City of Edmonton

City Plan

GHG Emissions and Energy Analysis for the City Plan Evaluation Scenarios

Briefing

August 13, 2019

This technical study was initiated to inform the development of The City Plan. The technical studies were considered alongside public engagement, modelling and professional judgment to determine overall outcomes for The City Plan.

SSG whatIf?

City Plan Background

Edmonton's City Plan is being developed with a target of doubling Edmonton's population to two million people over a number of decades. This forward looking planning needs to be assessed from the perspective that integral choices are required related to growth; where will people live, where will people access services, and where will the new jobs be located.

The City Plan team is using modelling tools to simulate the effects of how an increase of population will impact each of these choices. Modelling tools can help us to understand what those choices might look like and the benefits and drawbacks associated with various land use and transportation permutations. This can be accomplished in part through evidence-based testing of possible growth scenarios and policy to demonstrate impacts at a city-wide scale.

The approach taken to developing the draft City Plan land use concept involves a four-step process of:

1. developing three evaluation scenarios;
2. modelling the evaluation scenarios and evaluating their outputs against a set of performance indicators;
3. extracting learnings from the evaluation scenarios to inform the development of the draft City Plan land use concept scenario;
4. modelling and re-evaluating the draft City Plan land use concept against the indicators and updating the draft City Plan land use concept as needed.

Three evaluation scenarios were developed by the City Plan team that illustrate the potential locations and intensity of growth for Edmonton at 2 million people. They are intended to have comparatively different alternative growth patterns. The scenarios have been named the Central City, Node City, and the Corridor City to reflect the key features in the growth patterns. Narratives have been developed to describe the three 'cities' and provide an overview of the built form, transportation, employment, green networks, and open space envisioned. The concept of nodes and corridors is represented at different scales and with differing purposes within each of the evaluation scenarios. A Business as Planned scenario was also developed in order to understand the financial implications of current growth patterns into the future. The evaluation scenarios were compared to one another as well as the current baseline year.

A description of the business as planned, and evaluation scenarios is as follows:

The Business as Planned - The Business As Planned scenario assumes growth occurs according to the City's approved and strategic land use plans including Area Structure Plans (and associated Neighbourhood Structure Plans) included in the Plans in Effect.

The BAP scenario also includes plans for Area Restructure Plans including infill redevelopments such as Blatchford, Bonnie Doon, and Mill Woods Town Centre.

Central City ("City 1") – This scenario concentrates employment and population within a specific boundary centred mainly around current downtown and mature areas. Policies would focus on achieving a strong central core that is supported by a large concentration of population and employment within the Central Core boundaries. Nodes and corridors are mainly located within the central core with strategic nodes located outside the central core boundary.

Node City ("City 2") – This scenario attracts more people to reside in the central core and distributes new jobs to other areas of the city. Policies will work to ensure the city develops into a community of communities that are spatially bounded by 15 different City District boundaries. The Districts and a tiered network of activity centres (nodes) are the base structure elements of this scenario. Corridors are still present within this scenario however their location is more strategic in nature and overall play a supportive/secondary role in this scenario.

Corridor City ("City 3") – This scenario redistributes population and employment throughout the city along corridors with less concentration within nodes. There is a heavy focus on rebuilding, repurposing or reclaiming underutilized land (commercial, institutional, industrial) to distribute medium intensity development and green spaces to all parts of the city. Policies would pursue achieving more equitable and spatially distributed access to services, jobs and housing by emphasizing high density corridors. Nodes still exist within this scenario however their location is more strategic and they play a supportive/secondary role in this scenario.

Greenhouse Gas and Energy Consumption Assessment

The CityInSight model was used to calculate the estimated greenhouse gas (GHG) emissions and energy consumption forecasts associated with the City Plan Evaluation Scenarios.

In order to understand the GHG impacts, the Evaluation Scenarios included a range of changes to energy and transportation infrastructure, and programs to encourage behavioural change. These together contribute to deep GHG emissions reductions. Examples of these changes include[1]:

- Increasing the energy performance of new dwellings and non-residential space to net zero by 2030;
- retrofitting all pre-2017 dwellings and commercial buildings with energy savings of 50% by 2050;
- fuel switching buildings to heat pumps;

1

- increasing solar and wind electricity generation;
- adding energy storage;
- increasing walking and cycling infrastructure;
- electrifying transit, personal and commercial vehicles; and
- decreasing waste consumption.

The key findings of the greenhouse gas and energy analysis conducted on the Evaluation Scenarios are as follows:

Of the three scenarios, City I results in the greatest GHG emissions reduction.

The GHG emissions reductions associated with each scenario are similar in 2065, with all exceeding a reduction of 75% or more over Business as Planned. The best performing scenario, City I, achieves a GHG reduction of 290 ktCO2e more than the worst performing scenario, City II.

	GHG emissions in 2065			
Scenario	BAP	City I	City II	City III
2065 total (MtCO2e)	14.47	3.25	3.61	3.42
% reduction in 2065 over BAP	N/A	77.6%	74.8%	76.0%
% reduction directly attributable to land-use and transportation policy	N/A	11%	6%	9%
% reduction attributable to other energy-reducing actions	N/A	89%	94%	91%

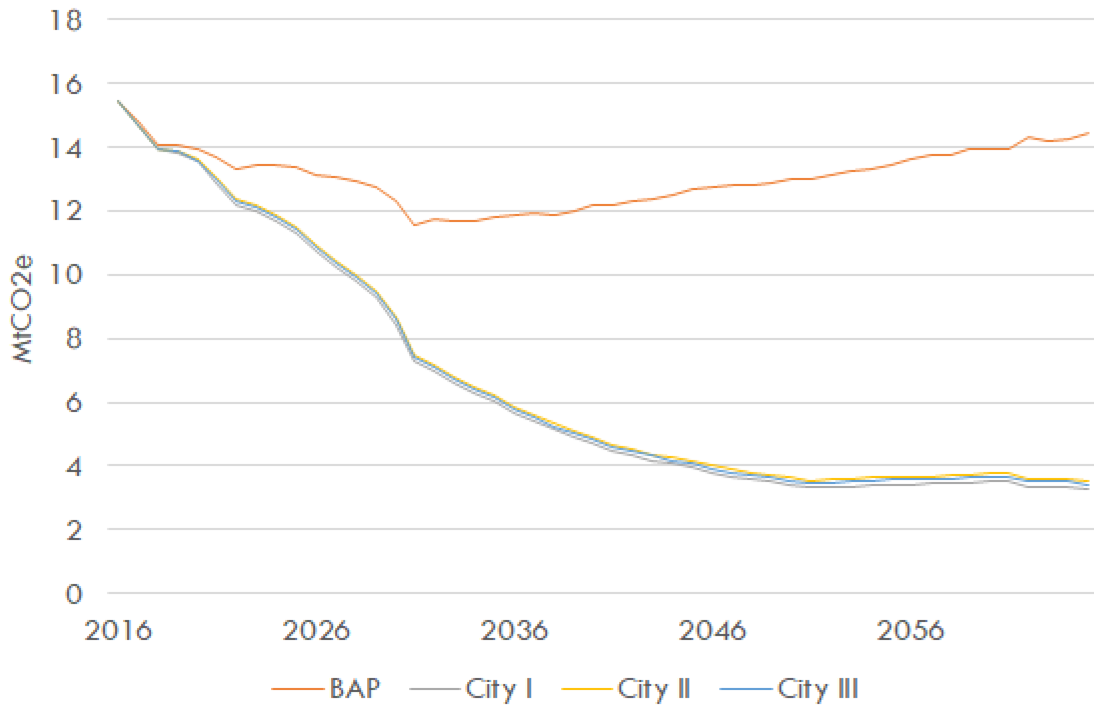


Figure 1: GHG Emissions for City Scenarios

The dwelling mix is not determining the GHG emissions pattern.

