some participants, others are attracted simply by the package of services offered by the City, such as contract management and auditing. Thus, a turnkey-style program addresses more than one barrier to homeowners undertaking energy retrofits — both the financial aspect and the hassle factor.



Solar water heating system

The total cost per home, including materials, installation, taxes and rebates, is about $6,500 to $7,900, according to the Solar City website. Each homeowner is expected to receive a 7 to 9% return on investment, with typical savings expected to be more than $20,000 over the lifespan of the retrofit, which is estimated at 25 years or more (see below for a discussion of payback periods and return on investment). Average annual greenhouse gas emission savings are estimated at 1,700 kg per participant.

Table 2 below offers more details comparing the Halifax Solar City program to Toronto's LIC program.

Toronto

The City of Toronto launched an LIC program[25] called the Home Energy Loan Program (HELP) in January 2014, following an amendment to Ontario legislation in October 2012. HELP falls somewhere in the middle of the spectrum between a hands-off and turnkey delivery style. While the City requires an energy audit to verify expected savings, homeowners are free to choose from a wide variety of retrofits, select their own contractor and manage the contractor themselves. Eligible retrofits include:

- thermal envelope (insulation for attic, exterior wall or basement; window or door replacement; air sealing)
- heat recovery/efficiency systems (furnace and boiler replacement, heat recovery ventilator, high efficiency water heater, drain water heat recovery system)
- water efficiency (toilet replacement)

The average loan is expected to be $10,000 per homeowner. The maximum loan amount is capped at 5% of property value, which means about $25,000 for the average home in the target neighbourhoods.

The City has partnered with Enbridge, which offers added incentives to participants. Enbridge will rebate the cost of the initial home energy audit if a participant chooses a retrofit designed to reduce home energy use by 25%. Enbridge also helps reduce hassle by sharing a shortlist of energy auditors accredited with NRCan that participants can use. The program helps participants access up to $2,650 in grants and incentives offered by Enbridge and Toronto Hydro.

Similar to Halifax Solar City, the first phase of Toronto's HELP program allows for 1,000 participants. During this first three-year phase, only four specific neighbourhoods are eligible. These areas contain pre-1980s (many are pre-1940s), two- to three-story semi-detached townhouses. During Phase 2, the program will expand to 15 to 20 neighbourhoods (based on a market demand survey), and Phase 3 may include a city-wide roll-out. These initial neighbourhood-based limitations on eligibility may make the program marketing and administration more manageable for a mega-city like Toronto.

Unlike the Halifax program, Toronto HELP requires participants to obtain the consent of any mortgage lender as a condition of eligibility (given that the loan will be a priority lien on the property, meaning the LIC loan must be paid back before the mortgage). It will be interesting to see if this proves to be a barrier to participation.

While results of Phase 1 are not yet available, the goals

Table 2. Comparison of Halifax and Toronto LIC programs

	Halifax Solar City	Toronto HELP
Delivery style	Turnkey One eligible retrofit City chooses and manages contractor	More hands-off Wide range of eligible retrofits Participant chooses and manages contractor
Eligible retrofits	Solar water heater	Building envelope / insulation Heat recovery / efficiency Water efficiency
Loan amount per home	$8,000	Average $10,000 Capped at 5% of property value
Number of participants	1,000	1,000
Grants/rebates/incentives available for each participant	$1,500	Up to $2,650 from Enbridge and Toronto Hydro
Average savings per participant	$200-750/yr (average $400/yr)	Varies; for a suite of retrofits that includes attic/wall/basement insulation, new furnace: $1,080/yr
Average payment per participant	$750/yr (including tax)	Varies; for a suite of retrofits that includes attic/wall/basement insulation, new furnace: $1,760/yr (15 yr term)
Interest rate(s) offered	10 year - 3.5%	5 year – 2.5% 10 year – 3.75% 15 year – 4.25%
Energy/GHG emission savings	1,700 kg per participant	Above suite of retrofits could reduce natural gas consumption by 56%
Total program budget	$8.3 million	$10 million
Administrative costs	$600,000	

of Toronto's program include reducing energy use by 25% overall, maintaining housing affordability, creating high-quality jobs, achieving established greenhouse gas reduction targets, and enhancing the quality of life for Torontonians.

Yukon

LICs have been used to finance renewable energy systems for off-grid residents in the rural Yukon since 1998.[26] It is an expansion of an LIC program set up in 1984 to help rural residents finance basic telecommunications infrastructure for their homes. The Yukon program is an example of a hands-off program. Neither an energy audit nor any evidence of energy or cost savings are required, there does not appear to be a list of eligible technologies, and homeowners manage the contractors themselves. The loan can be up to 25% of the property's assessed value, less all existing LICs.

Once a property owner obtains a quote for the cost of the energy improvement, the applicant and the Yukon Government agree upon a certain level of funding. A payback term of five, 10, or 15 years is chosen by the applicant, with interest calculated at the Bank of Canada daily rate at the time the LIC agreement is signed. The contractor submits invoices directly to the Yukon Government, which are paid upon final inspection and a statement of satisfaction from the property owner. The applicant pays back the loan on their property tax bill.

Between 1984 and 2006, the program financed about 600 grid connections in total; approximately 30 of those included a renewable electricity installation (mostly solar). Each project must be approved by a separate Order-in-Council. While this approval process would be too unwieldy for any larger-scale program, it shows how an LIC program could potentially operate with minimal rules and restrictions.

Guelph

The City of Guelph, Ontario, is working on developing an LIC program called the Guelph Energy Efficiency Retrofit Strategy (GEERS).[27] The program will be turnkey style and aims to keep the process as simple as possible for participating homeowners.

Homeowners will be offered a standard package of retrofit items that includes insulation, weather-stripping, windows, furnace, water heater, and comfort controls (i.e. a programmable thermostat). If an applicant has already completed one of these retrofits, he or she will receive credit for that. Pricing for this standard package will be based on the type of home and the square footage. The applicant will then get to choose from a selection of 'extras' such as rooftop solar (PV, thermal, or both), an electric vehicle charger, a rainwater harvesting system, re-roofing, a ground-source heat pump, and a micro combined-heat-and-power system. The City will manage all of the contracting.

GEERS emphasizes customer-friendliness. For example, each applicant will have a single point of contact at the City who is tasked with explaining the program, handling registration, and following up with the applicant throughout the process.

GEERS aims to achieve a 20-40% reduction in residential energy use, retrofitting between 2,000 and 3,000 homes per year between 2015 and 2031. Once the residential program is underway, the City of Guelph plans to tackle the industrial, commercial, and institutional sector.

Vancouver

The City of Vancouver[28] ran a pilot program in 2011–2012 that was discontinued due to disappointing uptake, offering some important lessons. While it was not technically an LIC program, since Vancouver does not yet have the legal authority to offer LIC loans, the City was helping homeowners to access financing for home energy efficiency upgrades and allowing them to pay back the loans on their municipal utility bills. The program was a partnership with VanCity Credit Union, which was the institution offering the financing. In addition, local utility companies (FortisBC and BC Hydro) offered rebate incentives for participants.

Feedback from City residents to program outreach staff indicated that the interest rate offered—4.5%—was too high. Some felt that the maximum loan amount ($10,000) was too low and not worth extending over a 10-year period. Flexibility was not being offered on the term (length) of the loan period.

The City of Vancouver is now seeking to amend its charter to allow repayments of the loans to be made directly through property taxes. This may allow the City to access lower interest rates that could be more attractive to local homeowners.

Edmonton

While the City of Edmonton[29] does not have an LIC program, it has provided start-up funding for a non-profit company (social enterprise) called C Returns, which provides a turnkey program that manages all the aspects of a home energy retrofit, short of actually providing financing. This model is based on the assumption that the major barriers to home energy upgrades are the hassle factor and lack of awareness about available or appropriate technologies, rather than lack of access to low-interest financing.

C Returns home energy audit

C Returns provides a package of services to coordinate a home energy retrofit from start to finish, including an energy audit, payback information on potential retrofits, project recommendations, management of a competitive bid process, completion of grant and rebate applications, and project management. C Returns can also help homeowners to secure financing, if necessary. The cost of a comprehensive assessment, in-home consultation and customized report is $295 plus tax. Many of the services can be accessed and managed on-line.

C Returns can evaluate a wide range of home energy improvement options, including building envelope improvements, solar power systems (PV and thermal), drain water and heat recovery ventilation systems, super-efficient heating and cooling systems, electricity reduction options and smart home items such as thermostats.

From 2013–2014, C Returns assessed nearly 100 homes. The first 12 homes were retrofitted at an average incremental cost of $7,220 each, with an expected average lifetime savings of $20,515 per home.[30] The program goal is to complete over 3,000 home audits and 1,500 green retrofits over the next three years.

Further references

The concept of using local improvement charges to support renewable energy and energy efficiency investments has been studied extensively the United States. LIC programs in the U.S. are also known as Property Assessed Payments for Energy Retrofits (PAPER) or Property Assessed Clean Energy Investments (PACE). Appendix E contains a sample list of resources and existing research on the topic.

After the housing crisis swept across the United States, the U.S. Federal Housing Finance Authority put a hold on many first generation PACE programs to limit the rise of property debt levels. Nevertheless, a new set of PACE programs has been emerging with added restrictions on the amount of LIC financing in relation to the property's existing debt to equity ratio.

Photo: Binnu Jeyakumar, Pembina Institute

What a Yellowknife LIC program could look like

Based on lessons learned from the literature and case studies described above, as well as interviews with Yellowknife experts, suggestions for a potential Yellowknife LIC program are outlined here.

Overview

Suggestions for a potential Yellowknife LIC program (named a 'Yellowknife Energy Savings Program') are outlined below, including:

- Eligible retrofits
- Aspects of program delivery
- Resident survey, outreach, and contractor engagement
- Energy audit / assessment
- Other conditions of participation

This report does not aim to put forward a comprehensive program design that is ready to implement. Many decisions still need to be made at the City and territorial government levels before this idea can move forward into the design phase. This report merely puts forward suggestions based on advice from key experts and stakeholders.

Our suggestion is for the Yellowknife Energy Savings Program to be more turnkey than hands-off in its approach. It could offer homeowners financing for a relatively limited suite of energy efficiency and renewable energy technologies, which have already proven to be cost-effective in the north. The focus would be on achieving savings from heating (rather than electricity), given that heating is a much bigger source of GHG emissions in Yellowknife. The eligible technologies would include wood/pellet stoves, high performance furnaces and boilers, and building envelope improvements.

Phase 1 of the program, estimated to last two to three years, would target 100 homes. This seems like a reasonable program size, given that Halifax and Toronto each targeted 1,000 homes in the first phase of their programs, and those cities are more than ten times the size of Yellowknife. Moreover, the federal EcoEnergy program completed 211 retrofits within the entire NWT over five years (2007–2012), so 100 retrofits in Yellowknife over two to three years seems realistic.

It may be wise to allow more applicants than the total target number of 100 participants, given the low follow-through rate experienced by other programs (about 25–50% for the City of Halifax). Therefore, approximately 200 applications could potentially be processed.

Given the nature of the eligible retrofits, the average loan size is expected to be around $10,000. Similar to Toronto, Yellowknife could cap loan size at 5% of property value. Therefore, the total program budget would be $1 million, plus administrative costs (see the next section below on costs, benefits and funding sources).

Recommended eligible energy retrofits

The program would offer a small bundle of options to help homeowners save in heating costs:

- Wood/pellet stoves (renewable energy option)
- High performance furnaces and boilers (energy efficiency option)
- Building envelope improvements (energy conservation option).

In consultation with Yellowknife experts, these options were identified as priorities for a potential LIC program in Yellowknife, for the following reasons:

- the technologies have been proven effective and durable in Yellowknife
- they are cost-effective over a reasonable payback period
- they have moderate to high GHG savings potential
- the cost falls within a range ($5,000 to $20,000) that could be difficult for homeowners to afford without a low-interest loan
- they could work well for most Yellowknife homes (widely applicable)
- many local contractors and suppliers are familiar with these technologies

Moreover, each of the options above is eligible for a rebate under the GNWT's Energy Efficiency Incentive Program, administered by Arctic Energy Alliance. The Yellowknife Energy Savings Program could help participants to access those rebates to lower the loan amounts needed. Since 2009, the Energy Efficiency Incentive Program has issued rebates each year for an average of 85 wood or pellet stoves, 57 furnaces or boilers and 14 insulation or air sealing projects (across the entire NWT).

Participating homeowners could potentially choose more than one of the above three options; they are not mutually exclusive.

See Table 3 below for a summary of estimated energy, cost and GHG savings from the three eligible retrofit options.

Wood / pellet stoves

Renewable energy option

A 2011 analysis by the Arctic Energy Alliance evaluated a wide variety of potential renewable energy and energy efficiency measures in terms of both the GHG savings per home as well as the likelihood that a high percentage of NWT homeowners would install the technology (due to such factors as affordability and payback period). They found pellet stoves were the top priority measure that should be promoted, with wood stoves in second place, since they had relatively high potential take-up and the highest overall GHG impact (insulation improvements came third).[31]

Photo: David Dodge, Green Energy Futures

Wood pellet stove

A wood or pellet stove, including installation, costs about $5,000. Rebates are available for up to a maximum of $700 per stove. Depending on the type and amount of fuel currently being used and the efficiency of the current system, a homeowner could expect to save between $1,700–2,300 per year; therefore the payback is 2 to 2.5 years. Stoves are expected to last 12 to 15 years.[32]

Participants interested in this option must understand and be prepared to deal with regular stove maintenance, which is somewhat more labour-intensive than a furnace.

High performance furnaces and boilers

Energy efficiency option

Efficient natural gas furnace

Given that Yellowknife homeowners are not allowed to use a wood or pellet stove as a primary heat source, every home in Yellowknife has a furnace or boiler. In many cases these could be replaced with models that conserve significant amounts of energy and reduce GHG emissions. More efficient furnaces and boilers could also be a good solution for those who feel they cannot manage the maintenance of a wood or pellet stove.

The 2014 price of propane in Yellowknife was $0.80/L, versus $1.28/L for oil. The expected savings of switching from an oil furnace to a high efficiency (95% DHW) propane condensing furnace for a home using 5,000 litres of oil per year is about $1,300 annually, which means a payback of approximately 5.7 years.[33]

Rebates of $600 are available for a gas or propane furnace with a 95% AFUE or higher, or a gas or propane boiler with 92% AFUE or higher.[34]

Building envelope improvements

Energy conservation option

"Building envelope" means the parts of the building that separate the indoors from the outdoors and need to be well insulated, properly sealed, and well ventilated. It is widely recognized that the first step in improving energy use is to find opportunities to conserve energy, or to avoid needing to burn so much fuel of any kind in the first place. Advantages of building envelope improvements include durability (no need to replace within the lifespan of the building) and guaranteed savings regardless of fuel price fluctuations.

