

# GETTING TO 1.5°C

DERIVING A LOCAL CARBON BUDGET  
AND MEETING THE AMBITION OF  
LIMITING EDMONTON'S EMISSIONS  
TO LEVELS THAT ALIGN WITH A GLOBAL  
AVERAGE TEMPERATURE INCREASE OF  
A MAXIMUM OF 1.5 DEGREES CELSIUS

## A Discussion Paper

Publication Date: July 2019



## INTRODUCTION

This Summary Report presents preliminary findings from modelling undertaken in response to City Council's approval of the Edmonton Declaration in 2018. The Edmonton Declaration<sup>1</sup> was developed concurrently with the City of Edmonton's hosting of the first Intergovernmental Panel on Climate Change (IPCC) Cities and Climate Change Science conference in March 2018.

The Edmonton Declaration highlights the need for cities to consider their actions through a lens that would limit global average temperature increase to 1.5 degrees Celsius (°C). This bold call to action was reiterated in an IPCC Special Report<sup>2</sup> that outlined the impacts of a 1.5°C increase in temperature, in an attempt to strengthen the global response to the threat of climate change.

This report goes a step further to also provide City Council with six "climate shifts" – a conceptual framework for moving beyond aspiration. If implemented, the climate shifts are expected to deliver emissions reductions consistent with Edmonton's local carbon budget, thereby limiting its emissions to levels aligned with a global average temperature increase of 1.5°C.

<sup>1</sup> [https://www.edmonton.ca/city\\_government/environmental\\_stewardship/change-for-climate-edmonton-declaration.aspx](https://www.edmonton.ca/city_government/environmental_stewardship/change-for-climate-edmonton-declaration.aspx)

<sup>2</sup> IPCC Special Report: Global Warming of 1.5°C <https://www.ipcc.ch/sr15/chapter/summary-for-policy-makers/>

# BACKGROUND

## EDMONTON'S COMMUNITY ENERGY TRANSITION STRATEGY

Edmonton's Community Energy Transition Strategy (CETS) was developed as a risk management response to a carbon constrained world. The strategy was designed to accelerate Edmonton along a low carbon pathway by taking direct and indirect actions to reduce greenhouse gas emissions, increase renewable energy and energy efficiency across all sectors. The actions were designed to position Edmonton to prosper in a low carbon economy, and to take advantage of emerging opportunities in clean technology and carbon abatement.

The following targets, relative to a 2005 baseline, were set in 2015 when City Council approved the Community Energy Transition Strategy:

- ▶ **Reduce community-based greenhouse gas emissions by 35% by 2035.**
- ▶ **Reduce energy consumption by 25% per person by 2035.**
- ▶ **Generate 10% of Edmonton's electricity locally by 2035.**

The actions recommended in the CETS were designed to support market transformation. Market transformation is based on real world observation of how emerging technologies become market norms. As a programming and policy approach, it uses a series of market interventions to alter market behavior by removing barriers and leveraging opportunities. This in turn accelerates the market uptake of the desired technology or action. Market transformation is the foundational objective of the majority of publicly supported energy efficiency and renewable energy programs.

**The pillars of market transformation include:** education and awareness, capacity building, incentives, and regulations.

**The economic modelling done to support the Community Energy Transition Strategy suggested that the plan would deliver a net present value of \$2.5 billion.** This means energy cost savings to buildings, industry and vehicle owners would be at least \$2.5 billion greater than their investment costs. If the cost of carbon is included (now a real dollar societal cost), this increased to a \$3.4 billion positive net present value.

In addition, 10 of the foundational CETS programs were modelled for their economic efficiency and overall societal benefit. Actions with societal benefit cost ratios greater than 1 were deemed economically beneficial to society; those greater than 2.5 were prioritized for early implementation.

The economic data was then combined with the wedge stabilization method (explained in the "Identifying the Climate Shifts" section of this document) for reducing greenhouse gas emissions, and through an iterative process, the target of 35% below 2005 levels by 2035 was derived. The 35% reduction target was shown to be economically prudent while also achieving significant carbon reductions. This target was also aligned with many leading municipal climate mitigation plans at the time.

## **THE IPCC REPORT INDICATES THAT THE REQUIRED "SYSTEMS TRANSITIONS ARE UNPRECEDENTED IN TERMS OF SCALE..., AND IMPLY DEEP EMISSIONS REDUCTIONS IN ALL SECTORS, A WIDE PORTFOLIO OF MITIGATION OPTIONS AND A SIGNIFICANT UPSCALING OF INVESTMENTS IN THOSE OPTIONS".<sup>2</sup>**

<sup>2</sup> IPCC Special Report: Global Warming of 1.5°C <https://www.ipcc.ch/sr15/chapter/summary-for-policy-makers/>

### **WHAT HAS CHANGED?**

Since drafting the CETS, the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement<sup>3</sup> was developed. The Paris Agreement's long-term goal is to limit the increase in global average temperatures to well below 2°C above pre-industrial levels, and to strive to limit the increase to 1.5°C. As of March 2019, 195 countries had signed the agreement and 184 have ratified or acceded to the Agreement, including Canada. These countries emit nearly 90% of the global greenhouse gas emissions. More recently, the United Nations' Intergovernmental Panel on Climate Change (IPCC) released a special report (noted below) that indicates deeper carbon emission reductions are necessary to prevent significant climate destabilization.

In addition to the increased urgency highlighted in international agreements and by the scientific community, climate change and the role cities play in providing solutions to it is becoming clearer. Although Edmonton has a long history of acknowledging climate change as an issue, support has recently grown for Edmonton to pursue meaningful emissions reductions. There has also been a significant shift in the awareness of climate change as an issue in the community. For the past two years, surveys have

indicated that 73% of Edmontonians understand that climate change is a significant issue that requires action. In recent years, Edmonton has also garnered international attention for its approach to transitioning to a low carbon future. This has further solidified its reputation as a leading, globally relevant community that is taking climate change action seriously.