The total dwelling mix shifts in all the scenarios by 2065, with 9% (City I), 7% (City II) and 11% (City III) fewer single family dwellings compared to Business as Planned. Because single family dwellings are typically associated with higher GHG emissions than other dwelling types, it may be expected that City III would have the fewest GHG emissions, particularly because it also has the highest combined share of apartments and row houses. However this is not the case and rather City I, with the highest share of apartment units located in the core and mature areas of the city, results in City I produced the lowest overall GHG emissions.

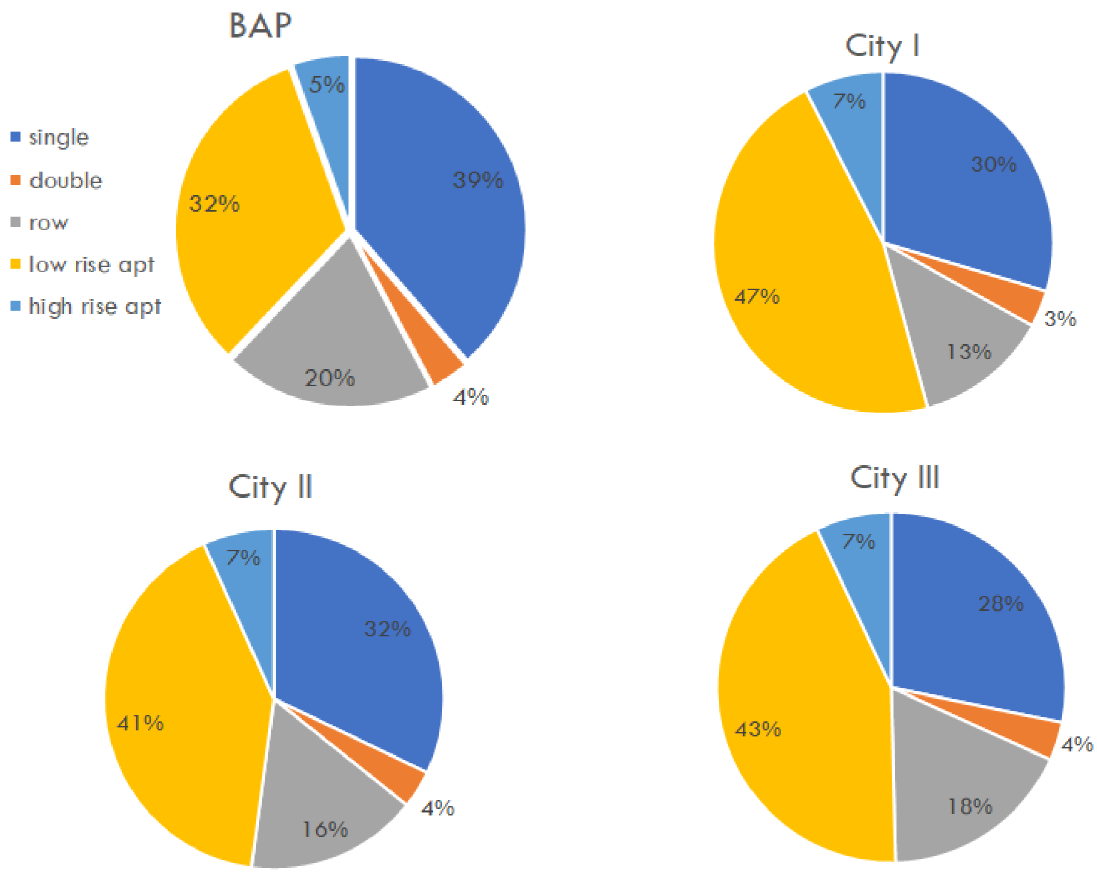


Figure 2: Dwelling shares by scenario, 2065

All City scenarios represent a shift away from single family dwellings to apartments.

In all three City scenarios, the share of singles declines, and the share of apartments doubles. Low rise apartments constitute more than 50% of the growth between 2016 and 2065, whereas the pre-2016 share of low rise apartments is just 12%.

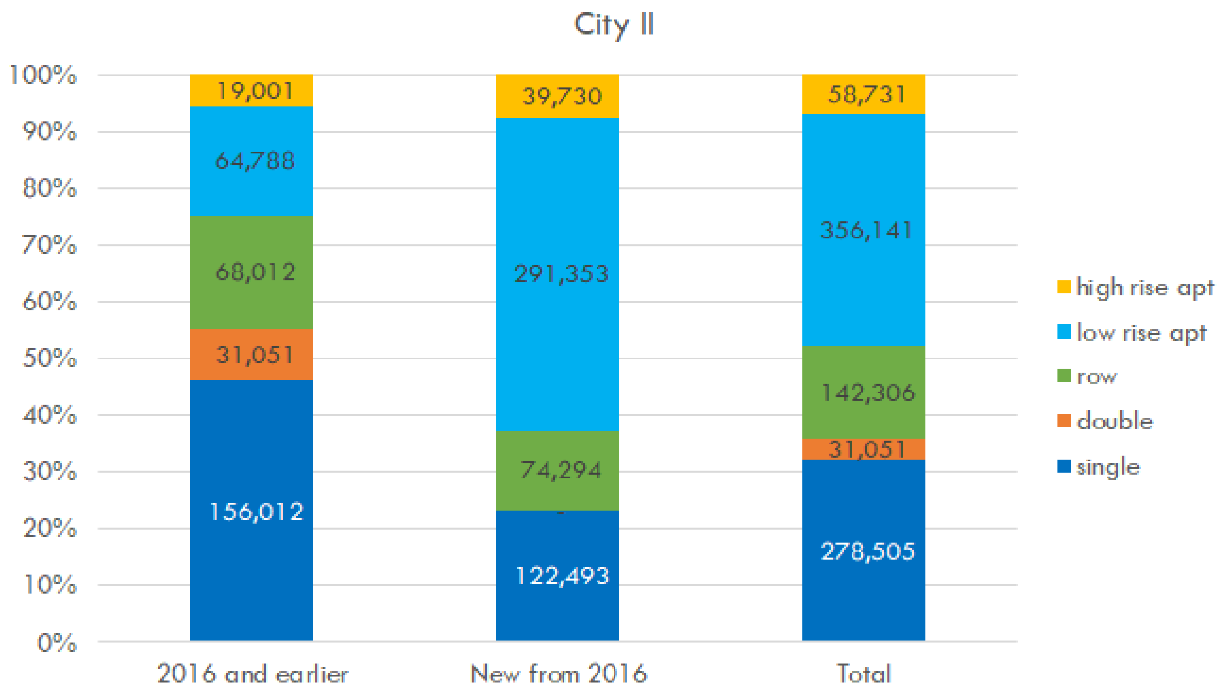


Figure 3: Dwelling shares for City II

In terms of variation across scenarios, the shifting of growth from single family dwellings to apartments in the City scenarios versus the BAP is apparent. City I has a greater emphasis on low rise apartments and fewer singles and rows than the other two City scenarios.

Because apartments are smaller than singles in floor space, one would expect overall floor space to decrease and therefore energy and emissions to decrease also. However, because the occupancy of apartments is assumed to be lower than singles and the population is held constant across the scenarios, the number of units is increased, resulting in a minimal impact on floor space and energy and emissions. This is based on the assumption that families will not move into apartments but rather that couples or single individuals would.