These types of retrofits would require careful assessment on a case-by-case basis to ensure cost-effectiveness and a reasonable payback period. Window and door replacement are among the most costly items in this category (windows cost approximately $1,400 each). Without including windows, a full building re-insulation might cost $30,000 to $40,000, which would likely go over the suggested cap on loans (5% of property value). However, partial building envelope improvements could also be possible and beneficial. Given that building renovations often have multiple purposes — improved look/style as well as energy efficiency — a cap on loan size could alternatively be set according to a multiplier of expected energy savings.

Improved insulation

Table 3. Comparison of savings from eligible retrofit options, compared to an 83% efficient oil furnace burning 4,000 L of oil / year

	Wood / pellet stoves	High efficiency propane condensing furnace	Building envelope improvements
Cost estimate	$5,000	$8,000	$5,000-$20,000
Rebate available	Up to $700	$600	$250 to 350
Expected annual savings*	$1,700 to $2,300	$1,300	Depends
Payback period	2 to 2.5 years	6 years	Depends
How long it lasts**	12-15 years	12-15 years	Often life of house
GHG savings	10.5 tonnes CO_2e per GJ	2.2 tonnes CO_2e per GJ	Depends

* Calculations are based on assumption that the home has been burning 4,000 L of oil per year. Savings will be greater and payback periods will be shorter with greater amounts of oil burned.
**While stoves and furnaces are often marketed as lasting 30 years or more, these appliances often last half as long in Yellowknife as in southern Canada due the wear and tear of harsh winters (pers. comm. Mike Stuhec).

Rebates of $350 are available for building envelope improvements that result in a decreased air leakage of 30% or more ($300 rebates are offered for a 20% decrease; $250 is offered for a 10% decrease).

The results of the EcoEnergy program (2007–2012) show that certain building envelope improvements (draftproofing, windows/doors and walls) were even more popular with NWT participants than space heating improvements. While draftproofing (a relatively cheap and easy upgrade) was the most popular, the second and third most popular improvements undertaken were windows/doors and walls, which indicates that NWT homeowners have an appetite for the more involved and expensive energy conservation projects. One option is for the City of Yellowknife to require draftproofing as a minimum first step before granting a loan for window, door, or wall upgrades. However, it may be wise to keep rules and restrictions to a minimum to lessen administrative costs and make the process simpler for applicants.

Other options

The following heating retrofit technologies were also considered for a Yellowknife Energy Savings Program but deemed impractical at the current time:

Pellet or wood chip boilers

Pellet or wood chip boilers could potentially assume more of the heat load for larger homes. However, these boilers are significantly more expensive ($25,000-$35,000) and the payback periods would be significantly longer. Moreover, homeowners are still required to have a fossil fuel based furnace or boiler as the primary heat source, so there is little incentive to try to cover all of the home's heating energy needs with wood fuel.

Solar hot water system

A solar hot water system could potentially offset about half of the energy needed to heat a home's water over the course of a year in Yellowknife, less than the energy contribution in Halifax which has a lower latitude and milder winters. While the price of a solar hot water system, including installation, is about $8,000 in Halifax, the cost would be significantly higher in Yellowknife ($10,000 to $15,000). If a Yellowknife homeowner is currently heating water with electricity, they might save

Introduction

Background

The City of Yellowknife ("the City") has been working with the Pembina Institute to explore innovative ways to finance energy efficiency and renewable energy retrofits for residential, commercial and municipal buildings. This work supports the City's renewed Community Energy Plan (2015–2025), approved in May 2014, and its ongoing efforts to reduce greenhouse gas (GHG) emissions.[1] The focus is on heat energy savings, given that Yellowknife's electricity is primarily supplied by hydro power which has minimal GHG emissions.

Energy retrofits are an important way for Yellowknife residents, businesses and municipal facilities to save money, reduce environmental and climate change impacts, and support the local economy. Popular heat-related retrofits in Yellowknife include installing wood or pellet stoves, improving insulation and air sealing, and switching to more efficient furnaces and boilers. Retrofits also give residents and businesses more security, since imported fossil fuels are costly, subject to sudden price increases, and potentially vulnerable to interrupted supply due to long transportation routes.

Many people do not have enough savings to pay for energy retrofits up front. They may also have difficulty getting a loan from a bank. Those who own energy-inefficient buildings may be trapped in a cycle of 'fuel poverty' since they must use a large portion of their incomes for monthly energy (utility bill) payments, leaving less savings available for making their buildings more energy efficient or switching to lower-cost sources of renewable energy. Effective financing programs can help residents break out of this fuel poverty cycle.

After initial research on various possible financing mechanisms, a decision was made in consultation with City staff and Yellowknife's Community Energy Planning Committee to focus on local improvement charges (LICs) as the most important financing program for the City to pursue in the short term. The main body of this report is about a Yellowknife LIC program for energy retrofits (named a "Yellowknife Energy Savings Program") that could be implemented to assist homeowners. Other potential financing and delivery mechanisms for municipal and commercial energy retrofit projects are outlined in Appendix D. These options were discussed with City staff and the Community Energy Planning Committee but viewed as less feasible and lower priority for now.

The territorial Cities, Towns and Villages Act (CTV Act) already allows municipalities such as Yellowknife to use LICs to help cover the costs of infrastructure investments that benefit a specific neighborhood, such as improvements to sewers and sidewalks. With their permission, the City charges residents in those neighbourhoods extra fees to cover the cost of the local improvements and collects the payments via their about $1,000 a year, resulting in a 10 to 15 year payback, but if they currently use propane to heat water then the payback would be as long as 33 years, which is likely longer than the life of the system. The GNWT already offers $700 rebates for on-demand propane water heaters.

Drain water heat recovery system

A passive drain water heat recovery system could be a great energy-saving option for some Yellowknife homes; however, it is best installed at the construction stage (new homes), and it is not expensive enough to warrant a loan. The technology itself (basically just copper piping) is very simple, effective, and unlikely to break or need replacement during the life of the home. It only costs about $500 to $800, and a $300 rebate is already available. The system takes heat from water running down the drain (usually from a shower) and recycles the heat back to the incoming water. It would not work well for people who primarily take baths. The system can be awkward to install in existing homes, especially if the house is only one story and has no basement, or if there is no room in the wall for the piping.

Air source heat pump

An air source heat pump is an electrically powered device that transfers heat from the outside air into a building. While these devices have been shown to work well in southern parts of Canada, their efficiency decreases with colder temperatures and they must be shut off below minus 15 or 20 degrees Celsius to avoid using excessive electricity.[35] Nevertheless, they can work well in moderately cold temperatures, and the Yukon Government offers rebates of up to $600 for these devices.[36] Given the price of electricity in Yellowknife, it is unlikely air source heat pumps would be economic for homeowners at this time; however, further research may be warranted.

Program delivery

A 'turnkey' approach is recommended for the Yellowknife Energy Savings Program, whereby the program would not only help residents access low-interest financing, it would also:

- include an assessment of energy costs and savings
- assist clients in securing contractors at a fair price
- provide convenient links to existing rebate programs

This type of approach has proven successful in Halifax's Solar City program. While the City of Toronto decided on a somewhat more hands-off approach by putting the onus on the homeowner to choose and manage the contractor in order to reduce its liability, Supervisor Marco Iacampo of the Toronto HELP program recommended that Yellowknife adopt the turnkey model.[37] The contractor market is much smaller and less developed in Yellowknife than in Toronto, so securing a contractor could be a key bottleneck for participants without assistance from the City (see "Contractor engagement" below).

Making the process as simple and straightforward as possible for participants will be key. In this regard it may be useful to learn from the Guelph GEERS program, which plans to emphasize customer-friendliness and have City staff walk applicants through each step of the process. One option Yellowknife might consider is to combine the LIC application process with the building permit application process, if such a permit is required for the desired retrofit, in order to streamline the process for the participant.

Arctic Energy Alliance is a well-established Yellowknife-based organization that is already geared towards helping residents achieve energy and cost savings (including through retrofits). AEA already provides several components that are proposed within the Yellowknife Energy Savings Program, such as offering subsidized energy audits, administering rebate programs, and conducting energy-focused education and outreach. It may make sense for the City of Yellowknife to negotiate a contract agreement with AEA whereby AEA receives a portion of the administration fee and in turn administers several aspects of the LIC program.

Figure 2 below outlines the proposed steps for setting up an LIC program and the broad components of such a program in Yellowknife:

The first step in the setup, creating an enabling law, is addressed in detail in Appendix A, while the third step, obtaining seed funding and financing, is addressed in Appendix C.

Figure 2: Setting up and delivering an LIC program in Yellowknife

SET-UP

- **CREATE enabling law**
- **SURVEY residents and ENGAGE contractors**
- **OBTAIN seed funding and financing**
- **MARKET and outreach**

DELIVERY

APPLICATION

- **STEP 1:** **Subsidized home energy audits by Arctic Energy Alliance** (not required for stoves or furnaces)
- **STEP 2:** **Homeowners select from recommended retrofits**
- **STEP 3:** **Application is accepted and loan agreement is signed**

WORK

- **Contractor is selected from approved list**
- **Contractor completes work**
- **City pays contractor**

LOAN COLLECTION

CITY COLLECTS REPAYMENT through property tax bill for set term

OR

as straight repayment if loan not required

Resident survey and outreach

Any LIC program in Yellowknife should be designed according to the specific needs of local residents and take into account the features of the local contractor market. The City is already undertaking an online survey to get residents' feedback on the overall Energy Plan.[38] It would be advisable for the City to conduct further research (either a survey or focus groups) to understand residents' perspectives on an LIC program specifically.

The City of Toronto contracted Ipsos Reid to carry out focus groups with residents about its proposed LIC program, in order to investigate level of interest in retrofits, receptivity to LIC financing methods, and questions or concerns, as well as to identify communications approaches that could maximize resident understanding and appeal.[39]

The results, released in April 2013, found that the main barrier to homeowners undertaking energy retrofits on their own was lack of a guarantee on savings. A professional energy audit/assessment, as well as City assistance in securing reasonable contractor rates and a low fixed-interest loan, may help to address this concern.

While Yellowknifers will likely have different perspectives and priority concerns than Torontonians, the Toronto study nonetheless flags issues that the City of Yellowknife should be prepared to deal with. The top concerns expressed by Toronto focus group participants included:

- Discomfort with the City acting as a bank, which some saw as not the proper role for the City. (Messaging could emphasize that the City is passing along preferential interest rates to residents rather than acting as a bank per se.)
- Fear that property taxes would be raised if the City knew the value of retrofits and renovations.

Transparency and clarity in an LIC program was key for Toronto focus group participants:

- Residents want clear information on how exactly the charge is transferred upon sale of the home, so it will not be a barrier to sale.
- Any administrative costs or surcharges for participating in the program should be communicated clearly up front.
- Residents want clear information about who will be held accountable and how any conflicts would be resolved between homeowners, government, contractors, etc.
- Residents want a clearly identified contact person who will manage the process and who they can go to with questions and concerns.

In terms of marketing and outreach, Ipsos Reid had the following recommendations:

- Focus group participants rank 'friends, family and neighbours' as their most trusted sources for information on home energy retrofits, as well as certified energy advisors. Word of mouth will be important to program success.
- All communication material and program design elements should emphasize control and decision-making authority being in the hands of the homeowner. While participants may need assistance, they still want options in which contractors to use, the rate of the loan and the length of the term.

With regard to the last point, Torontonians' preference for control was one reason that city went with a more hands-off program style where participants choose and manage the contractors themselves. While a Yellowknife program would likely work better with a turnkey approach, this may create tension given the strong ethos of independence and self-reliance amongst Yellowknifers. The City could consider ways to offer options wherever possible, allowing participants to retain a sense of control.

The importance of marketing and outreach cannot be overemphasized, according to those interviewed for this report who have experience with LIC programs. Inadequate outreach may have been one of the reasons why so few signed up for the Vancouver LIC pilot program.[40] The City of Halifax does regular events and advertising to raise awareness, and program representatives arrange many speaking engagements.

Given the conclusion above that owners of Yellowknife homes built in the 1960s and 70s may be prime candidates for an Energy Savings LIC Program, the City of Yellowknife could consider ways to target outreach towards these neighbourhoods, including by holding local events.

Contractor engagement

Contractors could be key allies for a Yellowknife Energy Savings Program, both in terms of outreach and promotion, and in terms of ensuring retrofits get completed within reasonable timelines and budgets. When a homeowner goes to a contractor to obtain a quote for a retrofit, the contractor should be well equipped to explain what kind of LIC loans are available, and where the homeowner can go to learn more about the program. This could be a win-win-win partnership for the contractor, the homeowner, and the City.

Contractors

Unfortunately, many Yellowknife homeowners currently find it challenging to obtain contractors for energy retrofit work, due to relatively low supply and high cost. The City could improve the situation by bringing together a group of willing contractors and working out the expected volume, type and timing of needed retrofits over the next several years, to allow contractors to scale up or adjust their services accordingly. The City might play an active role in scheduling retrofits during seasons that are traditionally less busy for contractors.

The City could put a 'basket' of expected retrofits out for bid ahead of time, in order to find contractors who prove they can deliver satisfactory work at reasonable prices. One option is for the City to reach ongoing supply services arrangements with a select group of contractors, choose the best one for each job on a case-by-case basis, and manage contracts directly on behalf of each participating homeowner, as the City of Halifax does. Another option is to create a pre-approved list of contractors (who have agreed upon price ranges) and let homeowners select and manage the contractors themselves from this list. This pre-approved list option was to be used by the City of Vancouver (before the program was cancelled). In either case, rigorous third-party audits of contract work will be necessary.

While Halifax pays contractors directly, the City of Toronto issues funds to the homeowner — 10% once the initial purchase order agreement is signed, and the remaining amount once the City verifies the work is complete and certified.

Building strong relationships with contractors was cited as a key factor of success in Manitoba Hydro's Power Smart LIC program, which has had 89,000 households participate since 2001 (receiving loans up to $7,500 each).[41] Coordination with contractors also provides convenience for the client; for example, in the case of furnace financing, one contract is used for both furnace purchase and financing.

Inadequate consultation with contractors was cited as a reason for the poor completion rate experienced by the 2008–2009 Berkeley FIRST residential loan program in California — while all 40 application slots were filled, only 13 projects were completed. Poor communication with the City resulted in contractors being concerned about getting paid on time.[42]

Energy audit / assessment

An energy assessment or audit process is a key first step to determine whether a proposed retrofit will save

Energy assessors

a homeowner energy and money, and to ensure that the payback period will not extend beyond the useful life of the retrofit. However, the assessment or audit process could be more or less in-depth depending on the proposed retrofit. For example, the assessment could be much simpler and less expensive if the proposed retrofit is either a wood or pellet stove or a furnace or boiler replacement, since much is known about energy and cost savings from those technologies. A more in-depth audit would be required for building envelope improvements, which can vary greatly from one building to another.