### **IPCC SPECIAL REPORT: GLOBAL WARMING OF 1.5°C**

The IPCC "Special Report: Global Warming of 1.5°C" was released in October, 2018. It represented the combined efforts of over 200 scientific authors, almost 800 expert reviewers, and 65 governments to provide the most up-to-date, conclusive science on:

- ▶ The current state and expected trends of anthropogenic climate change;
- ▶ The expected impacts of a 1.5°C increase in temperature on weather patterns, sea levels, biodiversity, species loss and extinction, reduction of ecozones, increases in ocean acidity and decreases in ocean oxygen levels (and the resulting risks to fisheries and ocean ecosystems), frequency of forest fires, and risks to human health, livelihood, and water supply; and
- ▶ The speed, scale and nature of the transition required to limit climate change to 1.5°C, or as close to this as possible.

The IPCC report indicates that the required "systems transitions are unprecedented in terms of scale..., and imply deep emissions reductions in all sectors, a wide portfolio of mitigation options and a significant upscaling of investments in those options". The purpose of the report was to strengthen the global resolve to take action against the threat of climate change, increase sustainable development, and support efforts to eradicate poverty.

<sup>3</sup> The Paris Agreement is an agreement within the United Nations Framework Convention on Climate Change, dealing with greenhouse-gas-emissions mitigation, adaptation, and finance, signed in 2016.

## THE EDMONTON DECLARATION

The Edmonton Declaration was developed in March 2018 as part of an event held in parallel to the Intergovernmental Panel on Climate Change (IPCC) Cities and Climate Change Science Conference. The Edmonton Declaration highlights the need for cities

to take the actions required to ensure that the global average temperature does not exceed 1.5°C. This call to action has since been endorsed through member networks, by over 4500 cities around the world.

### In brief, the Edmonton Declaration:

Engages all levels of government to recognize the immediate and urgent need for action that will limit global warming to 1.5 degrees celsius;

Recognizes that cities face some of the most significant impacts of rising GHG emissions and bear much of the costs for adaptation and mitigation;

Reinforces the importance and role of cities in achieving the targets in the Paris Agreement;

Calls on the science community and other levels of government to provide better data and tools for science-based decision-making; and

Asks cities to look beyond their borders at the impact of consumption on GHG emissions.

## ALIGNING THE COMMUNITY ENERGY TRANSITION STRATEGY WITH 1.5

**To assess the CETS' alignment with a maximum 1.5°C global average temperature increase, a local carbon budget needed to be developed. Setting targets based on a carbon budget allows municipalities to visualize the urgency of the need for change. Rather than identifying a year by which a reduction will be achieved relative to a baseline, the carbon budget emphasizes an emissions limit. Every year emissions are added to the atmosphere essentially reduces the remaining local carbon budget. This highlights the importance of early action. Edmonton's carbon budget has been developed and is presented with the CETS targets in the following section.**

### DEVELOPING THE CARBON BUDGET

A carbon budget is the total amount of CO<sub>2</sub> equivalent (CO<sub>2</sub>e) emissions permitted over a period of time in order to stay within a temperature threshold.

The latest science indicates that in order to restrict warming to less than 1.5°C, total CO<sub>2</sub>e emissions from all anthropogenic (i.e. human caused) sources around the globe, since 1870 should not exceed 2500 Gtonnes. By 2011, approximately 1900 Gtonnes had

been emitted, leaving 600 Gtonnes as a global carbon budget.

C40 (a network of the world's megacities committed to addressing climate change) subsequently allocated this budget in large part to the world's cities, as they are responsible for up to 70% of the world's emissions<sup>4</sup>. The approach used is called "contraction and convergence", in which high emitters are required to reduce emissions to a per capita emissions rate,

<sup>4</sup> C40 Cities. (2016). "Deadline 2020: How cities will get the job done". Retrieved from [https://assets.locomotive.works/sites/5ab410c8a2f42204838f797e/pages/5abbadcd74c4837dd55d0731/files/C40\\_-\\_Deadline\\_2020.pdf?1530279184](https://assets.locomotive.works/sites/5ab410c8a2f42204838f797e/pages/5abbadcd74c4837dd55d0731/files/C40_-_Deadline_2020.pdf?1530279184) on May 30, 2019.

and low emitters can increase their emissions to the same per capita rate by a set date.

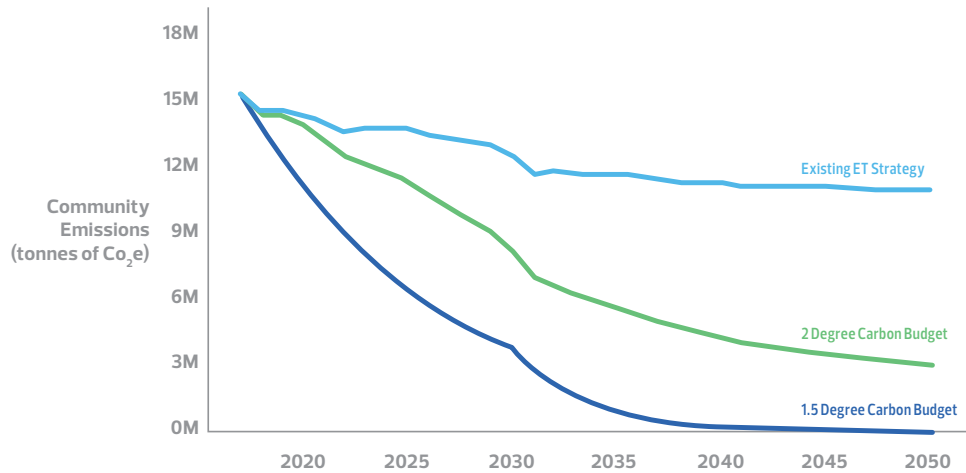
The per capita rates adopted were:

- ▶ By 2030, a maximum of 3.2 tonnes of GHG emissions per capita; and
- ▶ By 2050, a maximum of 0 tonnes of GHG emissions per capita (this is carbon neutrality).

