Appendix 2

2019

2019 Analytical Report

BRAMPTON COMMUNITY ENERGY AND EMISSIONS REDUCTION PLAN (CEERP)

PROJECT WORKING TEAM

Contents

2019 Analytical Report

Brampton Community Energy and Emissions Reduction Plan (CEERP)

1. Introduction

The City of Brampton, in partnership with Sheridan College embarked on the development of a Community Energy and Emissions Reduction Plan (CEERP) in 2018. The CEERP aims to integrate efforts of the municipality, local utilities and community stakeholders and create a roadmap that will improve energy efficiency, reduce greenhouse gas emissions, ensure energy security, create economic advantage (e.g., the repatriation of energy costs and generating jobs and businesses in the green economy) and increase resilience to climate change. The CEERP directly supports the goals of other City-approved plans including the Brampton 2040 Vision: Living the Mosaic, and Brampton Grow Green Environmental Master Plan and the Climate Change Action Plan as well as the Climate Emergency Declaration by Council.

Community energy plans (CEPs) consider all local energy flows that impact the activities within that community. CEPs identify solutions to increase efficiency for the entire energy value chain from supply through distribution to end-use. Improved energy efficiency and alternative energy sources can reduce overall energy costs for residents and local businesses as well as lower greenhouse gas (GHG) emissions. New technologies across the energy value chain are creating new opportunities at the community-level for the supply and distribution of energy. In addition to considering opportunities to reduce the release of carbon associated with energy use, the CEERP will also consider opportunities to sequester and stabilize carbon within the community.

Brampton's CEERP is a result of a two-year cross-sector collaboration that drew strength from the expertise and demonstrated leadership of the City, Sheridan College and members of a Task Force (TF), a team of community champions and principal advisors for the CEERP.

1.1 CEERP Documents

The Brampton CEERP Report has been designed to support implementation and consists of a set of three documents:

Document	Purpose	Owner	Submitted to
Community Energy and Emissions Reduction Plan	Provides context for the report and summarizes the recommended strategy and priority projects.	Task Force	City Council
2019 Analytical Report and Appendices **(this document)**	Summarizes the evidence-based rationale for the recommended strategy and priority projects.	Project Working Team	Task Force
2019 Engagement Report and Appendices	Summarizes the year-long process that culminated in	Project Working Team	Task Force

	the recommended strategy and priority projects.		

See section 11 for a list of appendices that support this report.

2. Project Governance

A Project Working Team (PWT) was established and comprised of representatives from the City of Brampton, Sheridan College, Alectra, Enbridge, Peel Region and the consulting team of Garforth International llc. See Appendix 1 for the PWT organizational structure and composition.

The PWT reported the results of their analytical work to the Task Force (TF). See the 2019 Engagement Report for more information on the TF.

3. Analytical Framework

Table 1 describes the scope of the CEERP which established the analytical framework for the collection, assessment and presentation of data and information.

Table 1: Brampton Community Energy Plan (CEERP) analytical framework

Item	Scope
Geography	Brampton municipal boundary
Sub-geography	Energy Planning Districts (EPDs) (see below for description)
Virtual sub-geography	corporate assets, regional assets
Baseline year	2016
Planning horizon	2041
End use sectors	homes, buildings, industry, transportation
Utilities	electricity, natural gas, transport fuels, other fuels, water
Energy end use	heating, domestic hot water, cooling, lighting, other power, industrial process, transportation
Energy distribution	electricity, natural gas, district energy
Analytical profiles	source energy use[1], site energy use[2], GHG emissions (based on source energy), cost (based on source energy), water use
Benchmarks	Canada, Ontario, selected international
Assessment profiles	Impacts of (or on) municipal, utility and other plans, economic development, health and social factors and policy, practice and institutional structures.

Thirty-nine CEERP-relevant energy planning districts and 4 heritage or non-relevant districts (Figure 2) were established to align with City of Brampton's Official Plan and population and employment growth projections (Figure 3 and 4).

[1] Source energy considers all energy flows from production to end-use.
[2] Site energy considers the energy use of at the meter by end-users (e.g., homes, buildings, industry and transportation).

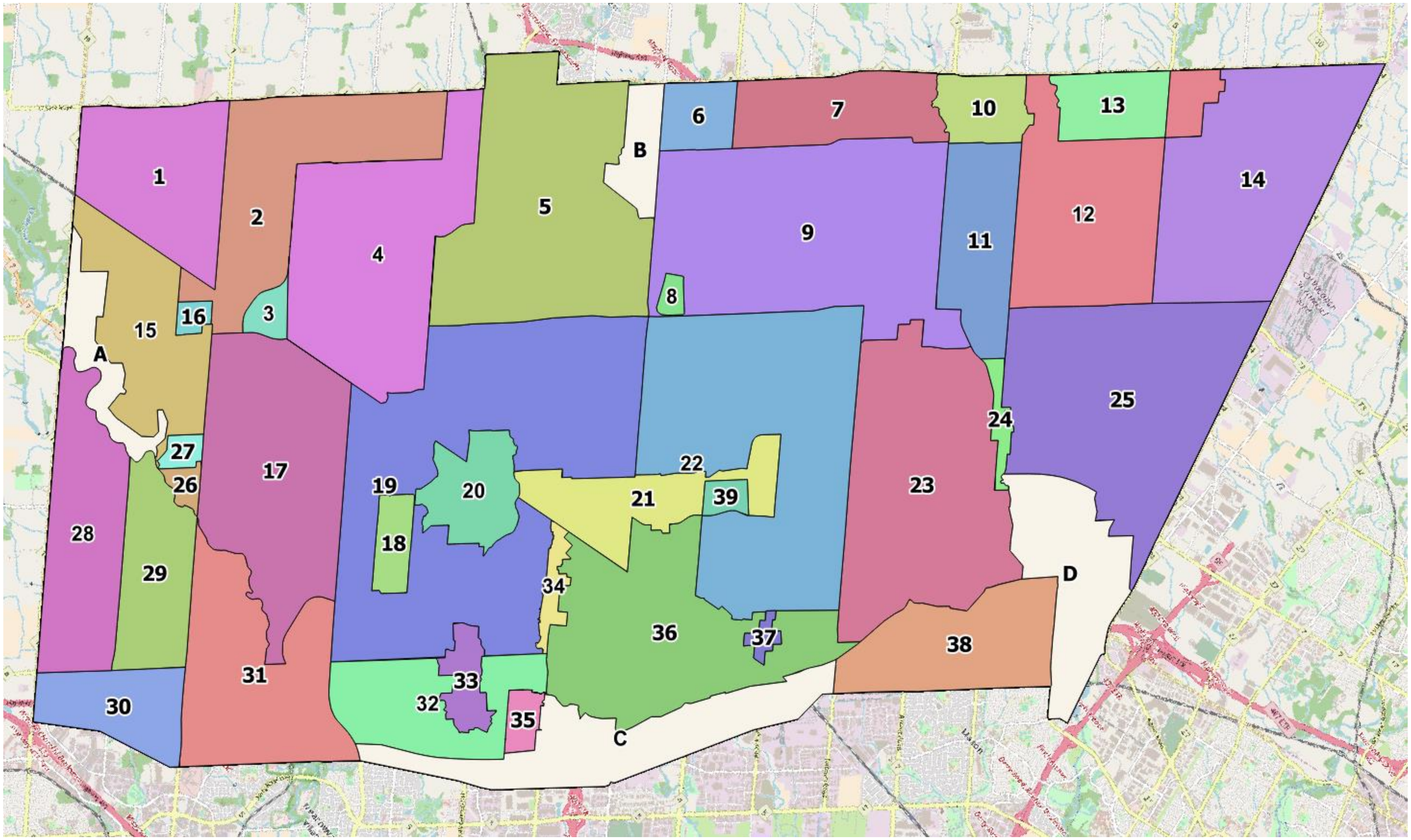

Figure 1: Brampton energy planning districts (EPDS)

Figure 2: City of Brampton framework for population growth

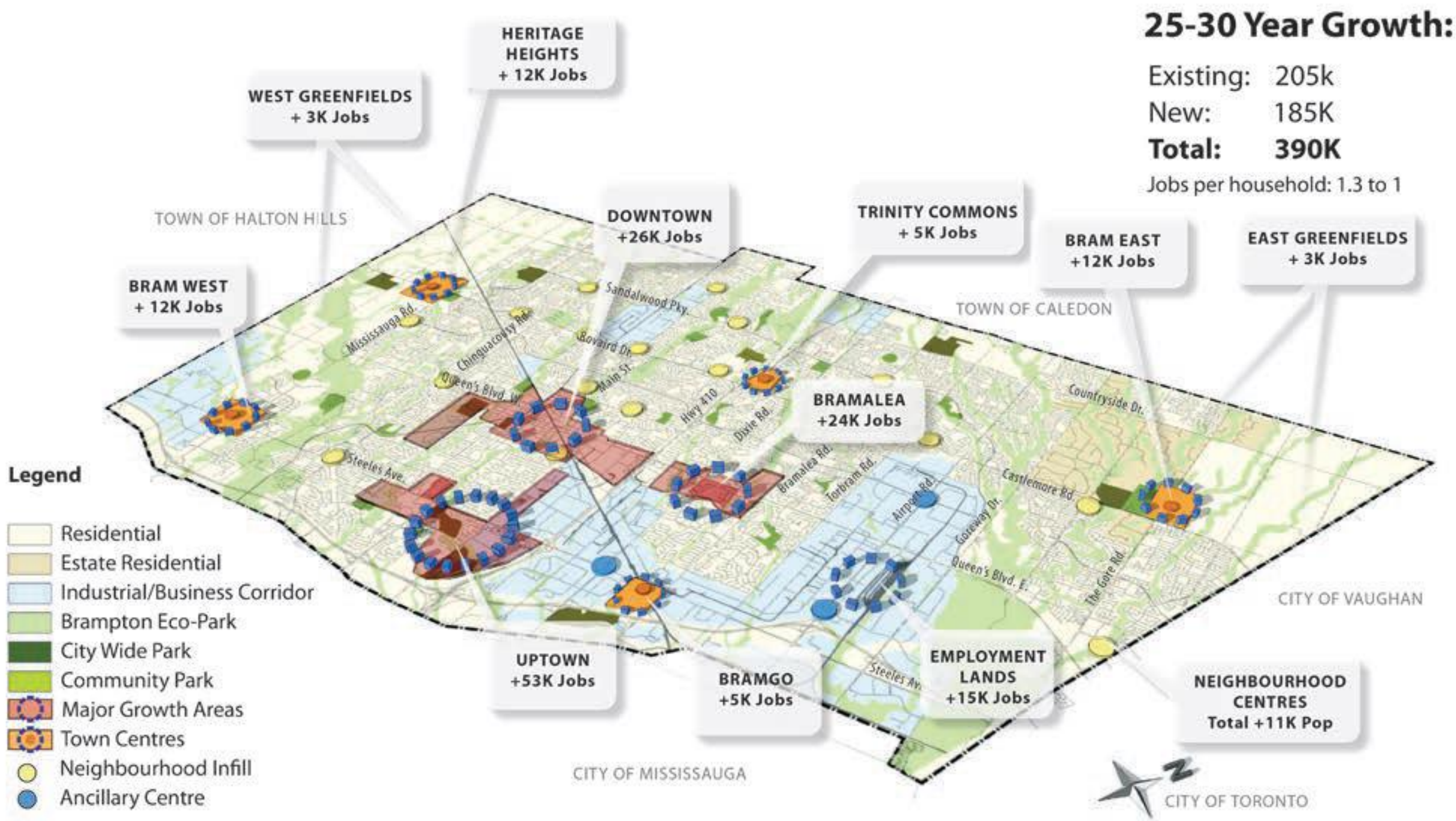

Figure 3: City of Brampton framework for employment growth

4. Methodology

what data will we need to inform the CEERP?

The following section is a summary of the data, information and assumptions that informed the analytical process.

4.1 Data and Information Gathering

Significant data and information were gathered to support the analytical process and the development of CEERP goals, strategic objectives, targets, priority projects and key performance indicators (KPIs). All data pertain to activity occurring within the municipal boundary of Brampton, Ontario. 2016 was chosen as the baseline year as it was the most recent Canadian Census.

See Appendix 2 for additional detail on the type, source and form of data and information collected.

4.2 Framing Goals

CEERP energy efficiency and emissions framing goals were established for 2041 to align with the City's planning framework. Framing goals were referenced to a 2016 baseline, as the most current census year, and selected independently of the Base Case (see next section for description). Framing goals were used to evaluate the performance of the Base Case and Efficiency Case simulations.

4.3 Base Case Assumptions

The Base Case is a "business-as-usual" picture of the future to 2041. To create this picture the PWT needed to establish several assumptions on what business-as-usual looks like. The approach was to include only short-term assumptions where legislation is already passed (e.g. Ontario Building Code) or where the technical evidence is overwhelming (e.g. average vehicle efficiency gains).

This means the Base Case does not reflect individual views of how Canada's energy and emissions future will evolve. The political shifts seen globally and in Canada demonstrate the risk of assuming a continuous bending of the curve by policy and practice towards lowering GHG emissions.

The PWT instead gave priority to measures that Brampton can influence, more-or-less, within the framework of current legislation. This underlines the opportunity and responsibility for individual communities to take the lead in dramatically reducing their GHG emissions, even with policy fluctuations going on around them.

This approach also underscores the need to update the CEERP every 5 years to respond to changes in legislation, policy and technical evidence.

The integrated analysis of the energy, GHG emissions and cost footprint of all energy end-use sectors in Brampton required alignment on a great number of interrelated assumptions. To ensure accuracy, PWT members with expertise across a range of disciplines collaborated to align assumptions and integrate data. See Appendix 2 for details on the assumptions used by the PWT to establish the Base Case.

4.4. Data Assessment

A summary of the analytical tools used by the PWT to assess Brampton’s data is provided in Appendix 2.

5. Baseline Findings

what is Brampton's starting point?

The following is a summary of the main baseline findings for source energy, emissions and cost for Brampton in 2016. See Appendix 3 for additional baseline analysis.

5.1 Energy Consumption

In 2016, Brampton's total source and site energy use were 92 million Gigajoules (GJ) and 67 million GJ, respectively.[3] Site energy use represented 109 GJ per capita. The transportation sector represented 35% of source energy use. The residential sector represented 26% of source energy use, and the industrial, commercial and institutional (ICI) sector represented 39% of source energy use (see Figure 4).

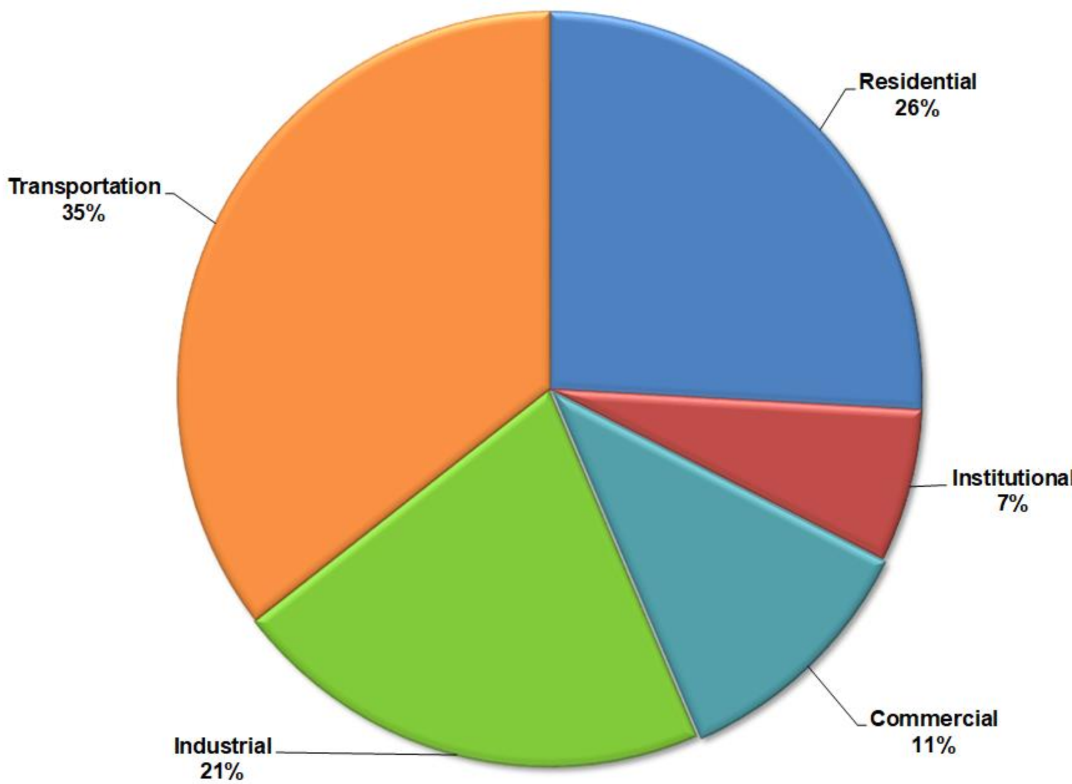

Figure 4: Brampton source energy use (%) by sector in 2016

The City of Brampton's corporate energy use (facilities, fleet and transit) represented 1.88% of the community's source energy use in 2016 (note: site energy was 1.75%). This highlights that while the City can lead by example, meaningful energy changes in Brampton require community-wide action (see Figure 1 in Appendix 3). The City of Brampton's *Corporate Energy and Emissions*

[3] Source energy considers all energy flows from production to end-use. Site energy considers the energy use of at the meter by end-users (e.g., homes, buildings, industry and transportation).

Management Plan (2019 – 2024): A Zero Carbon Transition provides a more detail to support the minimization of energy and emissions in existing and new facilities.

System losses[4] account for approximately 30% of source energy use (see Appendix 3 for more details). This highlights the opportunity to benefit the community by considering efficiency solutions that will also address system losses.[5]

5.2 GHG Emissions

In 2016, Brampton's emissions were 35 million tonnes (metric tons), or 5.6 tonnes for every Brampton resident. Transportation accounted for almost 60% of emissions while the residential sector accounted for 21% of emissions (Figure 5). The industrial, commercial and institutional (ICI) sector accounted for the remaining emissions (Figure 5).

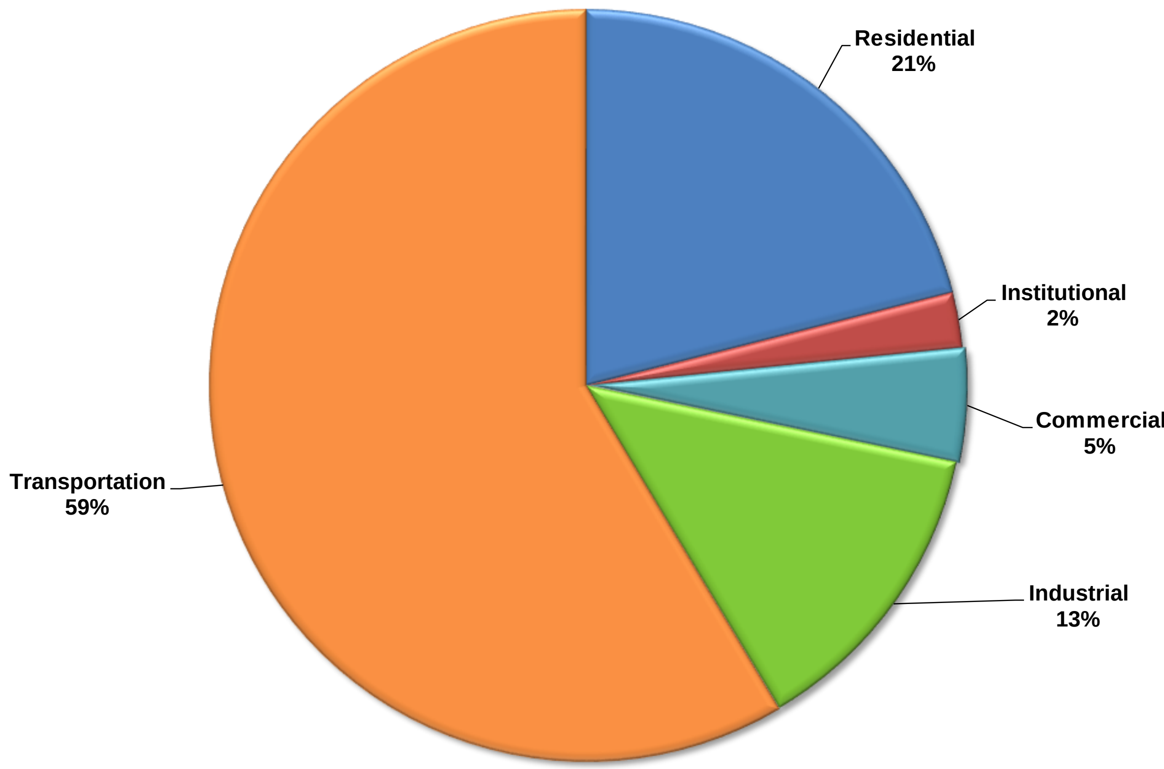

Figure 5: Brampton emissions (%) by sector in 2016

The use of natural gas contributes 38% of Brampton's emission (Figure 6) while the use of gasoline and diesel contribute 58% of emissions. Only 3% of emissions arise from the

[4] System losses include 1) conversion losses which occur when energy is transformed from one form to another (e.g., natural gas is used to create electricity) and 2) transmission and distribution losses which occur when energy is moved from one place to another (e.g., electricity is conveyed from generating facilities to end-users over transmission lines).

[5] The 30% site to source (conversion loss) is a combined number from the overall simulation effect of the source-to-site assumptions used for electricity (2.5:1), natural gas (1.047:1) and gasoline and diesel (1.1:1).

community's use of electricity (Figure 6). From a GHG emissions perspective, these results underscore the need to address heating which is the primary use of natural gas in homes and buildings and the need to build compact communities that will support transit and active transportation.

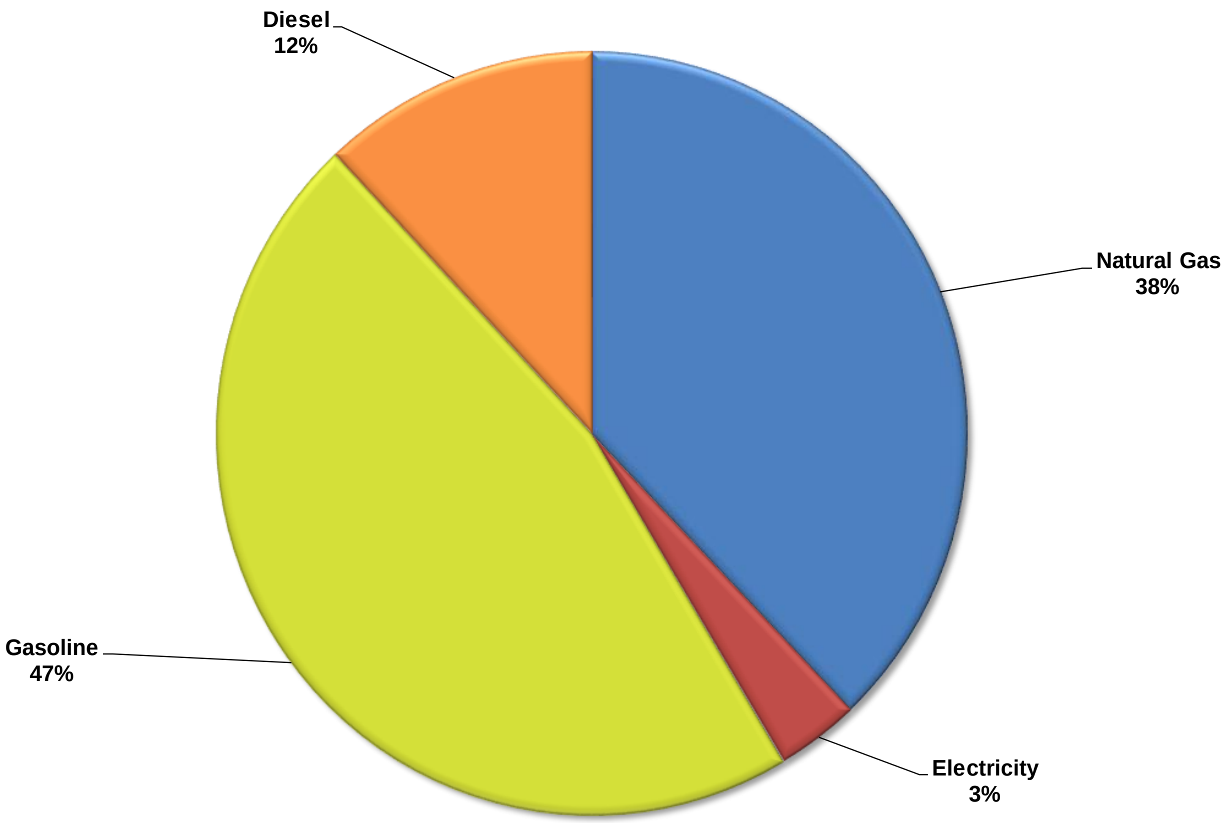

Figure 6: Brampton emissions (%) by utility in 2016

5.3 Energy and Water Costs

The Brampton community spent $1.8 billion on energy and water in 2016. At least $1.4 billion (77%) of those energy dollars left the community.

Transportation accounted for more than half of total costs (Figure 7).

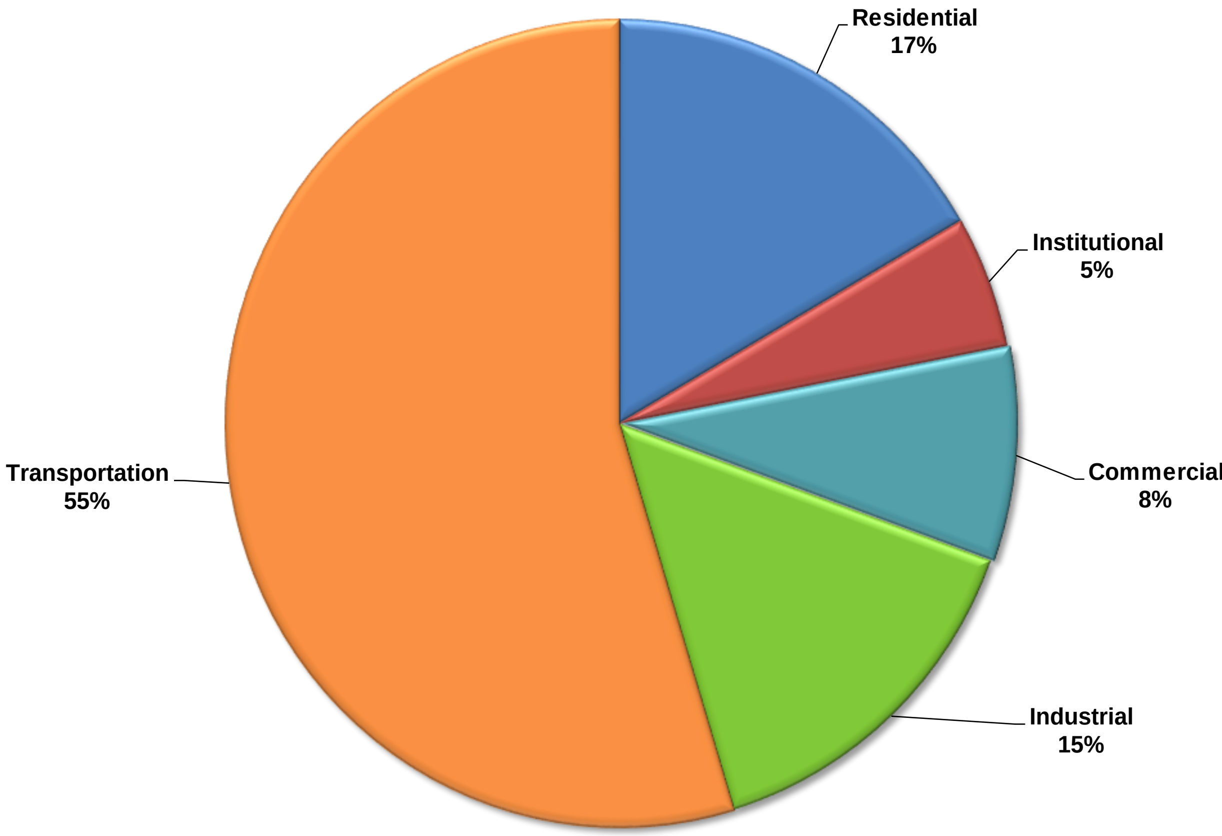

Figure 7: Brampton energy and water costs (%) by sector in 2016.

After fuels for transportation, electricity was then highest energy cost (31%) with natural gas use accounted for 11% of costs.

Approximately 30% of the energy that Brampton pays for does not reach homes, buildings or vehicles. This energy is primarily lost as heat when one form of energy is converted to another and through transmission and distribution. Electricity accounts for most of these costs.

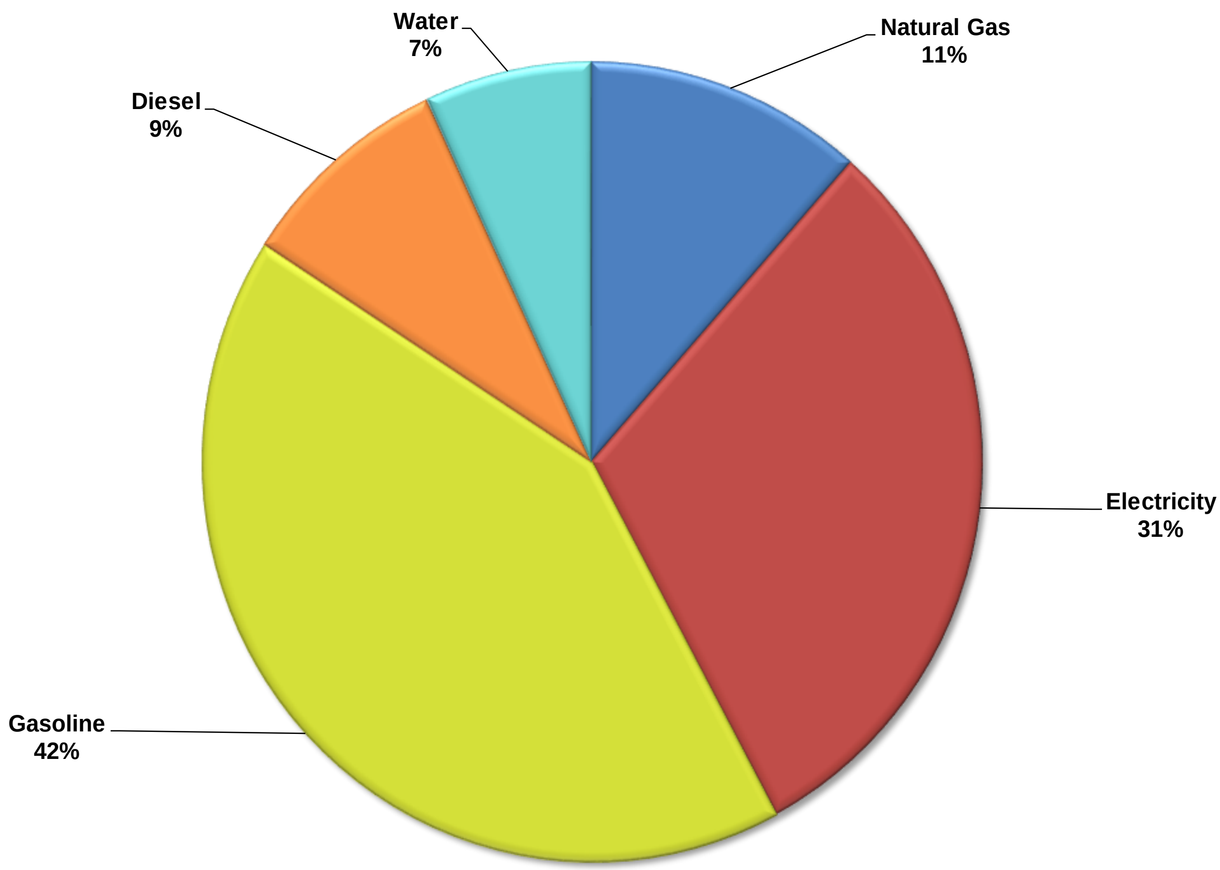

Figure 8: Brampton energy costs (%) by utility in 2016.