While scaled-down or targeted audits can help save costs, there is also benefit in encouraging homeowners to use the opportunity to have a full energy audit done on their home, to find out whether additional upgrades or energy efficiency/conservation opportunities exist.

In Halifax, applicants undergo an initial energy assessment and receive a feasibility report detailing their estimated return on investment and the system cost after all rebates and incentives. About 5 to 10% of homes are deemed non-feasible and screened out, but these applicants still receive a report with an explanation. Typically homes are screened out because they will not save enough money on upgrades to justify the cost, or they are deemed structurally unsuitable.[43]

Both Halifax and Toronto require third-party verification that the retrofit was completed as planned, but do not require a full post-retrofit energy audit to determine actual energy and cost savings. While a post-retrofit energy audit would be ideal in order to determine the GHG and cost savings achieved by the program as a whole, this step may be too expensive and impractical as a requirement for each participant. A smaller selection of participants could receive a post-retrofit energy audit as part of program evaluation.

Other conditions of participation

The Halifax program allows participants to pay off any outstanding balance partially or fully at any time with no penalties. If the home is sold, the participant has the option of repaying the outstanding balance at that time, or transferring the loan to the new homeowner. According to staff with Halifax Solar City, there have been no problems reported so far related to the sale of homes with these LIC loans attached to them.

The customer agreement signed by Halifax Solar City registrants requires participants to notify their insurance provider about the new system being installed (and purchase appropriate insurance coverage), notify potential home buyers about the lien on the house, and to provide any buyer with a copy of the agreement with the City.

The City of Toronto has been more concerned about the risk of LIC loans complicating real estate transactions, and requires homeowners to obtain the consent of their mortgage provider. It will be interesting to learn as the Toronto program unfolds how mortgage lenders are reacting to the program.

Photo: Binnu Jeyakumar, Pembina Institute

Photo: Roberta Franchuk, Pembina Institute

Benefits, costs and funding sources

Benefits of an LIC program

An LIC program for energy efficiency and renewable energy improvements could create significant financial and non-monetary benefits for both the City and individual residents. City-wide benefits include:

- creating a more comfortable and affordable place to live
- stimulation of local economic development, particularly in the construction/retrofit sector and the biomass energy sector
- progress in achieving the City's GHG reduction targets, and demonstration of the City's continued leadership on climate action

Benefits for individual homeowners include:

- immediate savings through lower utility bills
- improved health and comfort for residents
- lower fixed interest rates for longer repayment terms (eg. up to 15 years) than homeowners could obtain on their own
- equal access to financing regardless of homeowner income
- transferability of the loan with the property

The first phase of the Yellowknife Energy Savings Program (targeting 100 homes) is estimated to potentially save each homeowner on average per year:

- about $1,300 in energy costs (not including cost of the investment)
- 40.3 GJ of energy
- 3.75 tonnes of carbon dioxide equivalent (CO_2e)

These calculations are explained fully in Appendix B.

Briefly here, the estimates are derived from the actual experience of the EcoEnergy Retrofit program. Homeowners who undertook space heating and insulation/building envelope improvements between 2007–2012 through this program saved an average of 40.3 GJ of energy and 3.75 tonnes of CO_2 per year. For a Yellowknife homeowner using oil to produce 40.3 GJ (given the 2014 price of oil), this would translate to $1,344 in savings. A homeowner using electric baseboard heating would save a much greater amount ($3,248), but relatively few Yellowknifers use electric heating given the cost, and CO_2e savings would be minimal in this case given that Yellowknife electricity is mostly powered by hydro. This correlates well with the estimate of $1,300 in expected savings per year from replacing an oil furnace with a propane condensing furnace (see Table 3. Comparison of savings from eligible retrofit options, compared to an 83% efficient oil furnace burning 4,000 L of oil / year).

With a total of 100 participants in Phase 1, Yellowknife's Energy Savings Program is expected to save residents about $130,000 per year in total, while reducing CO2 emissions by about 375 tonnes per year.

The Yellowknife Energy Savings Program would not benefit renters, who occupy about half of the dwellings in Yellowknife, although 64% of renters live in apartments. In total, about 15.7% of households in Yellowknife are renters in single detached, semi-detached or row houses, none of whom would likely benefit from a property tax based LIC program.

Payback periods and return on investment

Using a simple payback (total cost divided by annual savings) is common in business decisions. However, this method does not take into account rising fossil fuel costs, the life expectancy of the system, increasing future savings or the likely costs associated with the status quo or alternative options.

A return on investment (ROI) calculation takes into account the lifespan of the system, and would assume at least a 5% escalation rate in energy costs.

For example, the Halifax Solar City program estimates that the average homeowner payment will be $750 per year, and the average savings will be $400 per year, which adds up to a net cost of $350 for 10 years. From an ROI perspective, however, the program offers each homeowner a 7 to 9% return on investment, with typical savings expected to be more than $20,000 over the lifespan of the retrofit (estimated at 25 years or more), with average annual savings of $425. Annual savings are expected to outweigh annual payments after about eight years (creating a positive cash flow starting around year nine).[44]

It would be helpful for the City of Yellowknife to emphasize the return on investment perspective, rather than simple payback calculations, in marketing and outreach for its program.

Costs of an LIC program

The Yellowknife LIC program would ideally be revenue neutral, meaning all costs would be recovered from participants (including administrative fees).

It is envisioned that the legislative amendment enabling LICs in the NWT would require any municipality to recover the full cost of the program from local improvement charges, including the financing costs of short-term debt and long-term debt (see Appendix A for a sample draft legislative amendment). Any risk of municipalities themselves defaulting on loans could be addressed by retaining adequate Ministerial oversight.

A small grant or loan would be required for administrative set-up costs, estimated at approximately $150,000.[45] Ongoing administrative costs for the Yellowknife Energy Savings Program could be as high as $80,000 per year, judging by the cost of programs in other cities.[46] The City of Toronto charges each participant an administrative fee of 2% of the value of the loan; however with only 100 participants in Phase 1 of the Yellowknife Energy Savings Program and an average loan value of $10,000, a 2% administrative fee would only amount to $20,000. The City of Yellowknife may need to charge a higher fee, but this will make the program less attractive to participants. The City will need to work particularly hard to reduce and streamline administrative costs as much as possible. Offering participants a limited range of proven options for eligible retrofits will help. A contract with Arctic Energy Alliance for parts of program delivery might also help to leverage existing resources and reduce potential duplication.

The City would require access to a guaranteed low-interest source of program funds, about $1 million in start-up capital for a Phase 1 program targeting

100 homes. This would likely involve borrowing from a financial institution, with the territorial Minister's approval. However, other options for seed funding and financing mechanisms are outlined below.

Seed funding and financing options

The City of Yellowknife has five main options for obtaining the $150,000 in start-up funding and $1 million in capital needed to finance an LIC program:

- Borrow from a financial institution (requiring a Ministerial exemption or a City-wide referendum)
- Use existing capital reserves
- Land sale or endowment
- Access grants for start-up seed funding (would not address financing issue)
- Establish an internal revolving fund for start-up seed funding (would not address financing issue)

These and other options for consideration are discussed in more detail in Appendix C.

Most municipalities have access to low-interest financing from financial institutions that can be used to support the LIC loan program. For example, the City of Yellowknife is financing its new water treatment plant with a 15-year loan at 3.4% interest. Section 112 of the territorial Cities, Towns, and Villages Act (CTV Act) requires NWT municipalities to obtain voter approval or a Ministerial exemption from voter approval in order to take on long-term debt above certain limits. A simple amendment to the CTV Act or a Ministerial exemption for the City of Yellowknife's LIC program would allow the program to be financed through a bank.

The City of Halifax obtained a $5.5 million loan from the Federation of Canadian Municipalities' (FCM) Water Conservation Fund to partially cover its Solar City program budget which totaled $8.3 million. While reporting requirements are more onerous with FCM loans than with a financial institution, the Fund issues loans at one point below the standard interest rate. According to Halifax's Energy Manager, the program could have gone ahead with a bank loan instead; however the FCM loan provided added comfort.[47] The Solar City program was eligible for this particular fund because of its link to water; it is not clear whether Yellowknife's LIC program would qualify for an FCM loan.[48]

Another option is to set aside capital to form a large enough floating fund to cover the first phase of projects. Toronto was able to finance its HELP program by committing up to $20 million from its existing working capital reserve fund. This may not be practical or possible for a city the size of Yellowknife.

The Toronto Atmospheric Fund (TAF) is an arm's-length organization mandated to reduce greenhouse gas and air pollution emissions in the Toronto area, including by increasing energy efficiency in buildings (see Appendix D). TAF was formed out of a $23-million endowment resulting from the sale of Toronto municipal land. A land sale by the City of Yellowknife would be governed by the Land Administration bylaw, which is prescriptive in terms of what can be done with the money.

While grants would likely not be large enough to cover the full program budget (including financing), they could be accessed for seed funding to cover program design, set-up and initial outreach. A grant for up to $150,000 was offered for 2015–2016 from Natural Resources Canada (NRCan) for purposes such as this; NRCan previously gave a start-up grant to Toronto's HELP program. Halifax's start-up administrative costs were covered by a $550,000 grant from FCM. Toronto received seed funding amounting to about $1 million from TAF, Ontario Power Authority, NRCan, Enbridge and Toronto Hydro.

It is also possible for local governments to establish revolving funds to provide start-up funds for an LIC program. Both the City of Hamilton and the City of Edmonton have established internal revolving funds where they reinvest savings gained from initial municipal energy retrofit projects into other municipal energy efficiency improvements. While setting up a formal revolving fund may be an unnecessary administrative burden for Yellowknife, the City could simply set aside some of its gas tax money or Community Energy Plan funds in order to support an LIC program.

Conclusion: Key factors for success

There appears to be a need and a significant demand for an LIC program in Yellowknife, particularly among owners of houses built in the 1960s and 70s. An estimated 60% of Yellowknife homes are rated below EnerGuide 70, leaving substantial room for improvement.

The Yellowknife Energy Savings Program would ideally follow a 'turnkey' approach, whereby the program would not only help residents access low-interest financing; it would also:

- include an assessment of home energy costs and savings
- assist clients in securing contractors at a fair price
- provide convenient links to existing rebate programs

The program would offer homeowners financing for a relatively limited suite of energy-efficiency and renewable energy technologies, which have already proven to be cost-effective in the north. The eligible technologies (all heating-related) would include wood/pellet stoves, high performance furnaces and boilers, and building envelope improvements.

Given the lessons learned in other jurisdictions with LIC programs, the following are seven key factors that could help a Yellowknife Energy Savings Program be successful:

1. Low interest rates

Interest rates seem to be the biggest single factor in whether or not LIC programs have gotten off the ground and attracted participants.

Manitoba Hydro's Power Smart program and Clean Energy Works Oregon have both had substantial uptake (89,000 and 3,000 households respectively) due to attractive interest rates, despite offering non-transferable loans that are attached to the individual rather than the property.

On the other hand, Vancouver's pilot LIC program attracted very few participants due to a 4.5% interest rate. Feedback on the Berkeley FIRST program also indicated that 27 of 40 participants withdrew in large part because the program's interest rates were higher than expected.[49]

2. Get the loan size right

If the loan amount is too large, there is a risk that the retrofit will not produce the expected payback within a reasonable time period, and the homeowner could be dissatisfied or default on the loan. The City of Toronto caps its loans at 5% of the property value.

On the other hand, there are risks of offering loans that are too small (under about $5,000). The administrative costs of managing loans for many small projects add up, and the City gets less 'bang for the buck' in terms of energy and GHG savings. Small loans may encourage homeowners to choose only the lowest-hanging fruit and miss opportunities for deeper retrofits with greater energy and cost savings in the long run. Finally, the program may attract few participants in the first place, since homeowners are more likely to be able to pay for smaller projects out of their own savings or on credit.

3. Effective marketing and outreach

While inadequate outreach was observed to be a significant factor in the poor uptake of the Vancouver LIC pilot program, staff at Halifax Solar City point to effective marketing and outreach as the biggest key to their success. The City's communications team was involved right from the early stages of program design. The team aims to create 'buzz' by doing regular events, advertising and speaking engagements to raise awareness. The Toronto HELP program organizers contracted Ipsos Reid to identify communications approaches that could maximize resident understanding and program appeal.

News Bulletin #7 June 2014

Solar City

Hello Solar City Community,
With spring now here, the Solar City Program is running full speed again. Scotian Renewables and Thermo Dynamics spent the winter roughing in equipment inside homes and April has seen the completion of a lot of systems. Lots of other solar news to catch up on too!

Solar City Registration Open and Growing
General registration is now open for the Solar City Program at www.halifax.ca/solarcity. Since opening up the registration again in early March, over 1,000 new homeowners have signed up and will be getting a free solar assessment in the next 3 months. Registration is now easier than ever.

Next Open House
June 12, 6-7 pm
Halifax North Memorial Library, 2285 Gottingen Street

New to the Solar City Program? This is a great chance to ask questions and hear how the program runs. Typically a 20 minute presentation is given by the HRM Solar City staff followed by Q&A. Thermo Dynamics also has demo equipment set-up. More than 500 people have attended our Open House nights. Please RSVP to solarcity@halifax.ca to secure a seat at this Open House! More Open Houses will be coming. Of course you can always call or visit the website too.

Contact Us
Website:
halifax.ca/solarcity
Email:
solarcity@halifax.ca
Phone:
(902) 240-8208

In this issue
- Registration Opens
- Solar Fiesta Recap
- Next Open House – June 12
- Halifax's Solar Energy Map
- Solar In the City
- Solar City by the numbers
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- Solar Fast Fact – cloud cover?
- Looking for volunteers to be mapped
- Shape Your City's Energy Future
- Dalhousie's GEEN
- We want your comments and feedback

HALIFAX
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Effective outreach goes beyond marketing strategies to forging partnerships with important allies. It will be important for Yellowknife to reach agreements with contractors in order to ensure residents can get energy retrofits done within reasonable timelines and budgets. These contractors will also be on the front lines of outreach and promotion, with opportunities to educate prospective and existing clients about the financing program, so these contractors will need to receive training and materials from the City.

Real estate agents may be another important partner for the City. First, it may be necessary to address their questions and concerns about the program, given that some may view the LIC loan as a complicating factor in house sales and mortgages. On the other hand, energy retrofits represent improvements to home value, and real estate agents need to be aware of the selling points.[50] An important factor that will drive homeowners' interest in energy retrofits is whether potential buyers will pay more for the house as a result; therefore, increased awareness of EnerGuide standards and ratings within the housing market will contribute to success of the LIC program.