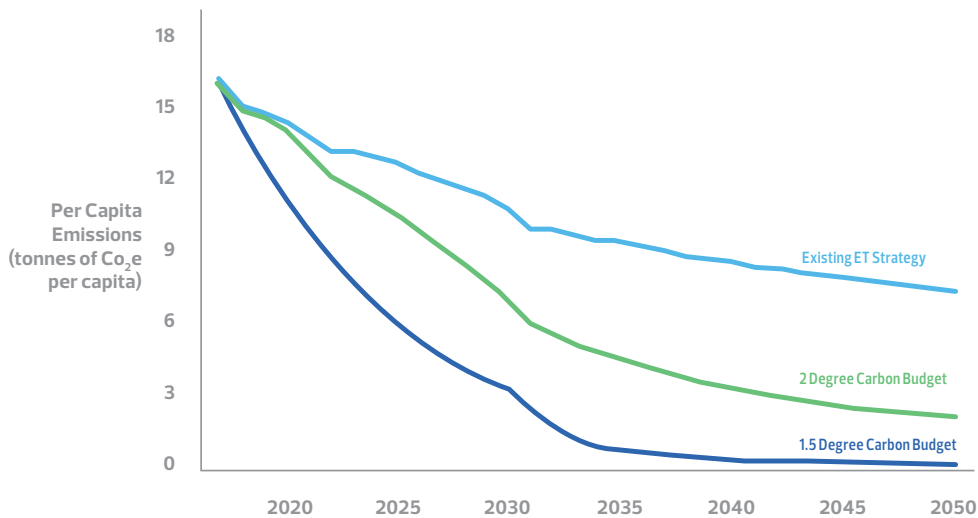
### Edmonton's Carbon Budget

Using this methodology, Edmonton's carbon budget has been calculated to be 155 Mtonnes between 2017 and 2050. The graphs that follow illustrate:

- ▶ Projected emissions in the context of Edmonton's carbon budget if the existing CETS is implemented;
- ▶ The required emissions trajectory with a 2 degree carbon budget target; and,
- ▶ The required emissions trajectory with a 1.5 degree carbon budget target.



The following graph displays the same information on a per capita basis:



**Both of these graphs demonstrate that implementing only the actions outlined in the current Energy Transition Strategy will not be sufficient for Edmonton to stay within its carbon budget, and limit its emissions in alignment with ensuring a maximum 1.5°C global average temperature increase.**

# IDENTIFYING THE CLIMATE SHIFTS

Executive Committee of Edmonton’s City Council requested preliminary recommendations for possible changes to Edmonton’s CETS, if it was determined the targets and actions are not aligned with the 1.5°C commitment.

## CityInSight is a state of the art, city-scale, energy emissions and finance model.

CityInSight incorporates and adapts concepts from the system dynamics approach to complex systems analysis. For any given year within its time horizon, CityInSight traces the flows and transformations of energy from sources through energy currencies (e.g. gasoline, electricity, hydrogen) to end uses (e.g. personal vehicle use, space heating) to energy costs and to GHG emissions. An energy balance is achieved by accounting for efficiencies, conservation rates, and trades and losses at each stage in the journey from source to end use.

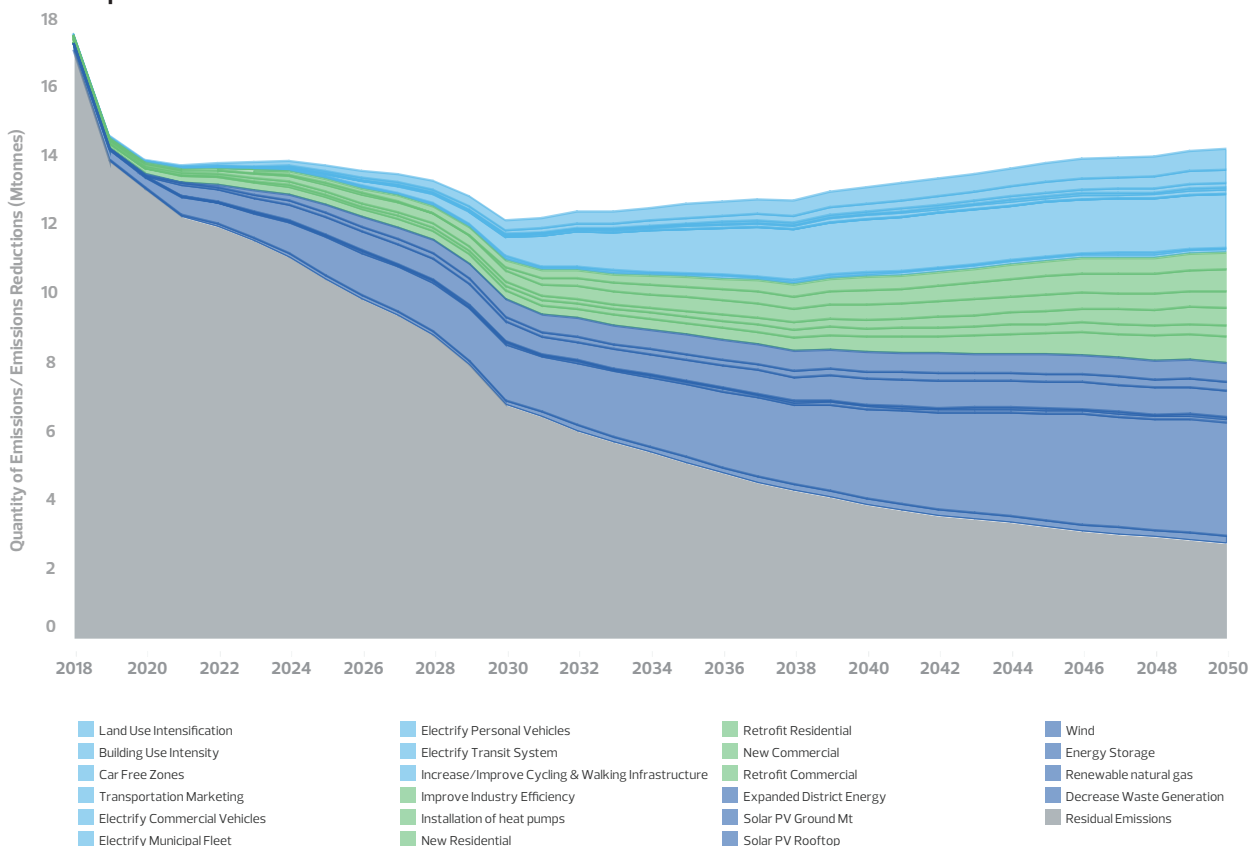
In 2018, the CityInSight greenhouse gas emissions model was used to model potential actions that could further reduce Edmonton’s emissions.