5.4 Water

The residential sector accounts for almost three quarters of the water consumption in Brampton (Figure 9). Energy is used to pump water and wastewater. Water conservation and efficiency program will also reduce the energy used to heat water.

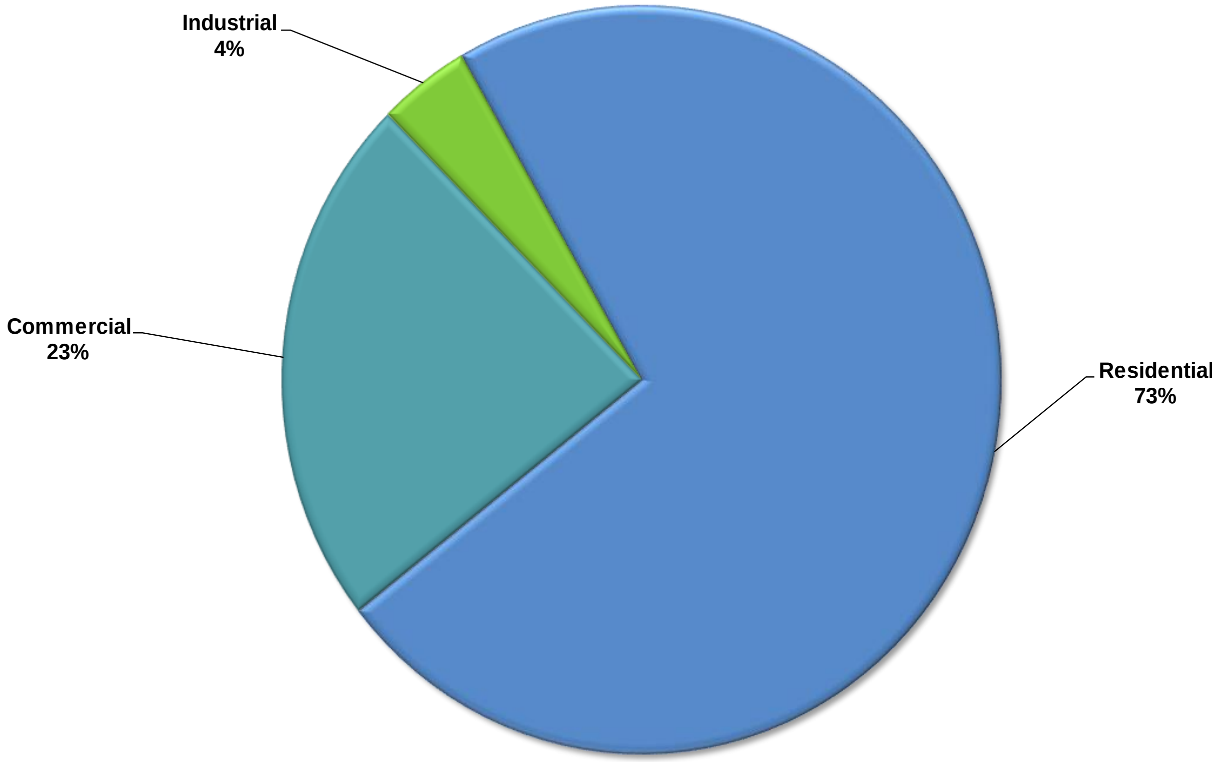

Figure 9: Brampton water use (%) by sector in 2016.

5.5 Benchmarking

On average, homes and buildings in Brampton are approximately half as efficient as global benchmarks indicating an opportunity to improve energy performance (Table 2).

- Energy use per home is 7% less than the provincial average and 50% higher than the Danish average.
- Energy use in the residential sector per square metre (m^2) is 32% lower than the Canadian average and more than twice the German A-rated home.
- Energy use in non-residential buildings per square metre (m^2) is 18% lower than the Canadian average and more than twice the German average.
- Emissions per capita were 40% less than the national average, 25% less than the provincial average, approximately twice global best practice and ten times the Government of Canada target for 2050 based on the Paris Climate Agreement.

Water use per home is about 5% above the Ontario average and 7% above the national average, when adjusted for household size.[6]

Table 2: Provincial, national and global comparison of Brampton energy use and GHG emissions.

Indicator	Brampton Baseline	Canada Average	Ontario Average	Comparable Best Practice
Energy use/household (GJ)	99	106	107	68[7]
Residential sector energy use per m^2 (GJ)	0.6	0.79		0.29[8]
Non-residential sector energy use per m^2 (GJ)	1.4	1.65		0.72[9]
Emission per capita (tonnes CO_{2e})	5.6	9.7	6.2	3.5[10]

5.6 Conclusion

Most of Brampton's energy costs come from gasoline and diesel, most emissions come from gasoline and natural gas and most energy waste cost comes from electricity. The CEERP should be developed to address all three energy sources.

[6] Based on data from Environment Canada and StatsCan.
[7] Denmark
[8] German A-rated home
[9] Germany
[10] Copenhagen, Denmark

6. Business as Usual Findings

where is Brampton headed, if no local action is taken?

The following is a summary of the main Base Case findings for source energy, site energy, emissions and energy cost for Brampton in 2041[11]. Table 3 provides a summary of changes between 2016 and 2041. See Appendix 3 for additional Base Case analysis.

6.1 Energy Consumption

By 2041, population and employment growth are estimated to increase site energy use by 26% and source energy use by 28%. Both the population and the workforce are expected to increase by 51% and 73%, respectively, during this time.

6.2 GHG Emissions

Despite population and employment growth, increases in GHG emissions are expected to be relatively moderate (approximately a 13% increase) by 2041 due to a projected increase in vehicle efficiency and reduction in the carbon intensity of the natural gas grid (note: this does not include pipeline leaks). However, they remain approximately twice global best practice and ten times the Government of Canada target for 2050 based on the Paris Climate Agreement.

6.3 Energy Costs

Energy costs are estimated to increase 200% to 410% by 2041. These increases reflect both higher prices as well as population and employment growth.

Table 3: Summary of projected changes between 2016 and 2041 in Brampton for energy use, emissions and energy costs.

2016 Baseline	2041 Business-as-Usual
Brampton used 92 million Gigajoules of energy.	Growth in population and employment increase energy use by 30%.
The transportation sector represented 35% of source energy use. The residential sector represented 26% of source energy use, and the industrial, commercial and institutional (ICI) sector represented 39% of source energy use.	No material change
On average, homes and buildings in Brampton are approximately half as efficient as global benchmarks.	Gap widens against global best practice
Systemic and end-user inefficiencies represent approximately half of the total energy use in Brampton.	No material change
The City of Brampton's corporate source energy use for facilities, transit and fleet represents 1.88% of the community's source energy use.	No material change

[11] While much of the literature around energy and emissions planning uses a time horizon of 2050, the City's Official Plan and other master plans are aligned with the Provincial Growth Plan for the Greater Golden Horseshoe Area which assigns regional population growth targets to 2041.

On average, Brampton residents release 5.6 tonnes of greenhouse gas emissions each year.	Reduces to 4.4 tonnes per capita due to a projected increase in vehicle efficiency, a reduction of carbon intensity of the natural gas grid and higher efficiency of new homes and buildings.
Emissions twice global best practice and 10 times the Paris Agreement.	No material change
$1.8 billion spent on electricity, natural gas, gasoline and diesel within the community.	Spending estimated increase to $5.4 billion (low risk) to $9.4 billion (high risk).
Less than 22% of the money spent on energy remained in the Brampton economy.	No material change

7. Efficiency Case Simulations and Results

how might Brampton change its energy future?

The following section provides a summary of the simulations that were conducted to identify a CEERP strategy for Brampton. See Appendix 2 and for more detail on the methodology and assumptions, respectively, supporting the simulations.

Three scenarios were developed and simulated to test their ability to achieve the following energy consumption and GHG emissions framing goals:

- Reduce energy use by 50% by 2041 from 2016,
- Reduce absolute greenhouse gas emissions by 50% by 2041 from 2016 and
- Reduce absolute greenhouse gas emissions to meet the 2050 national commitments.[12]

Scenario development was based on three combinations of the following priorities:

- Increase energy efficiency,
- Maximize heat recovery,
- Extend and integrate energy distribution and
- Maximize clean and renewable energy supply.

Scenarios included the following measures[13]:

- Efficiency of new homes and buildings,
- Efficiency of existing homes and buildings,
- Efficiency of industry,
- District energy in existing and new areas,
- Efficient local heat and electricity generation,
- Renewable solar heat and electricity generation,
- Transportation mix and efficiency,
- Ontario electricity grid generating mix and
- Natural gas network source mix.

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[12] Based on the Paris Climate Agreement, this represents an 80% reduction in absolute greenhouse gas emissions by 2050 based on 1990 levels or a 90% reduction based on 2016 levels.

[13] Geothermal, wastewater (sewer) heat recovery and hybrid solar systems (PV and thermal) are not analytically included. However, they are logical options to consider at the level of a specific building or neighbourhood. The creation of neighbourhood scale Generation 3 and 4 district energy, including the appropriate governance and institutional structures, will facilitate the wider use of multiple types of heat sources including ground-effect geothermal, and recovery from sewer, industrial, and chiller wastes. The Scenarios include Solar PV and Solar Thermal, which from a statistical standpoint, includes project specific hybrid combinations.

The three scenarios[14] were:

- Scenario 1
    - All end-use efficiency measures including transportation measures
- Scenario 2
    - All end-use efficiency measures including transportation measures
    - District heating
    - Solar thermal
- Scenario 3
    - All end-use efficiency measures including transportation measures
    - District heating
    - Solar thermal
    - Solar photovoltaic (PV)

Scenarios was simulated under three efficiency case implementation regimens:

- low action
- reference
- high action

In addition to energy and emission reductions, the energy savings that would flow to the community were also estimated.

Given the poor performance of Scenarios 1 and 2, the PWT eliminated these two scenarios from further consideration.

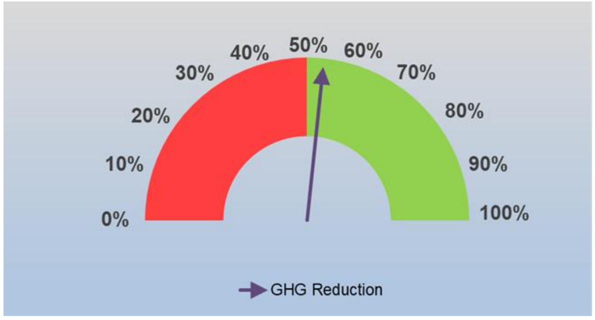
The simulation results for Scenario 3 were as follows:

- **Low Action Efficiency Case** – Scenario 3 failed to meet the City's energy and emission framing goals.

  Given the poor performance of the Low Action Efficiency Case for Scenario 3, it was eliminated from further consideration.

- **Reference Efficiency Case** – Scenario 3 missed the City's energy framing goal by 9% and exceeded the City's emissions framing goal by approximately 7% (Figure 10) and made major progress towards the national 2050 emissions goal (emissions would remain approximately 3 times higher).

[14] Water was included as a utility in all three scenarios.



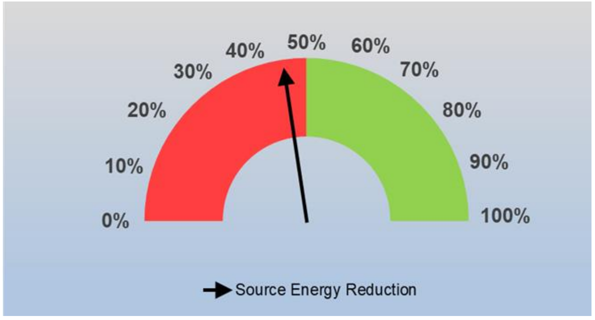
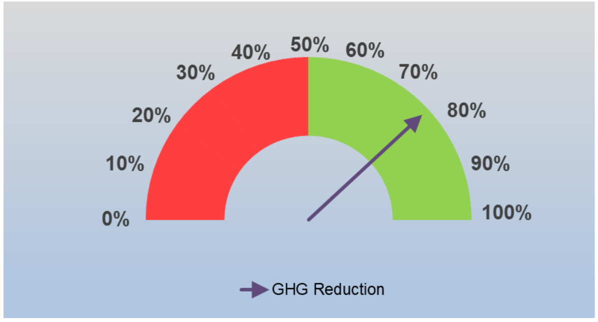


Figure 10: Results for the Reference Efficiency Case for Scenario 3 against the 2041 50% reduction framing goals. Arrow indicates percent reduction achieved for greenhouse gas emissions (left) and energy use (right).

- **High Action Efficiency Case** – Scenario 3 exceeded both the City's energy and emissions framing goals (Figure 11) but still missed the national 2050 emissions goal (emissions would remain slightly less than double).



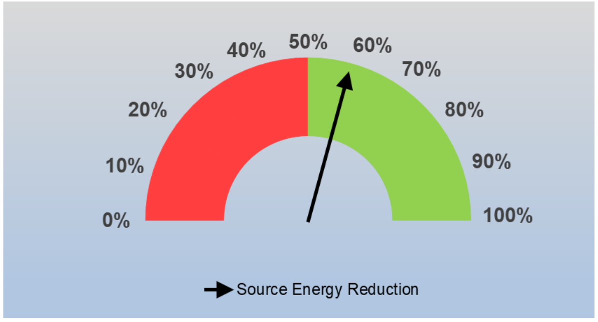


Figure 11: Results for the High Action Efficiency Case for Scenario 3 against the 2041 50% reduction framing goals. Arrow indicates percent reduction achieved for greenhouse gas emissions (left) and energy use (right).

See Appendix 5 for additional information on the performance of the Reference and High Action Efficiency Cases.

8. CEERP Efficiency Case

The TF approved the Scenario 3 Reference Efficiency Case as the CEERP Efficiency Case. It is estimated that the Reference Efficiency Case would avoid between $26 billion to $39 billion in cumulative energy costs by 2041.[15]

Based on the results of the simulations, the TF aligned on:

- A goal to increase community-wide energy efficiency at least 50% by 2041 from 2016 levels recognizing selected efficiency measures will consider the entire system from supply through distribution to end-use.

- A goal to reduce GHG emissions by at least 50% by 2041. By doing so, the TF is respecting the science that supports the international emissions reduction target of the International Panel on Climate Change while setting an emissions reduction goal that can be demonstratively implemented based on current global best practice. Implementation of the CEERP will put Brampton on a path to achieve national targets. Regular 5-year CEERP updates will capture advances in local, regional and global best practice to accelerate the transition during later years of the CEERP implementation.

[15] Price assumptions are provided in Appendix 2.

9. Brampton Energy Flows

Sankey diagrams were developed to visualize Brampton's energy, emissions and energy costs flow for the:

- 2016 Baseline
- 2050 Base Case
- 2050 CEERP Efficiency Case

Appendix 6 provides a complete set of the Sankey diagrams developed and explanation of their history and use.

Figure 12 provides a sample of a Sankey diagram and how to read it. The Sankey represents the source energy for Oakville in 2016 (i.e., baseline)

Focusing on energy, examining the changes between the Sankey diagrams for the 2016 baseline and 2050 Base Case shows the increase in end-use energy consumption, waste energy and unused transportation energy from 2016 to 2050, if no local action is taken.

Again, focusing on energy, examining the changes between Sankey diagrams for the 2050 Base Case and 2050 CEERP Efficiency Case shows the decrease in end-use energy consumption, waste energy and unused transportation energy, if the CEERP is implemented.

The Sankey diagrams also highlights that system losses (i.e., conversion, transmission and distribution losses) and end-use inefficiency consume half of the energy we purchase. Brampton consumers pay for the energy at the point of production. However, Brampton consumers only get to use the energy that reaches the electricity or natural gas meter, or gasoline or diesel pump.

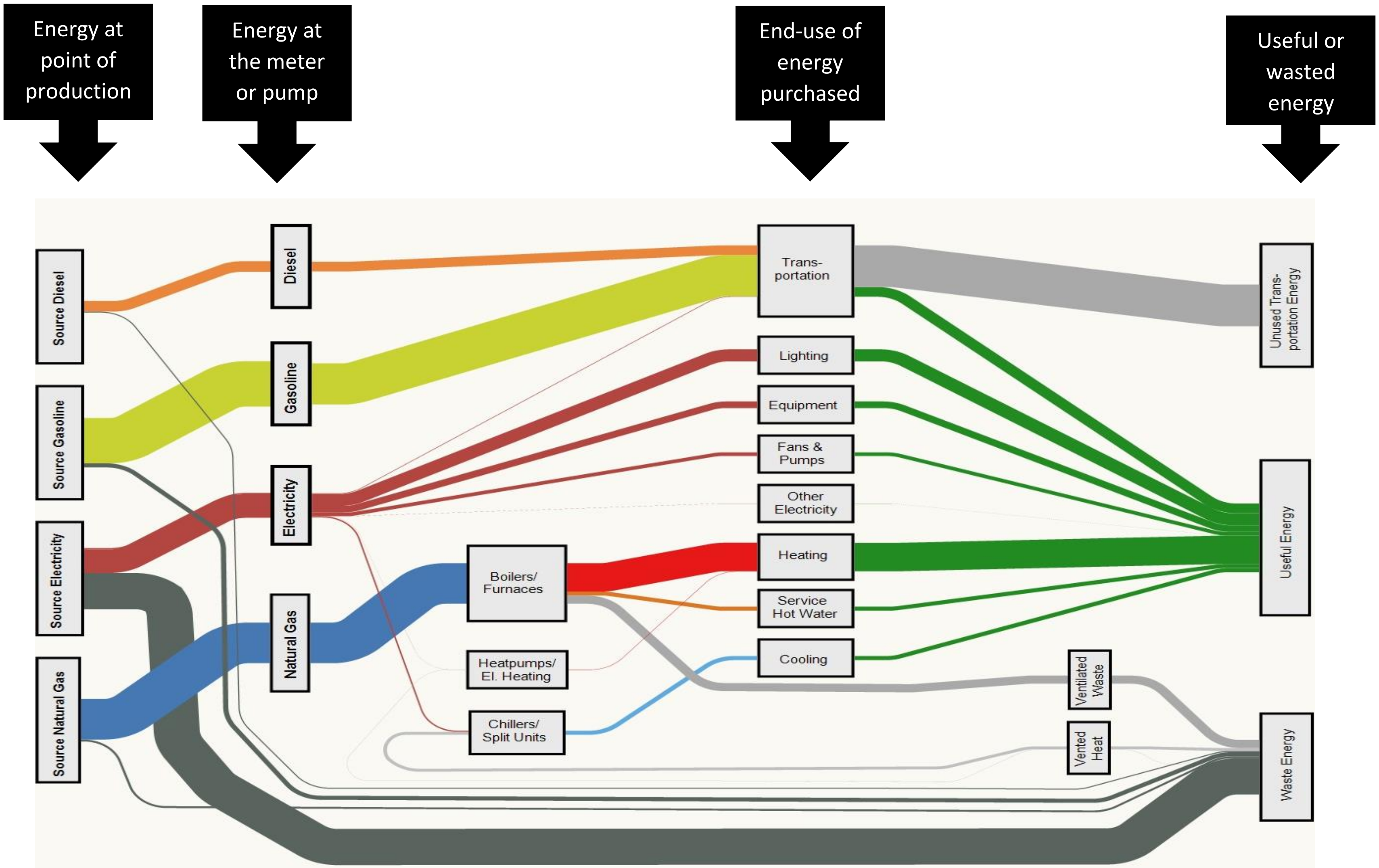


Figure 12: How to read the Sankey diagram for source energy flow in Brampton in 2016. The grey colour on the right represents energy (regardless of source) that is paid for but not used. The green colour on the right represents useful energy.

10. CEERP Recommendations

PWT recommendations were based on the CEERP Efficiency Case.

10.1 Priority areas

The PWT identified four priority areas. The following provides a high-level rationale for each priority area.

10.1.1 Home and Building Efficiency

Canada: Energy efficiency is recognized as the first fuel of a sustainable global energy system.[16] The built environment is the third largest emitting sector in Canada and most existing homes and commercial and institutional buildings will still be in operation in 30 years.[17] Consequently, this sector has been identified a priority for action by the federal, provincial and territorial governments.

Brampton: The built environment accounts for 44% of Brampton's energy use and 28% of greenhouse gas emissions. Brampton homes are the source of 21% of greenhouse gas emissions. The residential sector also accounts for almost three quarters of the water consumption in Brampton.

10.1.2 Industrial Efficiency

Canada: Industrial activity is most often regulated and guided by broader global best-practices and standards. Industry is driven to reduce their bottom line with continuous improvement in energy and water management. Many companies also have corporate-wide emissions standards responding to both customer pressure and public opinion in many different countries.

Brampton: Brampton's industrial sector demonstrates higher energy, emissions and water performance relative to global best practice than other sectors. However, there is still an opportunity to share this energy and water management expertise within the community to promote world class energy performance. The industrial sector in Brampton does consume 21% of total source energy.

10.1.3 Local Energy Supply and Distribution

Canada: Energy is lost when it is converted from one form to another (e.g., when natural gas is used to generate electricity) and when it is moved from one location to another. Over half of the energy flow in Canada is lost before it reaches consumers. The cost of these system losses is borne by end-users. Bringing generation (e.g., solar photovoltaics, combined heat and power) and distribution (e.g., district energy) closer to home can reduce system losses. Modern district

[16] Reference: https://www.iea.org/topics/energyefficiency/
[17] Source: Natural Resources Canada

energy distribution systems are recognized as an important pathway to decarbonize urban heating and cooling.[18]

Brampton: Close to half the energy spent to heat and power homes, buildings, and industry in Brampton is lost through end-user and system inefficiencies. The highest conversion losses are associated with electricity use. Increasing local electricity generation would reduce the economic impact of these losses on the community.

In 2016, solar photovoltaics accounted for less than 0.5% of total electricity generation in Brampton.

The use of natural gas contributes almost 40% of Brampton's emission which underscores the need to identify measures that address the heating, cooling and hot water needs of homes and buildings through the local distribution of heat and, to a lesser extent, cooling. As Brampton grows and increases urban density in certain areas, there is an opportunity to provide district heating and cooling. District energy worldwide is seen as a scale enabler to systematically reduce GHG emissions from heating and cooling. Combined heat and power would also contribute to increasing local electricity generation and reduced system losses. Establishing significant district energy, initially with gas-fired combined heat and power as one element, creates a pathway to effective thermal decarbonisation.

10.1.4 Transportation Efficiency

Canada: The transportation sector represents almost 25% of national greenhouse gas emissions. Almost half of these emissions arise from the use of personal automobiles.

Brampton: Transportation accounts for almost 60% of community-wide greenhouse gas emissions and half of the total dollars spent on energy in Brampton.

10.2 Strategic Objectives

The PWT made 13 recommendations based on these priority areas each with targets for 2041 (Table 4). These recommendations form the strategic objectives by which the Task Force can achieve the CEERP vision and goals.

Underlying these strategic objectives is an overarching enabling recommendation to make Brampton a "smart energy community" by continuing to use data and evidence-based decision making to optimize energy and climate performance.

The following recommendations are made for the consideration of the TF in identifying implementation priorities for the first five years:

- Implement interoperable smart metering for gas, electricity, heating, cooling and water
- Implement comprehensive traffic count and vehicle activity metering systems
- Create interoperable protocols to enable neighbourhood level building automation
- Implement an integrated "smart energy community" analysis and reporting platform

[18] http://www.districtenergyinitiative.org/

- Ensure “smart energy community” measures align with wider “smart city” goals

Table 4: Summary of CEERP priority areas, strategic objectives and 2041 targets.

Priority Area	#	CEERP Strategic Objective	2041 Target
Home and Building Efficiency	1A	Increase efficiency of existing homes.	Achieve a 35% residential sector efficiency gain by retrofitting 80% of existing homes.
	1B	Increase efficiency of existing buildings.	Achieve a 22% commercial and institutional sector efficiency gain by retrofitting 60% of existing buildings.
	1C	Increase delivered efficiency of new property	Achieve a 17% Ontario Building Code efficiency gain.
	1D	Increase water efficiency of existing homes and buildings	Achieve a 34% water efficiency gain
Industrial Efficiency	2A	Proliferate best practice to all local industry	Achieve a 20% industrial sector efficiency gain.
Local Energy Supply & Distribution	3A	Implement district energy in high growth districts with a mix of combined heat and power and other low-carbon heating and cooling sources	Serve 70% of existing target property and 80% for new target property with district heating in areas targeted for densification or new growth.
	3B	Install solar hot water in lower growth districts	Serve 10% of hot water and heating needs in homes not served by district energy with solar hot water.
	3C	Generate significant amounts of solar power installed on suitable rooftops and other locations	Supply 8% of Brampton’s electricity needs with locally generated solar power.
Transportation Efficiency	4A	Reduce average trip length	Reduce average trip length by 7.5% for light-duty vehicles.
	4B	Increase trips by bike and walking	Increase the share of passenger kilometers travelled (PKT) by bus, bike and walking by 10%
	4C	Increase trips by bus and GO Train	Increase the share of passenger kilometers travelled (PKT) by GO Train by 15%
	4D	Increase use of electric vehicles	Increase electric share of light-duty vehicles by 30% and heavy-duty vehicles by 10%
	4E	Increase efficiency of vehicles	Increase efficiency of gas/diesel vehicles by 36% efficiency gain and electric vehicles by 20%

The following sections provide some additional commentary on the strategic objectives.

10.2.1 Strategic Objective 1A and 1B

The current energy efficiency retrofit market for home and building owners and contractors is relatively unattractive. Historically, market uptake of retrofit programs has been low. From the perspective of the contractor, the effort to prepare customized proposals is high and the closing rate is low. Low volumes and the fact that every project is specific to each household means that material costs are expensive and performance guarantees are risky. From the home and building owners' perspective, obtaining understandable bids from various contractors is burdensome. They are responsible for finding their own sources of funding based on their individual credit rating. Finally, the low volumes result in retrofit costs that typically exceed the value of the energy saving, even over many years.

To address these challenges, the PWT recommends offering standardized energy retrofits to homes and commercial and institution buildings at high volumes. Contractors benefit from increased project predictability, improved margins and vastly higher project volumes. Home and building owners benefit from a simplified transaction, guaranteed pricing, lower cost pre-financed retrofits and a simple billing and payment mechanism.

A similar program would be considered for commercial property owners once the program for the residential sector was running.

In addition, property-assessed financing has the distinct advantage of tying the efficiency investment to the property, mitigating the risk of the home and building owner that their payback period is longer than the time they remain (or intend to remain) in the home or own the building.[19] Attractive interest rates and borrowing terms can be achieved for home and building (residential and commercial) owners while reducing or eliminating their up-front capital costs.

The following recommendations are made for the consideration of the TF in identifying priorities for implementation during the first five years:

- Create a Retrofit Entity to:
  - offer quality-controlled standardized retrofits by property type and age
  - deliver by partnering with local contractors
  - offer property-assess financing to homeowners to encourage uptake
  - attract third-party financing
- Require energy performance labels when homes and buildings are rented or sold (see Strategic Objective 1C for details)
- Encourage Sheridan to develop supporting workforce programs

[19] Provincial Local Improvement Charges (LIC) regulations were amended in 2012 to enable voluntary energy and water efficiency upgrades of private homes and buildings, allowing Ontario municipalities to provide long-term, low-cost financing for residential, commercial and industrial building energy and water conservation retrofits.

10.2.2 Strategic Objective 1C

The International Energy Agency (IEA) recommends mandatory energy labelling of homes and buildings to promote efficiency. Natural Resources Canada offers a voluntary home labelling program. However, European Union best practice includes emissions and source energy indicators. [20]

According to the Pembina Institute, the uptake of voluntary home labelling programs in Canada has been hampered by a lack of familiarity with the rating system and a shortage of comparator homes in the market.[21] Both barriers would be addressed through a mandatory program. Disclosure of the energy performance of homes and buildings transform the market for energy efficiency.

The following recommendations are made for the consideration of the TF in identifying priorities for implementation during the first five years:

- Offer energy performance labels when buildings are rented or sold (see insert on previous page)
    - Raise customer awareness and expectations through comprehensive outreach
    - Engage mortgage lenders to provide energy-efficient mortgages
    - Engage Alectra, Enbridge, key builders and realtors as champions
- Explore opportunities for net zero neighbourhoods in target net-zero energy planning districts (see Strategic Objective 3A)
- Encourage Sheridan to develop supporting workforce programs

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[20] Intelligent Energy Europe, "Improving Dwellings by Enhancing Actions on Labelling of the EPBD" (2011). Found at: https://ec.europa.eu/energy/intelligent/projects/en/projects/ideal-epbd

[21] Pembina Institute, "Home Energy Labelling Requirement at Point of Sale: Pilot Program Design" (2012). Found at: https://www.pembina.org/pub/home-energy-labelling-requirement-at-point-of-sale-pilot-program-design

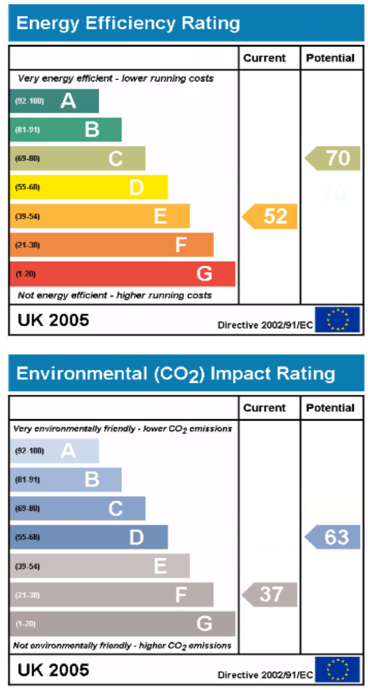

Figure 13: Example of a Home Energy Performance Label from the United Kingdom

10.2.3 Strategic Objective 1D

The following recommendations are made for the consideration of the TF in identifying priorities for implementation during the first five years:

- Include water efficiency package in standard energy retrofit (e.g., low flow faucets, showers, and toilets)
- Create rainwater harvesting, grey water and xeriscaping information and resource network
- Consider xeriscaping as option for the retrofit entity

10.2.4 Strategic Objective 2A

The following recommendations are made for the consideration of the TF in identifying priorities for implementation during the first five years:

- Encourage community industrial best practice networks or communities of practice
- Host global best practice events
- Share industrial energy management expertise in Brampton
- Encourage Sheridan to develop relevant workforce programs

10.2.5 Strategic Objective 3A

District energy (DE) systems supply thermal energy (heating and/or cooling) to multiple buildings from a central plant or from several interconnected but distributed plants; thermal energy is conveyed with water through a close network of pre-insulated pipes to meet end users' need for cooling, heating and domestic hot water. Historically, steam networks have been used and are still used in some older systems. A DE system is comprised of three sub-systems which include the collection and/or generation of thermal energy, the distribution of that thermal energy from the plant(s) to end-users and the transfer of the thermal energy to the energy consumer.