4. Phase in gradually

Due to current bottlenecks in local contractor availability for home energy retrofits, it will be particularly important for Yellowknife to phase in its Energy Savings Program. By opening up clear communication channels and establishing formal agreements with contractors, the City can encourage contractors to scale up or adjust their services. The program must allow time for the contractor market to grow and develop.

It is anticipated that Phase 1 of the Yellowknife Energy Savings Program will allow for a maximum of 100 participants over the course of two to three years. This time could be lengthened or the number reduced, depending on feedback from residents and contractors during program set-up and over the first year.

5. Make it simple for participants

Newer programs such as GEERS in Guelph and C Returns in Edmonton are recognizing that the hassle factor may be equally or more important than lack of access to low-interest financing in preventing people from doing home energy retrofits. Therefore, a successful LIC program must be easy for homeowners to understand and involve only a few clear steps. Homeowners should have a clear and consistent point of contact at the City (or Arctic Energy Alliance) to answer their questions and guide them through the process.

The program must be designed to help people overcome the hassles associated with identifying energy-saving opportunities, figuring out the right technology, finding and managing a contractor, and getting a fair deal. These services are incorporated into the turnkey approach. At the same time, the Ipsos Reid survey results from Toronto indicated that homeowners want to retain a sense of control over the process, which means having key choices available to them such as the length of the loan term.

One of the lessons the City of Halifax learned is how difficult it is to make a program simple for participants; Solar City has required extensive teamwork from not only the City's energy team but its legal, finance, and communications departments.[51]

6. Streamline administration

If administrative costs are ultimately to be fully covered by charges on program participants, and there are relatively few participants in a small program, then administrative costs must be kept to a minimum in order to avoid charging unreasonable fees and driving away participants.

Streamlining administration is also necessary to keep the program financially sustainable. An on-bill LIC program run by BC Hydro from 1990 until 2002 was ultimately cancelled because administrative costs took up almost half the program budget.[52]

A small city like Yellowknife has limited administrative capacity, and must make use of all available resources and partnerships. A contract with Arctic Energy Alliance for parts of program delivery might help to leverage existing services and reduce potential duplication.

Streamlining can be enhanced by offering participants a limited range of eligible options for retrofits and by reaching service agreements with contractors ahead of time.

7. Win political support

An LIC program for Yellowknife will be impossible without an amendment to the territorial CTV Act, which will require the support of political leaders and top staff within the GNWT. Other communities in the NWT have shown their support for an LIC amendment through a resolution by the NWT Association of Communities.

Photo: Yellowknife City Hall by Alan Sim via Creative Commons

Appendix A: Required changes to Cities, Towns and Villages Act (CTV Act)

Overview

Changes to the CTV Act could be made along similar lines as recent amendments in other jurisdictions such as Ontario[53] and Nova Scotia[54]. In 2012, Ontario became the first Canadian province to specifically enable LIC-type financing.[55]

The CTV Act could be amended in three simple ways to provide a tax-based municipality such as Yellowknife with the authority to establish LIC-based energy efficiency programs:

- Clarify what kinds of local improvements can be done (i.e., include energy efficiency works and renewable energy works)
- Clarify where the local improvements can be carried out (i.e., private property) and who can access local improvement funding (i.e., individual property owners)
- Allow municipal councils to approve LIC programs as a whole rather than requiring bylaws to be passed for each individual local improvement

Kinds of local improvements

The CTV Act, which is only applicable to tax-based communities, currently defines local improvement to mean "a work that will have a benefit to the real property in a particular geographic area within the municipality". This kind of work may add value to groups of — or individual — property owners in a particular geographical area.

Municipalities typically use LICs to help cover the costs of infrastructure investments that benefit a specific neighborhood, such as improvements to sewers and sidewalks. The neighborhood benefiting from the improvements would then pay for the improvements through their property taxes. Using LICs for energy efficiency and renewable energy improvements is a new application for this financing mechanism, but consistent with the broader intent of LICs. Nevertheless, for greater certainty, it may be prudent to amend the CTV provisions relevant to LICs to include energy efficiency and, if desired, renewable energy investments.

In Ontario the definition of what a local improvement could support was amended to include the following clause:

> (q) constructing energy efficiency works or renewable energy works.

Where and with whom local improvements can be carried out

Both the Nova Scotia and Ontario legislative changes clarified that individual property owners can access funding for local improvements. The Ontario amendment introduces the use of an agreement between the municipality and a property owner, and enables a special charge for local improvement works on particular properties to be placed on the property tax roll and receive priority lien status.

Ontario added the following clause to allow a local improvement on private property:

> Scope of local improvement
>
> (2) The power to undertake a work as a local improvement includes, without limitation, the power to,
> (a) undertake the work as a local improvement, including undertaking the work on private property;

The Nova Scotia amendment includes the following:

> 104A (1) The Council may make by-laws imposing, fixing and providing methods of enforcing payment of charges for the installation of energy-efficiency equipment on private property with the consent of the property owner including, without restricting the generality of the foregoing, solar panels.
>
> (2) A by-law passed pursuant to this Section may provide
>
> (a) that the charges fixed by, or determined pursuant to, the bylaw may be chargeable according to a plan or

method set out in the bylaw;

(b) that the charges may be different for different classes of development and may be different in different areas of the Municipality;

(c) when the charges are payable;

(d) that the charges are first liens on the real property and may be collected in the same manner as other taxes;

(e) that the charges be collectable in the same manner as taxes and, at the option of the Treasurer, be collectable at the same time, and by the same proceedings, as taxes

Flexibility for municipalities to pass bylaws for entire LIC programs

The CTV Act currently constrains the development of a local improvement program because of the need to pass a bylaw with three readings, in addition to the need for public consultation for each individual LIC. This section is designed for local improvements with a larger geographical area that encompasses multiple private properties. However, this clause would be overly cumbersome for a local improvement program targeting individual private properties. The Ontario legislation includes the flexibility for allowing a municipality to pass an entire LIC program:

Local improvement charges by-law

36.5 (1) If the municipality has the authority to undertake a work, it may, in accordance with this Part, pass a by-law to undertake the work as a local improvement for the purpose of raising all or any part of the cost of the work by imposing special charges on lots upon which all or some part of the local improvement is or will be located.

(2) A by-law under subsection (1) may be a by-law to authorize the undertaking of a specific work for which the municipality has given notice under clause 36.6 (2) (a) or a by-law to authorize the undertaking of works which satisfy the requirements of a municipal program for which the municipality has given notice under clause 36.6 (2) (b).

Notice of local improvement charges by-law

36.6 (1) Before passing a by-law to undertake a work as a local improvement under section 36.5, the municipality shall give notice to the public of its intention to pass the by-law.

(2) The public notice of the intention to pass the by-law shall include, (a) a description of a specific work the municipality intends to undertake; or (b) a description of a program that the municipality has or intends to establish to undertake the types of works set out in the notice.

In summary, the CTV Act could be simply amended to provide tax-based municipalities with the authority to establish a local improvement program by:

- Clarifying the uses of a local improvement to include energy efficiency works or renewable energy works
- Specifying that a local improvement can be administered on private property
- Allowing for the flexibility of a local improvement program

Proposed legislative changes

AN ACT TO ENABLE MUNICIPALITIES TO USE LOCAL IMPROVEMENT CHARGES FOR ENERGY EFFICIENCY MEASURES

Summary

This Bill amends the Cities, Towns and Villages Act to enable municipalities to use their local improvement charge authority to finance property-assessed pay-as-you-save energy efficiency investments in private local buildings.

The Commissioner of the Northwest Territories, by and with the advice and consent of the Legislative Assembly, enacts as follows:

1. **The Cities, Towns and Villages Act is amended by this Act.**
2. **The definition of "local improvement" in section 1 is amended by adding** "or a work to promote energy efficiency or renewable energy on a particular parcel of real property within the municipality" to the end of the definition.
3. **The definition of "local improvement bylaw" in section 1 is amended by adding** "or a program for a series of local improvements that promote energy efficiency on individual parcels of real property" to the end of the definition.
4. **Section 107 is amended by adding the following after subsection 107(4):**
   (5) For greater certainty, the borrowing of money by a municipal corporation for the purpose of financing a local improvement, as authorized under section 120, shall be considered a municipal purpose.
5. **Subsection 117(1) is amended by striking out** "bylaw" **and substituting** "bylaw authorizing a single local improvement under subsection (2) or a bylaw authorizing a program for local improvements under subsection (3)".
6. **Subsection 117(2) is amended by striking out** "local improvement" **and substituting** "single local improvement benefitting multiple parcels of real property".
7. **Section 117 is amended by adding the following after subsection 117(2):**
   (3) A bylaw authorizing a program for a series of local improvements that promote energy efficiency on individual parcels of real property must
      (a) recover the full cost of the program, including the financing costs of short-term debt and long-term debt, from local improvement charges levied against the parcels of real property that benefit from the local improvements; and
      (b) set out
         (i) the total cost of the series of local improvements authorized as a program;
         (ii) the proportion of the costs that would be financed by
            (1) local improvement charges levied against the parcels of real property that benefit from the local improvements
            (2) general revenue of the municipal corporation; and
            (3) any short-term debt and long-term debt;
         (iii) the period over which the local improvement charges would be payable;
         (iv) the conditions on which the local improvement charges, in respect of a parcel of real property, could be paid in a lump sum;
         (v) the nature of the energy efficiency measures eligible under the program and the nature of eligible costs; and
         (vi) a description of the parcels of real property that are eligible under the program.
8. **Subsection 118(1) is amended by striking** "local improvement bylaw" **and substituting** "bylaw authorizing a single local improvement under subsection 117(2)".
9. **Subsection 119(1) is amended by striking** "local improvement bylaw" **and substituting** "bylaw authorizing a single local improvement under subsection 117(2)".

10. **Paragraph 121(1)(c) is repealed and the following substituted:**

(c) authorize

(i) in the case of a bylaw for a single local improvement under subsection 117(2), the levy of a local improvement charge against the real property that council considers principally benefits from the local improvement; or

(ii) in the case of a bylaw authorizing a program for local improvements under subsection 117(3), the levy of local improvement charges against each individual parcel of real property that benefits from the local improvement.

Photo: Legislative Assembly of Northwest Territories @ Yellowknife by Hideyuki Kamon via Creative Commons

Appendix B: Estimates for energy and cost savings from Phase 1 of a Yellowknife energy savings program

Summary

The first phase of an LIC program in Yellowknife (targeting 100 homes) is estimated to potentially save each homeowner on average per year:

- about $1,300 in energy costs
- 40.3 GJ of energy
- 3.75 tonnes of carbon dioxide equivalent (CO_2e)

The estimates are conservative and derived from the actual experience of the EcoEnergy Retrofit program. Homeowners who undertook space heating and insulation/building envelope improvements between 2007–2012 through this program saved an average of 40.3 GJ of energy and 3.75 tonnes of CO_2 per year. For a Yellowknife homeowner using oil to produce 40.3 GJ (given the 2014 price of oil), this would translate to $1,344 in savings. A homeowner using electric baseboard heating would save a much greater amount ($3,248), but relatively few Yellowknifers use electric heating given the cost. Coincidentally, $1,300 also represents a rough estimate of expected savings per year from replacing an oil furnace with a propane condensing furnace (see Arctic Energy Alliance Savings Calculations below). Note that homeowners who switch from oil furnaces to wood/pellet stoves can potentially save much more than $1,300 per year ($1,700 to $2,300 per year in the hypothetical case outlined below).

With a total of 100 participants in Phase 1, Yellowknife's Energy Savings Program is expected to save residents about $130,000 per year in total, while reducing CO_2 emissions by about 375 tonnes per year. This represents a reduction of about 0.9% of Yellowknife's total residential CO_2e emissions per year (estimated at 43,653 t CO_2e).[56]

The actual energy and cost savings from a Yellowknife Energy Savings Program are impossible to predict exactly, since savings depend on many factors, including:

- how many participants choose each of the three program options (wood stove, furnace upgrade, or insulation improvements)
- the nature of each participant's existing heating system (e.g. electric or oil)
- how much fuel each participant currently uses
- the efficiency of each participant's current furnace
- what other energy efficiency measures residents adopt based on energy audit recommendations

The figures above do not represent net cost savings; they do not subtract the costs of doing the energy retrofits or consider interest payments on loans. Costs of insulation/building envelope improvements in particular would be highly variable and case-specific, and data is not available from the 2007–2012 EcoEnergy Retrofit program on how much homeowners paid in total for their retrofits. It is worth noting that simple payback calculations (cost of the retrofit divided by difference in current energy prices between old system and new energy-efficient system) are not the best way to evaluate the economic benefit of a retrofit or renewable energy installation. Instead, a return on investment calculation may be more appropriate whereby the cost of energy is assumed to increase over time, and thus the homeowner's savings will also increase over time.

According to the 2011 Census, there are 6,935 residential dwellings in Yellowknife. Analysis has shown that the total energy use by residential dwellings in Yellowknife for 2013 was 600,539 GJ and GHG emissions were 43,653 t CO_2e. This means that the average household energy use was 86.6 GJ and the average household GHG emissions were 6.3 t CO_2e. Thus, the expected average energy savings per home (40.3 GJ) from a Yellowknife Energy Savings Program loan represents about 47% of average household energy use, and the expected average GHG emission savings (3.75 t CO_2e) represents about 60% of average household GHG emissions.

EcoEnergy Retrofit Program data

The federal EcoEnergy Retrofit Program ran from April 2007 to March 2012 and provided homeowners with grants up to $5,000 for eligible energy efficiency measures. The program required an energy assessment

Table 4. Cost savings based on EcoEnergy Program energy savings

	Energy savings	Conversion to heating equivalent*	Price (2014)*	Cost savings
Electricity	40.3 GJ	11,200 Kwh	$0.29/Kwh	$3,248
Oil	40.3 GJ	1,050 L	$1.28/L	$1,344

* Calculated using Arctic Energy Alliance's Space Heating Calculator.

using the EnerGuide Rating System before and after work was completed.

During the life of the program, 1,074 homes in the NWT were evaluated.[57] Based on the data from pre-retrofit assessments, potential savings for those homes ranged between 2.7 and 7.3 tonnes of CO_2/home/year and between 32 and 84 GJ of energy/home/year. This amounts to averages of 5.51 t of CO_2/home/year and 56 GJ/home/year.

However, not all of the energy efficiency potential was utilized. Instead, actual upgrades represented energy savings of between 8 and 51 GJ/home/year. The average NRCan incentive payout for all of NWT was $1,447/ home.

The average energy savings were 40.3 GJ/home/year and 3.75 t of CO_2/home/year. Using the average of those energy reductions and equating them to savings in either electricity or oil consumption results in $1,344 to $3,248 per home per year in heating cost savings. See Table 4.