As part of this exercise, two important concepts ensure locally relevant, financially viable, technically achievable solutions:

- ▶ Wedge Stabilization Assessment; and
- ▶ The Marginal Abatement Cost Curve.

The specific actions or interventions that were modelled have been provided in Appendix 1, grouped into categories identified as “Climate Shifts”. It is important to note that the specific measures and interventions represent a starting point, and through additional consultations and analysis, they will require modification.

Impact of Actions on Emissions over Time



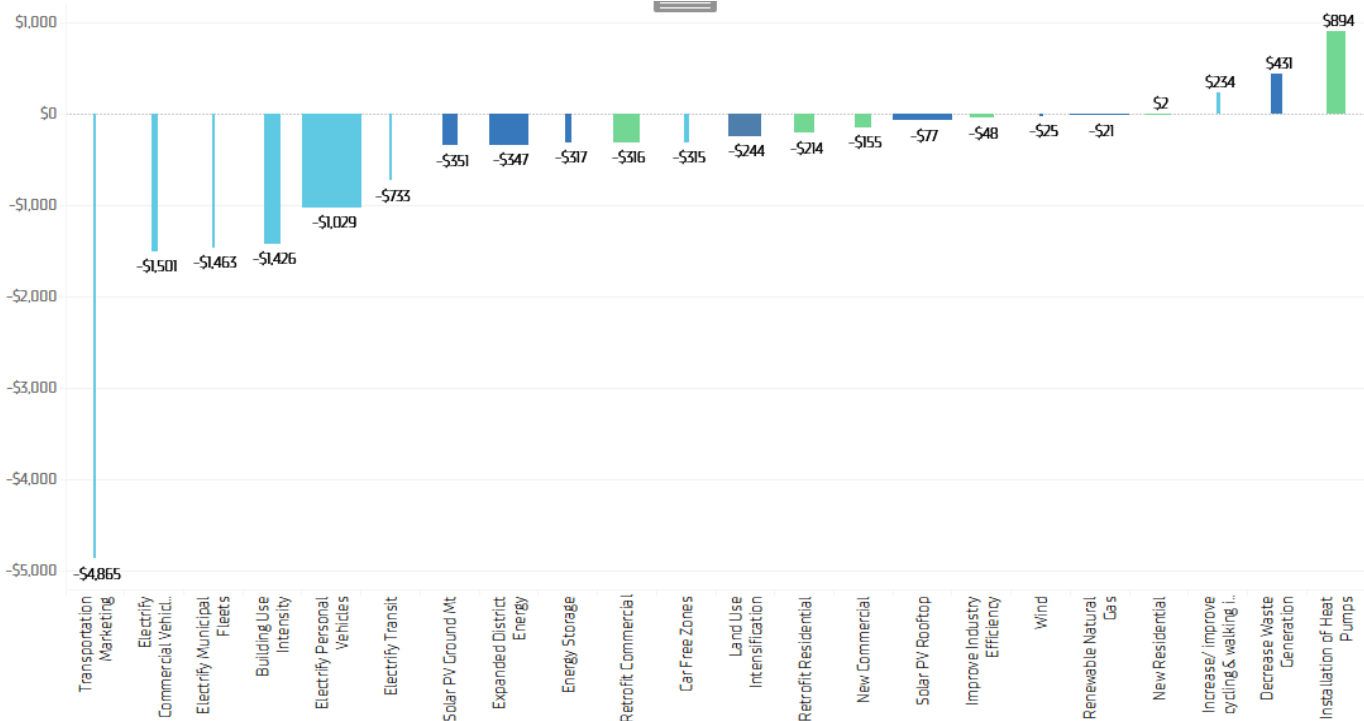
## WEDGE STABILIZATION ASSESSMENT

**A Wedge Stabilization Assessment is a useful tool for demonstrating that:**

- Global warming can be addressed using commercially available technologies to reduce emissions;
- Even if we invest significantly in each “wedge”, no single measure (or even a handful of measures) can reduce emissions to levels aligned with the recommendation of the international scientific community and current international goals; and,
- The magnitude of emissions reductions in any one measure seem small in isolation but collectively are required to achieve deep reduction targets.