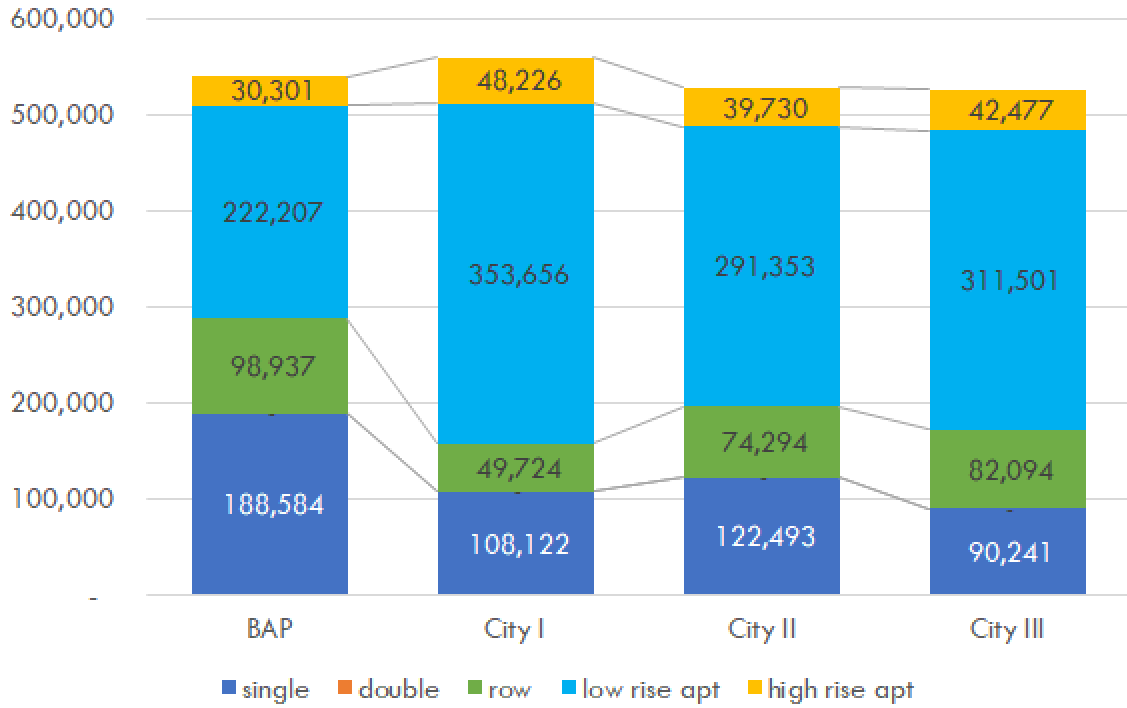


Figure 4: New dwellings, 2016-2065

The impact on total dwellings implies a more urbanised city, with a much greater share of low rise apartments and some larger apartments.

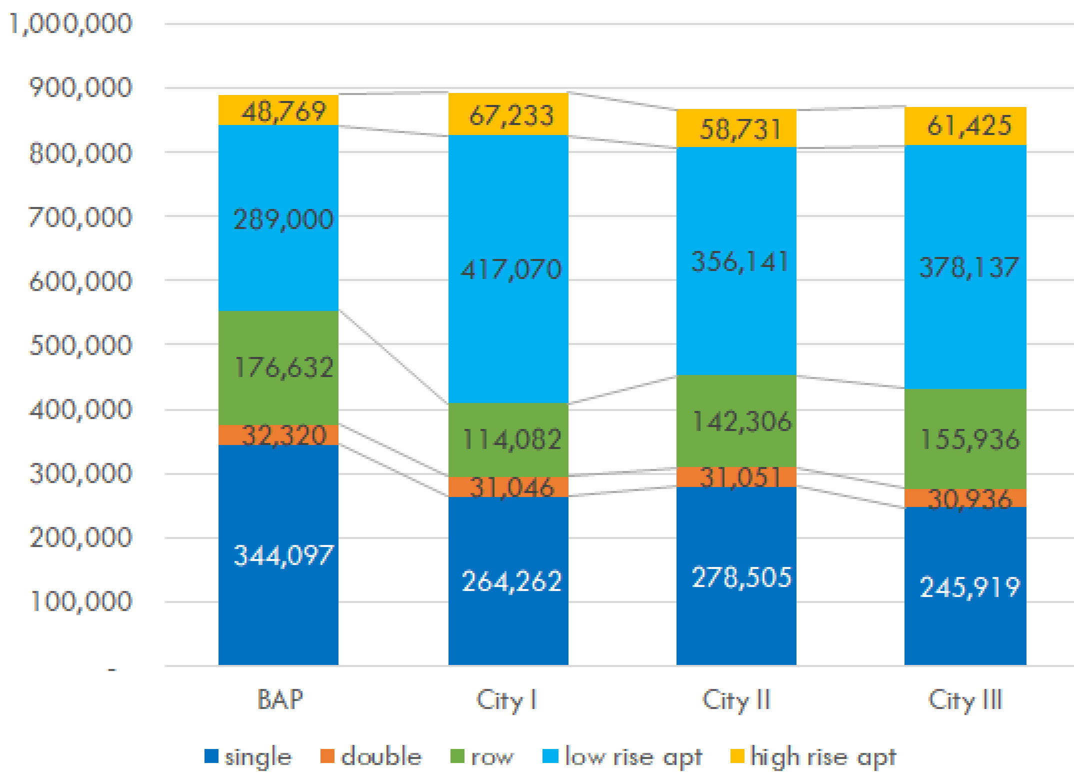


Figure 5: Total dwellings, 2065

Transportation, not dwelling type, is driving the GHG emissions reductions in City I.

Household-related GHG emissions were calculated for each of the City scenarios. The most significant emissions difference appears in the transportation sector, implying that the location of the dwellings may influence patterns of GHG emissions more than the type of dwelling in this analysis.

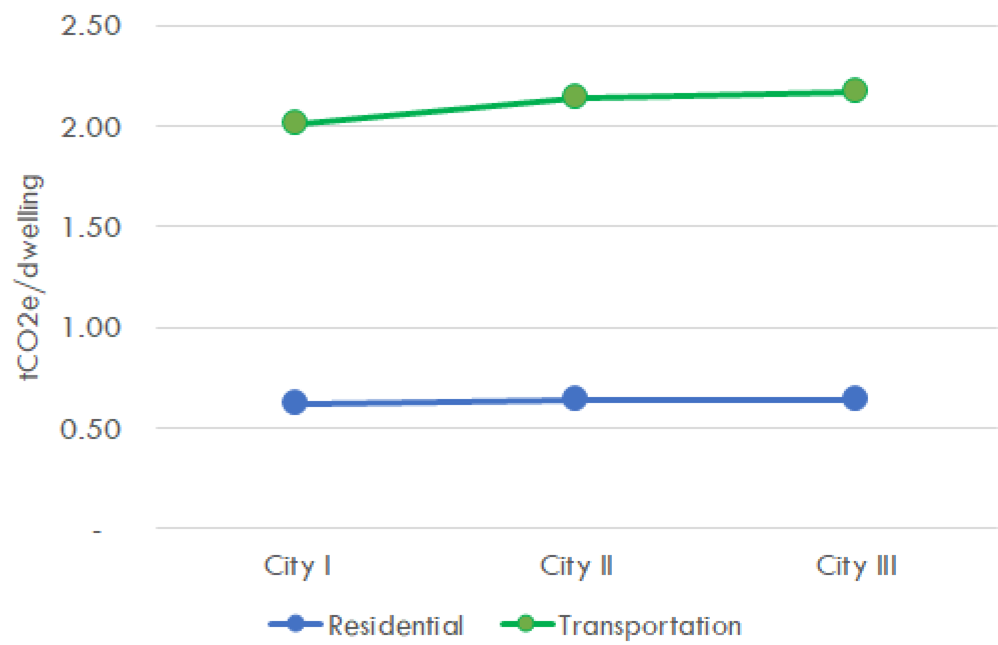


Figure 6: Comparison of GHG emissions reductions, 2065

This assessment is borne out by a review of total vehicle-kilometres travelled (VKT) in each of the scenarios. City I results in 2.4 billion km less of driving per year than City II by 2065 (52 km/week/household) and 1.6 billion km (35.5 km/week/household) less than City III.