A barrier to the uptake of district energy is the lack of appropriate governance structures to manage long-term investment in infrastructure. A DE network is typically run as a thermal utility by a company that operates all the plants and networks, ensures service quality and manages the metering and billing of the heating and cooling services. The network allows for economies of scale since the generation of heat in a few larger plants is more efficient than having thousands of boilers each heating their individual building. It also enables valuable energy currently wasted in electricity generation, industrial and other processes to be cheaply captured and delivered to other consumers. Consequently, the creation of a district energy company with appropriate governance to offer heating and selected cooling services is considered an immediate priority.

Combined heat and power (CHP) systems produce electricity and thermal energy from a single fuel source (e.g. natural gas, biomass). When electricity is generated in large scale regional gas-fired power plants, as much as 60% of the energy value is lost (most as heat at the point of generation and the remainder during transmission). This systemic inefficiency can be addressed by generating electricity within the community and capturing the heat for use in a DE system.

Modern DE systems (Figure 2) facilitate creating a flexible portfolio of many kinds of low carbon heat sources. These include large solar-thermal, arrays, biofuel boilers and CHP, sewage waste heat recovery, geothermal arrays, and even boilers using renewable electricity. District energy enables the potential decarbonization of heating and cooling homes and buildings. None of these future possibilities to further reduce the GHG impacts of heating and cooling have been included in the current analysis and are possible upsides.

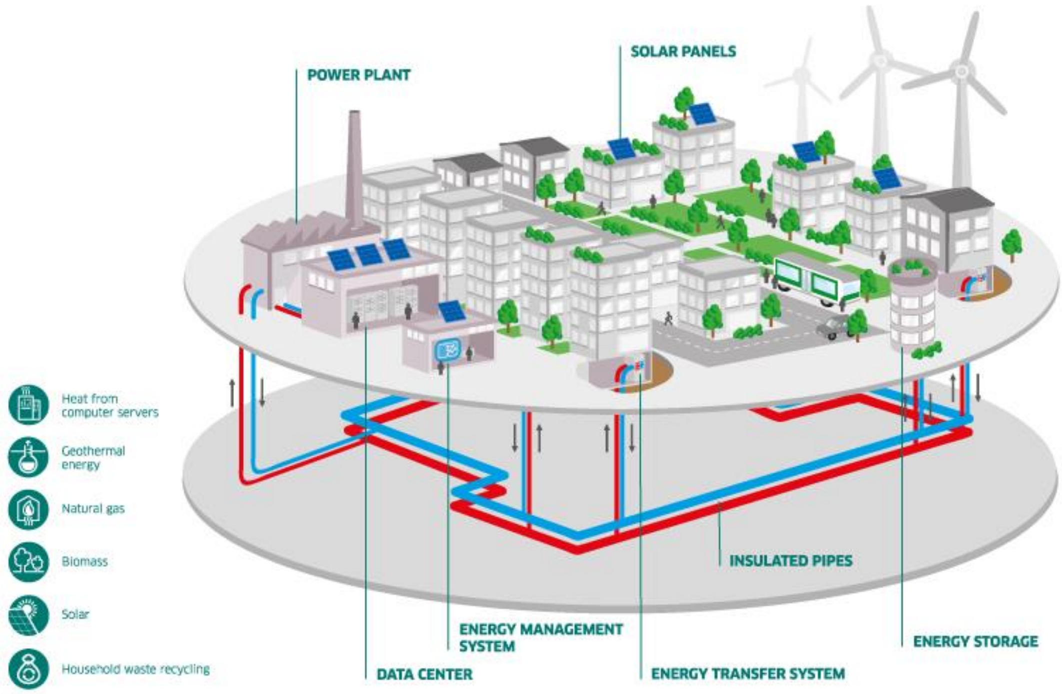

Figure 14: Modern district energy system[22]

By aligning the energy planning districts (EPDs) with Brampton's urban structure and growth plans, the following EPDs were identified as candidates for district energy (Figure 3):

- Densification EPDs: 18, 19, 20, 21, 23, 32, 33, 34, 35, 36, 37, 39
- Net-zero development EPDs: 1, 2, 6, 7, 14, 15, 16, 26, 27, 28, 29, 30, 38

The following recommendations are made for the consideration of the TF in identifying priorities for implementation during the first five years:

- Create a district energy company with appropriate governance to offer heating and selected cooling services
- Raise customer awareness through comprehensive outreach
- Engage Alectra, Enbridge, key builders and realtors as champions
- Ensure the Official Plan, secondary plans and other planning and development tools include measures to promote district energy.
- Establish property, planning and construction guidelines to enable the development of district energy by the private sector
- Implement best-practice networks and energy centres
- Include significant combined heat and power in a balanced supply portfolio
- Showcase Sheridan College as a "living-example"

[22] Image Source: Enegie

- Encourage Sheridan to develop a district energy workforce program
- Work to ensure alignment with Region of Peel's Official Plan to help influence the upcoming amendments that seek to incorporate energy planning policy
  Promote district energy as a priority with the Peel Climate Change Partnership (the Region's Climate Change Master Plan (2020 – 2030) contains the following Action 8: Enable alignment of Regional actions with transition toward diversified and decentralized energy systems.)

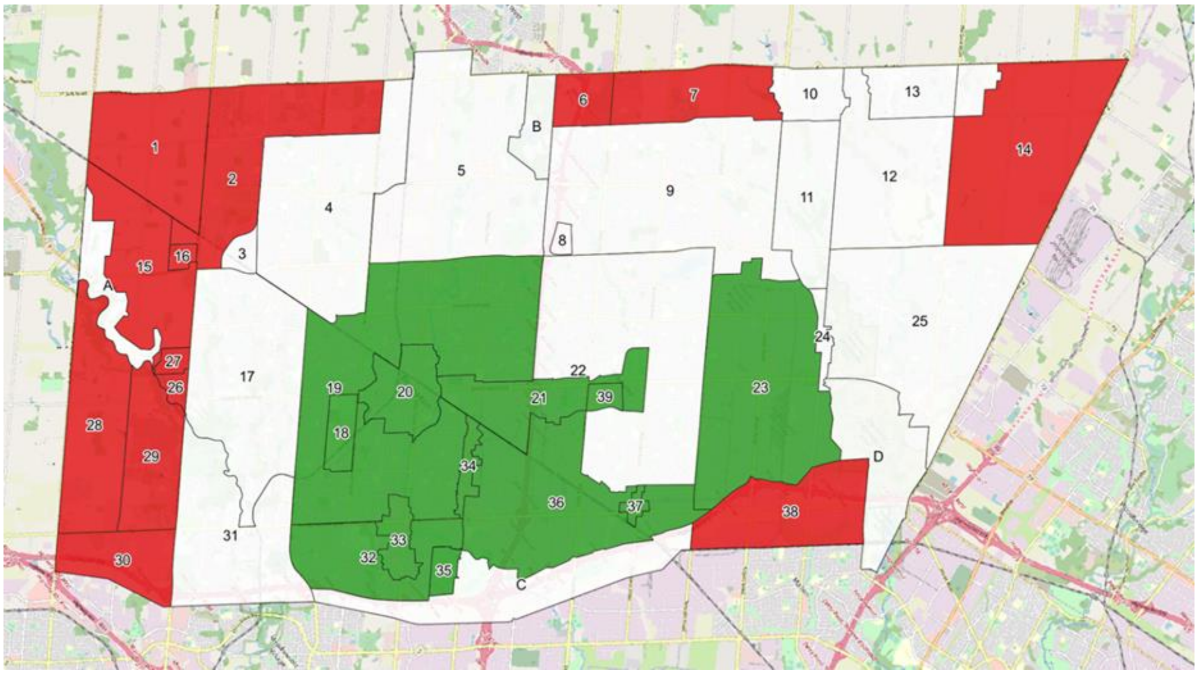

Figure 15: Identification of Energy Planning Districts as candidates for district energy. Areas planned for densification are represented in green. Areas planned for new growth are represented in red.

A detailed city-scale district energy business case is recommended as a high priority action after the approval of the CEERP as the logical first step in the due diligence to move strategy 3A foreword. Sheridan is a very small-scale example, and their experience is relevant background. Sheridan has achieved significant GHG reductions from their Integrated Energy and Climate Master Plan.

10.2.6 Strategic Objective 3B

The following recommendations are made for the consideration of the TF in identifying priorities implementation during the first five years:

- Raise customer awareness through comprehensive outreach
- Engage Enbridge, key builders and realtors as champions
- Include in relevant policy, planning construction guidelines
- Include solar hot water system installation as an option in the efficiency package offered to homes and business by the Retrofit Entity (see Strategic Objective 1A and 1B)

- Encourage Sheridan to develop workforce program

10.2.7 Strategic Objective 3C

The following recommendations are made for the consideration of the TF in identifying priorities implementation during the first five years:

- Raise customer awareness through comprehensive outreach
- Engage Alectra, key builders and realtors as champions
- Include in relevant policy, planning construction guidelines
- Include PV installation as an option in the efficiency package offered to homes and business by the Retrofit Entity (see Strategic Objective 1A and 1B)
- Encourage Sheridan to develop a workforce program
- Consider future alignment with the Region of Peel Renewable Energy Strategy (completion in fall 2020)

10.2.8 Strategic Objective 4A

The following recommendations are made for the consideration of the TF in identifying priorities implementation during the first five years:

- Ensure the Official Plan, secondary plans, transportation and transit master plans include specific targets and measures to contribute to the objectives, including:
    - Mixed-use compact neighbourhood design
    - Increased local job to population ratios
    - Local social destinations
    - Shared vehicle services

10.2.9 Strategic Objective 4B & 4C

The following recommendations are made for the consideration of the TF in identifying priorities implementation during the first five years:

- Ensure the Official Plan, secondary plan and transportation and transit master plans include specific targets and measures that will contribute to achieving these objectives, including:
    - Multi-modal transportation nodes
    - Competitive transit services
    - Pedestrian and transit-oriented development
    - Bike, e-bike and walking routes
    - Congestion pricing
- Consider future alignment with Peel Region’s Sustainable Transportation Strategy (2018) with its set goal of a 50% sustainable mode share by 2041.
- Consider alignment with Peel Region’s Strategic Goods Movement Network Study (enabling the off-peak delivery pilot) and the work of the Peel Goods Movement Task Force.

10.2.10 Strategic Objective 4D

The following recommendations are made for the consideration of the TF in identifying priorities implementation during the first five years:

- Raise customer and fleet owner awareness of electric vehicles (EVs) through comprehensive outreach
- Engage vehicle dealers and manufacturers as champions of EVs in the community
- Ensure transportation and transit master plans include measures to promote EVs including:
    - EV parking and charging stations (including workplace, shopping and district charging stations)
    - Designated parking for electric vehicles
- Electrify municipal and transit fleets
- Ensure the Official Plan, secondary plans and other planning and development tools include specific targets and measures to promote EVs
- Include installation of an EV charging stations as an option in the efficiency package offered to homes and business by the Retrofit Entity (see Strategic Objective 1A and 1B)
- Embrace and lead changes in national & provincial policy

10.2.11 Strategic Objective 4E

While it is recognized that the Brampton community does not have direct control over increasing the efficiency of vehicles, the following recommendations are made for the consideration of the TF in identifying priorities implementation during the first five years:

- Raise customer and fleet owner awareness of the benefits of increased fuel efficiency through comprehensive outreach
- Engage vehicle dealers and manufacturers as champions for increased vehicle efficiency
- Embrace and lead changes in national and provincial policy

11. List of Appendices

Appendix 1	Project Working Team Composition
Appendix 2	Methodology
Appendix 3	Baseline and Base Case Findings
Appendix 4	Scenario 3 Simulation Assumptions
Appendix 5	Efficiency Case Performance
Appendix 6	Brampton Sankey Diagrams

Appendix 1 – Composition of the Project Working Team

Figure 1 outlines the organization and composition of the Project Working Team (PWT) for the development of the Brampton CEP.

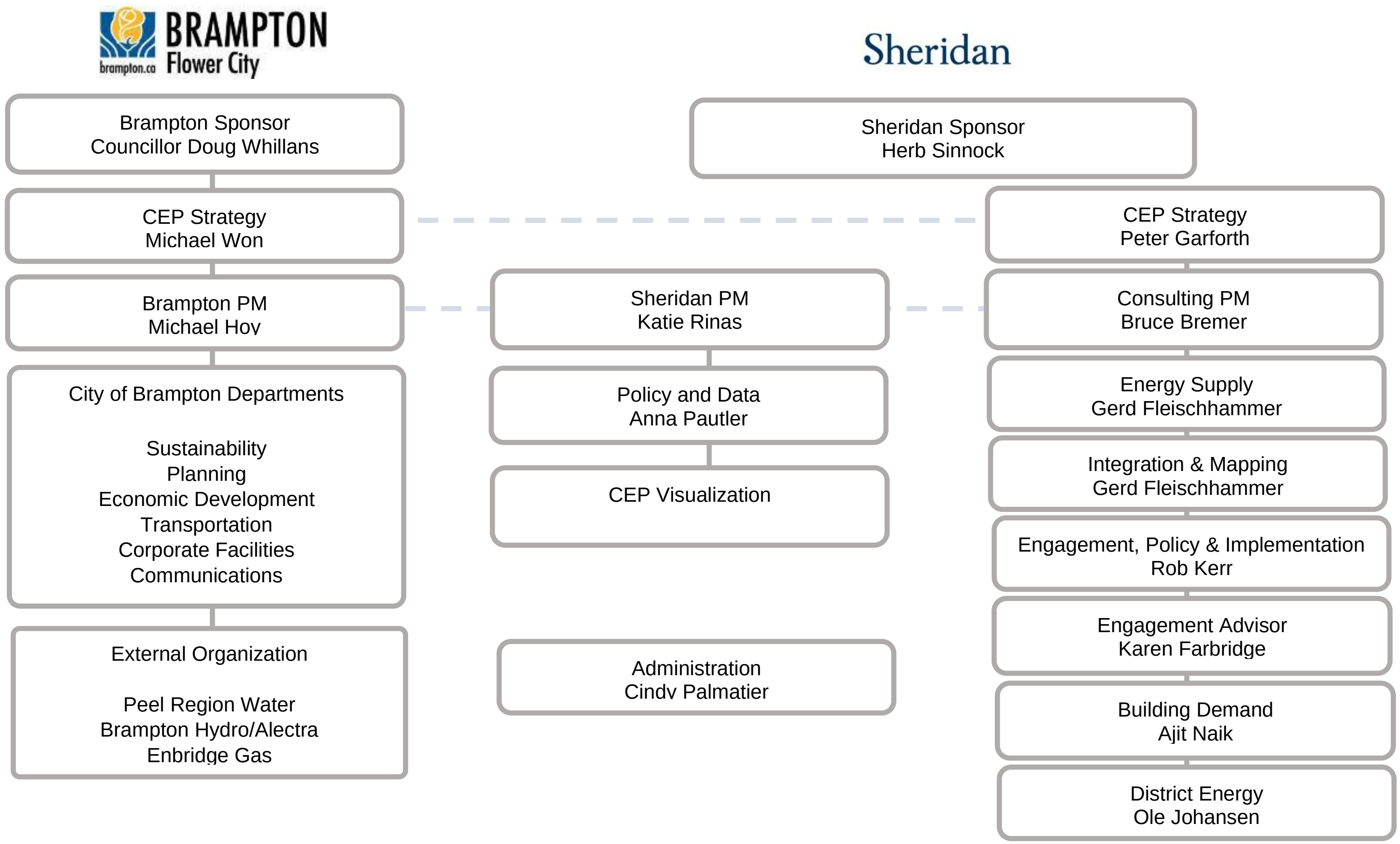

Figure 1: Organizational Structure and Composition of the CEERP Project Working Team (PWT)

Appendix 2 – Methodology

This appendix summarizes the data, information and assumptions that informed the analytical process.

Contents

1. Data and Information Sources

Main sources of data for the development of the Brampton Community Energy and Emissions Reduction Plan (CEERP) are summarized in Table 1. All data pertain to activity occurring within the municipal boundary of Brampton, Ontario. 2016 was chosen as the baseline year as it was the most recent Canadian Census.

Table 1: Main sources of data for the Brampton CEERP

Type	Source	Form
Municipal property	City of Brampton (public website)	Residential and non-residential parcel and structures (Address points) and Building footprints
Building turn-over	City of Brampton	Demolition permits
Natural gas	Enbridge Gas	2016 consumption by six-digit postal code
Electricity	Brampton Hydro	2016 consumption data and generation (solar photovoltaic) by address
Water	Peel Region	2016 consumption data by sector and six-digit postcode
Transportation activity	Transportation for Tomorrow Survey 2016 City of Brampton	Public transit, walking, cycling and motor vehicle use data – residential and commercial
Region public transit	Metrolinx	GO Train and GO Bus activity
Traffic counts	City of Brampton Peel Region Province of Ontario	Through traffic information as done on local, regional and provincial roads
Vehicle use	IHS Markit	Inventory by vehicle type, size and fuel type
Fuel sales	Kent Group Ltd	Gasoline and diesel sales used to validate transportation analysis
Population growth	City of Brampton	City forecast from planning
Employment growth	City of Brampton	City forecast from planning

Brampton population and employment data are summarized in Table 2 and 3, respectively.

Table 2: Brampton Population Data

Indicator	2016	Year-to-year growth	2031	Year-to-year growth	2041	Year-to-year growth	2050
Population (#)	614,100	2.2%	834,000	0.7%	886,700	0.5%	925,000
Homes (#)	169,304		234,600		250,500		261,000
Average home occupancy (#)	3.63		3.56		3.54		3.54

Average home size (m^2)	160		149		146		143

Table 3: Brampton Employment Data

Indicator	2016	Year-to-year growth	2031	Year-to-year growth	2041	Year-to-year growth	2050
Jobs (#)	194,927	2.4%	275,600	1.0 %	303,700	1.1%	334,000
Jobs/ population	0.32		0.33		0.34		0.36
Area (1000 m^2)	14,728		19,638		20,948		22,000
Density (m^2/job)	76		71		69		66

2. Framing Goals

CEERP energy efficiency and emissions framing goals were established for 2041 to align with the City's planning framework:

- Reduce energy consumption per capita 50% below 2016 levels; and
- Reduce absolute emissions by 50% from 2016 levels.

Framing goals were referenced to a 2016 baseline and selected independently of the Base Case. Framing goals were used to evaluate the performance of the Base Case and Efficiency Cases.

3. Base Case Assumptions

The Base Case is a "business-as-usual" picture of the future to 2041. To create this picture the PWT needed to establish several assumptions on what business-as-usual looks like. Their approach was to include only short-term assumptions where legislation is already passed (e.g. Ontario Building Code) or where the technical evidence is overwhelming (e.g. average vehicle efficiency gains).

This means the Base Case does not reflect individual views of how Canada's energy and emissions future will evolve. The political shifts seen globally and in Canada demonstrate the risk of assuming a continuous bending of the curve by policy and practice towards lowering GHG emissions.

The PWT instead gave priority to measures that Brampton can influence, more-or-less, within the framework of current legislation. This underlines the opportunity and responsibility for individual communities to take the lead in dramatically reducing their GHG emissions, even with policy fluctuations going on around them.

This approach also underscores the need to update the CEP every 5 years to respond to changes in legislation, policy and technical evidence.

The integrated analysis of the energy, GHG emissions and cost footprint of all energy end-use sectors in Brampton required alignment on a great number of interrelated assumptions. Ensuring that assumptions aligned, and integration of data was as accurate as possible relied on the collaboration of subject matter experts across the PWT.

The following is a list of the key assumptions used for the Base Case. Each assumption was aligned with the relevant subject matter experts within the City and PWT. For example, assumptions on annual population growth in each energy planning district (EPD) was validated by the City's Planning Department (see Figure 1).

3.1 Efficiency of Existing Homes and Buildings

- The pool of buildings existing in 2016 could reduce through demolition at a rate driven by recent history. However, in Brampton this was assumed to be "de minimus" and all buildings in 2016 were assumed to be operating in 2041 or demolished as part of a neighborhood-focussed redevelopment. This assumption was validated by demolition permit data.
- The pool average efficiency of each major category of existing property was assumed to be the same in 2041 as it was in 2016. While some buildings will be made more efficient in the normal course of business, others will deteriorate, resulting in the overall pool at average efficiency.

3.2 Efficiency of New Homes

- New homes are added at a rate driven by population growth estimates supplied by the City's Planning Department.
- The number of residents per home fall modestly between 2016 and 2041.
- New home types between single detached home, multi-unit home etc. are added to all EPDs based on the land-use development plans of each neighbourhood in dialogue with the City's Planning Department.
- New homes floor areas are somewhat smaller than historic averages.
- The efficiency of each home archetype is assumed to be 100% compliant with the current iteration (2012 and amendments) of the Ontario Building Code (OBC). The OBC is now one of the most efficient in North America. In the real world, full compliance from an energy performance perspective is not always the case, so this Base Case assumption represents an improvement over current market actual practice.

3.3 New Commercial and Industrial Buildings

- New commercial and industrial buildings are added at a rate driven by employment growth estimates agreed with the City's Economic Development Department.
- They are added to EPDs designated for mixed use and employment aligned with the City's Planning Department.
- Type and area of new buildings is based on assumed employment mix.
- As for new homes, the efficiency of each non-residential building archetype is assumed to be 100% compliant with the current iteration (2012 and amendments) of the OBC.

3.4 Transportation

- The 2016 Baseline represents vehicle kilometers travelled by vehicle category, passenger kilometers traveled by journey category, and resulting fuel use, cost and emissions was developed using the Transportation of Tomorrow Survey, Ministry of Transportation (MTO) highway transit data, retail fuel sales, wider benchmarking and adjustments aligned with the City's Transportation Strategy team.
- Base Case light duty vehicle kilometers are aligned with the City's population growth estimates to 2041.
- Heavy duty vehicle kilometers are driven by employment growth to 2041.
- Fleet mix remains the same to 2041.
- Fleet efficiency increases by 0.2% annually to 2041 (this is the pool average for all vehicles of all ages).
- Modality splits remain the same as 2016.
- Off-Road and domestic navigation emissions are estimated from Ontario emissions reports indexed for the City's planned population growth.[1]

3.5 Water

- Existing homes, buildings and industry is assumed to be unchanged
- New homes, buildings and industry is assumed to be 20% more efficient than current average

3.6 Energy Pricing

- Lower and higher price outlooks are used to estimate risk and opportunity.
- Lower range aligned with Independent System Electricity Operator's (IESO's) Ontario 2017 Long Term Energy Plan and discussions with Brampton Hydro and Enbridge Gas.
- Higher range based on utility risk planning estimates wherever possible and with discussions with Brampton Hydro/Alectra and Enbridge Gas.

See Figures 2, 3 and 4 for more detail on energy price outlooks.

3.7 Energy Supply to Brampton

- Electricity and natural gas continue to be supplied by sources outside the management of the Corporation of the City of Brampton.
- The mix of the functional use of electricity and natural gas for home heating, hot water, cooking, lighting, other home functions and for commercial and industrial process remains unchanged until 2041.
- The Ontario power generating mix between nuclear, gas, wind, solar and hydro remains broadly the same as in 2016, following The Atmospheric Fund (TAF) 2016 estimate with minimal average index reduction from 32 to 28 kg CO_2e/MWh.
- The regional natural gas supply has a reduced greenhouse gas index assuming an added mix of biogas and power-to-gas from renewable electricity. The reduction of the index is assumed to be about 20% by 2041.

[1] Canada National Inventory Report 1990 to 2016 https://unfccc.int/documents/65715

- Any new local power and heat generation inside Brampton's boundary is considered "de minimus".

3.8 Greenhouse Gas Pricing

- Ontario Cap and Trade was in effect in 2016 and its continuity was an underlying assumption at that time. The market was closed in 2018. A carbon tax was started in Ontario on April 1, 2019.
- For the Base Case, the lower and higher ranges of greenhouse gas process reflect experiences in comparable markets in North America and Europe, including the California/Quebec Emissions Trading Scheme, BC Carbon Tax and the European Union Emissions Trading Scheme.

3.9 Water Pricing

- Lower and higher price outlooks are used to estimate risk and opportunity.
- The price outlooks are PWT estimates, based Peel, York and Halton regional, and Provincial, narratives on long-term demand and supply outlooks.
- The outlooks assume significant price growth in coming decade driven by the demands of growth for new and improved infrastructure. This assumed to slow in the following decade.

Figure 5 provides more detail on water and wastewater costs.

4. Data Assessment

A summary of the robust analytical tools used to assess data is provided in this section.

Figures 6 illustrates how data was assessed to establish 2016 baselines for energy consumption, emissions and energy costs.

Figures 7 illustrates how data was assessed to establish the 2041/2050 Base Cases for energy consumption, emissions and energy costs.

Figure 8 illustrates the Integrated Workbook (IW) that supported simulations of different efficiency scenarios ("Efficiency Cases") to test their ability to achieve energy and emissions goals. The IW was structured by EPD. The Efficiency Cases allow for a wide range of opinions to be simulated and tested against the conservative Base Case.

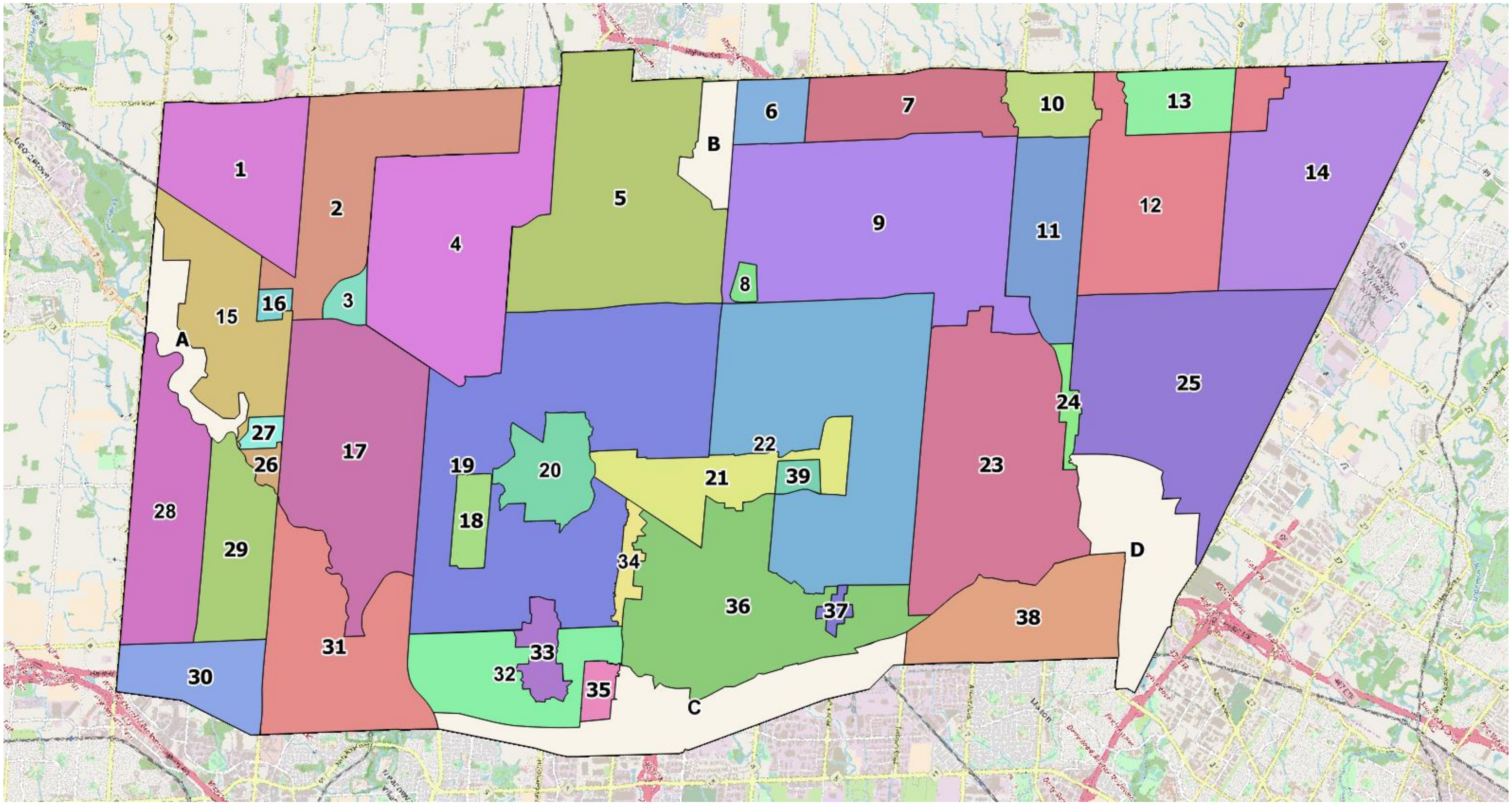

Figure 1: Brampton Energy Planning Districts

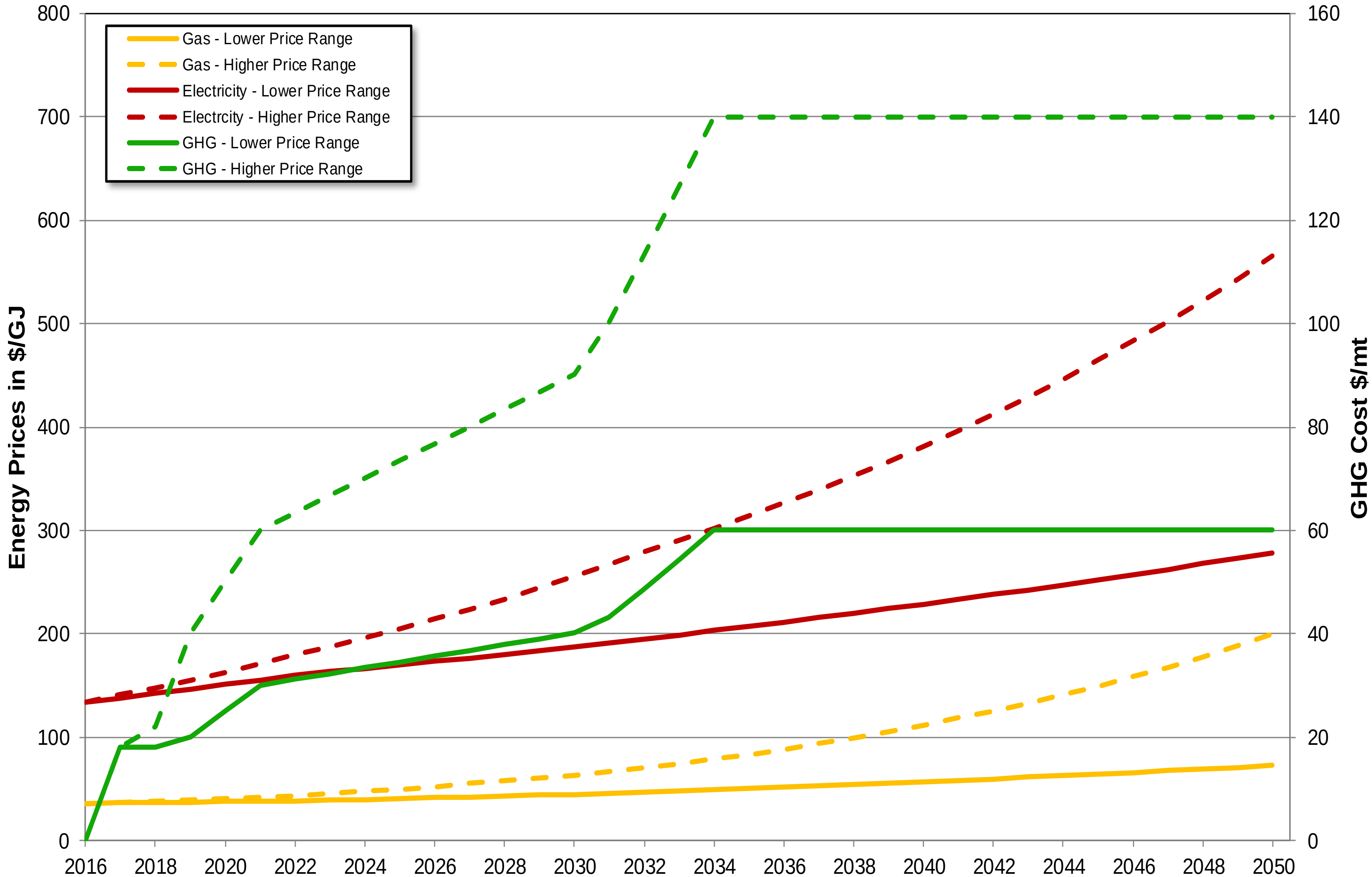

Figure 2: Projected prices for natural gas and electricity ($/GJ), and carbon price ($/MT), for Brampton residential customers from 2016 to 2050.