The majority of the ecoEnergy upgrades were focused on space heating, insulation of basement, attics and walls, and draft proofing — which aligns with two of the three proposed focus areas of the Yellowknife Energy Savings Program, namely:

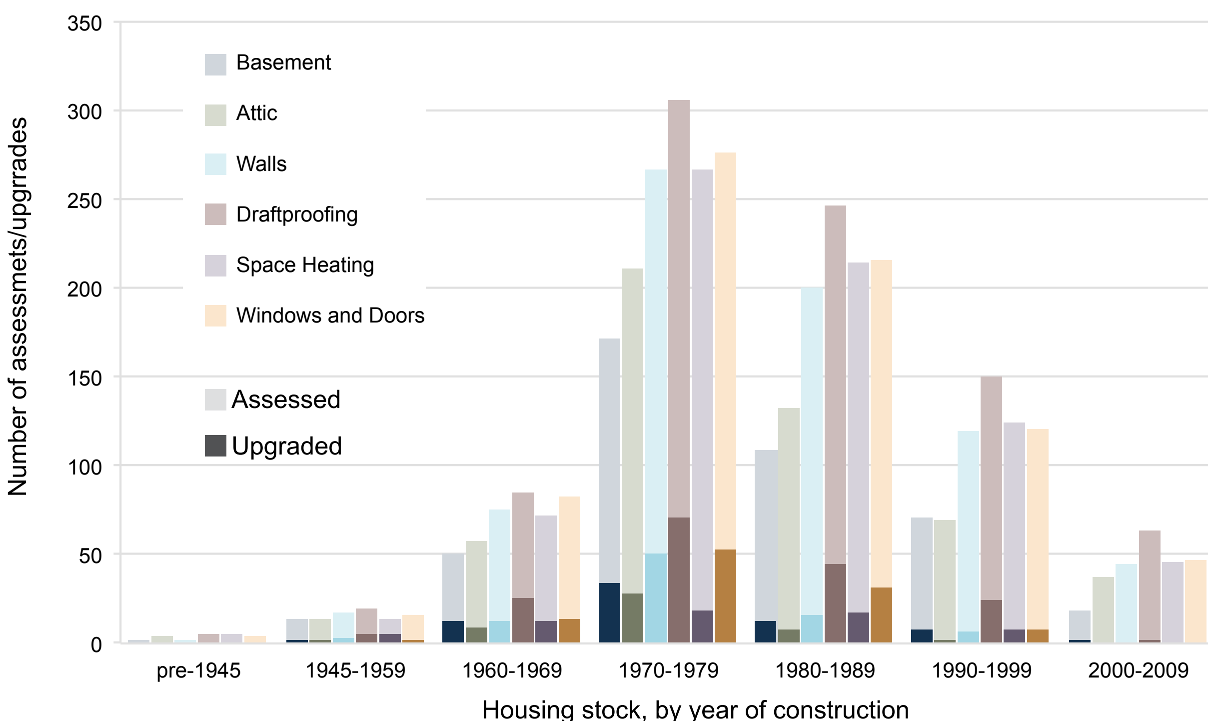
a) 'renewable energy' component – wood/pellet stoves

c) 'energy conservation' component – insulation and air sealing

Figure 1 shows the ecoEnergy upgrades (by type) that were suggested in NWT, by age of house, as well as the actual upgrades completed.

The energy assessments undertaken (1,074) represent about 8% of the housing stock in NWT. Only 20%

Figure 1: EcoEnergy retrofits in NWT



Data source: NRCan[58]

of those who undertook pre-retrofit evaluations implemented upgrades, completed the post-retrofit evaluation and received grants under the EcoEnergy program. It is interesting to note that the NWT had the lowest conversion rate of evaluations to execution in the country, only 20% compared to the Canadian average of 80% conversion. This may in part be due to difficulty securing qualified contractors and/or access to financing beyond the partial grant amount.

About 47% of the houses which had assessments done were built before 1980. This roughly matches the housing profile in Yellowknife, where about 40% of the dwellings were built before 1980.[59] However, owners of houses built before 1980 were much more likely to follow through with the upgrades: 28% vs. only 17% follow-through by owners of houses built after 1980. While houses built in the 1970s were subject to the largest number of upgrades compared to any other decade of construction, the highest rate of follow-through was with houses built in the 1960s (32%). For houses built before 1980, the three most popular upgrades were draftproofing, windows/doors and then walls. For houses built after 1980, the three most popular upgrades were draftproofing, windows/doors, and then space heating.

These results indicate that owners of Yellowknife houses built in the 1960s and 70s may be prime candidates for an Energy Savings LIC Program, and the program should target its marketing and outreach towards these neighbourhoods. Moreover, the popularity of building envelope improvements (not only relatively cheap upgrades such as draftproofing but also more expensive projects such as windows/doors) supports the need to include this as an option in the Yellowknife Energy Savings LIC Program.

Arctic Energy Alliance savings calculations

Arctic Energy Alliance has created a spreadsheet which calculates energy, cost, and GHG savings from space heating improvements. Taking into account the cost of each fuel type in a given year (electricity, oil, propane, wood pellets, cords of wood), the amount of fuel used by a given home, and the efficiency of the furnace/stove/system, the spreadsheet calculates how much energy and how many tonnes of CO_2 equivalent per GJ would be saved by switching from one fuel system to another. The spreadsheet also completes a simple payback calculation by dividing the installed cost by the yearly cost savings.

Savings calculations were made using this spreadsheet, using the following assumptions:

- A homeowner is switching from an 83% efficient oil burning furnace (a fairly common system in Yellowknife) to either a wood or pellet stove or a 95% efficient propane condensing furnace
- 2014 fuel costs are the baseline
- The home initially burns 4,000 litres of oil per year

Savings would be greater and payback periods shorter with greater amounts of oil burned.

Payback periods shown in Table 5 below are lower than those indicated in the spreadsheet, since available rebates have been subtracted from the estimated installed cost.

The lower range of the estimated cost savings for wood/pellet stoves represents the savings from using a wood stove, whereas the upper range represents savings from using a pellet stove. Savings would be greater for a wood stove if the homeowner cut his or her own wood rather than buying cords of wood at market price.

Table 5. Savings based on Arctic Energy Alliance savings calculations

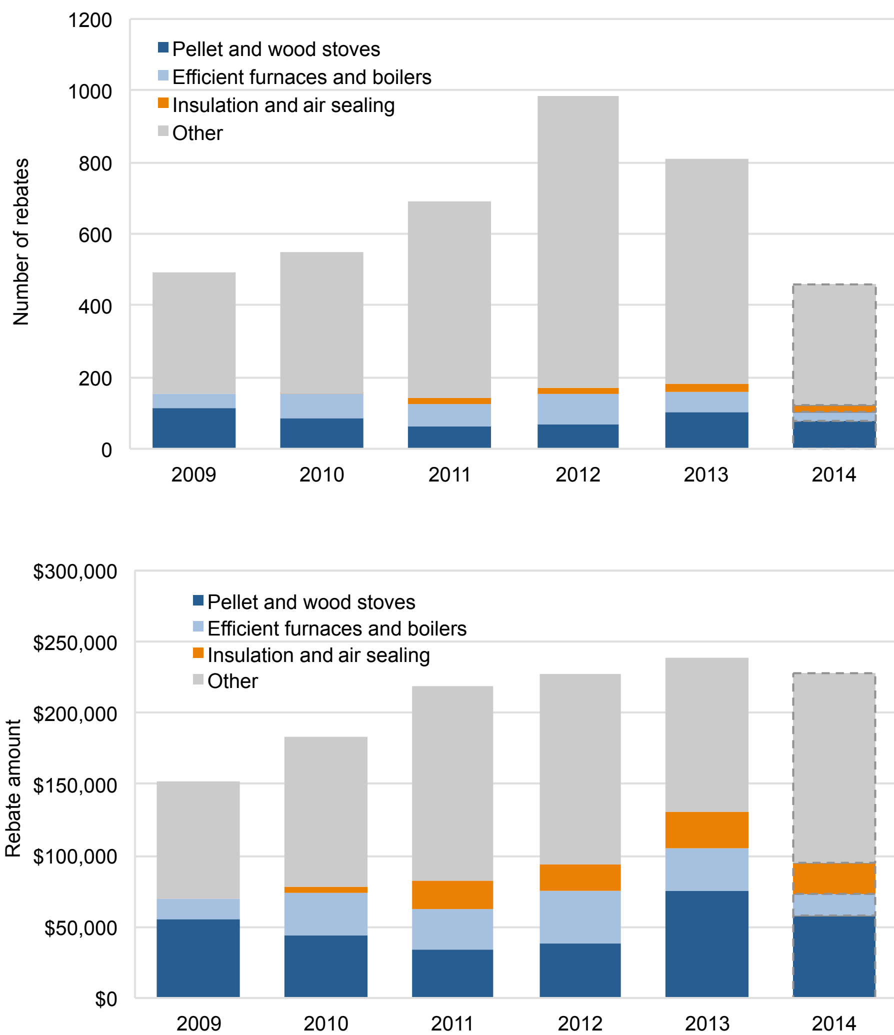
	Estimated cost	Rebate available	Estimated savings per year	Payback period (years)	How long it lasts (years)	GHG savings (t CO_2e / GJ)
Wood / pellet stoves	$5,000	Up to $700	$1,700 to $2,300	2 to 2.5	12-15	10.5
High efficiency propane condensing furnace	$8,000	$600	$1,300	6	12-15	2.2

Energy Efficiency Incentive Program rebate data

Arctic Energy Alliance has been administering rebates to residents of the NWT on behalf of the Government of the Northwest Territories to support energy efficiency upgrades in residential homes and businesses. The program is called the Energy Efficiency Incentive Program. Figure 3 shows data from rebates awarded in the city of Yellowknife within the past five years. Note that 2014 data is not complete.

The rebates awarded in Yellowknife are consistently numbering in the several hundreds and the dollar amount distributed per year has exceeded $200,000 for the past four years. The rebates that align with the types of energy improvements that would be eligible under the proposed Yellowknife Energy Savings Program represent somewhere between 20-30% of the total number of rebates issued; however, in terms of dollars they represent closer to 40-50%. This indicates that these types of energy improvements are the more expensive of those that Yellowknife residents wish to pursue and may warrant additional financing mechanisms.

Figure 3: AEA rebates in Yellowknife, by number and by dollar amount



Appendix C: Seed funding and financing options

The City of Yellowknife has five main options for obtaining the $150,000 in start-up funding and $1 million in capital needed to finance an LIC program:

1. Borrow from a financial institution (requiring a Ministerial exemption or a City-wide referendum)
2. Use existing capital reserves
3. Land sale or endowment
4. Access grants for start-up seed funding (would not address financing issue)
5. Establish an internal revolving fund for start-up seed funding (would not address financing issue)

Table 6 below shows how these sources might be used for administrative or program funding.

The following alternative funding methods used by other Canadian cities are also discussed below:

6. Carbon tax/carbon funds
7. Franchisee fees
8. New fees
9. Sponsorship

1. Loan

The municipality can secure a loan through its usual financial service providers or look to alternative financiers, such as the Federation of Canadian Municipalities. The intent is to secure a low interest rate by leveraging the city's borrowing power. The LIC loan has first lien rights and so is extremely low risk and provides a secure return to the municipality that will cover the city's borrowing costs.

a. From bank

Most municipalities have access to low-interest financing from financial institutions that can be used to support the LIC loan program. For example, the City of Yellowknife is financing its new water treatment plant with a 15-year loan at 3.4% interest. Section 112 of the territorial Cities, Towns, and Villages Act (CTV Act) requires NWT municipalities to obtain voter approval or a Ministerial exemption from voter approval in order to take on long-term debt above certain limits. A simple amendment to the CTV Act or a Ministerial exemption for the City of Yellowknife's LIC program would allow the program to be financed through a bank.

b. From Federation of Canadian Municipalities

The City of Halifax obtained a $5.5 million loan from the Federation of Canadian Municipalities' (FCM) Water Conservation Fund to partially cover its Solar City program budget which totaled $8.3 million. While reporting requirements are more onerous with FCM

Table 6. Funding and financing sources for administrative and program funds

		Administrative Funds (depend somewhat on program volume)	Program Funds (directly dependent on program volume)
Start-up funding (one-time access)	FCM grant	✓	
	Government grant	✓	
Ongoing funding (recurring access)	Bank loan		✓
	FCM loan	✓	✓
	Internal municipal funds (capital reserves, land sale, revolving fund)	✓	✓
	Charges to participants (admin fees)	✓	

Source: Adapted from Persram[60]

loans than with a financial institution, the Fund issues loans at one point below the standard interest rate. According to Halifax program staff, the program could have gone ahead with a bank loan instead; however the FCM loan provided added comfort and political support. The Solar City program was eligible for this particular fund because of its link to water; it is not clear whether Yellowknife's LIC program would qualify for an FCM loan.

2. Existing capital reserves

Another option is to set aside capital to form a large enough floating fund to cover the first phase of projects. This option depends on the municipality's capital reserves and the demand on those funds in the near term.

Toronto was able to finance its HELP program by committing up to $20 million from its existing working capital reserve fund. This may not be practical or possible for a city the size of Yellowknife.

3. Land sale or endowment

The Toronto Atmospheric Fund (TAF) is an arm's-length organization mandated to reduce greenhouse gas and air pollution emissions in the Toronto area, including by increasing energy efficiency in buildings (see Appendix D). TAF was formed out of a $23 million endowment resulting from the sale of Toronto municipal land. A land sale by the City of Yellowknife would be governed by the Land Administration bylaw, which is prescriptive in terms of what can be done with the money.

4. Grants

While grants would likely not be large enough to cover the full program budget (including financing), they could be accessed for seed funding to cover program design, set-up and initial outreach. Grants up to $150,000 are available from Natural Resources Canada (NRCan) for this purpose; NRCan has previously supported the LIC program concept. Halifax's start-up administrative costs were covered by a $550,000 grant from FCM. Toronto received seed funding amounting to about $1 million from TAF, Ontario Power Authority, NRC, Enbridge and Toronto Hydro.

These grants may not have been necessary to get the LIC programs in Halifax and Toronto off the ground, but they were helpful in reducing perceived risk and attracting political support.

5. Internal revolving fund

It is also possible for local governments to establish revolving funds to provide start-up funds for an LIC program. The municipality implements energy efficiency upgrades and uses the savings relative to business as usual to support LIC program set-up costs. In some cases, the revolving fund could either provide the full LIC financing (if it is large enough), or act as an intermediary lender, providing the upfront financing, until the LIC loans could be repackaged as municipal bonds or asset-backed securities.

The city of Hamilton, Ontario, completed an energy efficiency project, whereby 50% of the savings were absorbed by the municipality's operating budget but the other 50% were allocated to a retrofit fund.

Edmonton's Energy Management Revolving Fund finances energy retrofits of city facilities. The $30M fund has been used for a variety of energy-efficiency measures including lighting, HVAC and envelope upgrades. The amounts borrowed must be repaid over a period of up to eight years (some exceptions can increase that to 10 years), and the loans are repaid through the utility (energy) savings.