The wedge stabilization assessment leads to marginal abatement cost analysis. The marginal abatement cost curve combined with the stabilization wedges become iterative as the financials clarify practical achievability. This then drives the width of the wedge and hence the amount of emissions reductions that are deemed feasible within each wedge.

It should be noted that consultation with stakeholders is required to confirm and refine these actions. However, the preliminary wedge assessment shown here shows the speed, scale, and specificity of policy that will be required if Edmonton is to realign the CETS to a 1.5°C level of emissions limit.



## MARGINAL ABATEMENT COST CURVE

A marginal abatement cost curve (MACC) organizes mitigation options into discrete blocks based on a single, understandable metric: the net economic cost or benefit of emissions abatement. Both the capital costs and any anticipated savings are included in the analysis, and the final metric is expressed as the net present value per tonne of greenhouse gas emissions eliminated. The blocks are displayed with the lowest cost options or net cost savings (i.e. negative \$/tonne CO<sub>2</sub>e), shown on the left with increasingly costly options proceeding to the right.

The marginal abatement cost curve shown above was based on the emissions modelling completed in 2018. The results were taken into consideration when developing the Climate Shifts outlined in this report. It is important to note that additional financial analysis would be required to confirm recommended measures and establish specific action level policy objectives.

As the figure shows, many investments can have negative \$ per tonne values. This means they will actually pay back more than the initial investment over the life cycle of the measure. This is often



the case in marginal abatement cost analysis, as reducing energy use is the primary method of carbon reduction, and reducing energy use typically results in cost savings, albeit often over longer investment horizons.

## PRINCIPLES AND FOUNDATIONS

The CETS is already principle-based, taking a prudent and measured risk management approach to mitigating climate change. Although the actions in the CETS remain conceptually sound, they are generally not specific enough, and fall short of outlining clear pathways to the achievement of the outcomes. For a new plan to achieve the level of ambition aligned with a 1.5°C scenario, the policy statements must be specific, outlining the speed and scale of change and always accompanied by a clear pathway to the outcome (or a commitment to develop it in the near future). At a minimum, the following principles should be used as a guide when updating the CETS:

- ▶ All proposed actions should be shown by data and reputable science to reduce GHG emissions. Evidence-based, data driven, science based decision making is critical.
- ▶ "This is not easy, but..." – To suggest that the work required will be an easy undertaking by positioning things as 'low hanging fruit' or 'simple tweaks' will likely not result in success. Undertaking carbon reductions this aggressively will be difficult. But at the same time, this undertaking will have significant benefits. Things to note include:
  - » Edmonton has already started this journey with transformational initiatives such as Blatchford, innovative residential/business programming, award winning engagement and marketing through Change for Climate, rethinking waste, electrifying its buses, and with its commitment to procuring 100% green electricity for its own operations.
  - » Emissions reduction is about people, today and tomorrow, and is not done in isolation. It comes with significant societal benefits including the preservation of quality of life, job creation, economic diversification, financial paybacks,

better air quality, healthier people, and preserved natural spaces. Highlighting these co-benefits will be important to getting citizens to buy into the changes required.

- ▶ Speed and Scale – The level of ambition and the timeframe for achievement should be reflected in the policy objective or action.
- ▶ Innovation – The world is changing rapidly; the framework for action must be flexible enough to incorporate innovations along the way.
- ▶ Adaptive and Nimble Management – The plan will need to be dynamic, and will need to include mechanisms that will allow the City to respond to change quickly.
- ▶ The City Leads – A core foundation to any change management initiative is to act first and lead the way. The City will need to continue to demonstrate its commitment to this work by implementing the necessary changes within its own organization.
- ▶ Specific Policy Directions and Clear Pathways – It is not enough to say that the achievement of a goal such as net zero carbon buildings is a good idea. The statement must be accompanied by a timeline (e.g. by 2030) for achievement and a clear pathway (such as increased building energy efficiency requirements) to get there.
- ▶ Market Transformation: Regulation as an intervention – Market Transformation includes four pillars: education and awareness, capacity building, incentives, and regulation. Many of the measures being considered require certainty of universal participation and/or specific milestones to be met at predetermined dates. Regulation can provide that certainty.

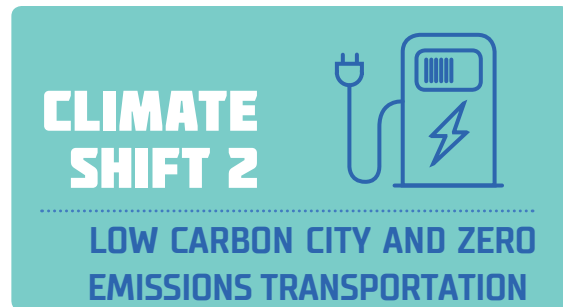


Currently Edmonton monitors its progress in reducing community greenhouse gas emissions against the following three targets:

- ▶ To reduce community greenhouse gas emissions by 35% by 2035 relative to 2005.
- ▶ To reduce per capita energy use by 25% by 2035 relative to 2005.
- ▶ To generate 10% of Edmonton's electricity locally.