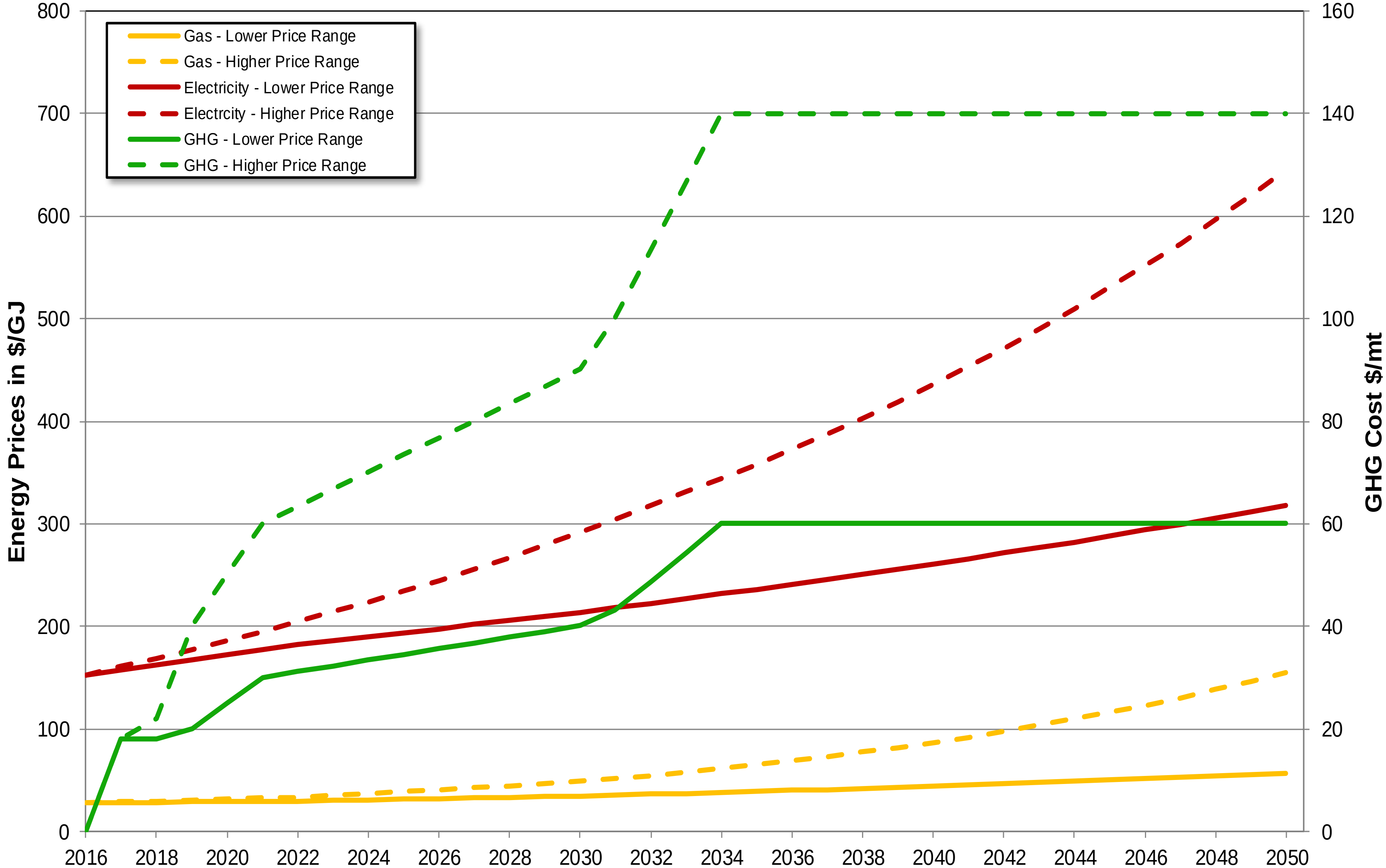

Figure 3: Projected prices for natural gas and electricity ($/GJ), and carbon price ($/MT), for Brampton commercial and institutional customers from 2016 to 2050.

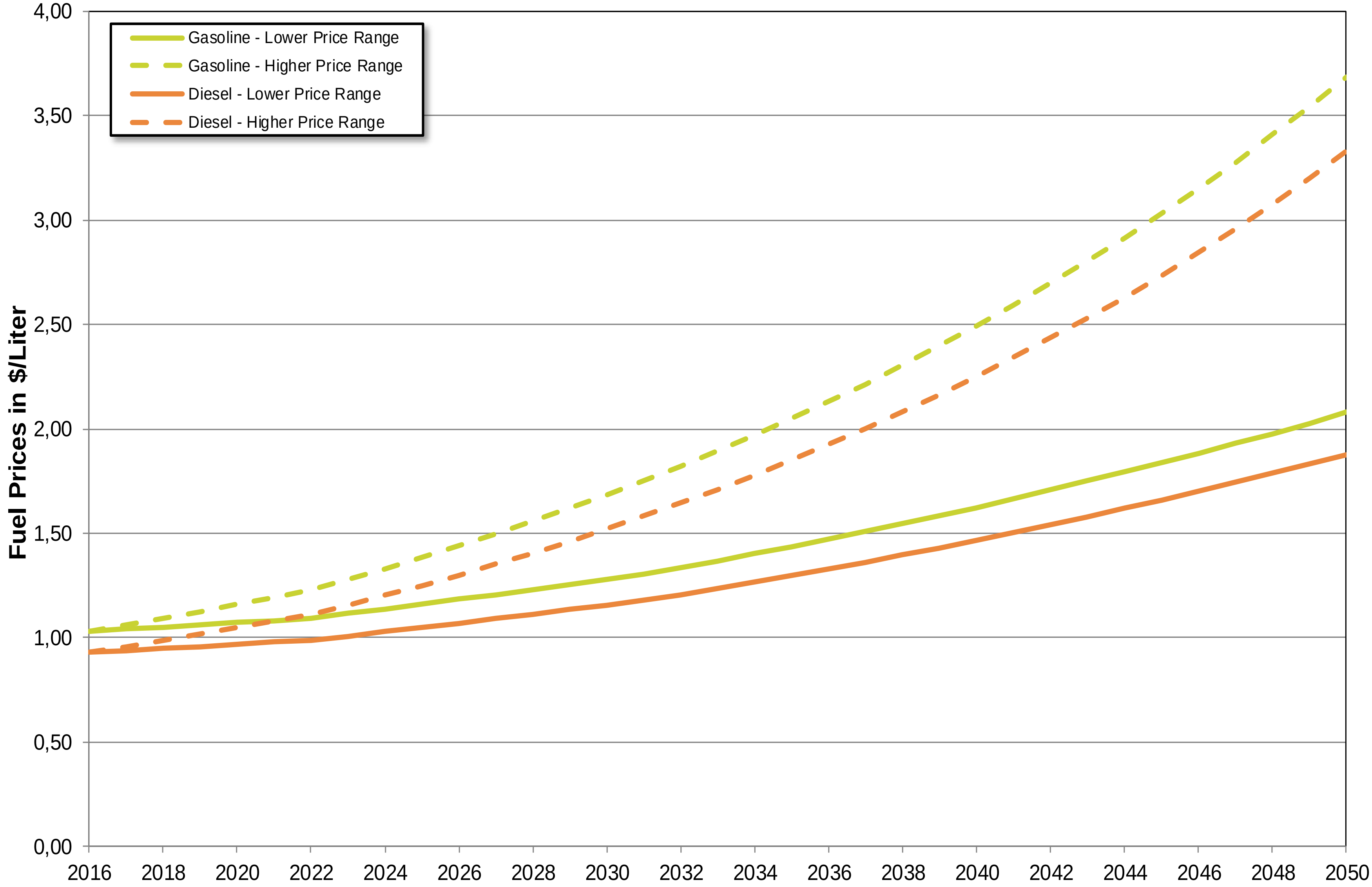

Figure 4: Projected prices for diesel and gasoline ($/litre) in Brampton from 2016 to 2050.

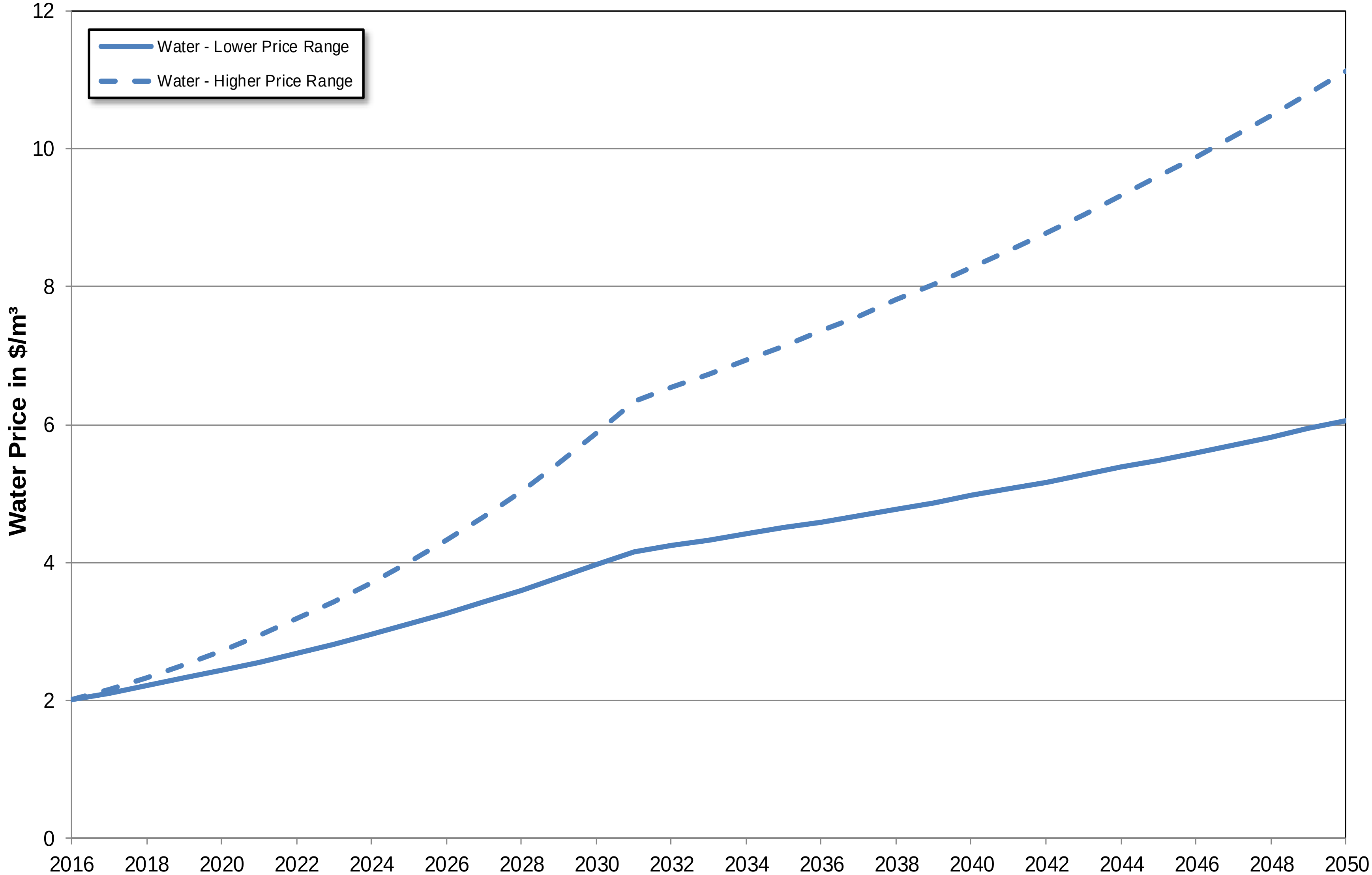

Figure 5: Projected prices for water and wastewater ($/m^3) in Brampton from 2016 to 2050.

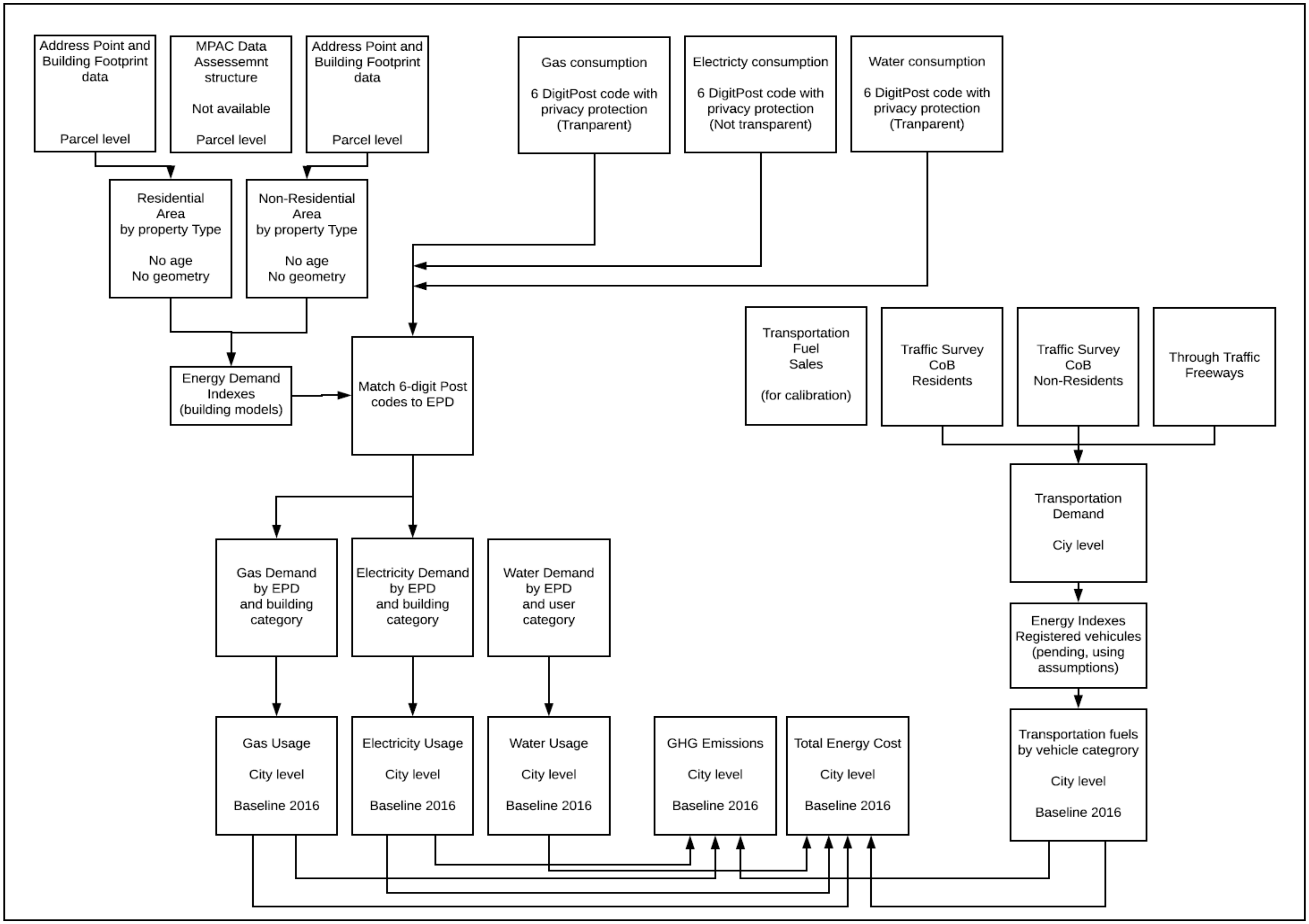

Figure 6: Assessment of data to establish Brampton 2016 baselines for energy, emissions and energy costs.

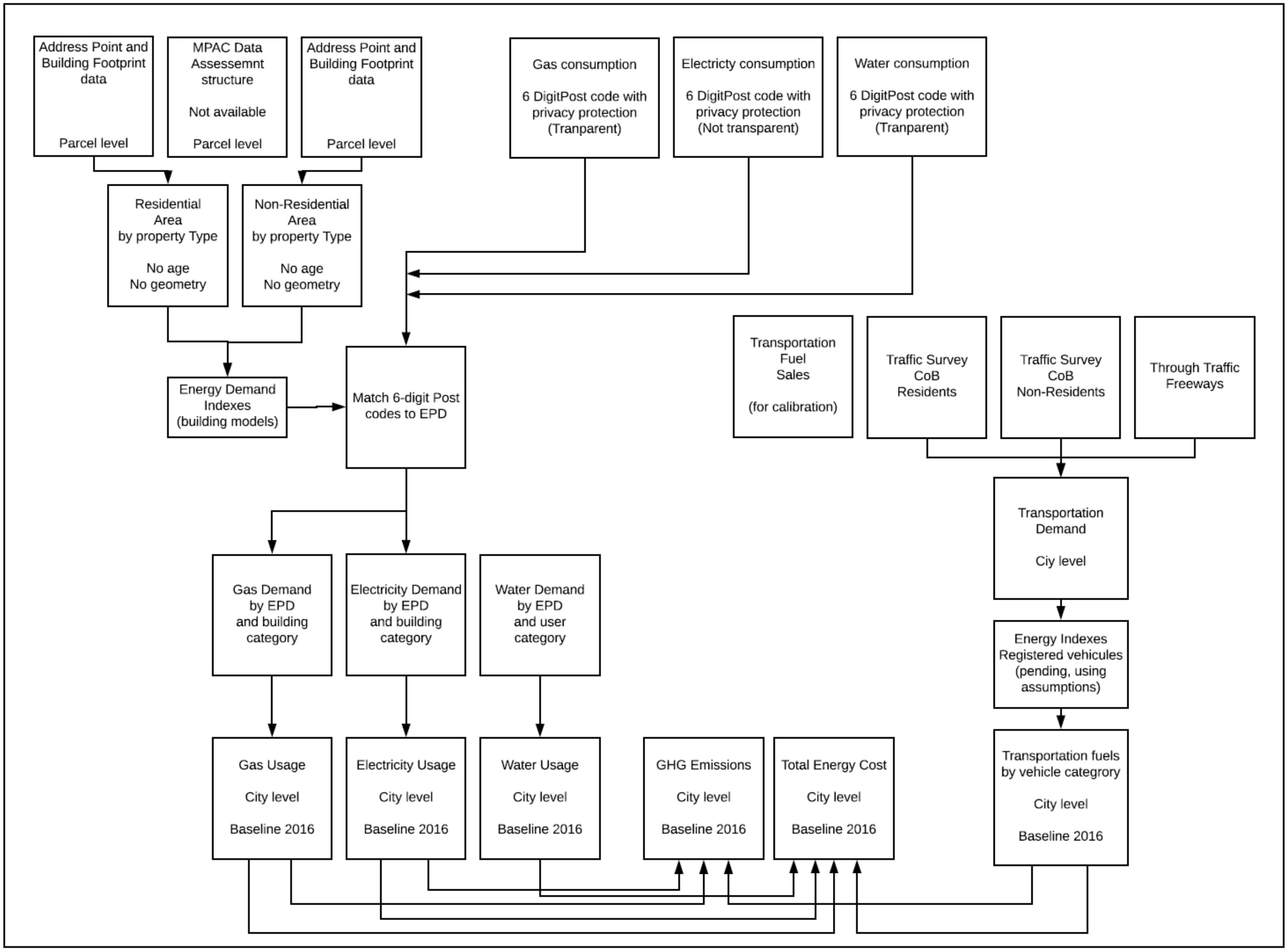

Figure 7: Assessment of data to establish Brampton 2041 and 2050 Base Cases for energy, emissions and energy costs.

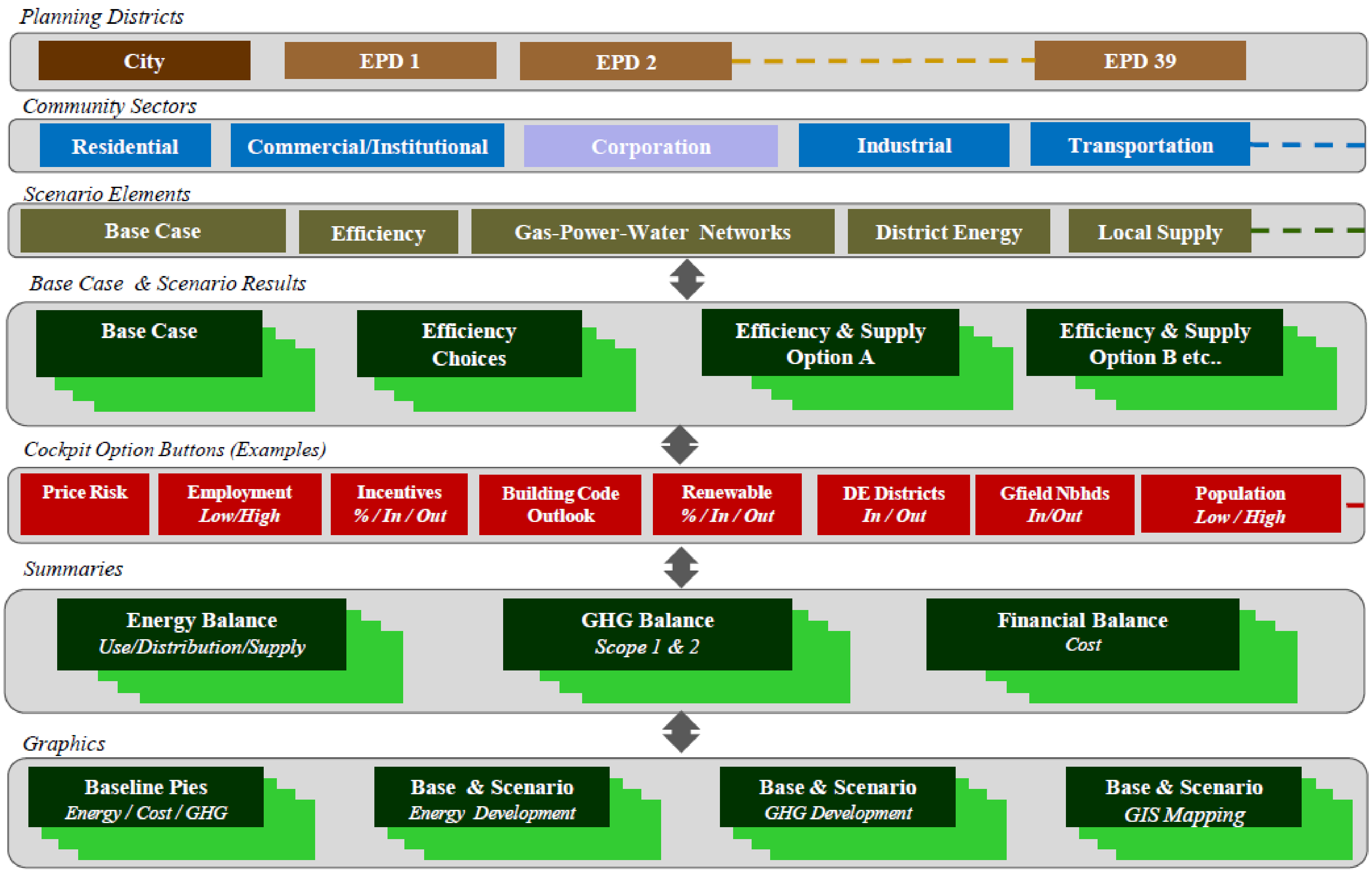

Figure 8: CEERP Integration Workbook

Appendix 3 – Baseline and Base Case Findings

This appendix provides the analytical outputs for source energy, site energy, emissions, energy cost and water. The data and assumptions underlying these findings are found in Appendix 2.

Contents

Source Energy Use

Brampton's total source energy use in 2016 was 92 million Gigajoules (GJ). Figure 1 shows 2016 source energy use by sector with the percentage consumed by municipal operations (facilities and fleet) separated. The City of Brampton's corporate energy use for facilities and fleets represents 2% of total energy use in 2016. Brampton homes represented 28% of Brampton's total source energy use while the transportation sector represented 35% of total source energy use. Industry represented 21%.

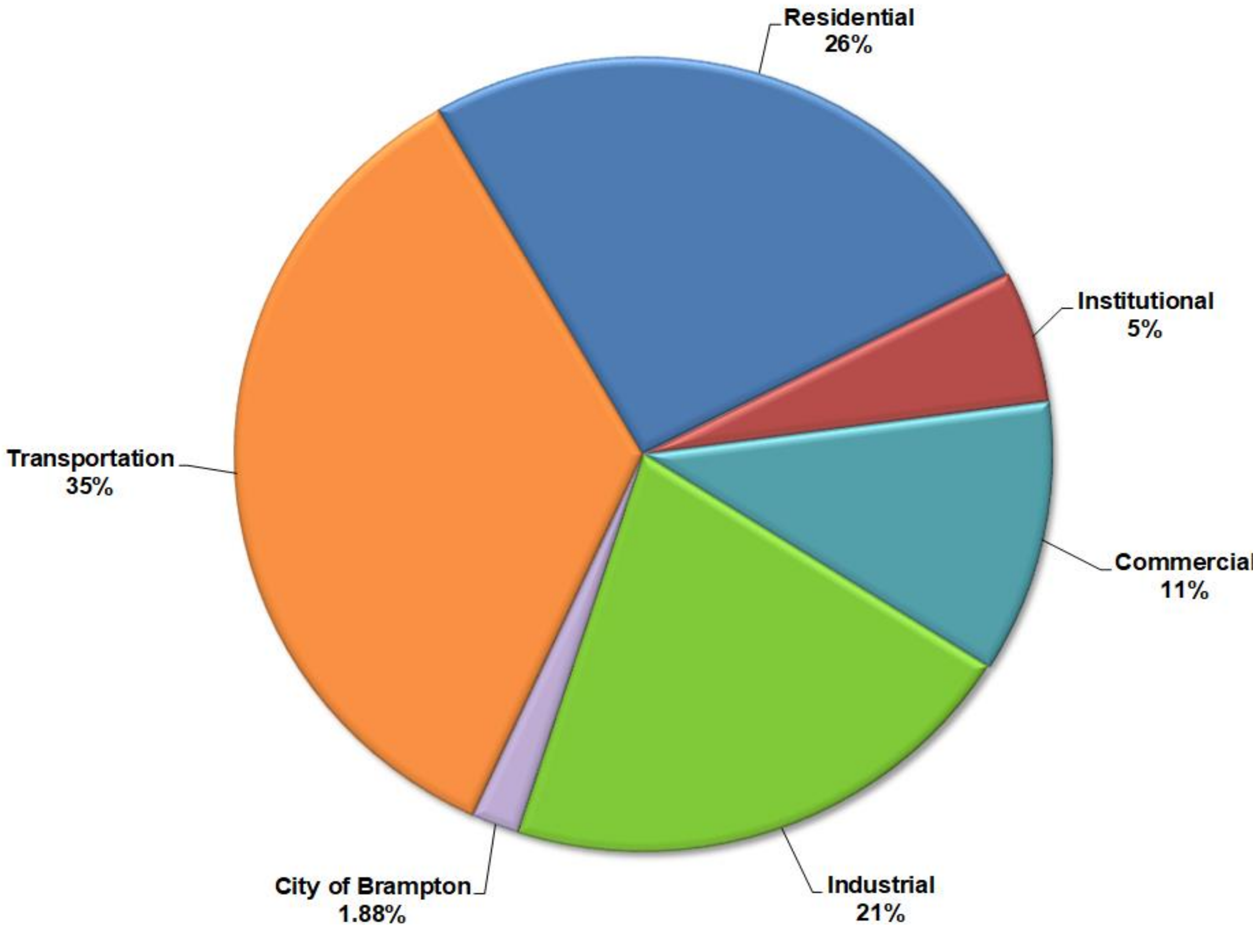

Figure 1: Brampton source energy use (%) by sector in 2016 with municipal facilities and fleet separated.

Figure 2 shows 2016 source energy use by sector with municipal facilities and fleet source energy use incorporated into the institutional and transportation sectors, respectively.

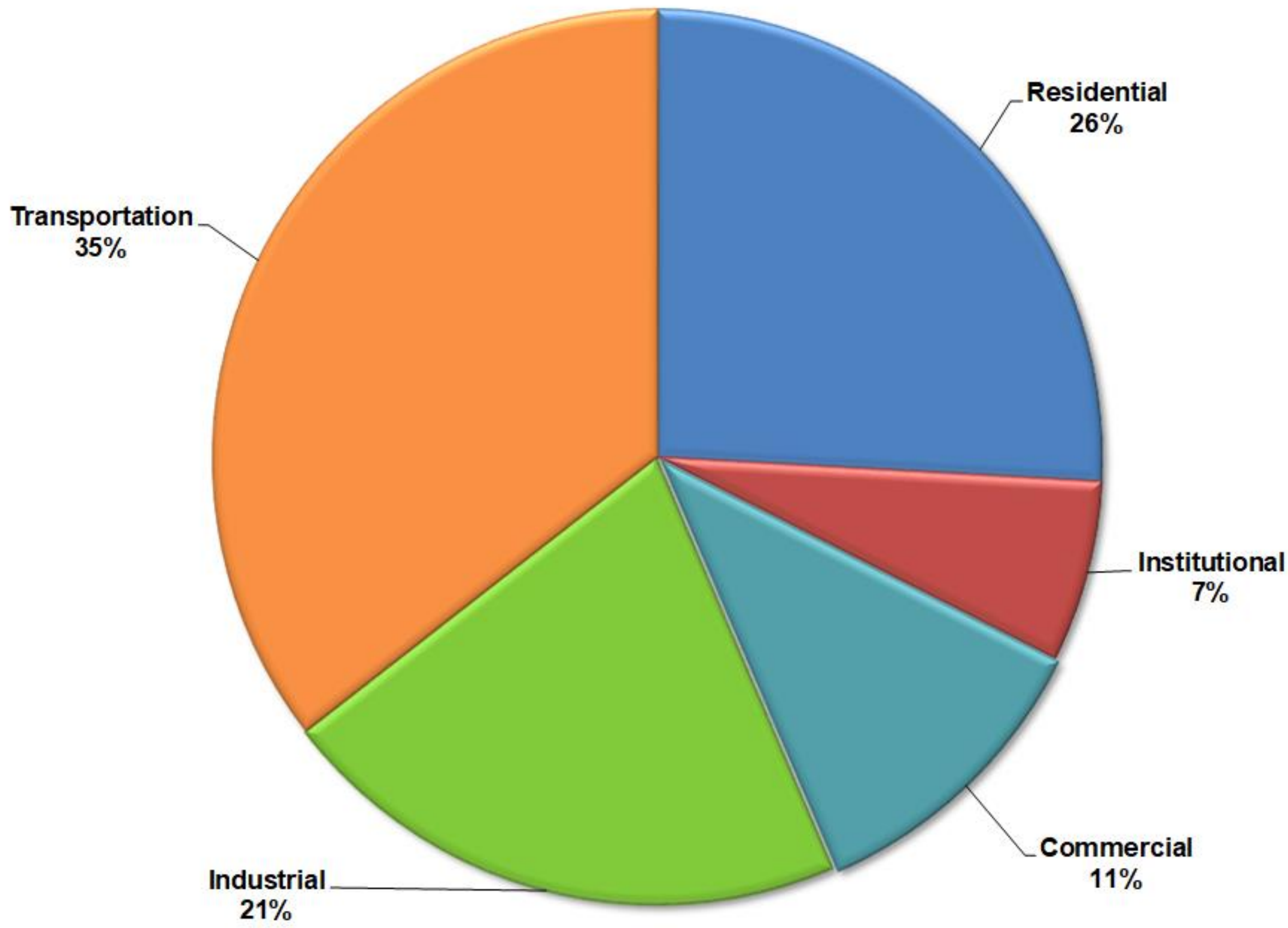

Figure 2: Brampton source energy use (%) by sector in 2016.