While setting up a formal revolving fund may be an unnecessary administrative burden for Yellowknife, the City could simply set aside some of its gas tax money or Community Energy Plan funds in order to support an LIC program.

6. Carbon tax/carbon funds

The City of Dawson Creek, British Columbia, has imposed a $100/tonne levy on its own greenhouse gas emissions, and the fund supports energy efficiency and renewable energy projects.

7. Franchisee fee

Some municipalities have increased the franchisee fee charged to utility providers. This fee is generally tied to utility consumption so ultimately the cost would be passed on to consumers. The fee could be increased and/or redirected to a separate fund for retrofits.

The town of Banff used proceeds from this fee to develop a conservation fund. There might be an appetite for increasing Yellowknife's franchisee fee if it has not yet been raised in alignment with property tax increases. In order to raise $150,000 (the estimated amount required for program set-up costs), the City of Yellowknife would have to increase the franchise fee by about 78 cents, or almost 3%.[61]

8. New fees

The City of Langley, British Columbia funded a new home rebate program by collecting an extra fee on new building permits. This concept could be used to collect seed funding to support the Yellowknife Energy Savings Program, whether the fees are from new building permits or a more appropriate municipal program.

9. Sponsorship

Corporate sponsorships allow private companies to get some form of public recognition through advertising, signage or monuments in exchange for significant donations or strategic funding arrangements to cities.

Photo: Binnu Jeyakumar, Pembina Institute

Appendix D: Other financing and delivery mechanisms for municipal and commercial energy retrofit projects

Municipal and commercial projects could be financed through the following mechanisms, discussed below:

1. Internal green financing mechanism
2. Arm's-length organization
3. Energy savings performance agreement (ESPA)
4. Energy service company (ESCO)
5. Crowdfunding

1. Internal green financing mechanism

A report was produced for the City of Yellowknife in 2006 by the Pembina Institute and SENES Consultants, as part of the City's initial energy planning process, which reviewed 12 municipal green financing mechanisms across North America and gave specific recommendations for setting up such a fund in Yellowknife. These recommendations included:

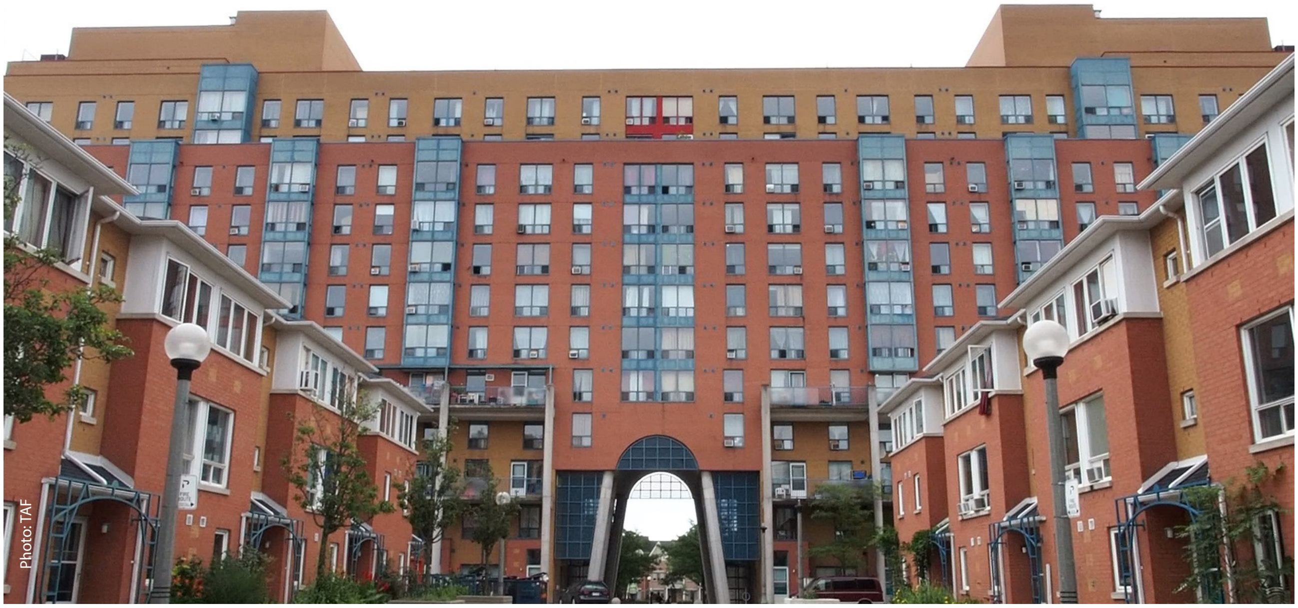
- "Establish a mixed financing mechanism that includes a revolving fund component to finance relatively small-scale regular retrofits and an annual allocation component that would be reserved for larger projects that would require Council approval. The revolving fund component would be sufficient to finance the feasibility and evaluation studies needed to maintain a steady flow of projects.
- "Limit eligibility to projects that produce energy savings capable of paying off the initial investment within eight years at an annual interest rate of 4.7% and ensuring that GHG emissions will not increase. Beyond these minimum requirements, projects will be selected to maximize GHG emission reductions, so that low GHG reduction opportunities are only financed if the available funds for a given year cannot be allocated on better opportunities. For projects that demonstrate a rate of return greater than 4.7%, the amortization period will remain constant at 8 years."[62]

2. Arm's-length organization

The Toronto Atmospheric Fund (TAF) is an arm's-length organization that is mandated to reduce greenhouse gas and air pollution emissions in the Toronto area. It was started in Toronto in 1991 with an endowment of $23 million resulting from the sale of municipal land. TAF is financially independent of the city and innovates, incubates and advocates for financial solutions to increase energy efficiency in buildings. TAF's approach has evolved over the years but it has moved increasingly towards 'impact investing' in energy retrofit savings and partnering with others in the private sector who are interested in realizing profits from energy savings.

Several years ago, TAF teamed up with Tridel Condos to conduct a kind of research/demonstration project. They built two new condominiums side by side — one followed the standard national building code, and the other was designed to outperform the national code by 41% in terms of energy efficiency. TAF provided a loan for the incremental cost of building the second condo to a higher standard. Tridel was able to repay the loan using only about half of the energy savings, and pocket the rest.[63]

In May 2014, TAF announced that it had designed and implemented its first energy services performance agreement (ESPA; see below) with the Robert Cooke apartment complex, a 123-unit apartment co-op. TAF provided the financing for about $460,000 worth of energy retrofits (heating, cooling, lighting and appliances) to be installed, and in return TAF will keep 75% of the savings over the life of the agreement (10 years). To make this agreement possible, TAF was able to secure reinsurance from Energi of Canada. This means that if there is a shortfall in savings, neither TAF nor the building owner are on the hook — the difference is covered by the insurance policy. The insurance costs between 2 and 5% of the total insured energy savings.



The Robert Cooke apartment co-op in Toronto received $460,000 in energy retrofits through an ESPA with the Toronto Atmospheric Fund

3. Energy savings performance agreement (ESPA)

An ESPA involves a company (service provider) that provides capital to build the retrofit and then reaps a portion of the savings. All of the risk is borne by the service provider and the reinsurer under the service agreement, so there is no loan involved.

An ESPA was developed by the Toronto Atmospheric Fund (see above) and piloted at the Robert Cooke apartment co-op in Toronto, where $460K of energy retrofits were fully financed through TAF. The apartment complex was then responsible for paying back that investment from the savings realized by the project.

Efficiency Capital Corporation has taken the TAF ESPA model and is offering it Canada-wide. Efficiency Capital has been working with TAF for the last six years and in mid-2014 started up as a for-profit company, the first of its kind in Canada. The company pays for the upgrade, manages the engineering, procurement and construction and is paid back over time out of the energy savings. If the savings do not materialize, the building owner is not obligated to pay the instalments. Instead, Efficiency Capital is compensated by an energy savings warranty, in this case provided by the reinsurance company Energi. The minimum project value must be equal or greater than $500,000.

This financing and delivery mechanism is appropriate for government bodies or large corporations, rather than individual homeowners.

4. Energy service company (ESCO)

Energy savings or energy service companies (ESCOs) are generally utility or equipment maintenance providers that implement an energy savings measure in the building on behalf of the building owner and then collect repayment from the cost savings of the higher efficiency unit. Honeywell, for example, provides an energy saving performance contract or a utility energy service contract. Similar to an ESPA, these contracts offer a means to implement energy efficiency, renewable energy and water efficiency projects without the building owner having to make any initial investment or take any risk. However, it also means that the building owner reaps less of the reward (savings). The advantage in using an energy service company is their experience and expertise in estimating savings and running projects. The company designs and installs the retrofit, assists in arranging funding to cover capital costs, and then gets repaid over the contract term from the cost savings generated by the energy retrofit. Repayments only begin after commissioning of the new unit. This type of arrangement could be established with any service provider willing to enter into this sort of contract, whether it is a utility provider or a maintenance contractor.

In 2011, TAF helped to broker an ESCO-type agreement between the City of Toronto and private energy management firm Glenbarra Energy Management Corp (GEMCO). GEMCO was to provide solar hot water systems at three city facilities (including the Toronto Zoo). TAF loaned the initial capital to GEMCO at commercial financing rates.

GEMCO would own and operate the systems and provide the facilities with hot water under a long-term energy purchase agreement. However, GEMCO abandoned the project when the Ontario Feed-In Tariff program for renewable energy was established. Due to TAF's financial structure the organization is able to take innovative risks, and lose on some investments, while trying out new business models to effect change.[64]

It is interesting to note that Yellowknife has seen successful ESCO contracts for energy retrofits established in the past. Arctic Green Energy established energy service contracts with the GNWT for the jail, Sir John Franklin school, and Inukshuk Housing Corporation (this last one also leveraged grants). Arctic Green Energy set up wood pellet boilers in those facilities and charged leasing fees based on expected savings. The company was able to finance this arrangement by securing a five-year lease agreement with RBC for 80% of the value of the boilers at low interest rates.[65] At first, facility managers were skeptical that any energy or cost savings would be realized, but they went ahead with the contract because it required them to take no risk. It turned out that the GNWT realized substantial savings from switching to wood pellet boilers. Eventually the GNWT stopped negotiating contracts with an energy service company and became confident enough of the expected savings to install wood pellet boiler systems with its own financing. In this way the GNWT is now able to keep all of the savings for itself.

There may be a role yet for energy service companies in Yellowknife to assist with municipal or commercial energy retrofits, if projects involved less proven technologies (higher risk). Such a company would have the opportunity to leverage existing services and rebates in Yellowknife. Arctic Energy Alliance offers businesses a Targeted Energy Audit at no cost as long as the business owner commits to making energy efficiency upgrades (under GNWT's CECEP program). In addition, the GNWT offers rebates up to $15,000 for energy retrofits in commercial buildings.

5. Crowdfunding

Another increasingly popular way of raising capital is through contributions by private individuals—the "crowd." These are essentially revolving funds that traditionally have been independent of any government body. The potential for crowdfunding clean energy projects is vast. Around the world there are several examples of successful crowdfunding for renewable energy: Solar Schools (U.K), Gencommunity (U.K.), Mosaic (U.S.), Abundance Generation (U.K.), Windcentrale (Netherlands).

The more successful crowdfunding models (Mosaic, Windcentrale) provide a return on investment for the contributors, involving somewhat complex administrative and financial structures. There may also be opportunities, however, to obtain donations from the 'crowd' for energy retrofit projects in public buildings such as schools, without providing any return back to contributors.

Arctic Green Energy established a successful energy service contract with the GNWT for Sir John Franklin school

Appendix E: References and list of resources and existing research on LIC programs

References

Boyle, Julian (2013). "LIC Financing of Municipal Energy Programs." Presentation by City of Halifax Energy Manager to Ontario Sustainable Energy Association. January 31, 2013. http://www.halifax.ca/Solar City/Other/documents/Solar CityLICOSEAWebinarJanuary312013.pdf

Brownlee, Michelle. (2013). Financing Residential Energy Savings: Assessing Key Features of Residential Energy Retrofit Financing Programs. Policy Brief. Sustainable Prosperity. http://www.sustainableprosperity.ca/article3848

C-Returns. "C-Returns makes a difference in greening Edmonton homes." June 18, 2014. https://creturns.com/news/makes-a-difference/

Canada Mortgage and Housing Corporation (2014). Northern Housing Report. http://www.cmhc-schl.gc.ca/odpub/esub/65446/65446_2014_A01.pdf

Canada Mortgage and Housing Corporation (2014). Housing Market Information Portal. Profile: Yellowknife. https://www03.cmhc-schl.gc.ca/hmiportal/#Profile/7860/3/Yellowknife

Chapman, Alex (2015). "Best of Both Worlds." Brighter Tomorrow. http://brightertomorrow.ca/best-of-both-worlds/

City of Toronto (2014). Home Energy Loan Program (HELP) – Frequently Asked Questions. http://windfallcentre.ca/energy/docs/incentives/HELP-Frequently-Asked-Questions.pdf

City of Yellowknife (2014). Community Profile. http://www.yellowknife.ca/en/city-government/resources/Budget/2015_Draft_Budget/5_Community_Profile.pdf

Environmental Commissioner of Ontario (2013). "Case Study: Toronto Pilot Retrofit Program." http://www.ecoissues.ca/index.php?title=Case_Study:_Toronto_Pilot_Retrofit_Program

Government of the Northwest Territories. Cities, Towns and Villages Act. S.N.W.T. 2003, c.22. http://www.justice.gov.nt.ca/pdf/ACTS/Cities%20Towns%20and%20Villages.pdf

Government of the Northwest Territories (2013). Northwest Territories Energy Action Plan: A Three-Year Action Plan and a Long-term Vision. http://www.iti.gov.nt.ca/sites/default/files/energy_action_plan_web_feb_20.pdf

Government of Nova Scotia. Bill No. 112: An Act to Amend Chapter 39 of the Acts of 2008, the Halifax Regional Municipality Charter. December 2010. http://nslegislature.ca/legc/bills/61st_2nd/3rd_read/b112.htm

Government of Ontario. City of Toronto Act. O.Reg 323/12 amending O. Reg. 596/06. October 2012. http://www.e-laws.gov.on.ca/html/source/regs/english/2012/elaws_src_regs_r12323_e.htm

Hood, Innes and Ken Cooper (2006). Lifecycle Cost Analysis: Energy Standards for New Buildings: Final Report. The Sheltair Group and SAR Engineering Ltd. Prepared for Arctic Energy Alliance. aea.nt.ca/files/download/36

Horne, M., I. Kessel and S. Montgomery (2006). Yellowknife Community Energy Planning Project: Action Area 5 - Financing Options for External Green Energy Projects. Pembina Institute and SENES Consultants Ltd. aea.nt.ca/files/download/33

Horne, M., I. Kessel and S. Montgomery (2006). Yellowknife Community Energy Planning Project: Action Area 1b - Financing Options for Internal Green Energy Projects. Pembina Institute and SENES Consultants Ltd. http://aea.nt.ca/files/download/34

Iacampo, Marco (2014). Presentation on Toronto's Home Energy Loan Program to Natural Resources Canada BEEWG-IFM Sub Committee. September 4, 2014.