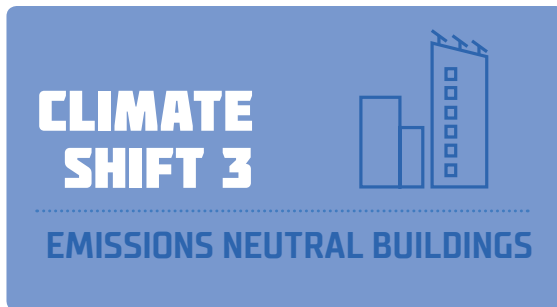
These targets were approved in 2015 and reflected the approach and level of understanding of emissions shared by many municipalities at that time. Expressing the City of Edmonton targets in the context of a local carbon budget communicates greater urgency, and more accurately represents Edmonton's contribution to global climate change.

The concept of a carbon budget can also be applied to municipal decision making by integrating carbon accounting into operating and capital planning. This can be done by likening it to 'emissions spending' or 'emissions savings'. In plain language, carbon emission impacts – negative or positive – would accompany the financial analysis of any operating or capital expense. If the expense was approved, the impact of that decision would be shown in relation to its effect on the community's overall carbon budget. This has been adopted successfully in Oslo, Norway, and was recently introduced in Vancouver, B.C. as a concept to be explored in response to that council's motion to declare a climate emergency.

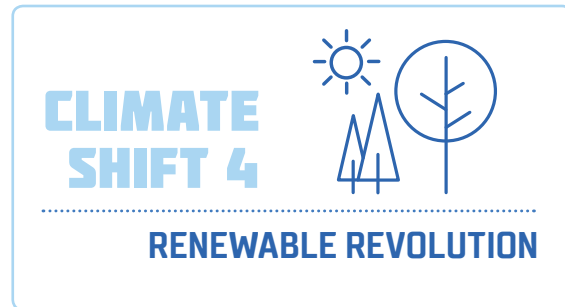


Intensification of land use reduces emissions but it also drives transportation choices. A built form that includes low carbon dwellings and a high proportion of trips taken by active transportation and public transit will reduce emissions in Edmonton. Combining low carbon city planning with the electrification of the transportation system is identified by leading climate networks such as C40 as the number one thing a city can do to accelerate deep carbon reductions. Examples of policy statements from other jurisdictions include:

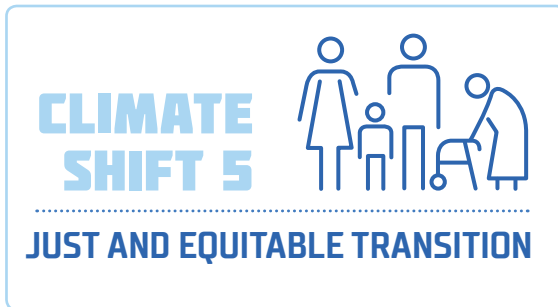
- ▶ Ensuring major areas of the city are car free and produce zero emissions by 2030 (C40 Declaration);
- ▶ Procuring only zero emission buses beginning in 2025 and targeting two thirds of all trips to be taken through active transportation or by public transit by 2030 (Vancouver).
- ▶ For the first time in Edmonton, the update to the Municipal Development Plan: City Plan, will be modelling the emissions impacts of various scenarios.



The carbon budget outlines the total quantity of emissions that are not to be exceeded. It follows from this that at some point in the near future, no new emissions can be added. Although conceptually the achievement of net zero carbon buildings is aligned with directions in the CETS, the policy documents do not specifically commit to net zero carbon by a specific date. For Edmonton's carbon budget to not be exceeded, the modelling suggests that all new buildings must be net zero carbon sometime before 2030, and all existing buildings must be net zero carbon by 2050. As noted in the principles and previously signalled by stakeholders, clear pathways for the achievement of this (such as raising energy efficiency standards) are required. Many jurisdictions around the world have made this commitment, including Montreal and Toronto. The federal government has signalled the goal of net zero ready buildings by 2030 in the Federal PanCanadian Framework on Clean Growth and Climate Change.

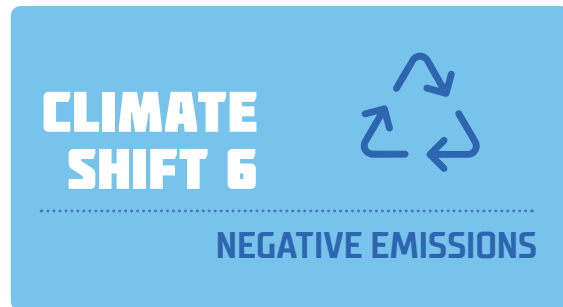


Zero emission fuel is required both to reduce existing emissions and to ensure no new emissions are added. A 100% renewable energy goal by 2050 (with interim milestones) calibrates the level of ambition required to stay within Edmonton's carbon budget. As part of the investigations of the 1.5°C scenario, an illustrative pathway was modelled for Edmonton that included renewable gas, renewable gas/geothermal district energy, solar photovoltaics, wind, energy storage, and decreased waste generation. The City of Edmonton is making large strides in its own operations with respect to this Big Climate Move, with its recent commitment to procure 100% green electricity. Also, significant effort is being invested in diverting significant quantities of waste from landfills. Several other jurisdictions have committed to a 100% renewable energy target and many have achieved it with respect to their electricity. Examples of cities that have committed to this target are Guelph, Ontario and recently Regina, Saskatchewan. The mayor of Georgetown, Texas, who recently visited Edmonton to have a public conversation with Mayor Iveson on this topic, has already achieved the target of 100% renewable electricity for its community.



Although this has not been modelled, ensuring that this is a just and equitable transition is a critical concept to entrench into climate change mitigation plans in Edmonton. The transition to a low carbon world will not affect all groups equally. The reality is that a significant amount of the Edmonton economy (a recent report<sup>5</sup> suggests nearly 30% of the provincial gross domestic product) is directly linked to the ongoing development of fossil fuels, and another significant proportion is indirectly linked to it. If deeper carbon reductions are to be pursued, this context cannot be ignored, and the impacts need to be fully understood and addressed. Deliberate attention will be required in Edmonton to ensure a just transition to a carbon constrained world. This move links closely with the subsequent Climate Shift regarding Negative Emissions.