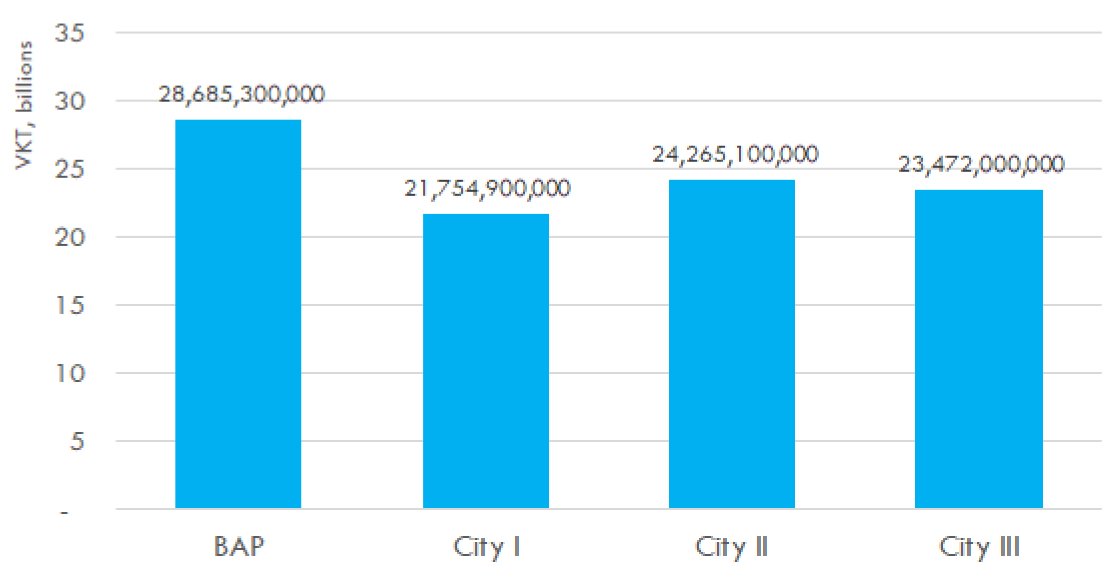
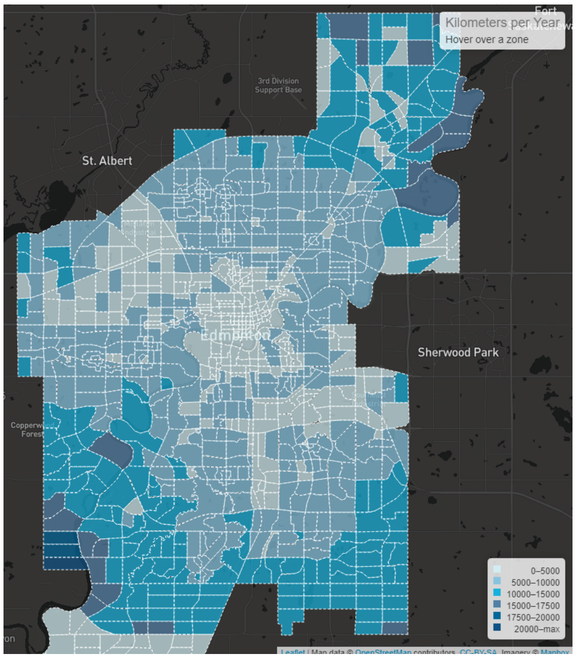


Figure 7: Vehicle kilometres travelled per year, 2065

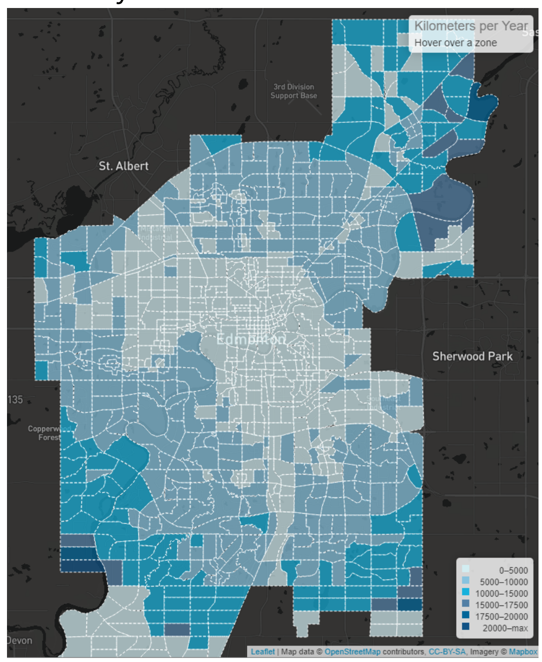
Land-use development patterns influence trip length. VKT is concentrated at the periphery of the City.

The decrease in vehicle transportation is apparent from a spatial comparison of VKT by zone for each scenario. Zones toward the centre of the City have less VKT than zones in the suburban areas. City I has less peripheral VKT than the other two City scenarios.

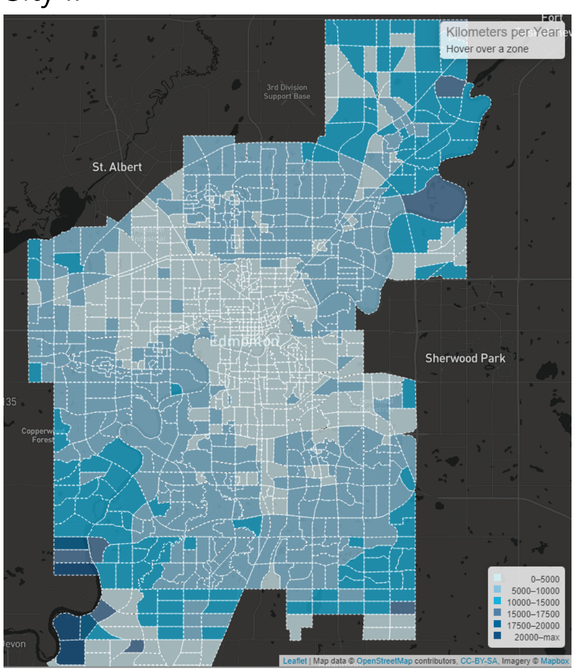
BAP



City I



City II



City III

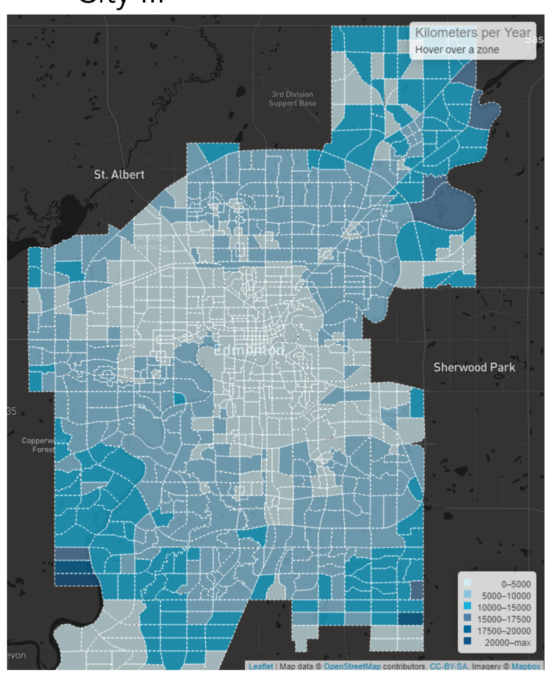


Figure 8: VKT by scenario, 2065

Transit mode share shows the opposite pattern, with higher concentrations in the centre of the City, and islands of high mode share outside of the centre and along corridors. The differences in mode share between City III and City I are subtle, but the general trend is that in City I, more zones have a higher transit mode share in the downtown area.