Ipsos Reid. (2013). CHEERIO LIC Program Evaluation Qualitative Research Study. http://www.cleanairpartnership.org/files/CHEERIO%20Qualitative%20Study%20-%20April%202013.pdf

Lee, Jeff. "Vancouver energy-efficiency program bombs." Vancouver Sun. February 21, 2013. http://www.vancouversun.com/technology/Vancouver+energy+efficiency+program+bombs/7907720/story.html

MoneySense. "Canada's Best Places to Live 2014: Full Ranking." http://www.moneysense.ca/canadas-best-places-to-live-2014-full-ranking

Natural Resources Canada (2013). Monthly Statistic Report, November 2013. Obtained from Jim Sparling, GNWT-ENR.

Ontario Clean Air Alliance. (2011). An Energy Efficiency Strategy for Ontario's Homes, Buildings and Industries. http://www.cleanairalliance.org/files/ee.pdf

Pembina Institute (2004). Using Local Improvement Charges to Finance Building Energy Efficiency Improvements: A Concept Report. http://www.pembina.org/pub/170

Persram, S. (2013). LIC Primer: Using Local Improvement Charges to Finance Residential Energy Upgrades. Sustainable Alternatives Consulting for CHEERIO (Collaboration on home energy efficiency and retrofits in Ontario). http://www.cleanairpartnership.org/files/Primer.pdf

Robinson, Andrew (2011). "NWT GHG Strategy: Be the change you want to see in the world." Presentation by Arctic Energy Alliance, January 31, 2011. In NWT Greenhouse Gas Strategy 2007–2011: Summary Report On Strategy Renewal Meeting, compiled by Cambria Marshall Cote. http://www.nwtclimatechange.ca/sites/default/files/Strategy_Renewal_Climate_Change_Network_mtg_2011.pdf

Ross, Selena. "Eleventh hour for Solar City." The Chronicle Herald. August 19, 2014. http://www.thechronicleherald.ca/metro/1230634-eleventh-hour-for-solar-city

Toronto Real Estate Board (2014). Historic Statistics: Toronto MLS Sales and Average Price (1968–2013). http://www.torontorealestateboard.com/market_news/market_watch/historic_stats/pdf/Historic_1409.pdf

Yukon Energy Solutions Centre and Yukon Energy, Mines and Resources (2013). An Evaluation of Air Source Heat Pump Technology in Yukon. http://www.energy.gov.yk.ca/pdf/air_source_heat_pumps_final_may2013_v04.pdf

Interviews

Arctic Energy Alliance. In-person meeting with Ken Baigent, Mike Stuhec, and Jennifer Wicks, October 30, 2014.

Boyle, Julian (City of Halifax Energy Manager). Phone interview on December 9, 2014.

Chapman, Alex (City of Guelph). Phone interview on December 12, 2014.

Fowler, Aleta (CanNor, member of Community Energy Planning Committee). In-person meeting on October 29, 2014.

Heyck, Mark (Mayor of Yellowknife). In-person meetings on October 14, 2014 and November 12, 2014.

Iacampo, Marco (City of Toronto, Supervisor of Energy Policy). Phone interview on November 3, 2014.

Kalapos, Gabriella (Executive Director, Clean Air Partnership). Phone interview on November 3, 2014.

Robinson, Andrew (former Director of Arctic Energy Alliance). Phone interview on November 12, 2014.

Scott, Craig (Ecology North Executive Director, member of Community Energy Planning Committee). In-person meeting on October 10, 2014.

Stoate, Tim (Toronto Atmospheric Fund). Phone interview, November 3, 2014.

Stuhec, Mike (Arctic Energy Alliance). Email communication, November 13, 2014.

Tylak, Stefan (Solar City Program Officer). Phone interview on November 4, 2014.

Wohlgemuth, Dwayne (Ko Energy). In-person meeting on November 3, 2014.

Wong, Dan (Yellowknife City Councillor; member of Community Energy Planning Committee). In-person meeting on October 29, 2014.

Wunderlin, Thomas (formerly of Arctic Green Energy). Phone interview, October 31, 2014.

Other resources and research on LIC programs

Review and analysis of the LIC program model

David Suzuki Foundation and Sustainable Alternatives Consulting Inc. (2011). Property-Assessed Payments for Energy Retrofits: Recommendations for Regulatory Change and Optimal Program Features. http://www.davidsuzuki.org/publications/downloads/2011/Property-Assessed-Payments-for-Energy-Retrofits-recommendations-1.pdf

Duffy, R., and Fussell, H. (2011). This Green House: Building Fast Action for Climate Change and Green Jobs. Columbia Institute. http://www.civicgovernance.ca/sites/default/files/publications/This%20Green%20House_Report.pdf

Federation of Canadian Municipalities (2012). Paying for Municipal Infrastructure: Alternative Financial Mechanisms for Municipal Governments. http://crcresearch.org/sites/default/files/u641/paying_for_municipal_infrastructure_alternative_financial_mechanisms_formunicipal_governments_final_eng.pdf

LIC programs in Canada

Bierth, C., Peyman, H., & Svedova, J. (2010). Addressing the Barriers to Energy Efficiency in Vancouver. ISIS, Sauder School of Business. http://www.sauder.ubc.ca/Faculty/Research_Centres/ISIS/Resources/~/media/A6AD2F658A8944CE9165C0622133E564.ashx

Dunsky Energy Consulting (2013). Local Improvement Charge (LIC) Financing Pilot Program Design for Residential Buildings in Ontario. Clean Air Partnership. http://www.cleanairpartnership.org/files/CHEERIO%20LIC%20Program%20FINAL%20REPORT.pdf

Scotiabank Group. (2011). Global Economic Research Special Report. http://www.scotiabank.com/ca/en/files/11/09/Energizing_Household_Energy_Efficiency.pdf

City of Toronto LIC program

City of Toronto. Announcement of Home Energy Loan Program. March 25, 2014. http://wx.toronto.ca/inter/it/newsrel.nsf/11476e3d3711f56e85256616006b891f/c4de0a03891dfc2c85257ca60047a6d8?OpenDocument

City of Halifax "Solar City" LIC program

City of Halifax. "Solar City." http://www.halifax.ca/SolarCity/ .

LIC programs in the U.S.

American Council for an Energy Efficiency Economy. (date unknown). Case Study: Clean Energy Works Oregon. http://aceee.org/files/pdf/case-studies/Portland_Clean_Energy_Works.pdf

City of Berkeley. (2010). Berkeley FIRST Final Evaluation. http://www.ci.berkeley.ca.us/uploadedFiles/Planning_and_Development/Level_3_-_Energy_and_Sustainable_Development/Berkeley%20FIRST%20Final%20Evaluation%20 current.pdf

Clean Energy Works Oregon. http://www.cleanenergyworksoregon.org/

Energy Efficiency Institute, Inc. (2013). Status Report for programs based on the Pay-As-You-Save (PAYS) system. http://eeivt.com/wordpress/wp-content/uploads/2013/02/PAYSstatus2_21_13.pdf

Fuller, Merrian. (2009). Enabling investments in energy efficiency: A study of energy-efficiency programs that reduce first-cost barriers in the residential sector. Fuller Energy & Resources Group UC Berkeley. http://erg.berkeley.edu/info/thesis/Fuller_2009_ResiFinancing%20ERG%20Final%20Paper.pdf

Home Performance Resource Centre. (2010). Best Practices for Energy Retrofit Program Design: Case Study: Clean Energy Works Portland. http://www.hprcenter.org/sites/default/files/ec_pro/hprcenter/best_practices_case_study_portland.pdf

Home Performance Resource Center. (2010). Best Practices for Energy Retrofit Program Design: Case Study: Long Island Green Homes. http://www.hprcenter.org/sites/default/files/ec_pro/hprcenter/best_practices_case_study_long_island.pdf

Photo: Binnu Jeyakumar, Pembina Institute

Endnotes

1. Since establishing its first Energy Plan in 2004, the City of Yellowknife has already reduced its own corporate GHG emissions by 24%.
2. The City of Yellowknife put forward this resolution. The NWTAC reaffirmed the resolution in 2014.
3. See section 7.10.9: "The GNWT will consider changes to the City, Towns and Villages Act to enable communities to use Local Improvement Charge legislation for the purposes of offering energy financing programs to individual property owners."
4. Government of the Northwest Territories, *Northwest Territories Energy Action Plan*, December 2013, section 7.10.9.
5. See in particular case studies about the Manitoba Hydro Power Smart program and Clean Energy Works Oregon in Brownlee (2013) and other references in Appendix E.
6. Ipsos Reid, *CHEERIO LIC Program Evaluation Qualitative Research Study,* 2013.
7. Natural Resources Canada, "EnerGuide rated new homes," http://www.nrcan.gc.ca/energy/efficiency/housing/new-homes/5035.
8. The City of Yellowknife also requires existing homes to meet an EnerGuide 70 rating or have R30 insulation; however, there are limited opportunities to enforce this bylaw (pers. comm. Arctic Energy Alliance, October 30, 2014).
9. Innes Hood and Ken Cooper, *Lifecycle Cost Analysis: Energy Standards for New Buildings*, June 2006, 17.
10. Data provided by Mike Stuhec, email on November 13, 2014.
11. AEA Space Heating Calculator. See Appendix B for more details.
12. Natural Resources Canada, Monthly Statistic Report, November 2013.
13. City of Yellowknife, Community Profile (2014).
14. Data obtained from MoneySense, *Canada's Best Places to Live 2014: Full Ranking.*
15. Michelle Brownlee, *Financing Residential Energy Savings: Assessing Key Features of Residential Energy Retrofit Financing Programs* (Sustainable Prosperity), 4.
16. Ontario Clean Air Alliance, *An Energy Efficiency Strategy for Ontario's Homes, Buildings and Industries*, 2011.
17. In 2013, 431 residential transactions were reported in Yellowknife, 12% below the 489 transactions in 2012. The 2006 census indicated 6630 dwellings in Yellowknife. Adding the 593 housing completions from 2007-2014, a total of 7223 dwellings was used to make the calculation estimates.
18. The 2006 census indicates there were 9330 private households in Whitehorse. The 2014 CMHC Northern Housing Report indicates that in 2006 there were just over 510 residential transactions in Whitehorse.
19. The 2006 census indicates 1,801,255 private dwellings in Toronto. There were 83,084 residential transactions in Toronto in 2006 (Toronto Real Estate Board, *Historic Statistics: Toronto MLS Sales and Average Price* (1968–2013).
20. Brownlee, 7 and 9.
21. Brownlee, 14.
22. Unless otherwise noted, information is sourced from: City of Halifax, "Solar City" and City of Halifax Energy Manager Julian Boyle, "LIC Financing of Municipal Energy Programs," presentation to Ontario Sustainable Energy Association, January 31, 2013.
23. Selena Ross, "Eleventh hour for Solar City," *The Chronicle Herald,* August 19, 2014.
24. Julian Boyle, pers. comm.
25. Unless otherwise noted, information sourced from: City of Toronto, Home Energy Loan Program (HELP) – Frequently Asked Questions, September 1, 2014; Marco Iacampo, presentation on HELP to Natural Resources Canada BEEWG-IFM Sub Committee, September 4, 2014; and Environmental Commissioner of Ontario, "Case Study: Toronto Pilot Retrofit Program."
26. Information sourced from: Pembina Institute, *Using Local Improvement Charges to Finance Building Energy Efficiency Improvements: A Concept Report*; and Matt Horne, I. Kessel and S. Montgomery, *Yellowknife Community Energy Planning Project: Action Area 5 - Financing Options for External Green Energy Projects* (Pembina Institute and SENES Consultants Ltd.), 2006.
27. Information sourced from: Alex Chapman, "Best of Both Worlds", *Brighter Tomorrow.*
28. Information sourced from: Jeff Lee, "Vancouver energy-efficiency program bombs," *Vancouver Sun*, February 21, 2013,
29. Information sourced from: C-Returns
30. C-Returns, "C-Returns makes a difference in greening Edmonton homes", June 18, 2014.
31. Andrew Robinson, Arctic Energy Alliance, "NWT GHG Strategy: Be the change you want to see in the world," presentation, in *NWT Greenhouse Gas Strategy 2007–2011: Summary Report On Strategy Renewal Meeting*, compiled by Cambria Marshall Cote (2011).
32. Data from AEA Space Heating Calculator and estimates by Arctic Energy Alliance staff (see Appendix B for more details).
33. Data from AEA Space Heating Calculator and estimates by Arctic Energy Alliance staff (see Appendix B for more details).
34. See http://aea.nt.ca/programs/energy-efficiency-incentive-program for more details on rebate criteria.
35. Yukon Energy Solutions Centre and Yukon Energy, Mines and Resources, *An Evaluation of Air Source Heat Pump Technology in Yukon*, May 2013.
36. Yukon Energy, Mines and Resources, 2014-2015 Good Energy

Rebate Program Eligibility Criteria. http://www.energy.gov.yk.ca/pdf/eligibility_criteria_2014_15_final.pdf

37. Marco Iacampo, pers. comm..

38. Launched in late 2014, the results of this survey were not available at time of drafting.

39. Ipsos Reid, *CHEERIO LIC Program Evaluation Qualitative Research Study.*

40. Gabriella Kalapos, pers. comm.

41. Brownlee, 9.

42. Brownlee, 7.

43. Julian Boyle, pers. comm.

44. Halifax Solar City website, "Frequently Asked Questions": http://www.halifax.ca/Solar City/Solar CityFrequentlyAskedQuestions.php

45. Gabriella Kalapos, pers. comm. The Halifax Solar City Program received a $550,000 grant to cover administrative start-up costs.

46. Gabriella Kalapos, pers. comm. Administrative costs for the Halifax Solar City Program are $600,000 for 1000 participants.

47. Julian Boyle, pers. comm.

48. The FCM's Green Municipal Fund may be another possible loan source; this fund was initially created from an endowment.

49. Brownlee, 7.

50. Arctic Energy Alliance has made efforts in the past to establish formal relationships with local realtors, working with them to include home energy ratings in their promotion of houses for sale. While some have been receptive, there has been reluctance to include energy ratings if the scores are low (AEA, pers. comm.).

51. Boyle, presentation.

52. Brownlee, 9. While the program had successful uptake, almost $10 million of the total $26 million cost to BC Hydro went towards research, administration, and overhead, which amounted to 29.34 cents/kWh saved, much higher than the cost of producing electricity.