In parallel, it is acknowledged that this transition will require investment and movement from all citizens. It will be critical to deliberately engage with and support vulnerable, diverse and low income populations, as the energy transition occurs. The transition must bring all members of society along, in ways that improve social equity and affordability. The low carbon world cannot be accessible only to the wealthy. Moreover, targets aligned with a 1.5°C scenario will require universal participation in order to be achieved. Special attention to the alleviation of issues such as energy poverty will be essential to a successful transition in Edmonton.



As indicated in a recently published guidance document drafted by New York City<sup>7</sup> and C40 with input from the City of Edmonton, there will be a need to address what is termed as residual emissions. Edmonton's first attempt at modelling a carbon neutral scenario by 2050 was unable to fully reduce enough emissions to stay within the local carbon budget. Although additional interventions (e.g. further decarbonization of the electricity grid) as well as innovation over the period will likely result in further emissions reductions, a certain proportion of emissions will remain.

As a result, mechanisms for absorbing CO<sub>2</sub>e will need to be explored and implemented prior to 2050. Technological mechanisms include sequestration, value add products, carbon upcycling, direct atmospheric carbon emissions removal and finally offsetting through global investments. The concept of negative emissions (e.g. carbon sequestration technology) is not new to Alberta but is relatively new in municipal climate change mitigation planning and it is rapidly evolving. Being on the front end of this could represent a significant economic opportunity for Edmonton in technology deployment, carbon accounting, circular economy and ecosystem restoration services. For instance, CleanO<sub>2</sub> is a Calgary-based company that recently deployed the world's first residential carbon capture device in Alberta called CARBiNX<sup>8</sup>. The resulting captured carbon is upcycled and used for a variety of products including cement additives and even soap.

<sup>5</sup> City Plan – Economic, Demographic and Market Study, Watson and Associates, May 2, 2019

<sup>6</sup> Energy Poverty is a term that is used to describe those households that spend more than 6% of their net income on energy (natural gas, electricity, transportation fuel, etc.). Recent data from the social enterprise, Empower Me, suggests that 22% of Albertan families live in energy poverty, at times, having to make monthly trade off decisions between groceries or paying their utility bill.

<sup>7</sup> Defining Carbon Neutrality for Cities & Managing Residual Emissions, C40 and NYC Mayor's Office of Sustainability, April 2019 (with input from City of Edmonton).

<sup>8</sup> From CleanO<sub>2</sub>'s website: CARBiNX is a sleek, carbon munching addition to your business, set to revolutionize the industry. Reducing energy demands through heat recovery and using our unique carbon capture process to produce a valuable by-product; carbonates

But beyond technology solutions, there is an opportunity to look at the carbon sequestration potential that restoration of natural ecosystems could provide. This tactic is being pursued by many cities around the world. Vancouver recently highlighted forest and coastal restoration as not just an adaptation strategy but also as a means to sequester carbon, indicating that it will remove one million tonnes of carbon annually by 2060.

## CONCLUSIONS

Edmonton's carbon budget was calculated to be 155 Mtonnes between 2017 and 2050. At Edmonton's current emissions levels (approximately 20 Mtonnes per year), the carbon budget threshold will be exceeded within 8 years. The findings of this work indicate that Edmonton's target, as outlined in CETS, of reducing 35% below 2005 levels by 2035 is not sufficient to keep Edmonton's greenhouse gas emissions within the 1.5 degree limit aspired to in the Edmonton Declaration.







Also, initial modelling attempts to develop an illustrative pathway that remained within the local carbon budget were not successful. This does not signal defeat; rather, it highlights the need to look deeper into the actions in the illustrative pathway and consider adding actions designed to sequester, offset or directly remove carbon from the atmosphere. This is referred to as residual emissions management. It is clear that achieving such significant emission reductions will be challenging in Edmonton; however, Administration's preliminary analysis, the work of other jurisdictions, and the advice of technical experts all confirm that it is technically achievable.

## POTENTIAL NEXT STEPS

It is important to point out that this report largely reflects the results of a technical exercise, and limited engagement was conducted beyond internal departments and the Energy Transition Advisory Committee. If directed to do so, Administration will use the ideas presented in this report as a foundation for additional technical analysis, economic and financial assessments, and deeper engagement with stakeholders and the residents of Edmonton. This will allow the City to more fully understand the challenges and opportunities represented by the categories of actions outlined above. All of the information collected would be used to develop updated targets and a comprehensive action plan and funding strategy to meet the goal of limiting Edmonton's emissions to levels aligned with a 1.5°C scenario for Council's consideration.

# APPENDIX I: MEASURES MODELLED FOR CONCEPTUAL 1.5°C ACHIEVEMENT

The following measures were modelled within the context of the local carbon budget. The measures have been grouped under the Climate Shifts:

CLIMATE SHIFT	1  TOOLS AND TARGETS	2  LOW CARBON CITY AND ZERO EMISSIONS TRANSPORTATION	3  EMISSIONS NEUTRAL BUILDINGS	4  RENEWABLE REVOLUTION	5  JUST AND EQUITABLE TRANSITION	6  NEGATIVE EMISSIONS
MODELLED MEASURES	Carbon Budget (155 Mtonnes of CO <sub>2</sub> e)	<ul style="list-style-type: none"> <li>Building Use Intensity</li> <li>Land Use Intensification</li> <li>Car Free Zones</li> <li>Transportation Marketing (Active and Public)</li> <li>Electric Vehicles</li> <li>Electric Transit System</li> <li>Increased cycling and walking infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>Improve Industry Efficiency</li> <li>Installation of heat pumps</li> <li>New buildings net zero (residential and commercial)</li> <li>Building retrofits (residential and commercial)</li> </ul>	<ul style="list-style-type: none"> <li>District Energy (renewable)</li> <li>Renewable Natural Gas</li> <li>Solar photovoltaics (community generation, microgeneration)</li> <li>Wind (imported from region)</li> <li>Energy storage</li> <li>Decrease waste generation</li> </ul>	Not modelled but must be considered in future economic modelling and transition planning	<ul style="list-style-type: none"> <li>Residual emissions after all other levers and measures are implemented</li> <li>This wedge also includes emissions that could be pushed down further (e.g. more aggressive decarbonization of the electricity grid)</li> </ul>
PERCENTAGE TOWARDS TARGET	Not Applicable	Up to 22%	Up to 20%	Up to 37%	Not Applicable	Up to 21%

## ACTIONS AND THEIR CONTRIBUTION TO BECOMING CARBON NEUTRAL BY 2050

ACTION NAME	DESCRIPTION	PERCENTAGE OF CONTRIBUTION TOWARDS BECOMING CARBON NEUTRAL BY 2050
Negative Emissions	Taking actions or deploying technologies that will absorb or sequester carbon.	21%
Renewable Natural Gas	<ol style="list-style-type: none"> <li>Maximizing biogas generation using sources from waste, wastewater and agriculture; and</li> <li>Purchasing additional renewable natural gas.</li> </ol>	23%
Electrify Personal Vehicles	Changing the personal vehicle market such that 100% of new sales are electric by 2030.	11%
Solar PV Rooftop	Scaling up to have 85% of new and existing buildings with solar PV installed on them by 2040.	5%
Expanded District Energy	Completing the Blatchford and Downtown District Energy systems, then expanding these, and adding new systems, fuelled through renewable sources, in three more areas of the city. This work would scale up until by 2030, district energy provides 10.7 GJ of energy to Edmonton annually.	4%
Retrofit Commercial	Retrofitting building envelopes in pre-2017 buildings to achieve thermal and electrical savings of 50%, scaling up the number of dwellings retrofit over time until 100% are complete in 2050.	5%

ACTION NAME	DESCRIPTION	PERCENTAGE OF CONTRIBUTION TOWARDS BECOMING CARBON NEUTRAL BY 2050
Land Use Intensification	Increasing population density such that 50% of population growth 2016 to 2027 is redirected from developing and planned neighbourhoods to mature and mature central core neighbourhoods, and 100% of population growth from 2027 to 2047 redirected from developing and planned neighbourhoods to mature and mature central core neighbourhoods.	4%
New Residential	Increasing energy efficiency for all new residential buildings over time from Alberta Buildings Code 2015 incrementally to net zero by 2025.	3%
Heat Pumps	Scaling up to have the following by 2050: 1. Air source heat exchange installed in 50% of dwellings and geothermal heat pumps installed in 25% of dwellings; and 2. Heating in 75%, and cooling in 100% of commercial and institutional buildings provided by electric heating and cooling systems.	2%
Industry	Reducing energy use by 75% by 2050 by improving electrical motor efficiency and improving processes.	3%
Retrofit Residential	Retrofitting building envelopes and lighting in pre-2017 dwellings to achieve thermal and electrical savings of 50%, scaling up the number of dwellings retrofit over time until 100% of them are complete in 2050.	4%
New Commercial	Changing requirements for energy performance from National Energy Code for Buildings 2011 to increase incrementally to net zero before 2030. Incrementally scales up to 100% of buildings before 2030.	2%
Building Use Intensity	Decreasing employee space intensity by 40%, and residential floor space intensity by 25% by 2050.	3%
Solar PV Ground Mt	Installing 20 MW per year from 2020 to 2050, such that by 2050 there are 600 MW of installed solar capacity installed on ~5300 acres of land in Edmonton.	2%
Reduce Waste	Diverting 90% of residential and commercial waste from the landfill.	1%
Electrify Commercial Vehicles	Changing vehicles such that 100% of new sales are electric by 2030.	1%
Energy Storage	Scale up to have 250 MW in decentralised storage by 2050.	1%
Car Free Zones	Establishing areas in the downtown core and university area (including the zones highlighted in the maps below) to which public vehicle traffic would be permanently closed. These areas would still allow service and goods delivery but would not permit any personal vehicles or transit. Pedestrian and bike traffic would be permitted in these areas.	1%
Increase cycling/ walking infra	Adding, improving and maintaining enough pedestrian and bike path/ lane infrastructure to result in 50% of all trips less than 2 km long being walked, and 50% of all trips less than 5 km long being biked by 2050.	0.6%
Wind	Acquiring 110 MW of wind power sourced outside the city, by 2050	0.6%
Electrify Transit	Transitioning 100% of the transit fleet from diesel to electric buses by 2030.	0.3%
Transportation Marketing	Providing customized transportation planning to 1% of citizens each year beginning in 2020, scaling up to 2% per year by 2050. The planning would be designed to achieve: 1) A 10–22% increase in transit trips; 2) A 10–13% increase in trips taken by walking; 3) A 26–30% increase in cycling trips; 4) 9% decrease in trips travelled in vehicles; and 5) A 5% decrease in vehicle kilometres travelled (VKT).	0.5%
Electrify Municipal Fleets	Changing municipal vehicles in batches every 5 years, such that 100% of the fleet is electric by 2030.	0.03%



For more information please visit: [changeforclimate.ca](http://changeforclimate.ca) or call 311

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