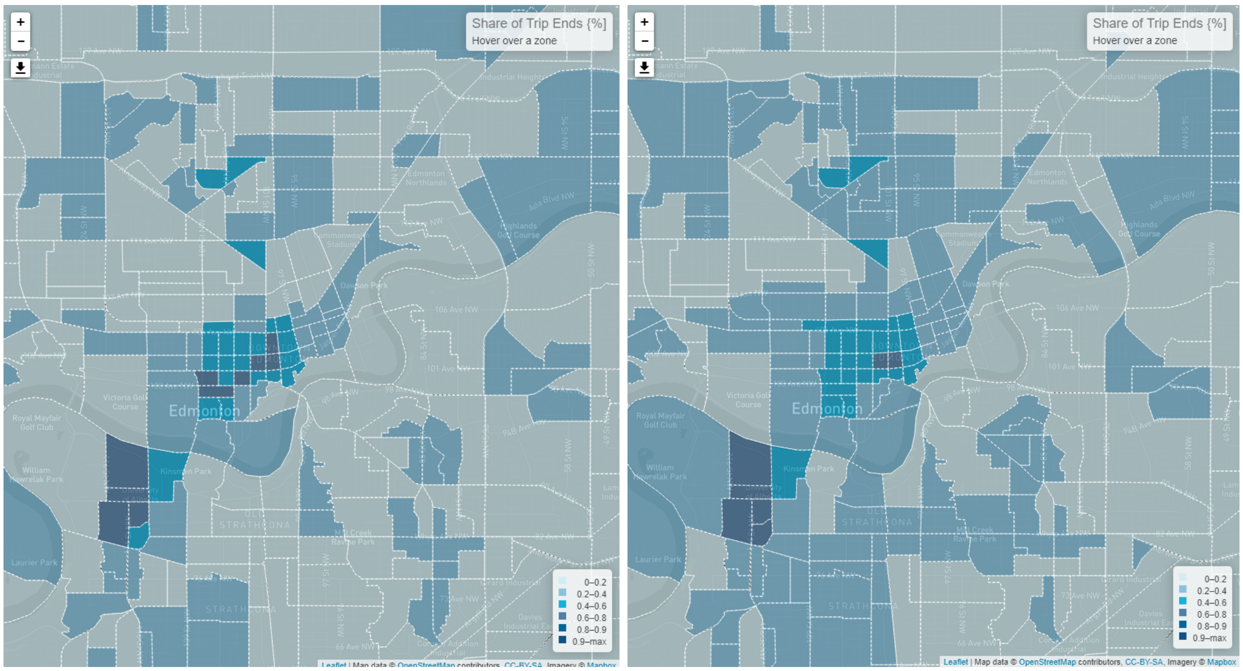


Figure 9: Transit mode share in the downtown, City III (left) vs City I (right), 2065

The City Scenarios represent a highly urbanised, pedestrian-oriented City; this is not the case with the BAP.

A comparison of active mode share in 2065 between City I and the BAP illustrates how increasing city density results in the frequency of active transportation increasing from negligible to highly significant in the core of the City. The health and GHG benefits stemming from this increase in active transportation can be attributed to land-use policy.

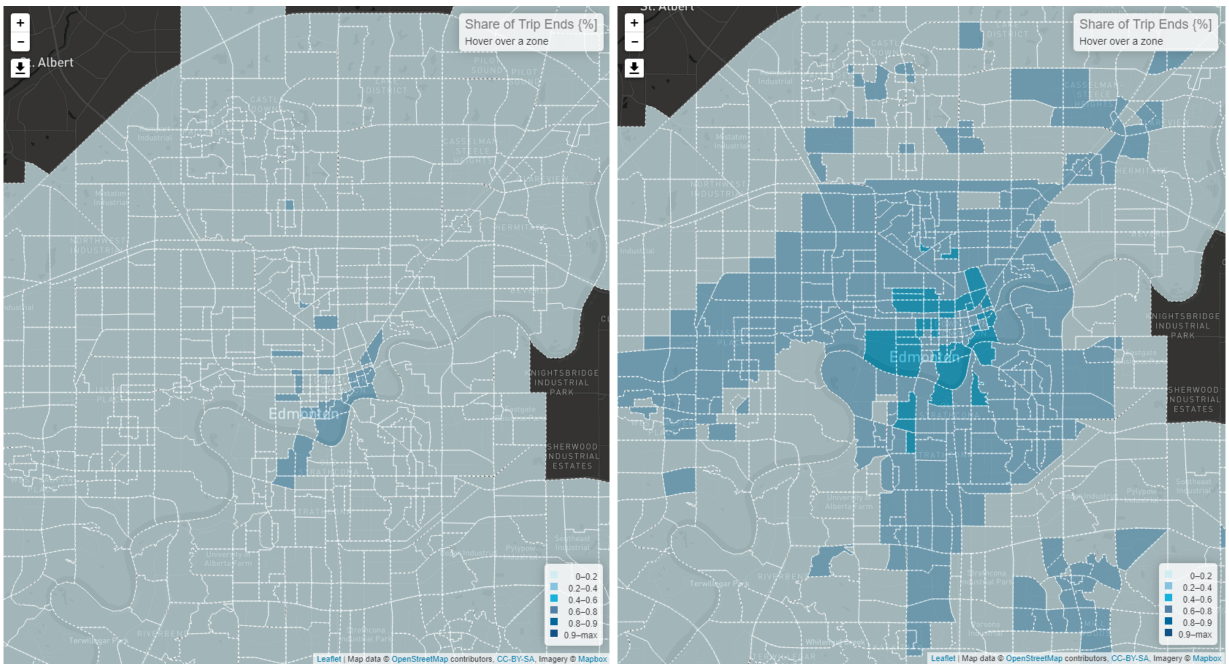


Figure 10: Active mode share, BAP (left) vs City I (right), 2065

When residential GHG emissions are considered spatially, as in Figure 11, City I has a noticeably different pattern of development than the other two City scenarios. There are higher concentrations of GHG emissions in the downtown and in what appear to be nodes on the periphery. The pattern in City II and III is more distributed on the outskirts of the City.