Figure 3 shows conversions losses by sector in 2016. Conversion losses occur when one energy source is converted to another (e.g., when electricity is generated from natural gas). Total conversion losses were approximately 30% of the total source energy purchased in 2016.

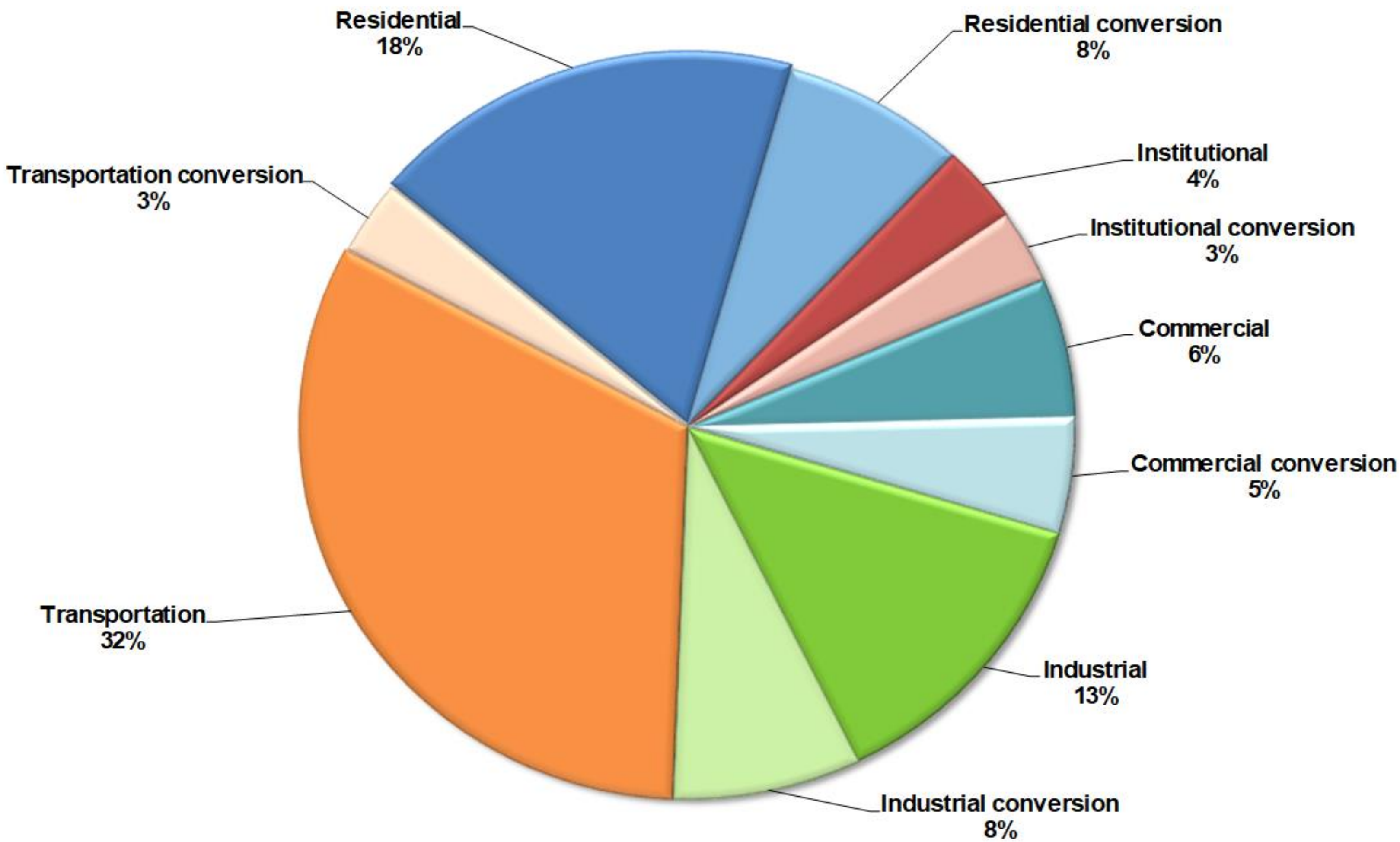

Figure 3: Brampton source energy use (%) by sector in 2016 with conversion losses by sector separated.

Figure 4 shows Brampton's total source energy use by utility in 2016 with conversion losses separated. The largest conversion losses are attributed to the electricity use at 22%.

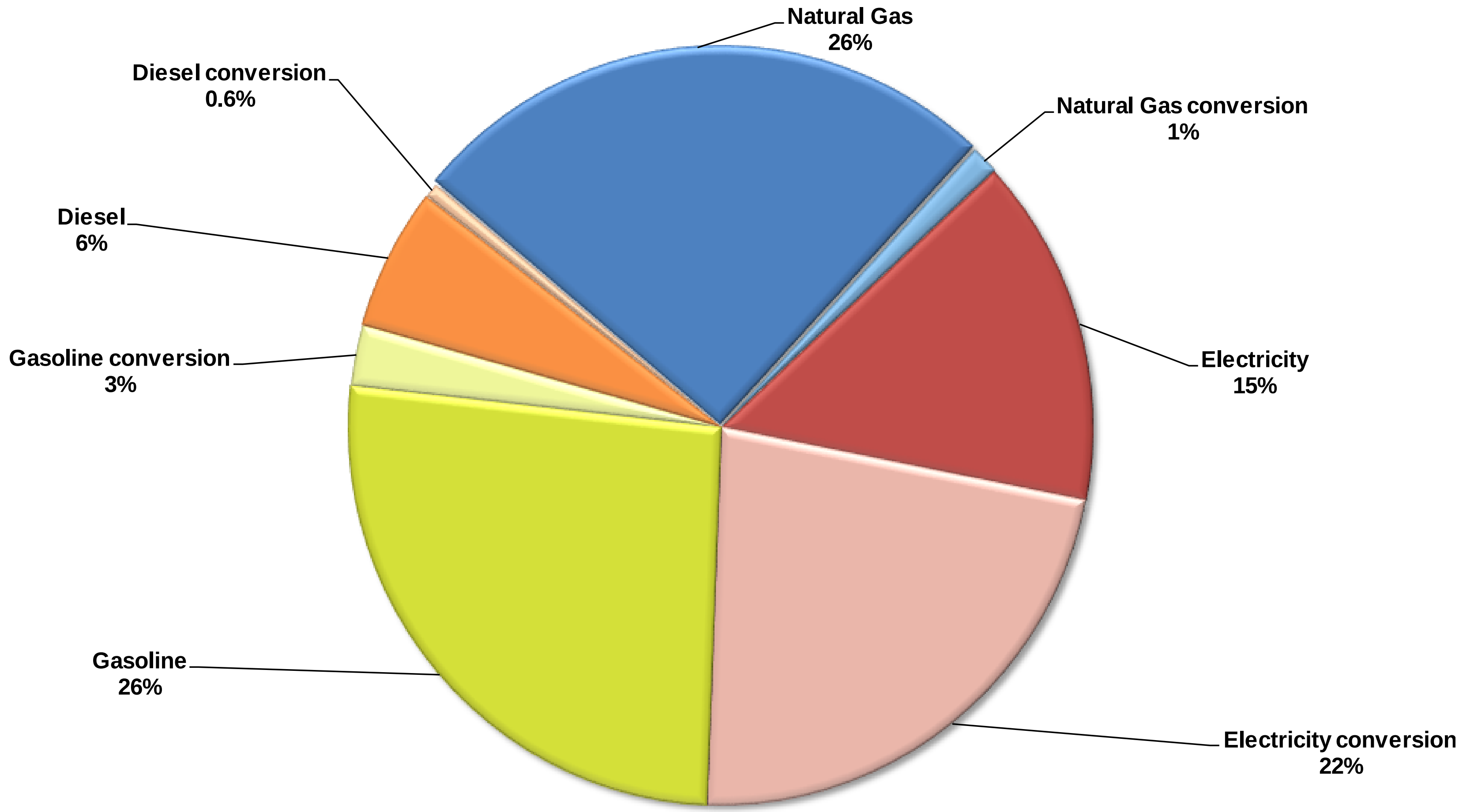

Figure 4: Brampton source energy use (%) by utility in 2016 with conversion losses by utility separated.

Figure 5 shows the projected annual increase in source energy use by sector from 2016 to 2050 in Brampton. Source energy use is projected to increase to 123 million GJ by 2050, a 30% increase. Population and employment growth are both projected to increase 51% and 73%, respectively, during the same time period.

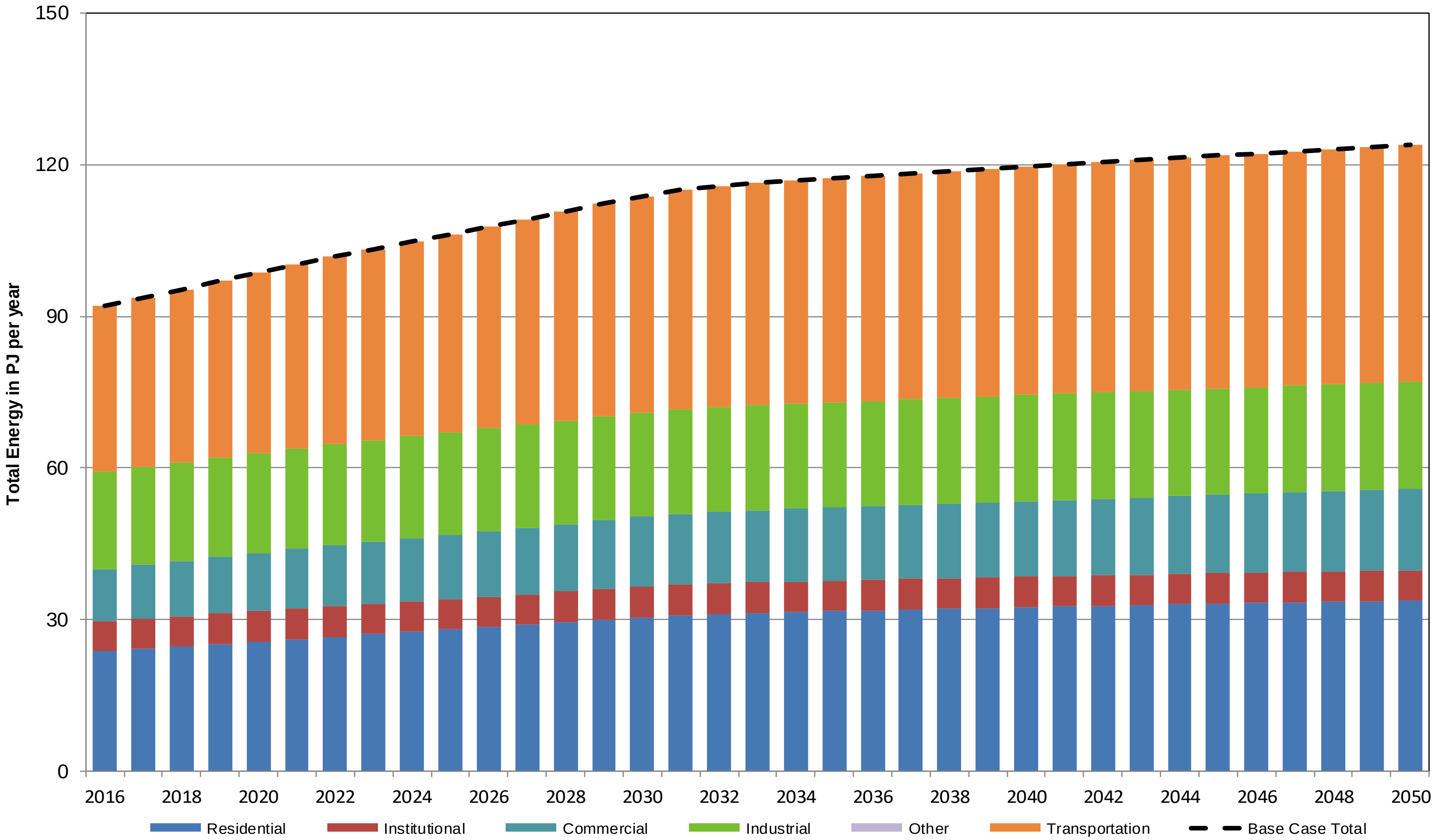

Figure 5: Projected increase in Brampton source energy use (PJ) by sector from 2016 to 2050.

Figure 6 shows the projected annual increase in source energy use by utility in Brampton from 2016 to 2050.

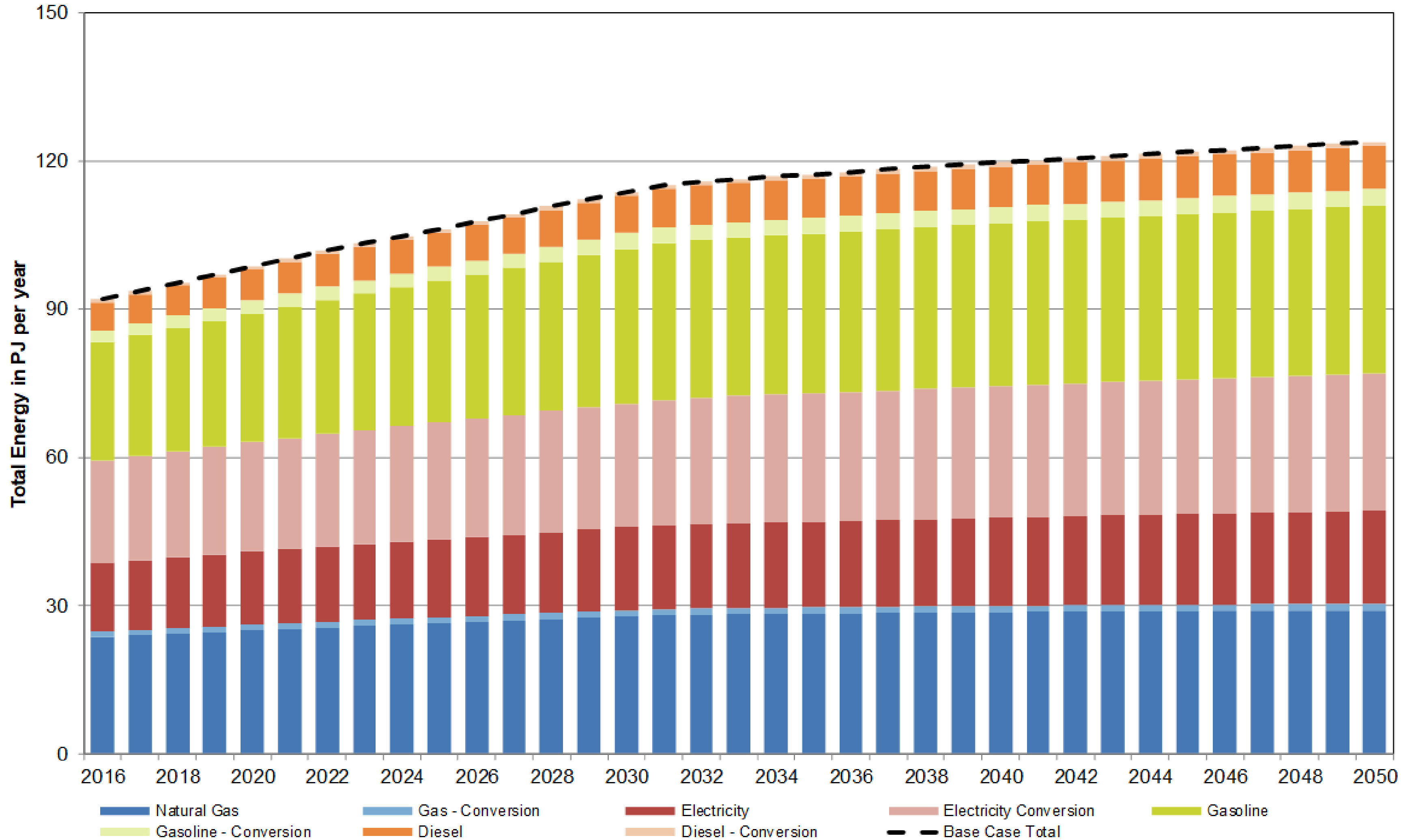

Figure 6: Projected increase in Brampton source energy use (PJ) by utility from 2016 to 2050.

Figure 7 shows the relative total source energy use for homes and buildings in Brampton by energy planning district (EPD) in 2016. Darker coloured EPDs have relatively higher total source energy use.

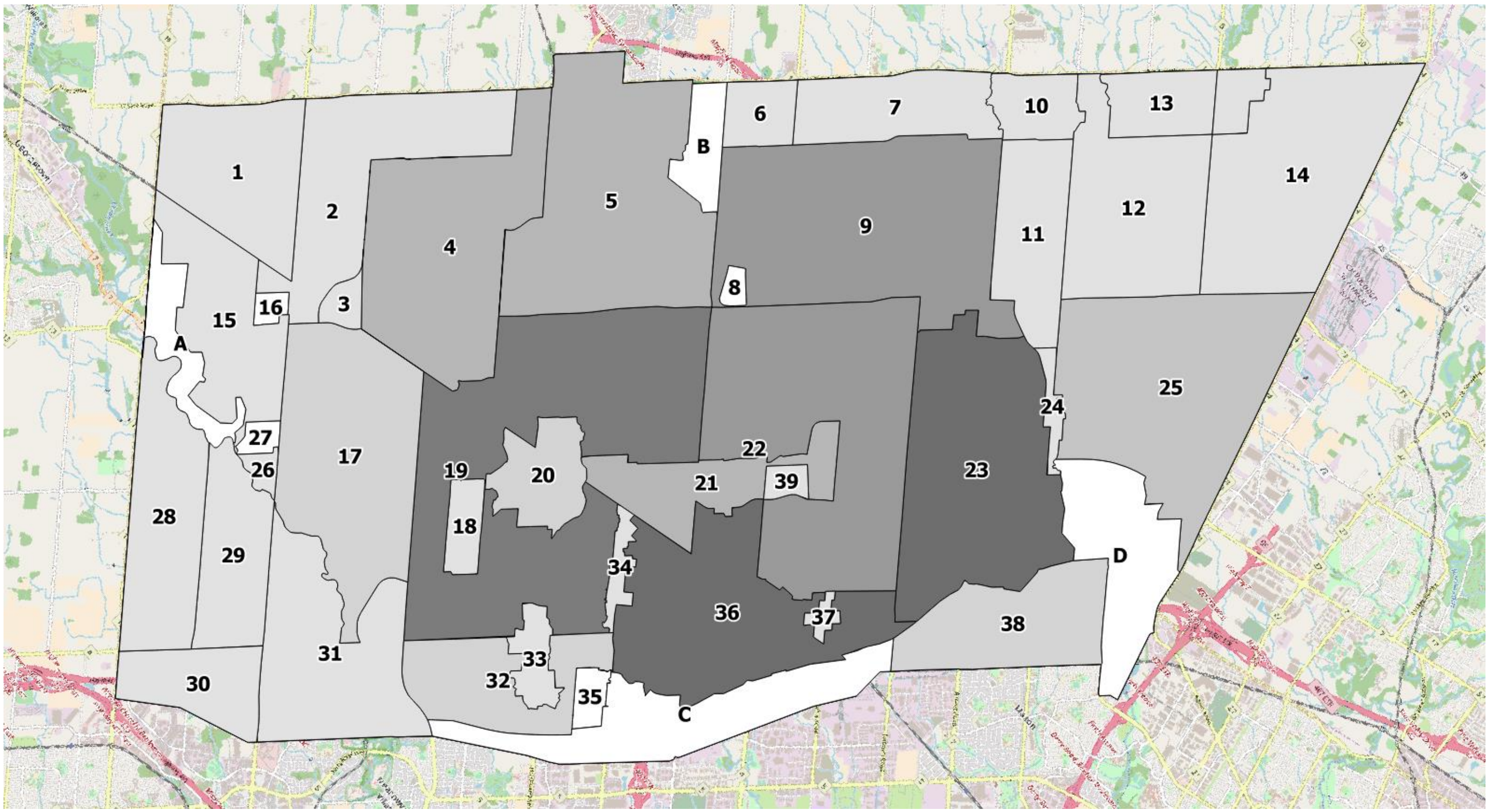

Figure 7: Relative 2016 source energy use for homes and buildings by energy planning district (EPD) in Brampton. Darker coloured EPDs have relatively higher total source energy use.

Figure 8 shows the projected relative total source energy use for homes and buildings in 2050 in Brampton by EPD. Darker coloured EPDs have relatively higher total source energy use.

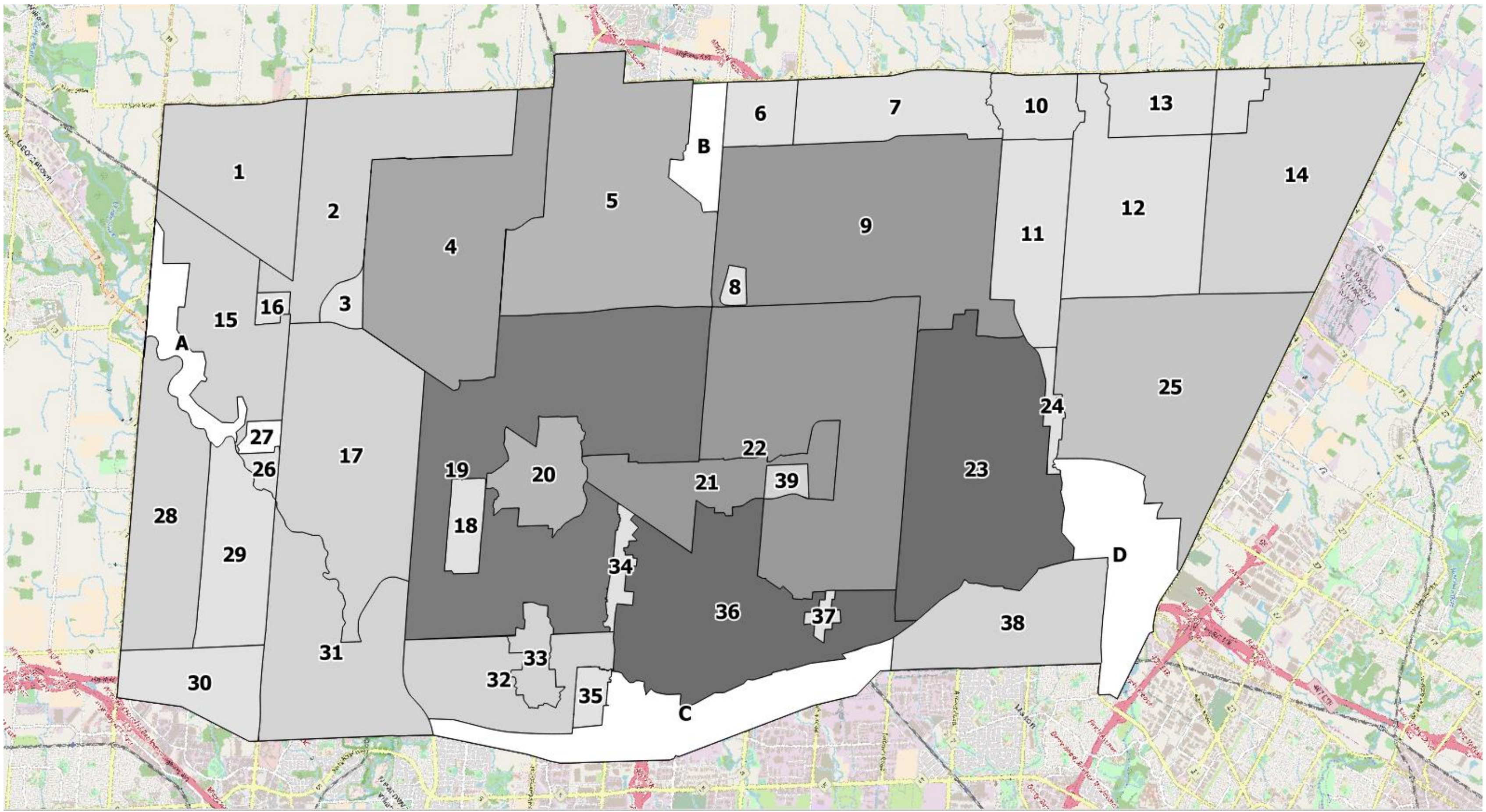

Figure 8: Projected relative 2050 source energy use for homes and buildings by energy planning district (EPD) in Brampton. Darker coloured EPDs have relatively higher total source energy use.

Figure 9 shows the projected relative change in total source energy use from 2016 to 2050 in Brampton by EPD. Darker coloured EPDs are expected to see a higher level of change during this period.

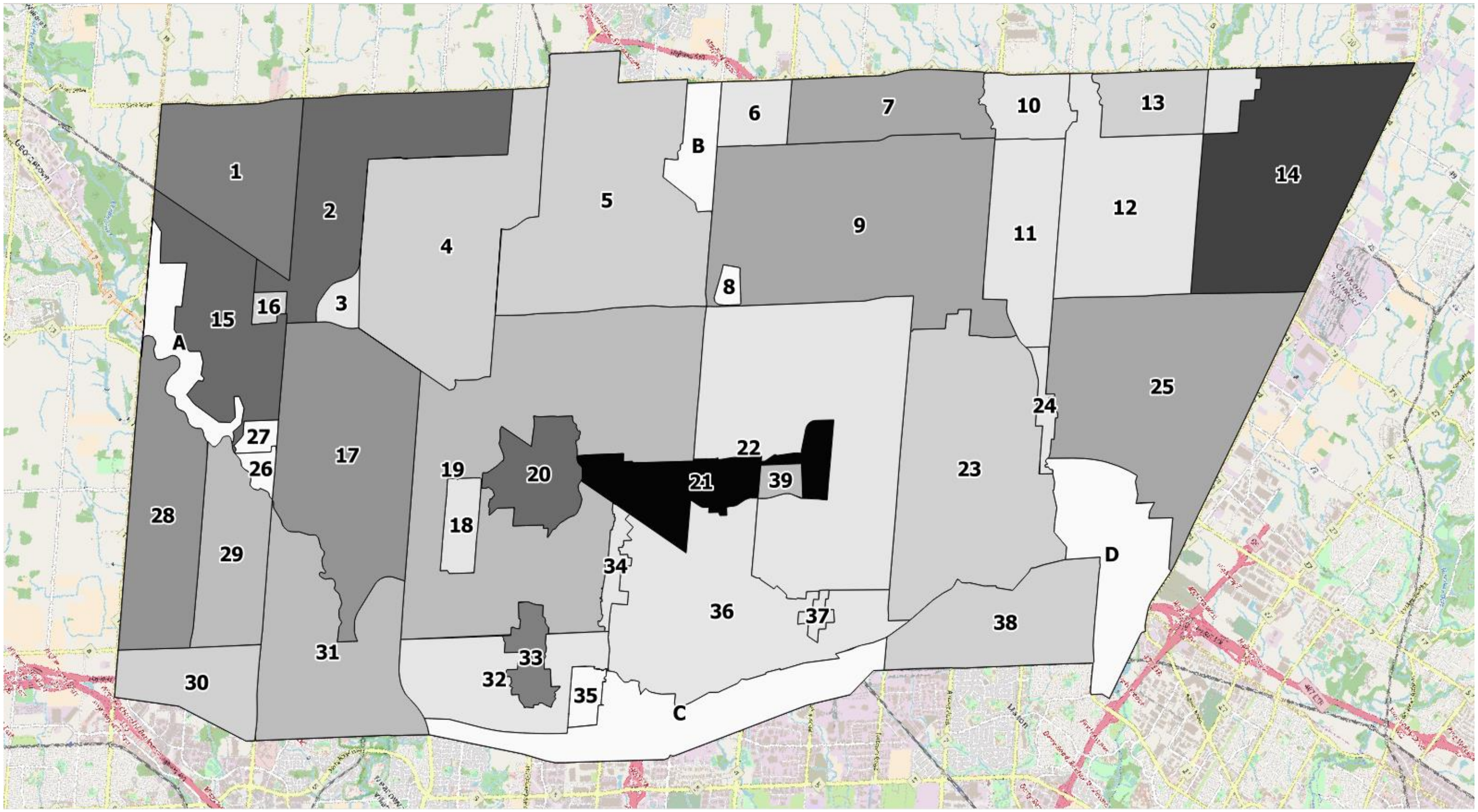

Figure 9: Relative increase in source energy use for homes and buildings from 2016 to 2050 by energy planning district (EPD) in Brampton. Darker coloured EPDs show greater change.

Site Energy Use

Total site energy use for Brampton in 2016 was 67 million GJ (or 109 GJ per person). Figure 10 shows site energy use for Brampton in 2016 by sector. The transportations sector represents approximately 44% total site energy use while the residential sector represents 25%.