53. Government of Ontario, *City of Toronto Act,* O.Reg 323/12 amending O. Reg. 596/06, October 2012.

54. Government of Nova Scotia, Bill No. 112: An Act to Amend Chapter 39 of the Acts of 2008, the Halifax Regional Municipality Charter, December 2010. http://nslegislature.ca/legc/bills/61st_2nd/3rd_read/b112.htm

55. In October 2012, the *City of Toronto Act* LIC regulation was amended to:

    1. expand the definition of qualifying capital works to include energy efficiency retrofits, renewable energy installation, water conservation measures
    2. expand the list of qualifying property to which LICs can apply to include individual private property itself, exclusive of City-owned frontage
    3. introduce the use of property agreement between municipality and property owner (in addition to by-law to place charge on tax roll)
    4. enable special charge for these particular works on these particular properties to be placed on property tax roll and receive priority lien status

56. Report for City of Yellowknife on residential heating loads/demands, forthcoming.

57. It is not known how many of these 1074 homes were in Yellowknife, but it can be assumed that a large portion of participating homeowners may have been in Yellowknife, given that Yellowknife contains about half of the population of the territory.

58. NRCan, *ecoENERGY Retrofit – Incentive Payment Report – November 2013.*

59. Canada Mortgage and Housing Corporation, *Housing Market Information Portal,* Profile: Yellowknife,

60. Adapted from S. Persram, *LIC Primer: Using Local Improvement Charges to Finance Residential Energy Upgrades*, Sustainable Alternatives Consulting for CHEERIO.

61. Based on calculations provided by Remi Gervais, email comm.

62. M. Horne, I. Kessel and S. Montgomery, *Yellowknife Community Energy Planning Project: Action Area 1b - Financing Options for Internal Green Energy Projects*, iv.

63. Toronto Atmospheric Fund, TowerWise, http://www.towerwise.ca/.

64. Tim Stoate, pers. comm.

65. Thomas Wunderlin, pers. comm.

Appendix E: Solar Installation Priority Table

Facility	Average of Billed Demand (Max k	Annual Power Use (kWh)	Annual Power Costs	Demand Fact	Base Load Consumption (kWh)	Recommended Solar Capacity	Estimated Current Installation Co	Solar Power Produced (kW)	Solar Power Percentage	Savings	First Year ROI
Multiplex	372	1,944,168.00	$ 460,676.55	60%	221,957	222	$ 688,005	221957	11%	$ 48,828	7.10%
Pumphouse # 1 (WTP)	200	1,197,600.00	$ 281,774.73	68%	136,712	137	$ 430,644	136712	11%	$ 30,077	6.98%
Pumphouse # 2	161	916,200.00	$ 231,104.16	65%	104,589	105	$ 329,455	104589	11%	$ 23,010	6.98%
Fieldhouse	121	691,872.00	$ 155,775.05	65%	78,981	79	$ 265,006	78981	11%	$ 17,376	6.61%
Pumphouse # 4	158	663,840.00	$ 166,083.96	48%	75,781	76	$ 252,550	75781	11%	$ 16,672	6.61%
Yellowknife Community Arena	201	525,420.00	$ 144,495.94	30%	59,979	60	$ 199,752	59979	11%	$ 13,195	6.61%
Pool	96	477,900.00	$ 115,969.61	57%	54,555	55	$ 181,667	54555	11%	$ 12,002	6.61%
Lift Station #5	92	476,400.00	$ 457,046.17	59%	54,384	54	$ 181,097	54384	11%	$ 11,964	6.61%
City Hall	95	447,200.00	$ 106,566.13	55%	51,050	51	$ 169,997	51050	11%	$ 11,231	6.61%
Pumhouse #3	84	331,800.00	$ 83,519.99	45%	37,877	38	$ 126,129	37877	11%	$ 8,333	6.61%
Fire Hall	55	237,560.00	$ 59,097.44	50%	27,119	27	$ 108,475	27119	11%	$ 5,966	5.50%
Lift Station #1	86	211,320.00	$ 59,571.24	28%	24,123	24	$ 96,495	24123	11%	$ 5,307	5.50%
Curling Club (Ice Plant)	74	185,400.00	$ 54,409.90	29%	21,164	21	$ 84,658	21164	11%	$ 4,656	5.50%
Public Works Garage	42	171,440.00	$ 43,045.55	46%	19,571	20	$ 78,283	19571	11%	$ 4,306	5.50%
Curling Club (Rest of Building)	49	158,640.00	$ 42,746.50	37%	18,110	18	$ 72,438	18110	11%	$ 3,984	5.50%
Lift Station #4	33	139,591.00	$ 29,062.17	48%	15,935	16	$ 63,740	15935	11%	$ 3,506	5.50%
Pumphouse #6	17	84,550.00	$ 20,487.96	57%	9,650	10	$ 38,598	9650	11%	$ 2,123	5.50%
Solid Waste Facility, Baling Facility	142	189,720.00	$ 65,056.62	15%	21,658	5	$ 25,000	5000	5%	$ 1,100	4.40%
Lift Station #6	72	116,480.00	$ 37,261.79	18%	13,298	5	$ 25,000	5000	4%	$ 1,100	4.40%
Lift Station #7	51	78,581.00	$ 22,108.73	18%	8,970	5	$ 25,000	5000	6%	$ 1,100	4.40%
Main Reservoir	16	66,420.00	$ 16,492.44	47%	7,582	5	$ 25,000	5000	8%	$ 1,100	4.40%
Lift Station #9	12	55,700.00	$ 15,568.60	53%	6,358	5	$ 25,000	5000	9%	$ 1,100	4.40%
Lift Station #8	10	42,200.00	$ 10,200.14	50%	4,817	5	$ 25,000	5000	12%	$ 1,100	4.40%
Solid Waste Facility, Landfill Cells	16	33,710.00	$ 9,965.23	24%	3,848	5	$ 25,000	5000	15%	$ 1,100	4.40%
Community Service Warehouse	6	30,390.00	$ 7,466.46	54%	3,469	5	$ 25,000	5000	16%	$ 1,100	4.40%
Pumphouse #5	5	26,150.00	$ 6,512.65	58%	2,985	5	$ 25,000	5000	19%	$ 1,100	4.40%
Electric Fence Ingraham Trail	9	22,520.00	$ 6,552.58	28%	2,571	5	$ 25,000	5000	22%	$ 1,100	4.40%
Lift Station #2	7	20,970.00	$ 5,649.09	32%	2,394	5	$ 25,000	5000	24%	$ 1,100	4.40%
Sombe K'e Plaza Building	5	20,840.00	$ 5,199.27	46%	2,379	5	$ 25,000	5000	24%	$ 1,100	4.40%
Public Works Storage Garage	6	18,865.17	$ 5,166.51	38%	2,154	5	$ 25,000	5000	27%	$ 1,100	4.40%
Heavy Equipment Garage	5	14,574.00	$ 3,944.92	33%	1,664	5	$ 25,000	5000	34%	$ 1,100	4.40%
Solid Waste Facility, Office Building	7	16,974.00	$ 4,261.50	26%	1,938	5	$ 25,000	5000	29%	$ 1,100	4.40%
Lift Station #10	5	13,380.00	$ 3,744.04	28%	1,527	5	$ 25,000	5000	37%	$ 1,100	4.40%
Lift Station #11	7	10,020.00	$ 3,542.65	16%	1,144	5	$ 25,000	5000	50%	$ 1,100	4.40%
Total	2318	9,638,355.17	$2,716,908.16			1,097	$ 3,780,769	1096516	11%	$241,234	

Appendix F: Three Year Budget Write-up and Template

Department/Division Public Works & Engineering / Community Energy Plan (CEP)/Sustainability and Solid Waste Management
Project Biomass Boiler Projects

Expenditures & Funding Sources	2016 carryover $	2017 $	2018 $	2019 $	Total $
Capital Cost:	**1,075,000**	**1,075,000**		**600,000**	**2,750,000**
Centralized Biomass Boiler	1,075,000	1,075,000			2,150,000
Second PH#1 Biomass Boiler				600,000	600,000
O&M Expenses					
FTE			90,080	94,600	184,680
Other			(157,000)	(179,500)	(336,500)
Total:					
Gas Tax Rebate		**1,075,000**		**600,000**	**1,675,000**
Grants					

Purpose
To install a centralized biomass boiler system to serve the Multiplex, Fieldhouse, Fire Hall, City Garage and Community Services Shop. As well as install a second biomass boiler at Pump House #1 as part of the second phase of the project.

Background
Phase 1 of the centralized biomass boiler project was publicly tendered in 2016 with an approved budget allocation of $1,075,000, with Phase 2 tentatively scheduled for 2017. There was one bidder for the project, but the final amount was $380,079.50 over the allocated budget for 2016. While the bidding contractor is highly competent and recommended, City Administration could not award the contract for the tendered amount as there was not sufficient budget allocated to cover the tendered amount.

The 2016 budget of $1,075,000 is carried over into the 2017 budget to create a total budget allocation in 2017 of $2,150,000. It is recommended that the entire project be tendered in its entirety rather than the previously recommended phased approach. City Administration hopes to gain some economies of scale with a much larger and complete project, but may require an increase in budget should the tender amounts come in high.

There is a Phase 3 of the project as shown on the enclosed sketch which includes Lift Station #5 and Public Works Parking Garage. City staff will complete a feasibility analysis to determine if this phase should occur. To date it is not included in the capital plan.

A second biomass boiler is planned for Pump House #1. Once the heat distribution pipe is installed between Pump House #1 and the Water Treatment Plant, boilers in both facilities can share their space heating loads. The remaining heat load of approximately 150,000 liters of oil, not covered by the capacity of the single biomass boiler, would need to be supplied by a second boiler installed in the system. This is the budget allocation shown in 2019.

Triple Bottom Line

Social
These projects will help reduce operational costs for the City of Yellowknife in regards to heating fuel consumption. Savings realized by these projects reduce City expenditures in these areas, thus savings in budget allocations for heating fuel.

Environmental
The estimated total GHG emission reduction for these two projects is 1,350 tonnes.

Economic
These projects also continue to provide economic benefit to operations in the areas of fuel and power consumption. Ongoing savings from CEP projects are estimated to have surpassed $650,000 at the end of 2015. These two installations alone are expected to save $157,000 and $179,500 in 2018 and 2019, respectively. This is dependent on the price of heating fuel remaining high.

Operational Impacts

During the 2016 budget deliberations, Phase 1 of the centralized project was approved along with one (1) full time permanent position. This position was not filled because the project was deferred until 2017 but is still accounted for in the budget. This position is still required because of the continued addition of biomass boilers to city operations. Once these projects are completed, the City will have five (5) biomass boilers to maintain and operate, plus an additional boiler in the design stages for City Hall and RCMP headquarters should it be approved. This full time position is shown in the expense table above for 2018 and forward as the position is not anticipated to be needed until late 2017 or early 2018.

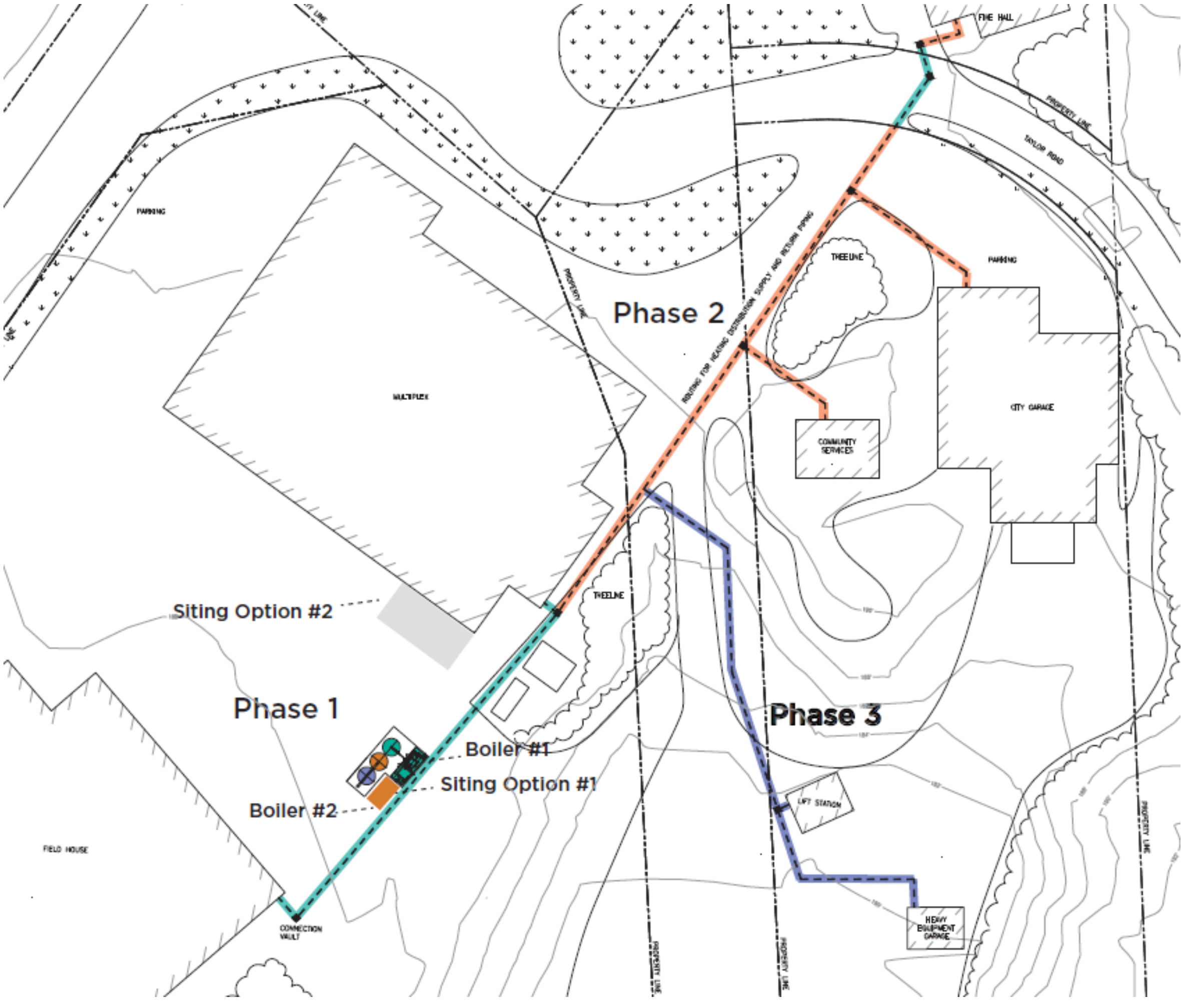


Photo: Phasing of the centralized biomass boiler project. Phases 1 and 2 to be completed in 2017. Phase 3 yet to be determined.