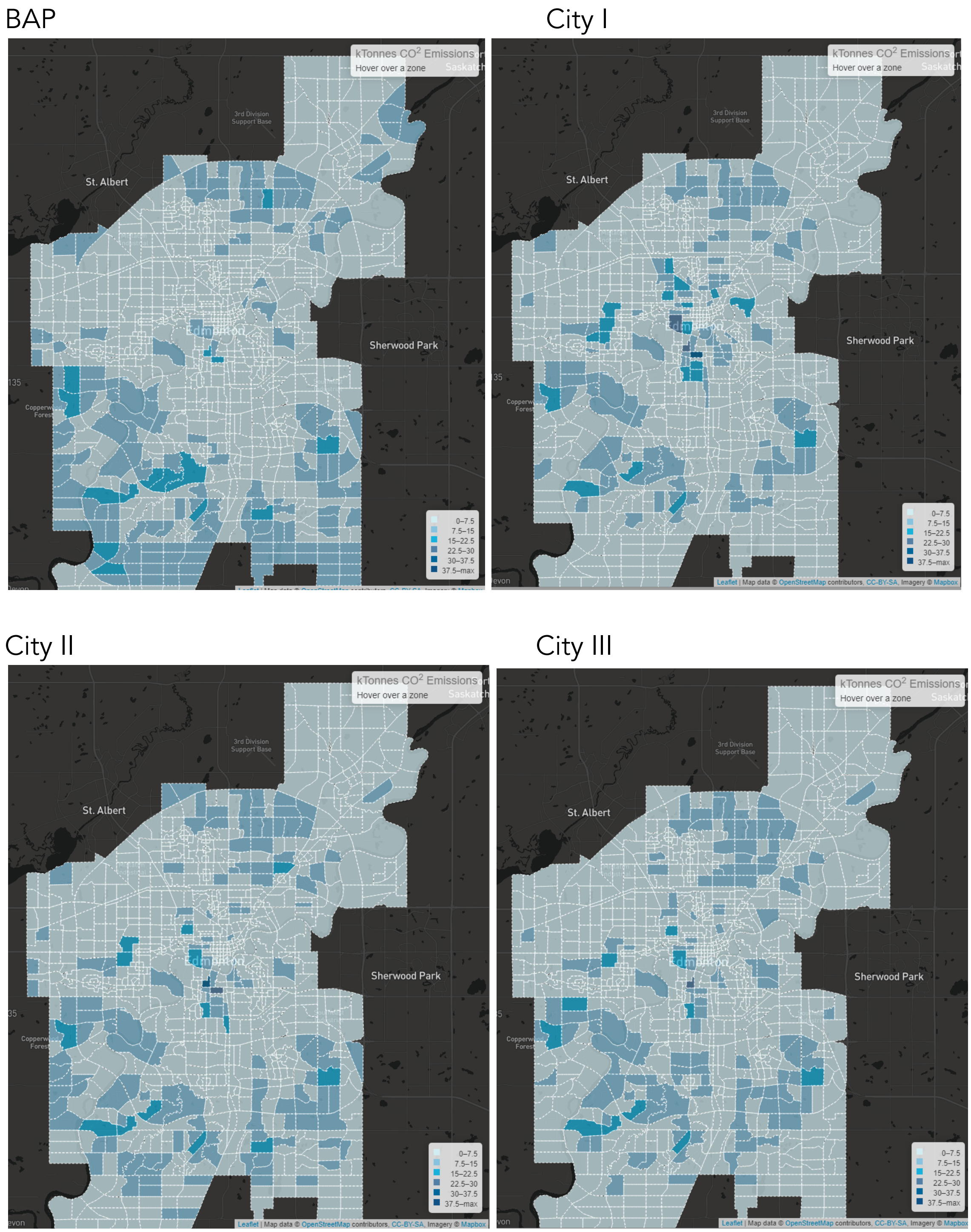


Figure 11: GHG emissions from residential dwellings, 2065

Intensification in City I increases the potential for major district energy systems.

The impact of the development patterns on district energy feasibility is apparent in an evaluation of the number of dwelling units and non-residential floor space in zones that exceed 150 MJ/m2, a heat density threshold for district energy. While the total number of dwellings increases by 50% in City I, non-residential floor space is relatively constant. Non-residential floor space is concentrated in the centre and nodes and does not vary across the scenarios the way that residential development does.

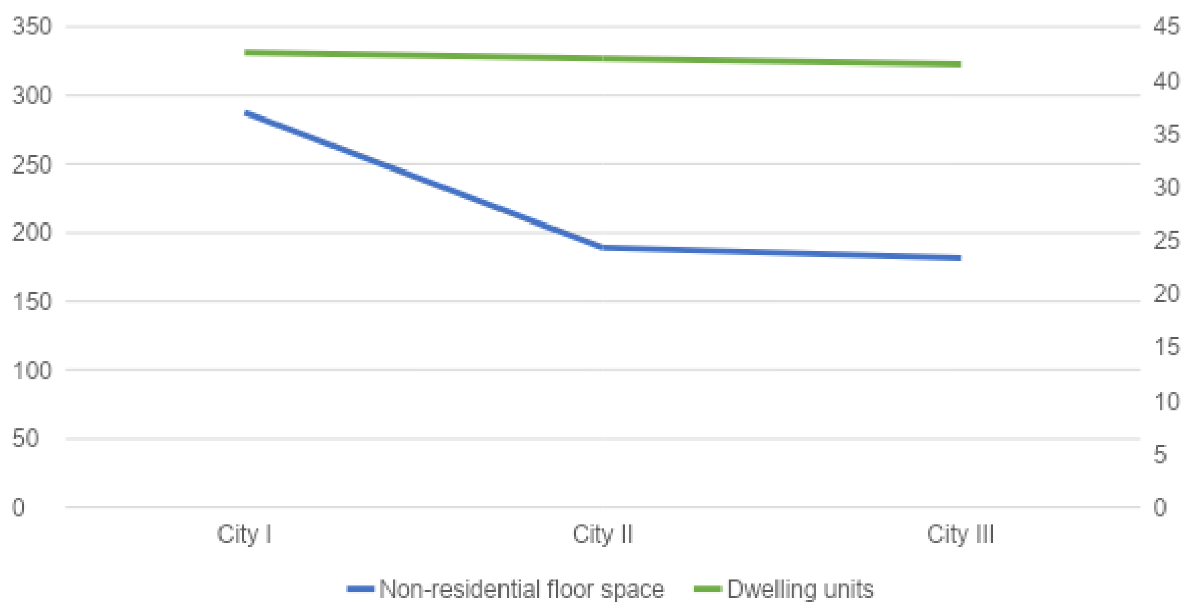


Figure 12: Dwellings and non-residential floor space in areas with sufficient density for district energy

The impact of the district energy expansion shows up in the sankey diagrams of energy in 2065. The district energy system (thermal network) in City I is 8.4 PJ versus just over 6 PJ in the other two scenarios.

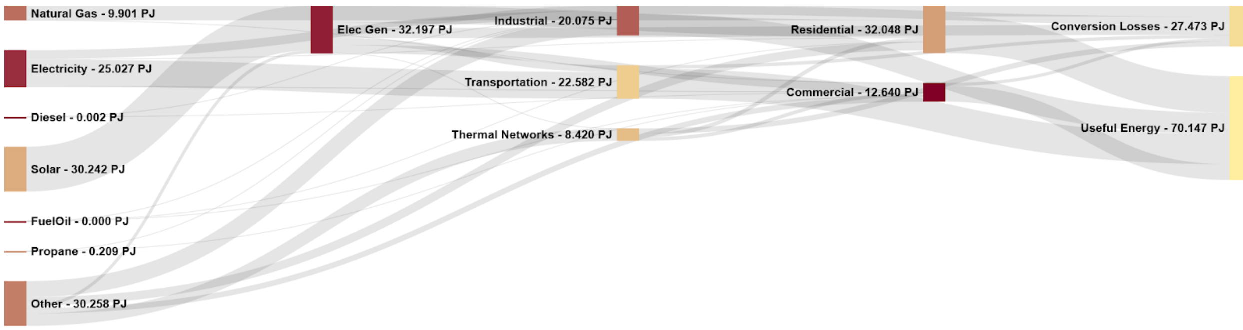


Figure 13: Sankey diagram for City I, 2065

City III has the lowest overall energy consumption in 2065, however, the larger district energy system in City I (assumed to be clean energy) means that City I has the lowest GHG emissions overall. The pattern of development in City I also results in greater solar PV generation, likely as a result of the increased number of dwelling units.