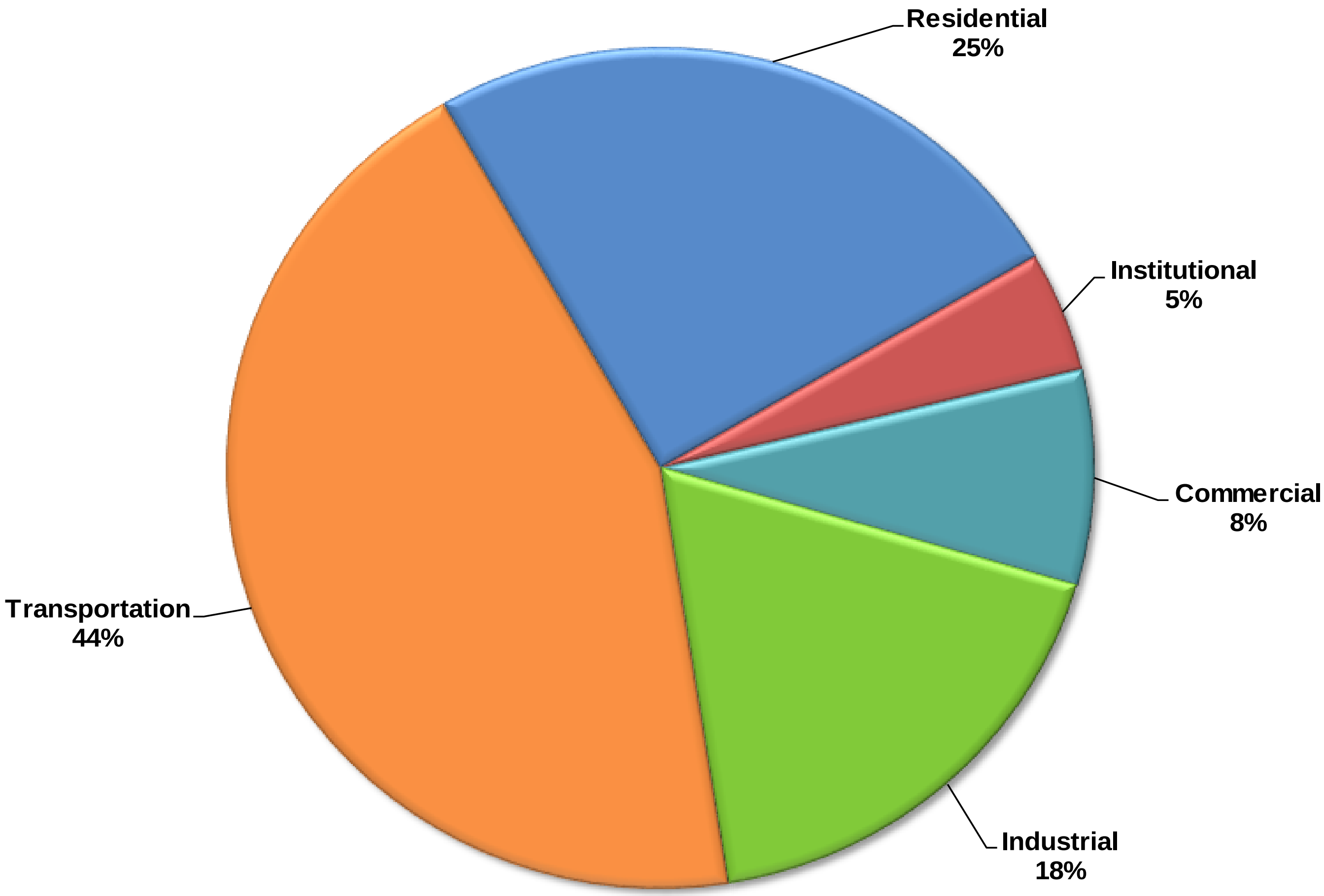

Figure 10: Brampton site energy use (%) by sector in 2016.

Figure 11 shows site energy use for Brampton in 2016 by utility. Natural gas and gasoline represent the largest share of total site energy use at 35% and 36%, respectively.

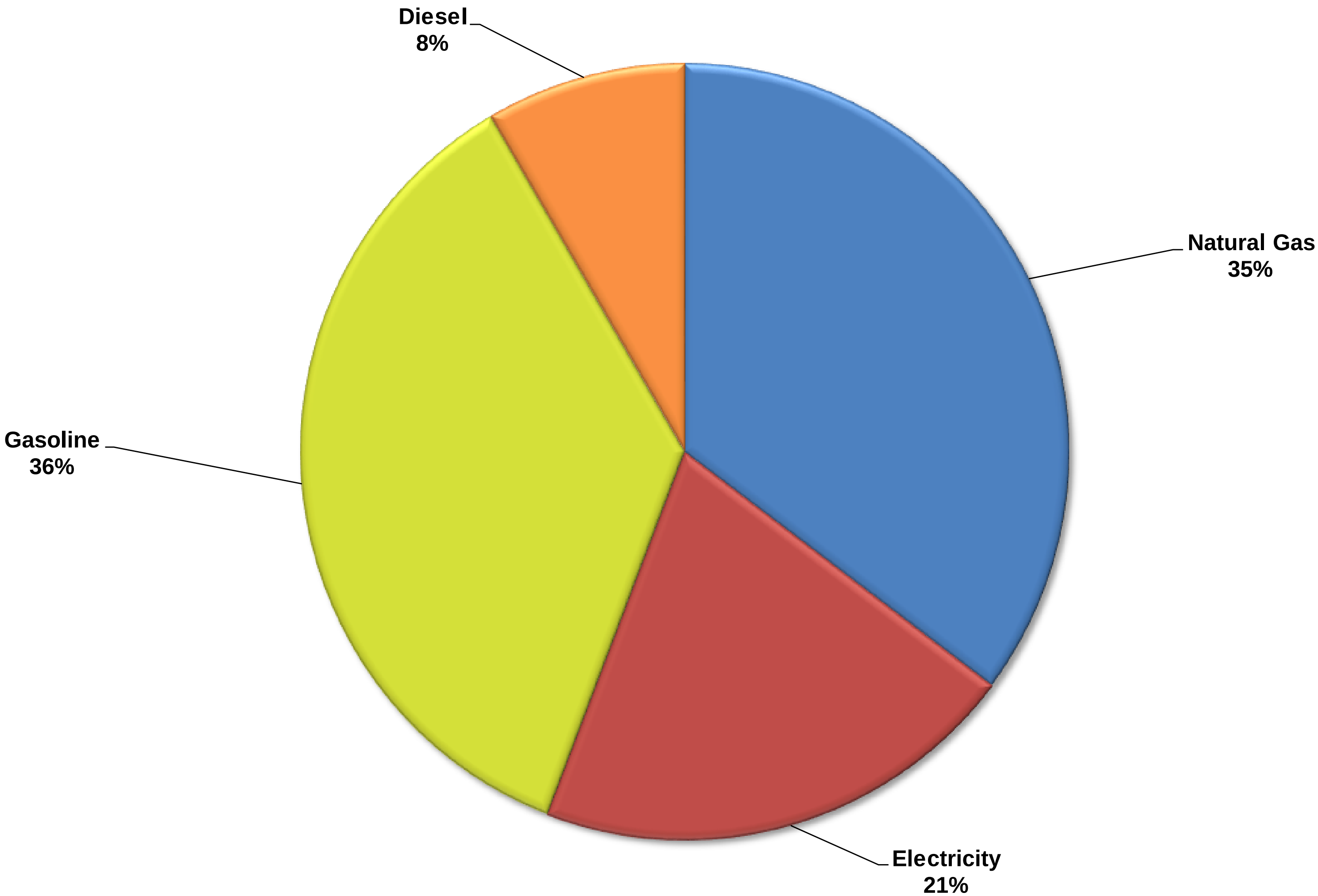

Figure 11: Brampton site energy use (%) by utility in 2016.

Annual site energy use in Brampton is projected to increase to 90 million GJ by 2050. Figure 12 shows the projected increase in annual site energy use by sector from 2016 to 2050 in Brampton.

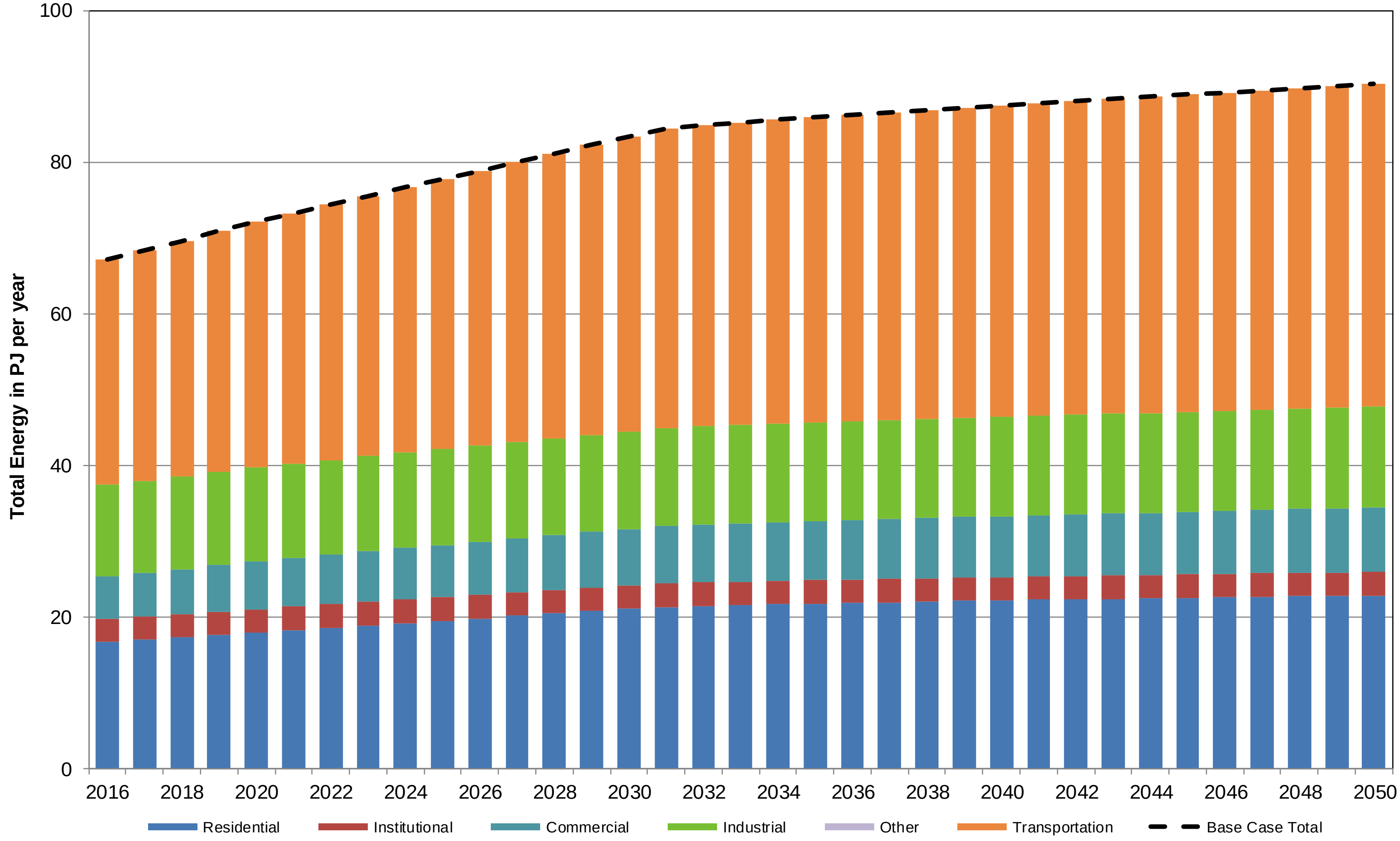

Figure 12: Projected increase in Brampton site energy use (PJ) by sector from 2016 to 2050.

The graph in Figure 13 shows the projected increase in annual site energy use by utility from 2016 to 2050 in Brampton.

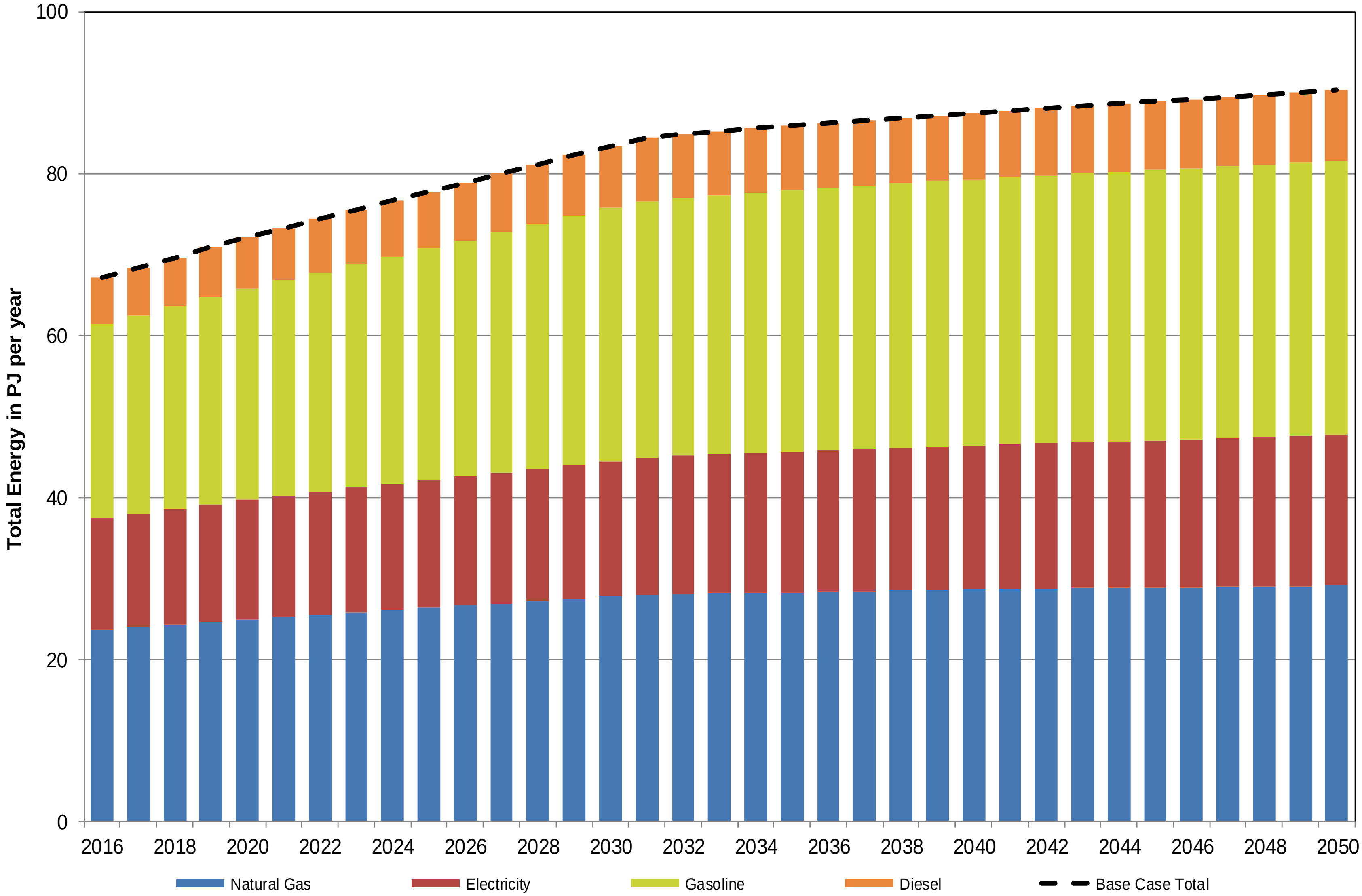

Figure 13: Projected increase in Brampton site energy use (PJ) by utility from 2016 to 2050.

Emissions

Greenhouse gas emissions for Brampton in 2016 were approximately 3.5 million M tonnes in 2016 or 5.6 tonnes CO2e per resident. Figure 14 shows Brampton emissions (%) by sector in 2016. The transportation almost 60% of emissions. Brampton homes represent 21% of emissions.

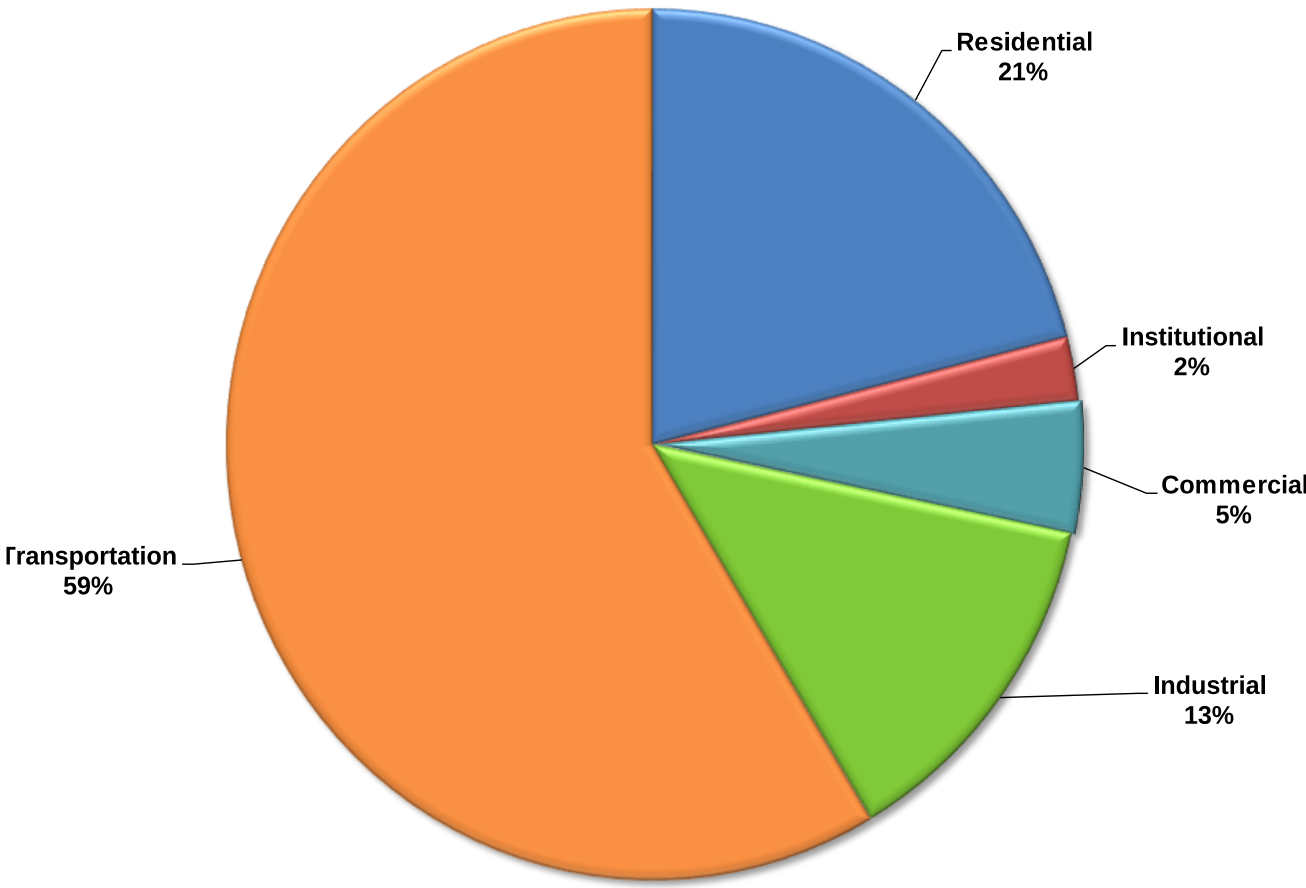

Figure 14: Brampton greenhouse gas emissions (%) by sector in 2016.

Figure 15 shows Brampton emissions (%) by utility in 2016. Energy for transportation contributed 59% of emissions followed by natural gas at 38%. Electricity only represented 3% of emissions.

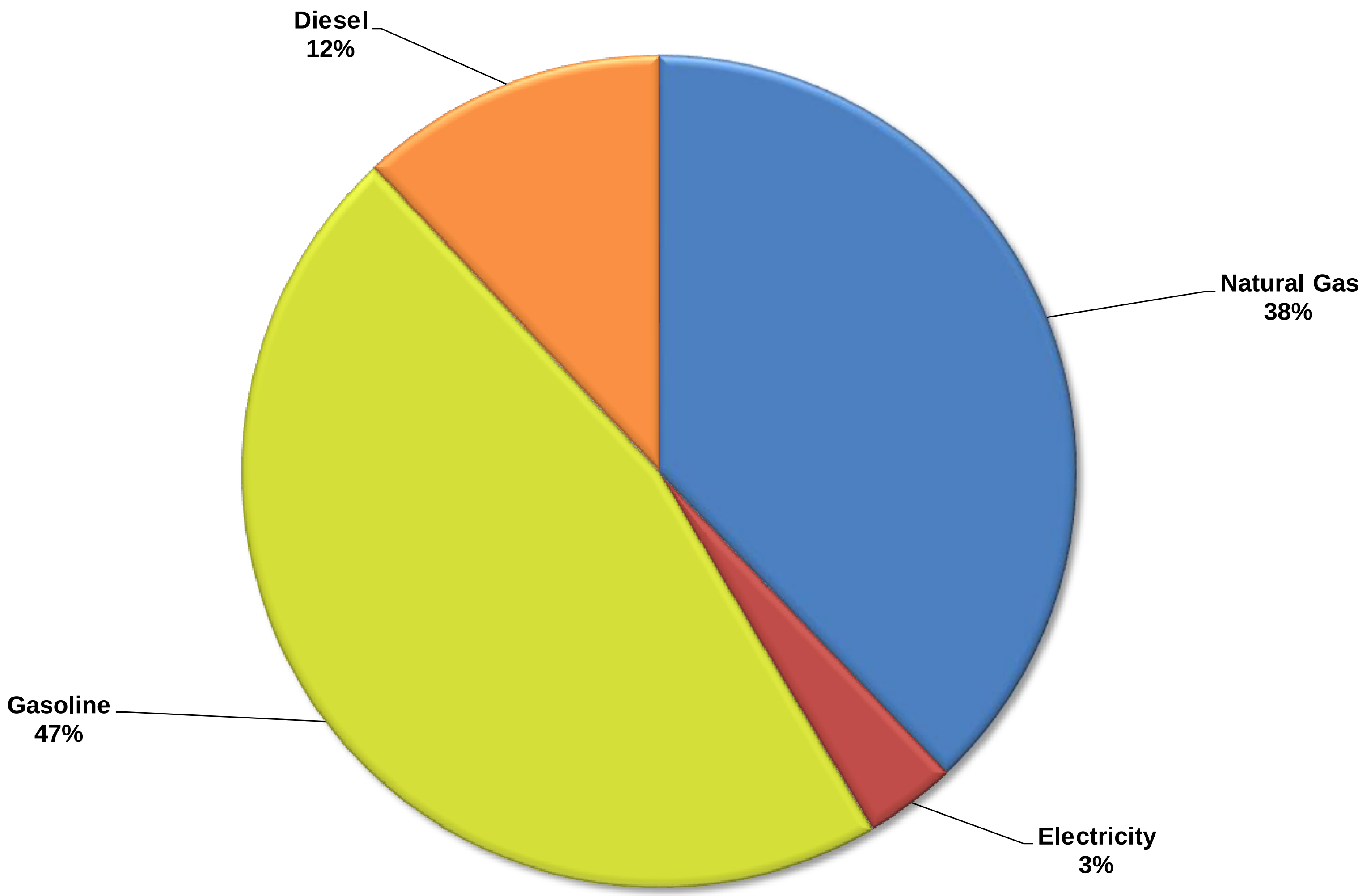

Figure 15: Brampton greenhouse gas emissions (%) by utility in 2016.

Annual emissions are projected to increase to 3.9 million tonnes in Brampton by 2050. This represents 4.2 tonnes/capita in 2050. Figure 16 shows the projected profile of annual emissions by sector in Brampton from 2016 to 2050.

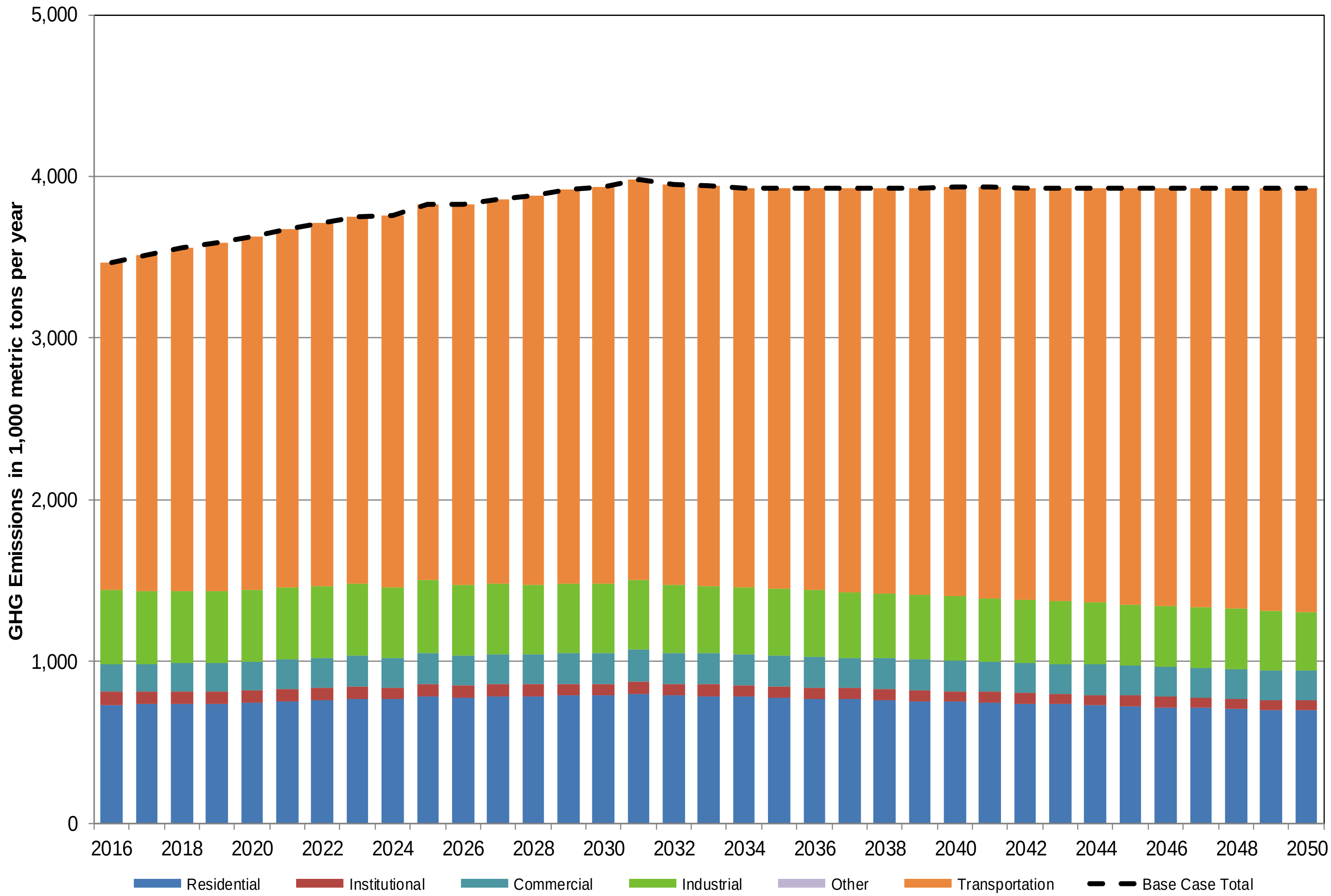

Figure 16: Projected Brampton greenhouse gas emissions profile by sector from 2016 to 2050.

Figure 16 shows the projected profile of annual emissions by utility in Brampton from 2016 to 2050.

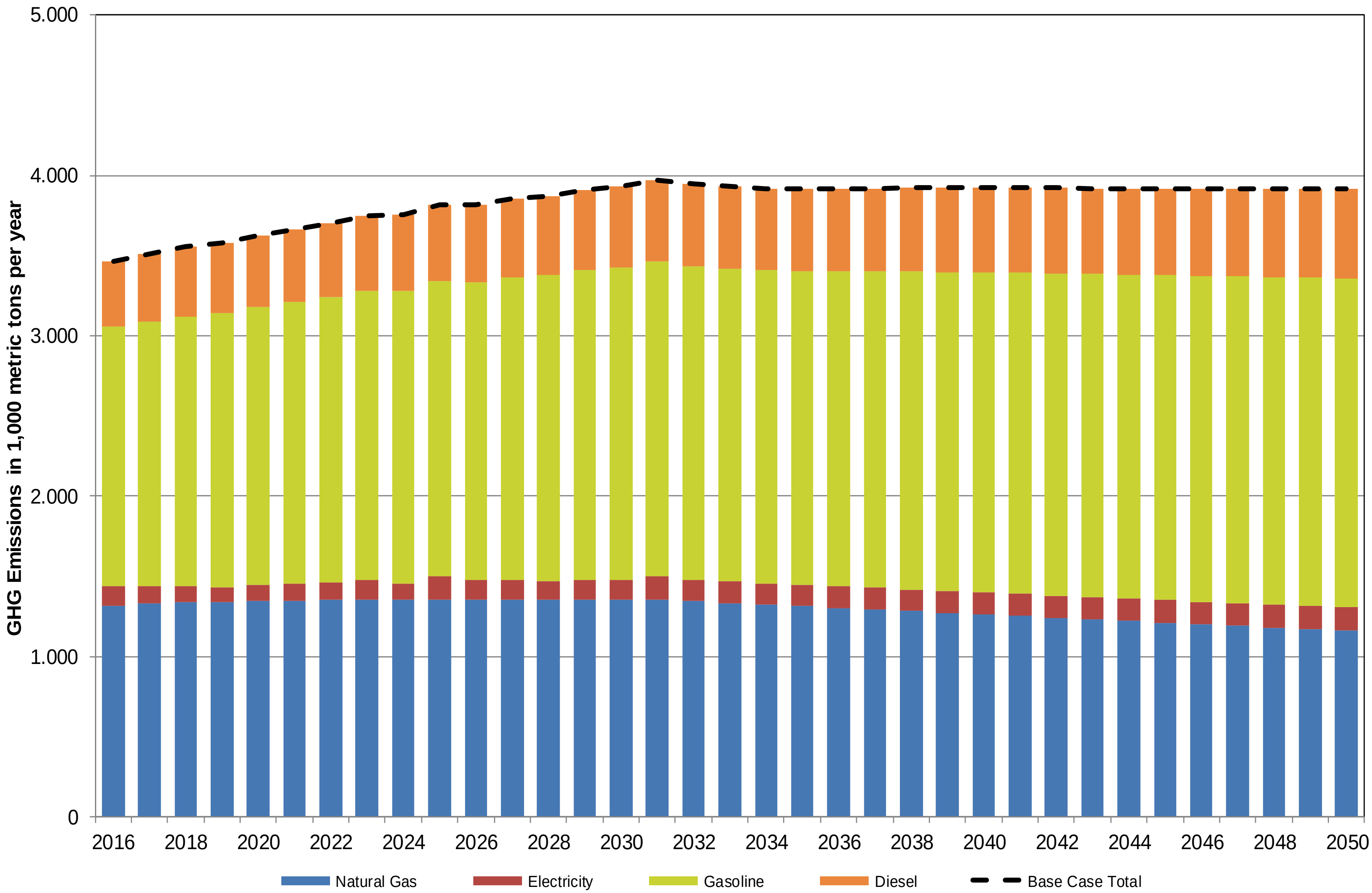

Figure 17: Projected Brampton greenhouse gas emissions profile by utility from 2016 to 2050.

Figure 18 shows the relative emission intensity (tonnes/km2) for homes and buildings in Brampton by EPD in 2016. Darker coloured EPDs have a relatively higher emission intensity.

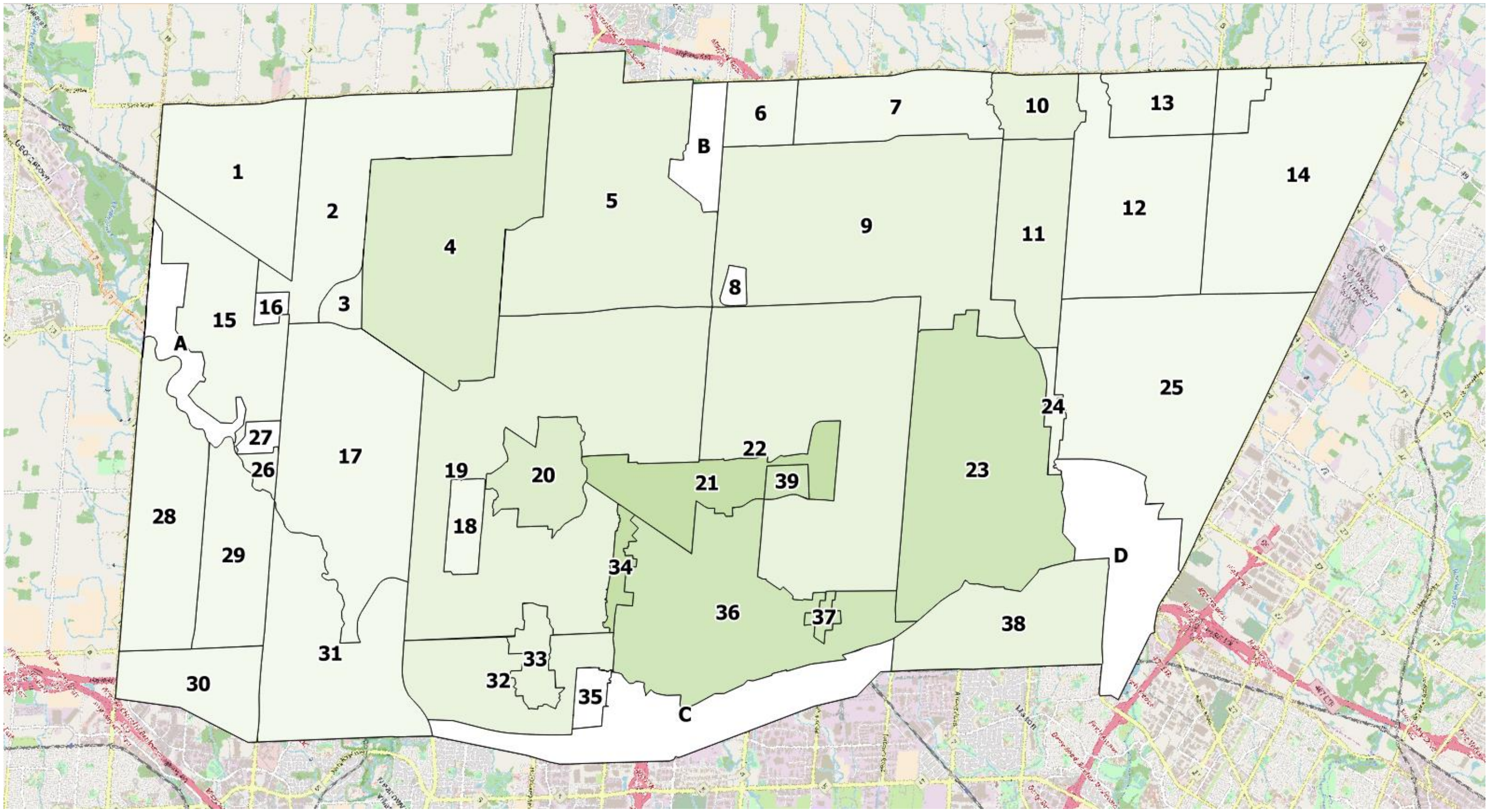

Figure 18: Relative green house gas emission intensity (tonnes/km2) for homes and buildings in Brampton by EPD in 2016. Darker coloured EPDs have a relatively higher emission intensity.

Figure 19 shows the projective relative emission intensity (tonnes/km2) for homes and buildings in Brampton by EPD in 2050. Darker coloured EPDs have a relatively higher emission intensity.

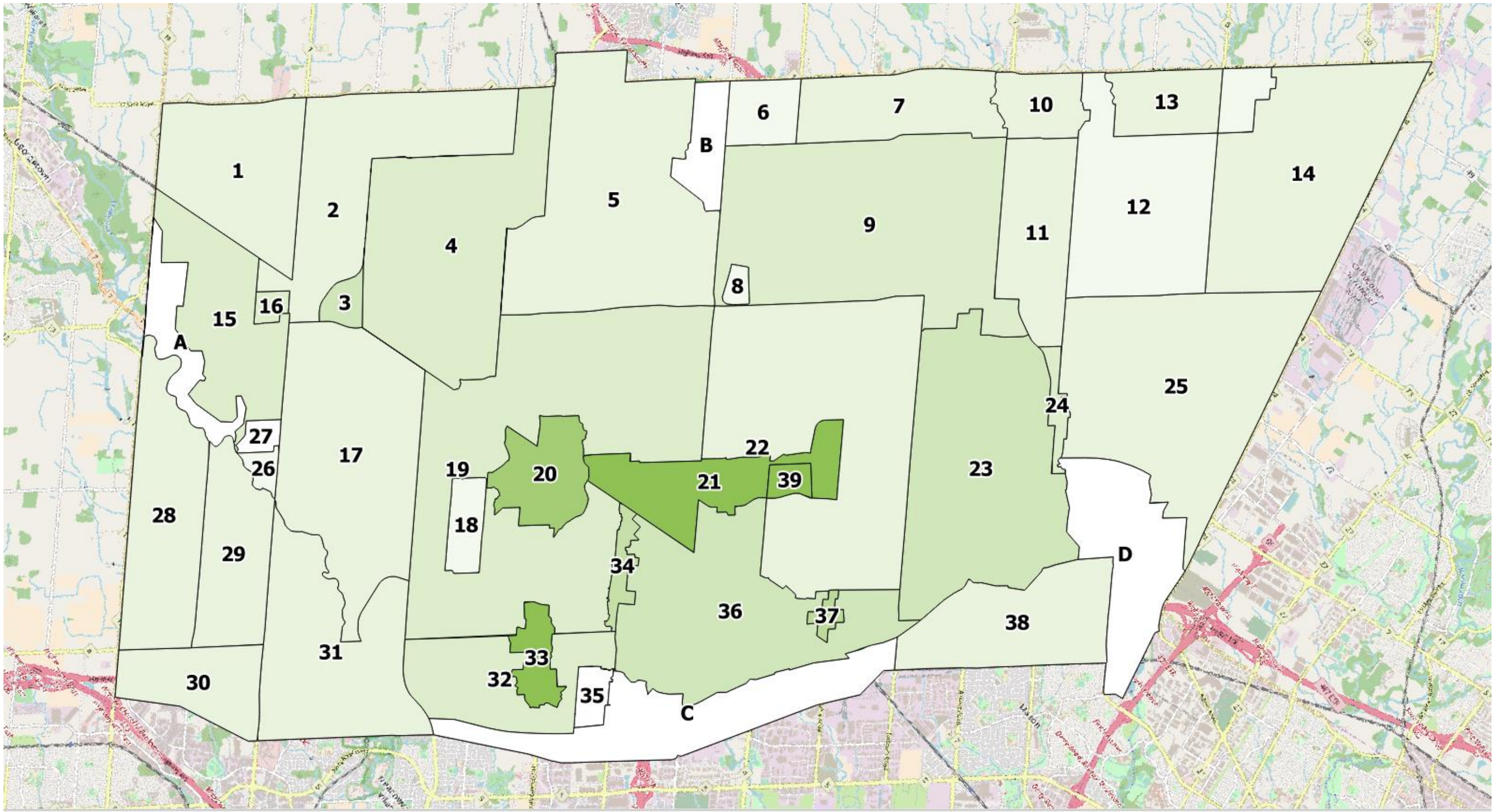

Figure 19: Projected relative greenhouse gas emission intensity (tonnes/km2) for homes and buildings in Brampton by EPD in 2050. Darker coloured EPDs have a relatively higher emission intensity.

Energy and Water Cost

The Brampton community spent $1.8 billion on energy and water in 2016. At least $1.4 billion (77%) of those energy dollars left the community. Figure 20 shows energy and water costs (%) by sector for Brampton in 2016. Transportation accounts for more than half of Brampton's costs. Homes account for almost a quarter of energy and water costs.

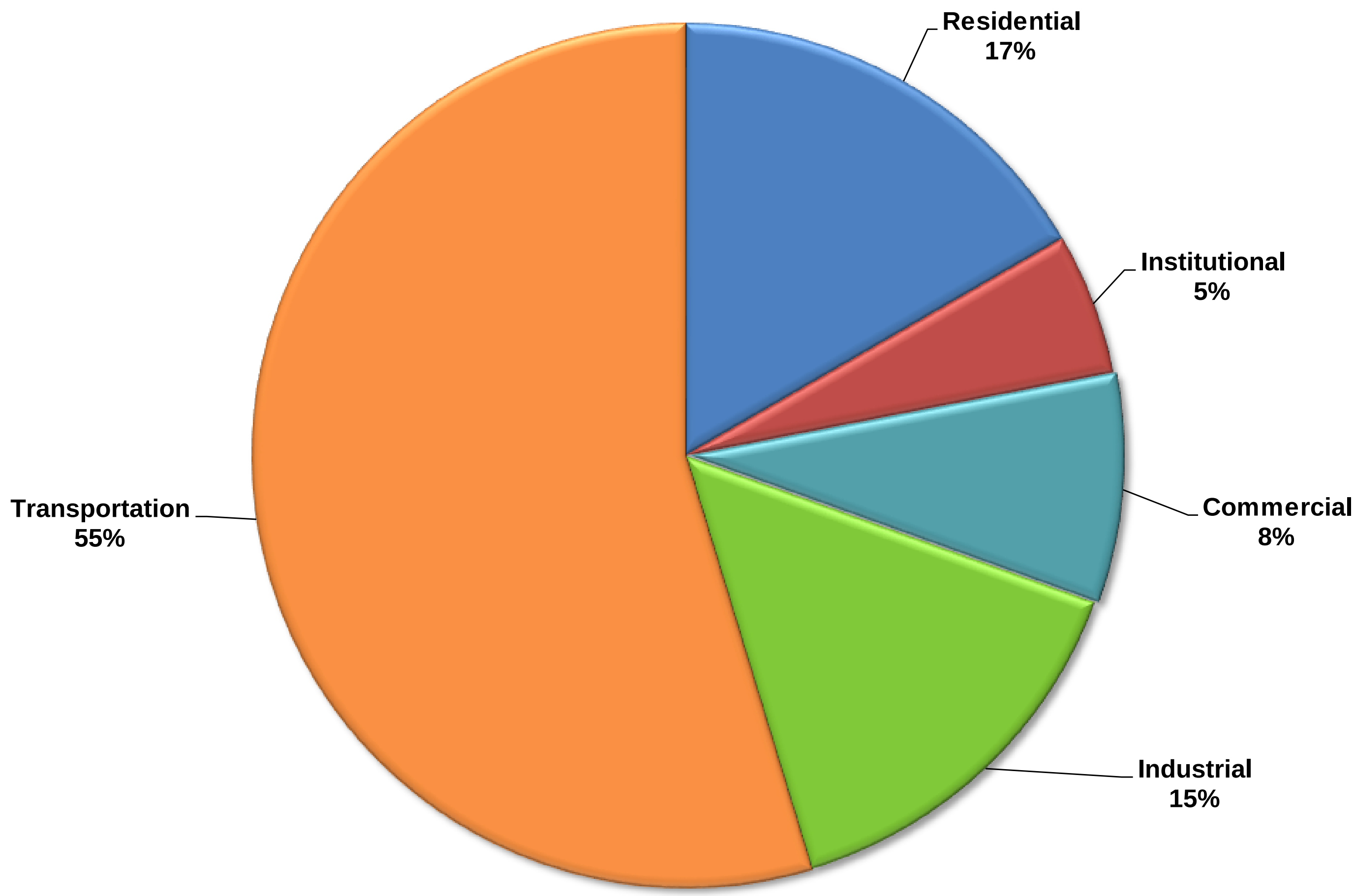

Figure 20: Brampton energy and water costs (%) by sector in 2016.

Figure 21 shows energy and water costs (%) by utility for Brampton in 2016. Gasoline represented the highest cost at 42% with electricity at 31%

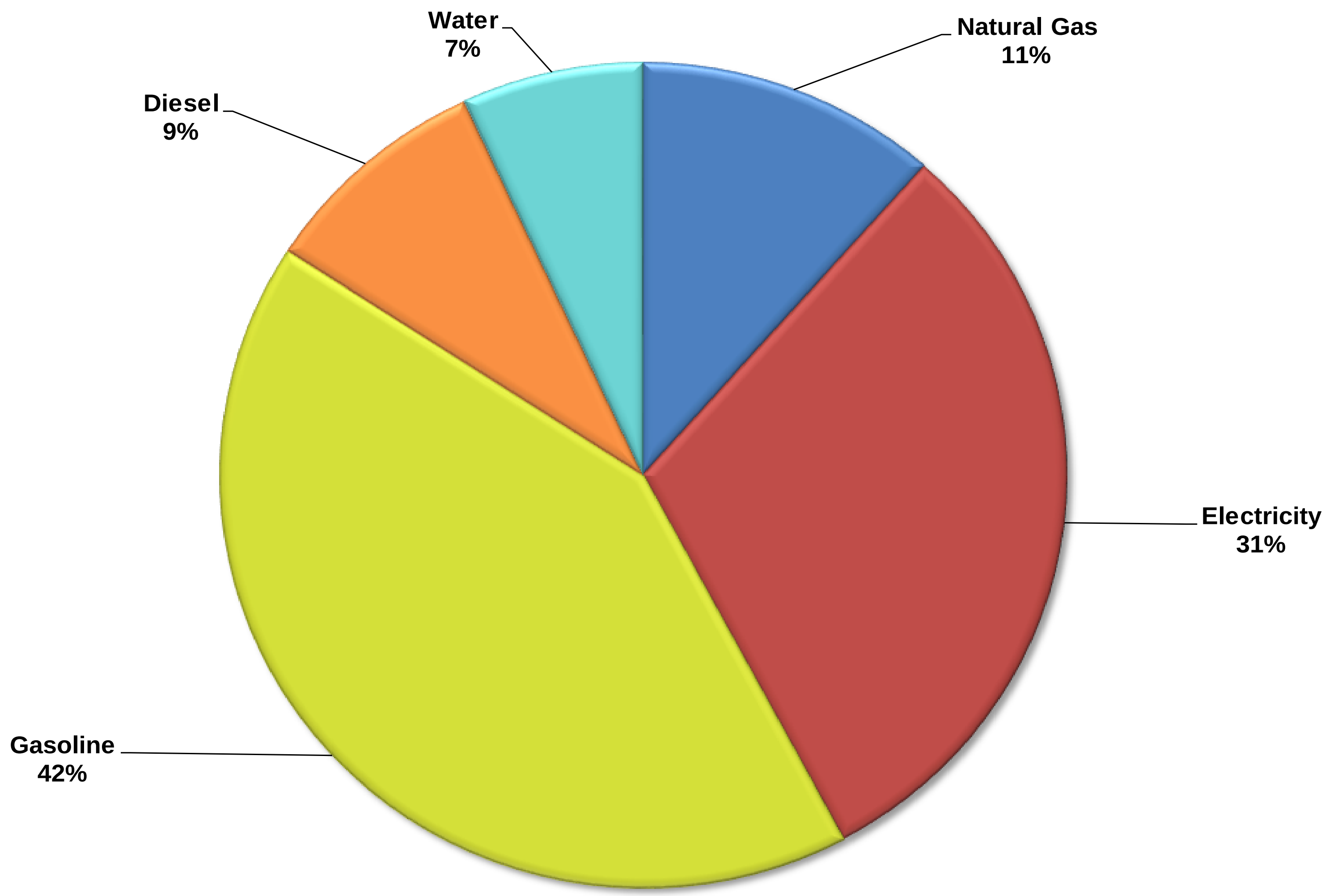

Figure 21: Brampton energy and water costs (%) by utility in 2016.

Energy costs in Brampton are projected to increase to $7.6 billion by 2050 under a lower range of cost projections. Figure 22 shows the annual projected increases to energy costs in Brampton from 2016 to 2050 by fuel type (including carbon) under the lower range of cost projections.

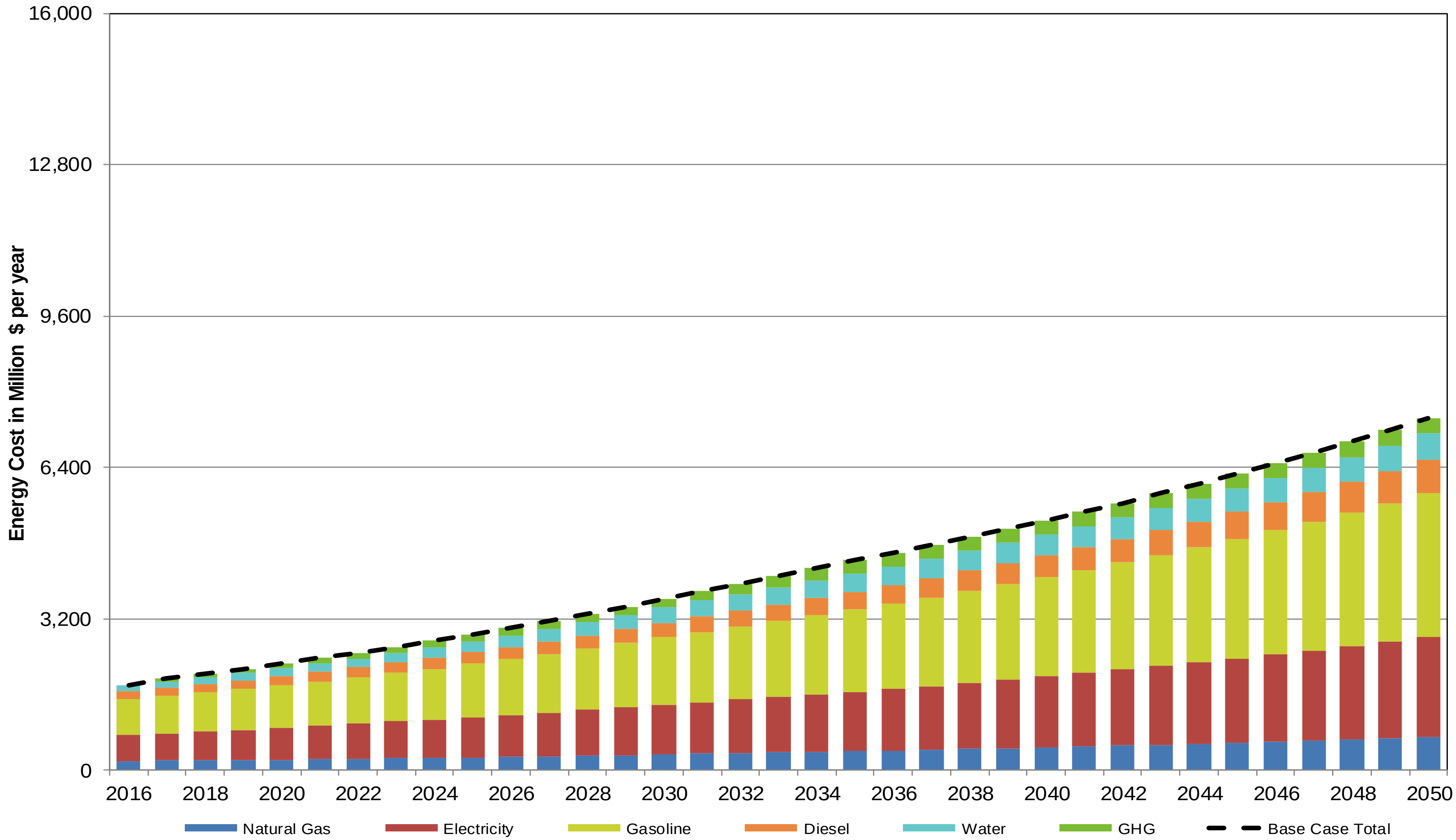

Figure 22: Annual projected increases to energy and water costs ($) in Brampton from 2016 to 2050 by fuel type (including carbon) under the lower range of cost projections.

Annual energy costs in Brampton are projected to increase to $15 billion by 2050 using a higher range of cost projections. Figure 23 shows the annual projected increases to energy costs in Brampton from 2016 to 2050 by fuel type (including carbon) under the higher range of cost projections.

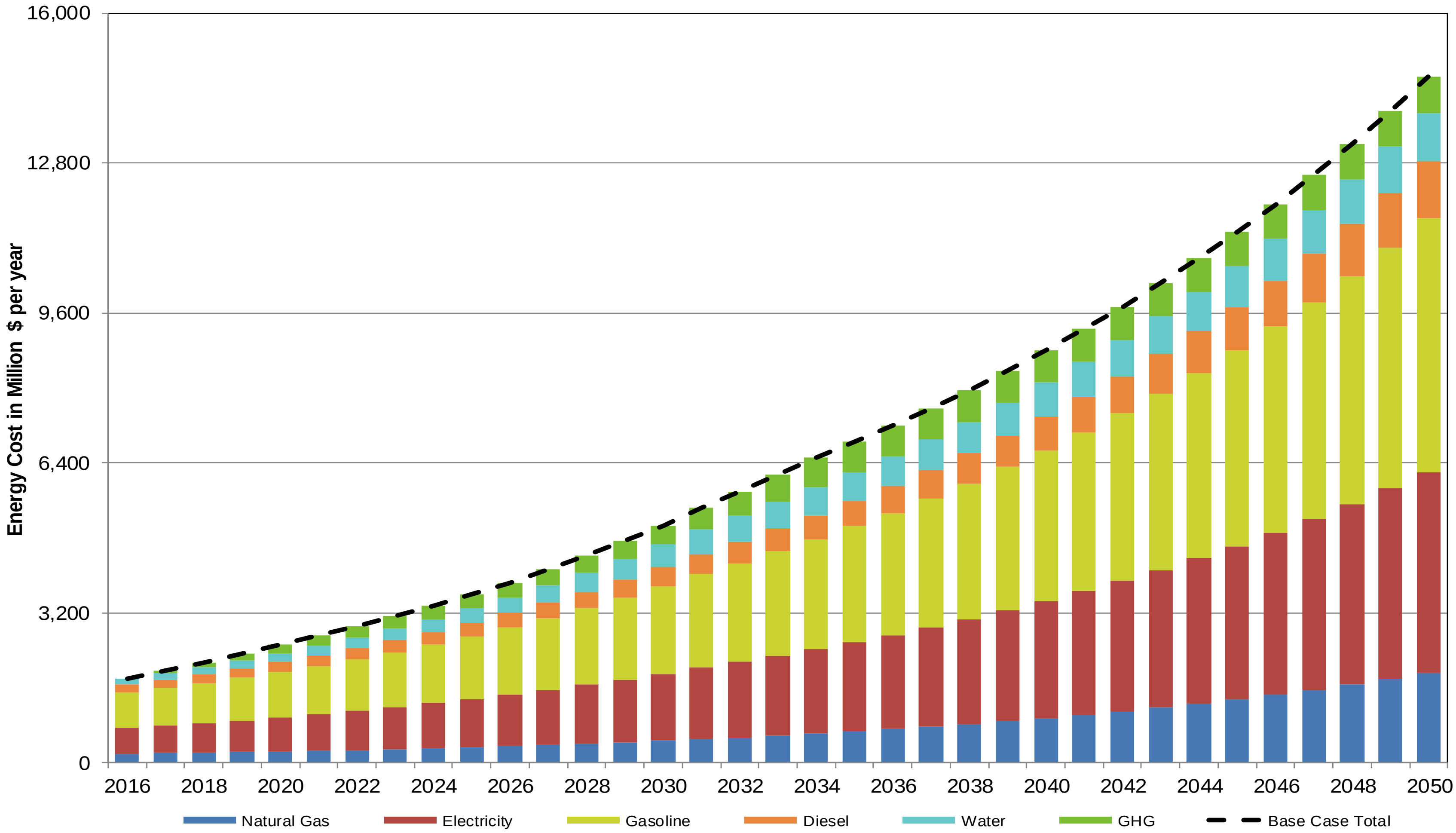

Figure 23: Annual projected increases to energy and water costs ($) in Brampton from 2016 to 2050 by fuel type (including carbon) under the higher range of cost projections.

Water

Brampton ratepayers consumed 64 million m3 of water in 216. Figure 24 shows water consumption by sector 2016. The residential sector consumed 73% of the water used in 2016.

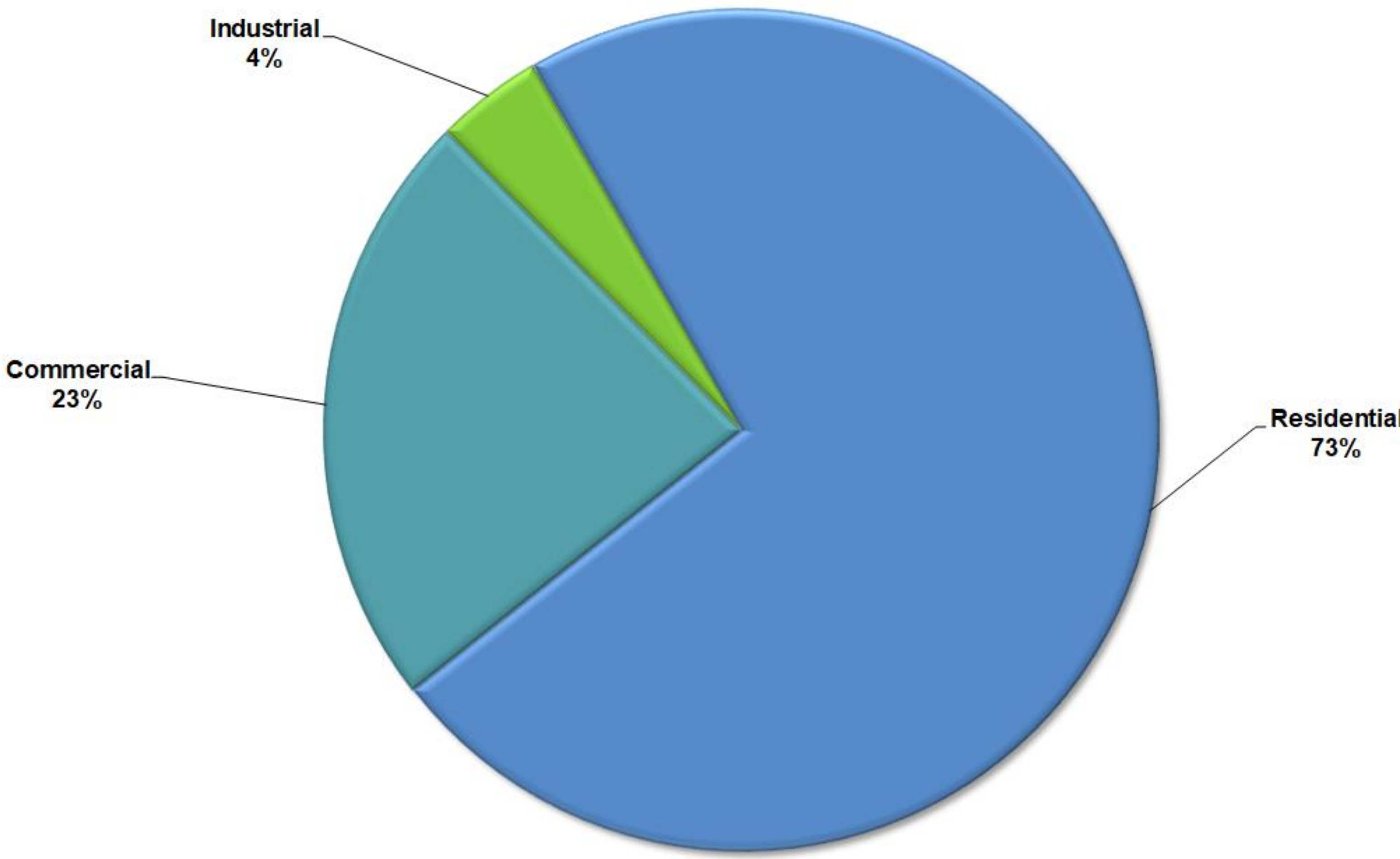

Figure 24: Brampton water consumption (%) by sector in 2016.

Figure 25 shows relative water use (cubic metre/km^2) by energy planning district in Brampton in 2016.

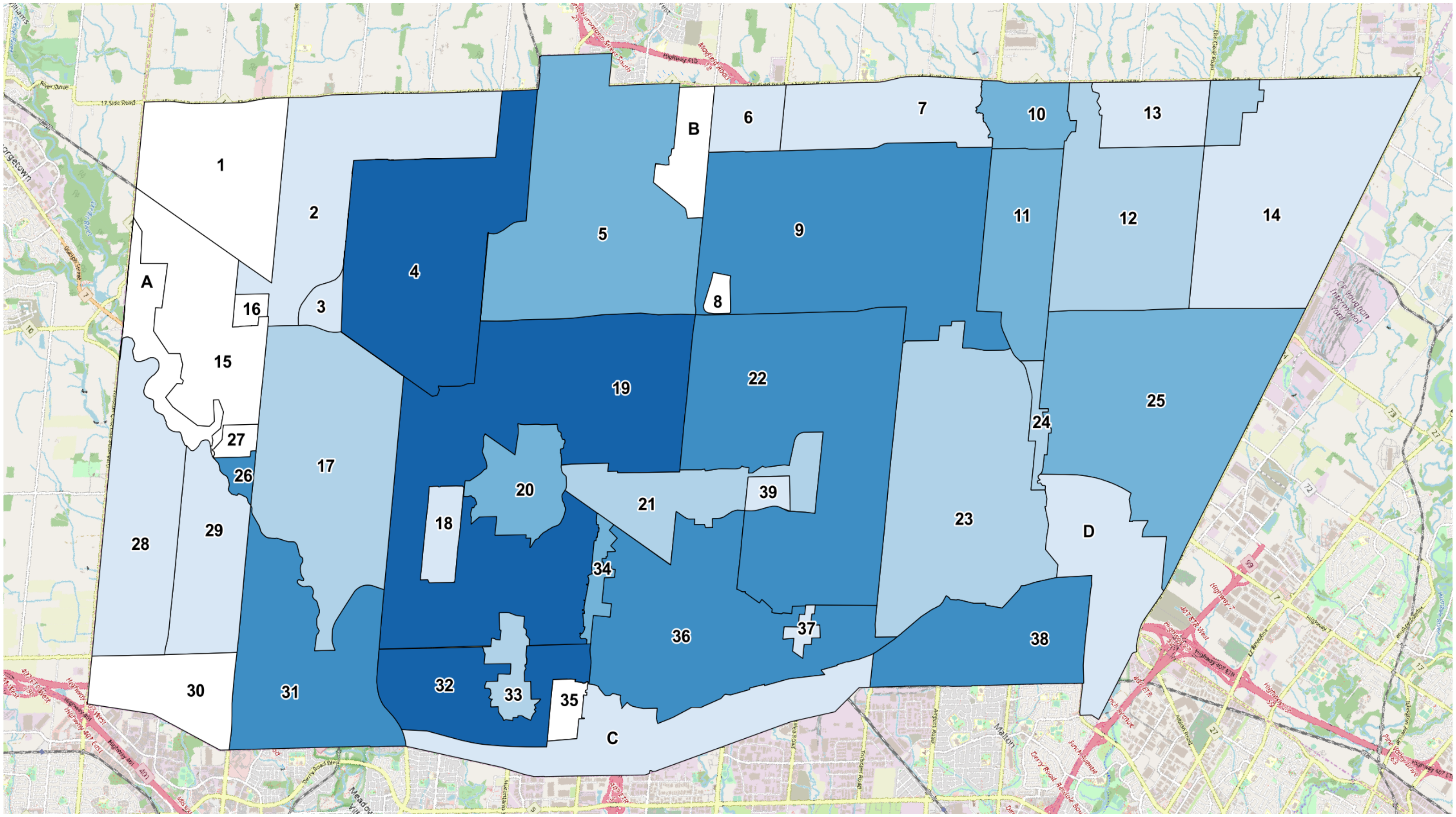

Figure 25: Water use (cubic metre/km2) for homes and buildings in 2016 by energy planning district (EPD) in Brampton. Darker coloured EPDs have relatively higher total water use density.