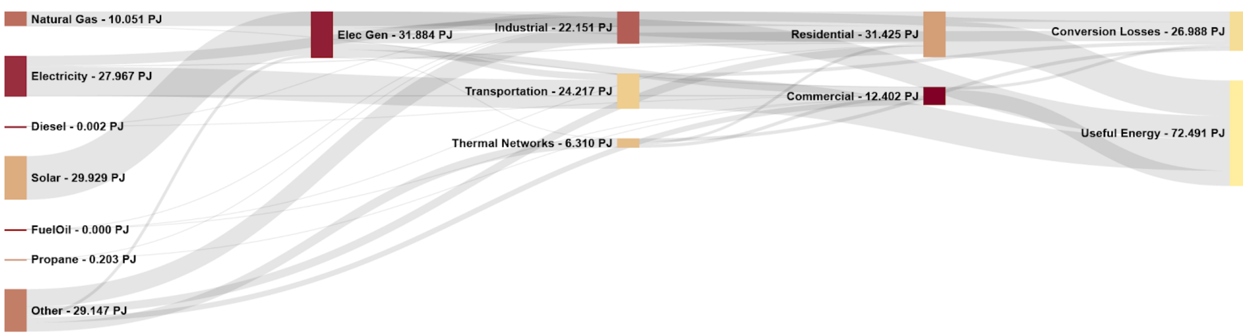


Figure 14: Sankey diagram for City II, 2065

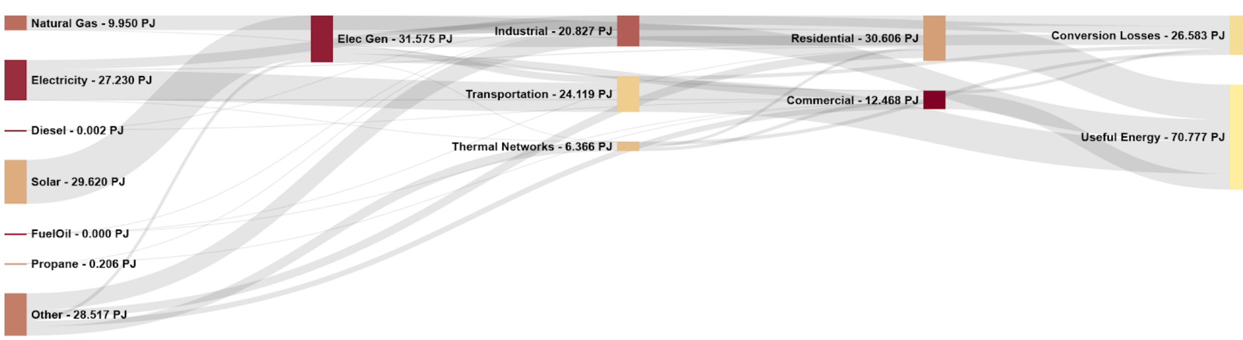


Figure 15: Sankey diagram for City III, 2065

The City Scenarios do not achieve the City's carbon budget.

As part of the Energy Transition update, a carbon budget was identified for 2019 to 2050, representing Edmonton's share of global emissions for a scenario that limits warming to 1.5 degrees. A scenario called Delivering on Paris Plus (DOP+) was modelled to evaluate how the City could achieve those targets. The land use, transportation technology and energy actions identified in City I Scenario mimic those of the DOP+ scenario. There is a difference between the DOP+ and City I scenario initially, but as vehicles are electrified and clean electricity comes online, this variation decreases. This is because, while the land-use changes in City I decrease vehicular trips, the trips have a negligible GHG impact when electrified with clean energy. There is, however, a financial impact, as an avoided vehiclular trip saves money, whether it is in an electric vehicle or a gas vehicle.

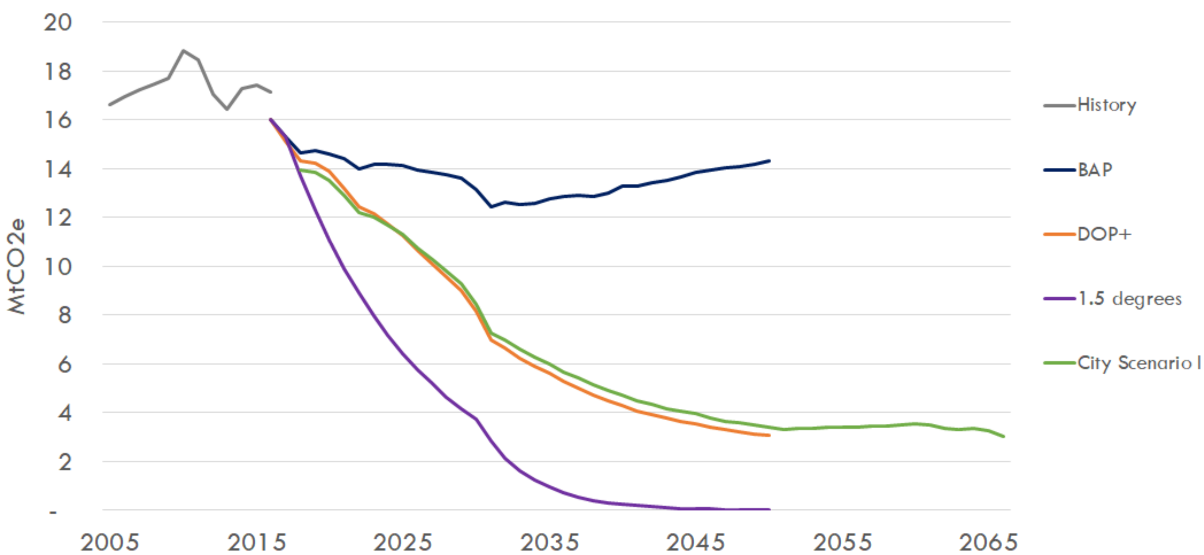


Figure 16: City I relative to the carbon budget and other low carbon scenarios

Every reduction counts, including the reduction that City I achieves over the other City scenarios.

While the GHG reductions of City I over City II and III may seem minor, from the perspective of the carbon budget every million tonnes of reductions counts. From 2019-2065, City Scenario I saves 6-9 MtCO2e over the other two scenarios (see Figure 17). The IPCC indicates emissions need to decline to net zero emissions by 2050 to have a reasonable chance of limiting warming to 1.5 degrees.[2]

[2] Rogelj, J., D. Shindell, K. Jiang, S. Fifita, P. Forster, V. Ginzburg, C. Handa, H. Kheshgi, S. Kobayashi, E. Kriegler, L. Mundaca, R. Séférian, and M.V. Vilariño, 2018: Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change,

Scenario	Cumulative emissions, over the period, (MtCO2e)	Average annual GHG emissions, 2050-2065, MtCO2e
1.5 degree budget (2019-2050)	155	0[3]
City I total (2019- 2065)	288	3.40
City II total (2019-2065)	297	3.63
City III total (2019-2065)	294	3.56

The cumulative reduction in emissions in City I over City II adds up year over year to equal total annual emissions in City I in 2045 and nearly triples annual emissions by 2065.

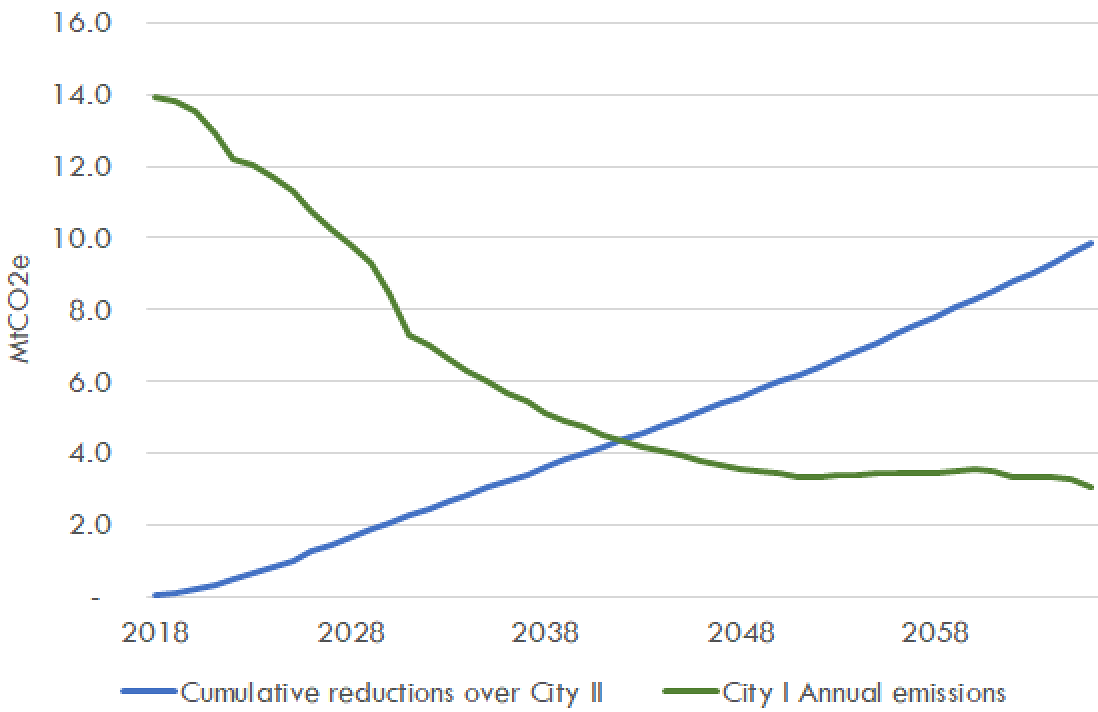


Figure 17: Impact of GHG emissions reductions from City I over City II

---

sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.

[3] GHG emissions are assumed to be 0 for the 1.5 scenario post 2050.

Mid-century, electricity is the dominant source of GHG emissions in the City scenarios, illustrated in Figure 18 for City I.

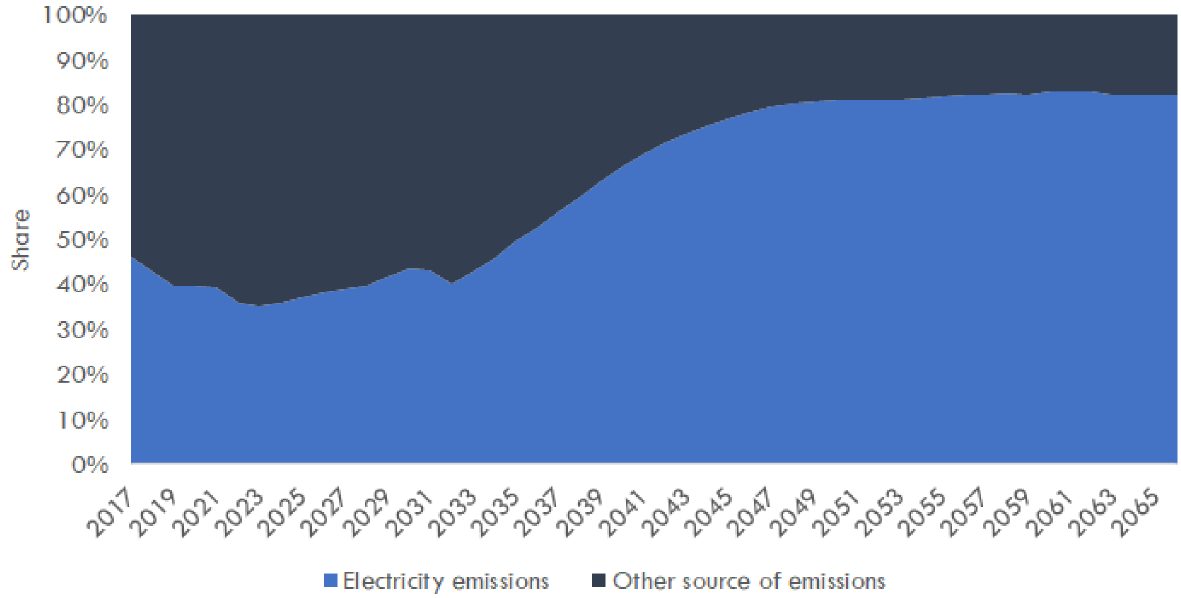


Figure 18: Emissions from electricity as a share of the annual total emissions, 2019-2065

If green electricity is introduced by 2030, the GHG emissions profile of the scenario is improved, as vehicles and heating are electrified.

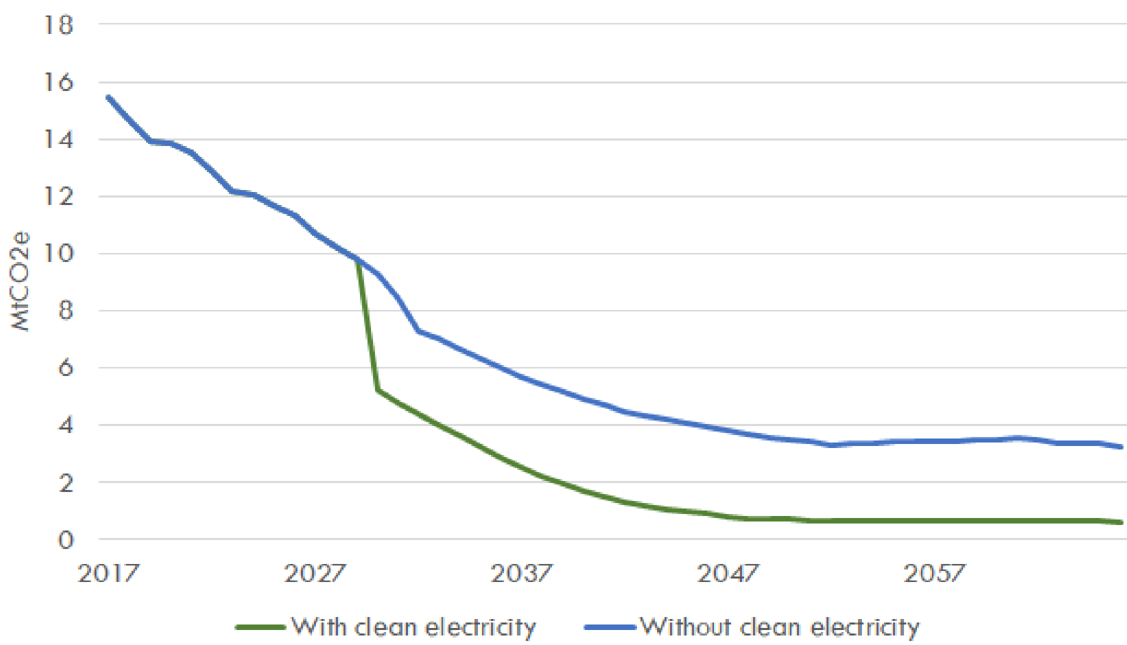


Figure 19: The impact of clean electricity on City I, beginning in 2030