Figure 26 shows projected water use (cubic metre/km^2) in 2050 by energy planning district in Brampton.

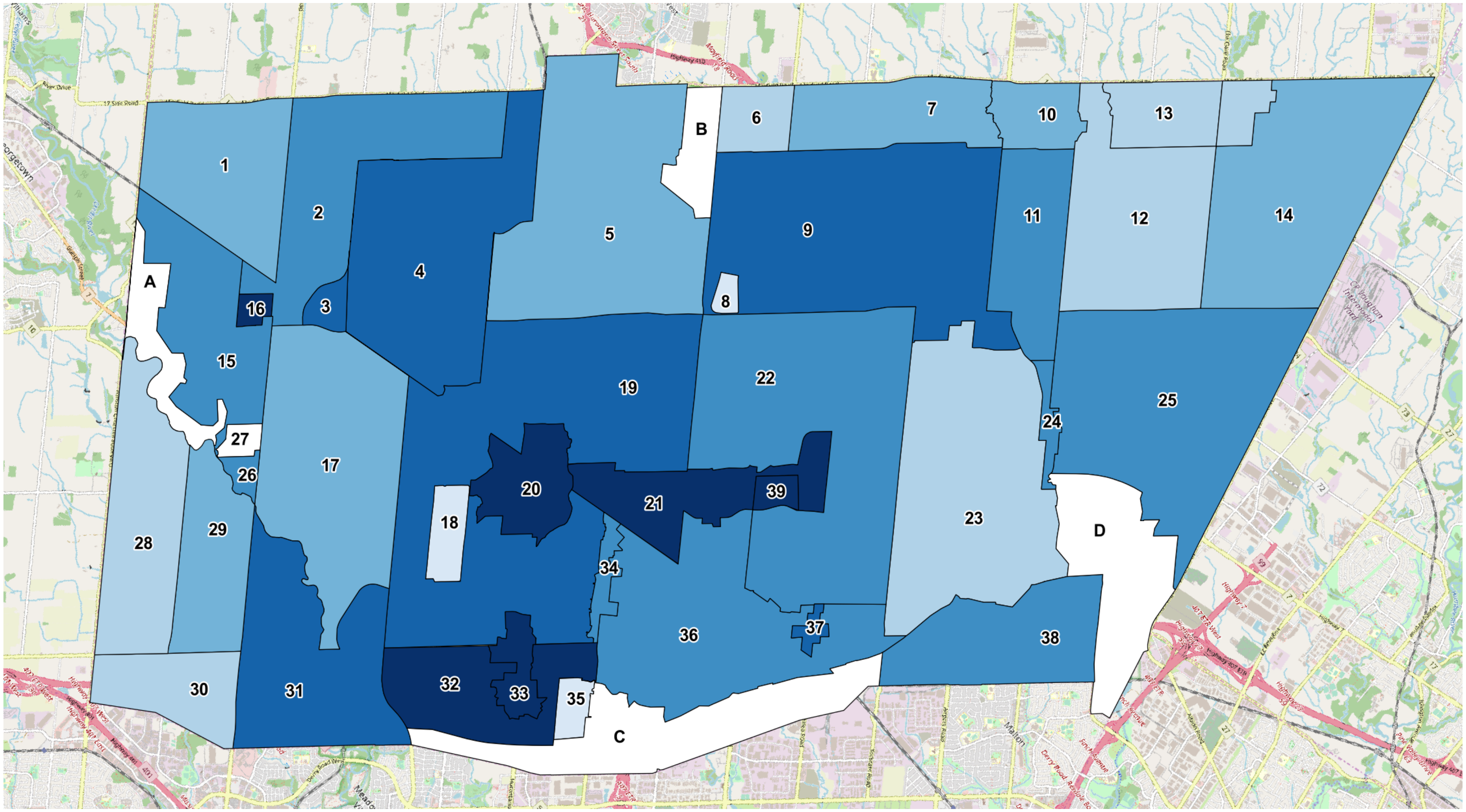

Figure 26: Projected relative water use for homes and buildings in 2050 by energy planning district (EPD) in Brampton. Darker coloured EPDs are projected to have relatively higher water use density.

Appendix 4 – Scenario 3 Simulation Assumptions

Appendix 4 provides details on the assumptions used for the Scenario 3 for the Reference and High Action Efficiency Case simulations. Simulation results are found in Appendix 5.

Contents

Overview

The next section provides details for:

- the measures simulated;
- the variable(s) chosen for the Reference Case simulation for each measure by the Project Working Team (PWT); and
- the variables that could be modified for each measure which were considered by the PWT.

Scenario 3 – Reference Efficiency Case Simulation Variables

Efficiency of existing homes and buildings

- Measure
  - most property to be retrofitted by 2041
- Reference Case variables
  - 80% of homes
  - 60% of buildings
  - efficiency gain approximately 33% / retrofit
- Simulation variables
  - market share
  - start and completion date
  - up to 25% more efficient retrofits

Efficiency of existing homes and buildings

- Measure:
  - new property 100% OBC compliant
- Reference Case variables
  - 1% above code to 2021
  - code increases of 10% in 2022 and 2032
- Simulation variables
  - 1% to 10% for each code change
  - years of code changes

Efficiency of industry

- Measure:
  - world-class continuous improvement
- Reference Case variables
  - 1% per year
- Simulation variables
  - 0% to 2% in 0.5% steps

District energy in existing and new areas & efficient local heat and electricity generation

- Measure:
  - implement district heating (DH) in target energy planning districts (EPDs)
- Reference Case variables
  - 70% of existing target property by 2041
  - 80% for new target property in year built
  - DH start in 2022
  - combined heat and power (CHP) implemented in 2023
  - EPDs 18, 19, 20, 21, 23, 32, 33, 34, 35, 36, 37 and 39 were identified by the PWT for densification based on City plans.
  - EPDs 1, 2, 6, 7, 14, 15, 16, 25, 26, 27, 28, 29, 30, 38 were identified by the PWT for net zero development based on City plans
- Simulation variables
  - shares from 40% to 90%
  - DH and CHP start year from 2021 to 2027
  - EPD selection
  - technical efficiencies – various

Renewable solar heat and electricity generation

Heat

- Measure
  - solar thermal on residential property not served by DE
- Reference Case variables
  - 10% share on target home heating and domestic hot water by 2041
- Simulation variables

    - share from 0% to 25%
    - implementation year

Electricity Generation

- Measure
    - solar PV on suitable rooftops and other locations
- Reference Case
    - 300 MW installed
    - Allocated by EPD power needs
- Simulation variables
    - Up to 400 MW in 50 MW steps

Transportation mix and efficiency

Trip length

- Measure
    - reduce average trip length
- Reference Case variables
    - 7.5% light-duty vehicle (LDV) trip length reduction
    - most impact in later years
- Simulation variables
    - up to 15% trip length reduction
    - vehicle category selectable

Modality

- Measure
    - increase active and shared transportation modes
- Reference Case variables
    - GO Train travel is 15% of person kilometers travelled (PKT) by 2051
    - Transit increase to 10% of PKT
    - Active transportation increases to 15% PKT
    - Most impact in later years
- Simulation variables
    - up to 20% mode share
    - vehicle category selectable

Fuel and Efficiency

- Measure
    - migrate to more efficient low-carbon vehicles
- Reference Case
    - LDVs & transit are 30% electric by 2051
    - heavy-duty vehicles (HDV) are 10% electric by 2051
    - liquid fuel vehicles achieve a 2% per annum efficiency gain
    - electric vehicles achieve a 1% per annum efficiency gain
    - linear year-to-year impact
- Simulation variables

    - up to 60% electric share
    - share selectable by major vehicle category
    - efficiency gains by vehicle type and fuel

Ontario electricity grid generating mix and natural gas network source mix

- Measure
    - anticipate lower carbon utilities
- Reference Case
    - electricity estimates used those of The Atmospheric Fund (TAF)
    - natural gas assumed a 1% per annum reduction
- Simulation variables
    - up to a 2% per annum reduction in natural gas

Scenario 3 – High-action Efficiency Case Simulation Variables

The following were the changes to the simulation variables:

- Existing home & building efficiency
    - increase share of retrofits to 90% by 2041 with 10% more efficient packages
- New home & building efficiency
    - 5% efficiency above Ontario Building Code
- Industrial efficiency
    - year-on-year improvement of 1.5% per year
- District heating
    - increase market shares to near 90% in target EPDs
    - combined heat and power (CHP) efficiency of 55%
- Solar thermal
    - double targeted share to 20% with start accelerated to 2020
- Solar PV
    - increase total installed capacity to 400 megawatt (MW)
- Transportation energy
    - increase of LDV trip reduction to 10%
    - increase transit to 15% of share
    - increase non-vehicle efficiency to 3% per year
    - increase percentage of electric LDV and transit buses to 60%

Appendix 5 – Efficiency Case Performance

This appendix provides additional information on the performance of the Reference Efficiency Case, as well as the High Action Efficiency Case. The Reference Efficiency Case was approved by the Task Force as the 2041 CEP Efficiency Case.

Contents

Background

Three scenarios were established for the simulations:

- Scenario 1
    - All end-use efficiency measures including transportation measures
- Scenario 2
    - All end-use efficiency measures including transportation measures
    - District heating
    - Solar thermal
- Scenario 3
    - All end-use efficiency measures including transportation measures
    - District heating
    - Solar thermal
    - Solar photovoltaic (PV)

Scenarios were simulated under three implementation regimens:

- low action
- reference
- high action

In addition to energy and emission reductions, the energy savings that would flow to the community were also estimated using a low and high price range.

Given the poor performance of Scenarios 1 and 2, the PWT eliminated these two scenarios from detailed consideration.

In addition, given the poor performance of Scenario 3 under the low action implementation regimen, it was also eliminated from detailed consideration.

Scenario 3 Reference Efficiency Case

Figure 1 shows the reduction in source energy use (Gigajoules (GJ)/capita) from 2016 to 2050 relative to the Base Case (dotted line) for Scenario 3 using the reference implementation regimen. The reduction in source energy use misses the energy framing goal by 10%.

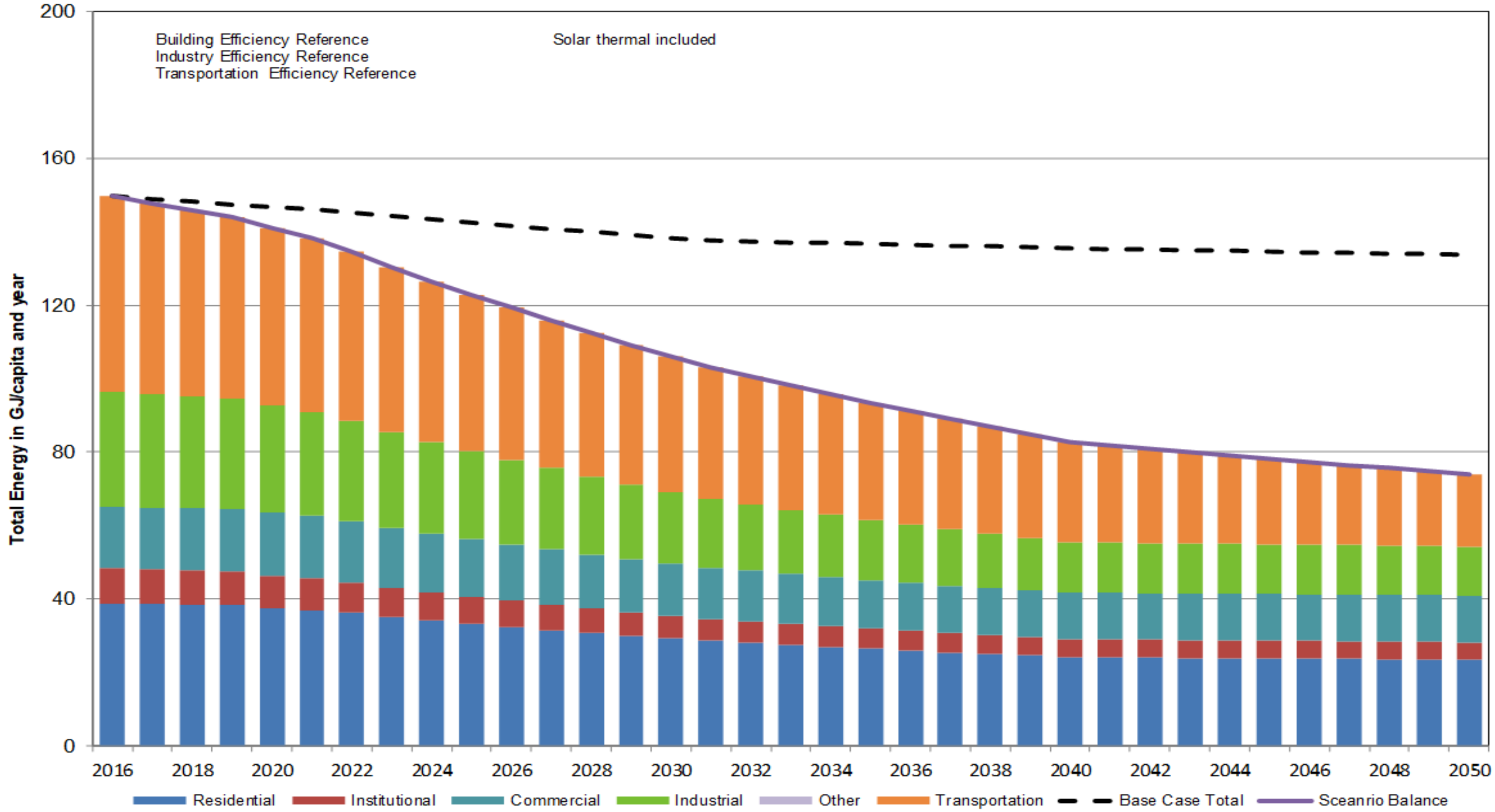

Figure 1: Projected reduction in source energy use (GJ/capita) by sector from 2016 to 2050 for Scenario 3 using the reference implementation regimen.

Figure 2 shows the performance of the three scenarios in reducing source energy use (GJ/capita) from 2016 to 2050 relative to the Base Case (black solid line) using the reference implementation regimen. All three scenarios miss the energy framing goal.

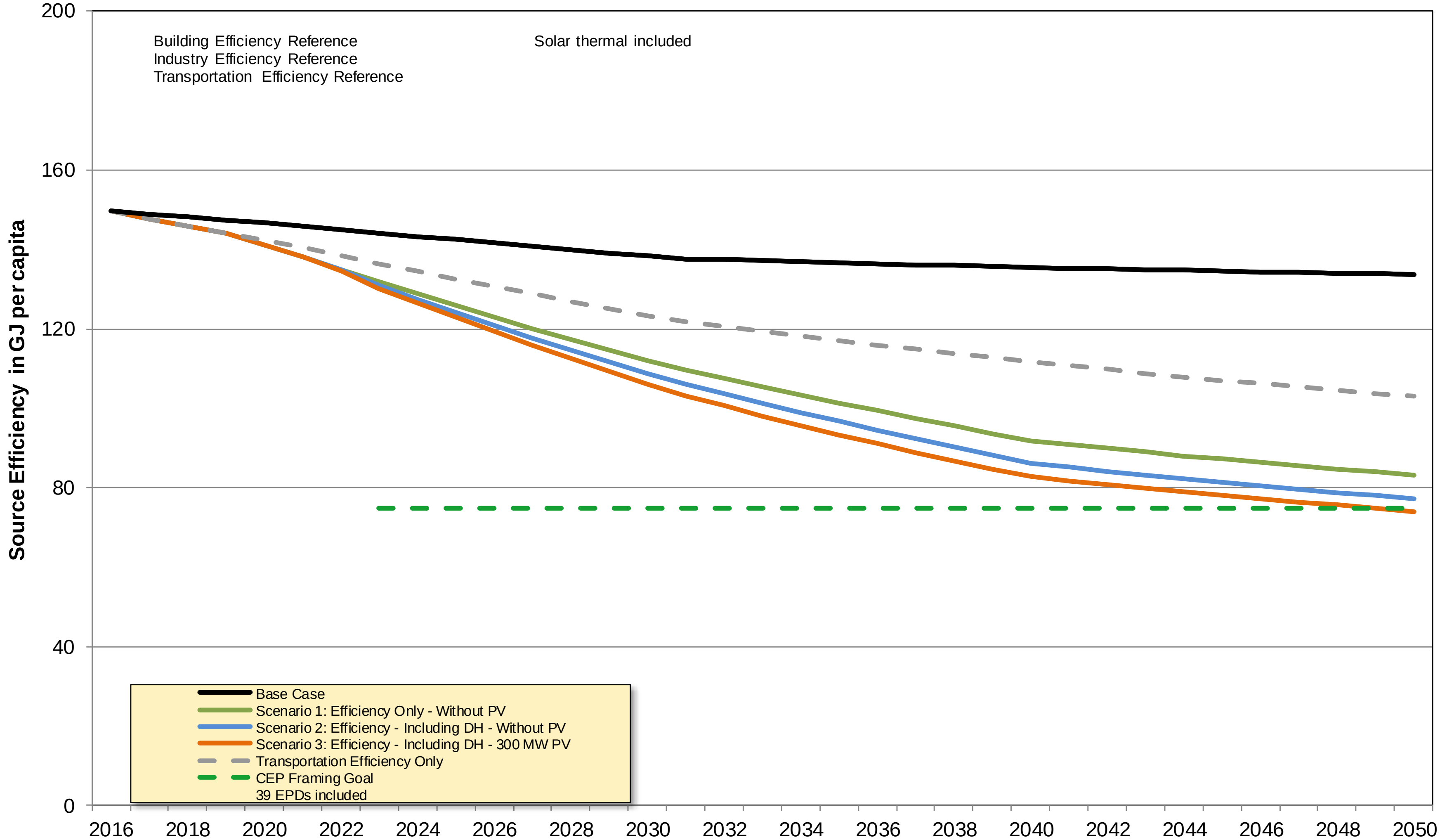

Figure 2: Projected reduction in source energy use (GJ/capita) by scenario from 2016 to 2050 using the reference implementation regimen.

Figure 3 shows the reduction in emissions (metric tons/year) from 2016 to 2050 relative to the Base Case (dotted line) for Scenario 3 using the reference implementation regimen. The reduction in emissions exceeds the emissions framing goal.

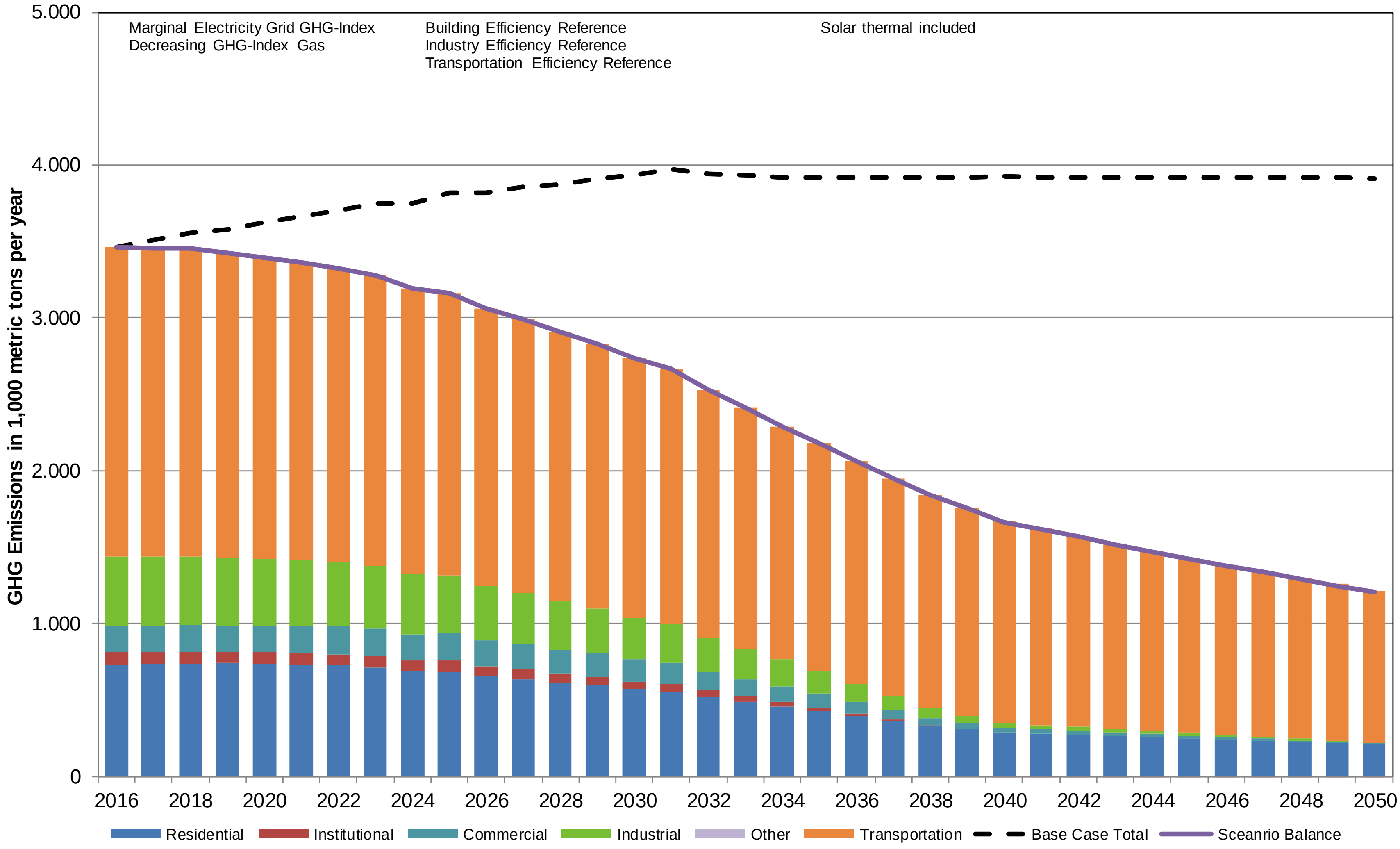

Figure 3: Projected reduction in greenhouse gas emissions (metric tons/year) by sector from 2016 to 2050 for Scenario 3 using the reference implementation regimen.

Figure 4 shows the performance of the three scenarios in reducing emissions (metric tons/year) from 2016 to 2050 relative to the Base Case (solid black line) using the reference implementation regimen. Scenarios 2 and 3 meet the emissions framing goal.

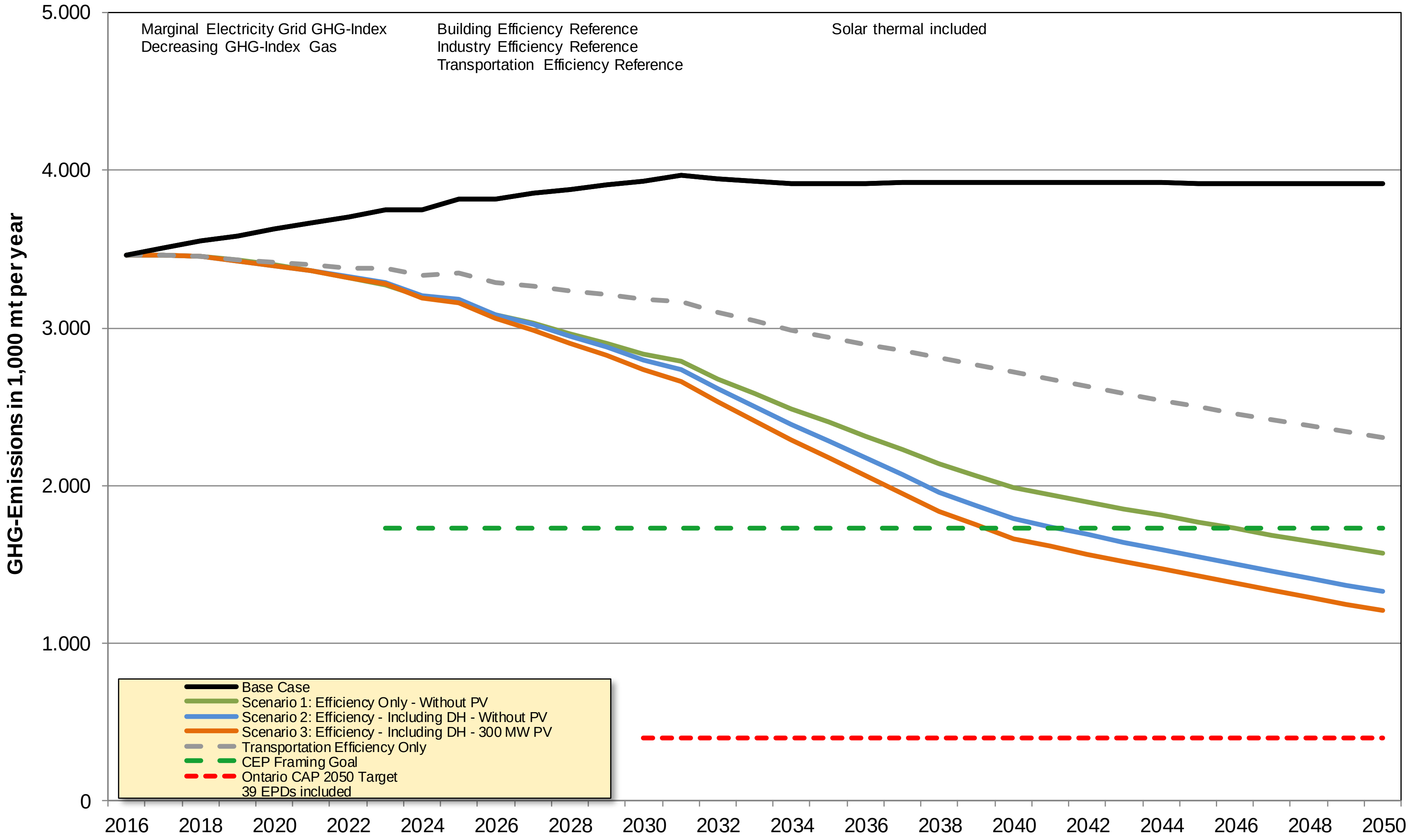

Figure 4: Projected reduction in greenhouse gas emissions (metric tons/year) by scenario from 2016 to 2050 using the reference implementation regimen.

Figure 5 shows the projected reduction in energy costs ($M) from 2016 to 2050 by fuel type, including carbon, relative to the Base Case (dotted black line) for Scenario 3 using the reference implementation regimen and the low energy price range. Estimated cumulative energy savings are $56 billion by 2050.

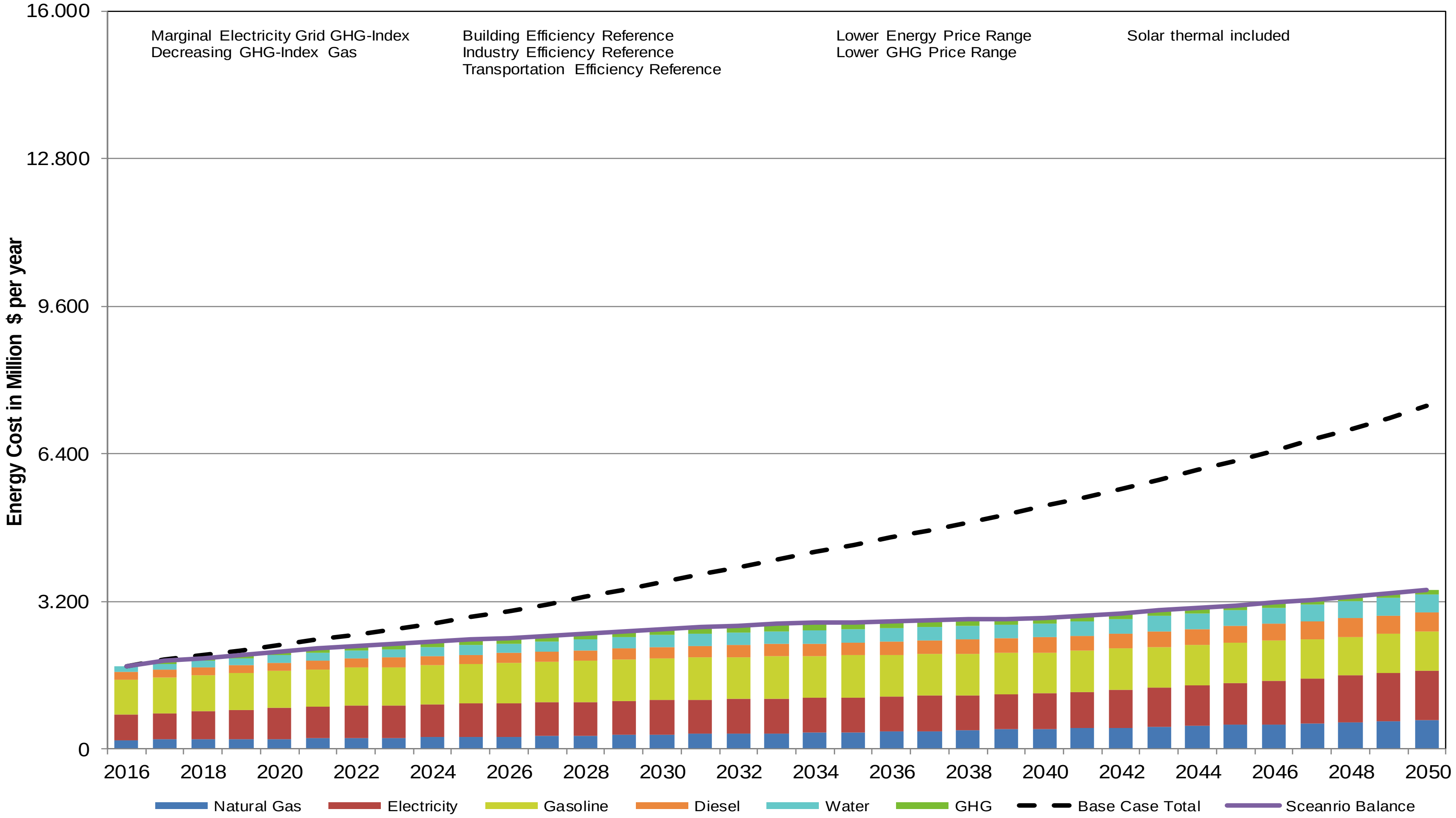

Figure 5: Projected reduction in energy costs ($M) by fuel type, including carbon, from 2016 to 2050 using the reference implementation regimen and the low energy price range.

The graph in figure 6 shows the projected reduction in energy costs ($) from 2016 to 2050 by fuel type, including carbon, relative to Base Case (dotted black line) for Scenario 3 using the reference implementation regimen and the high energy price range. Estimated cumulative energy savings are $93 billion by 2050.

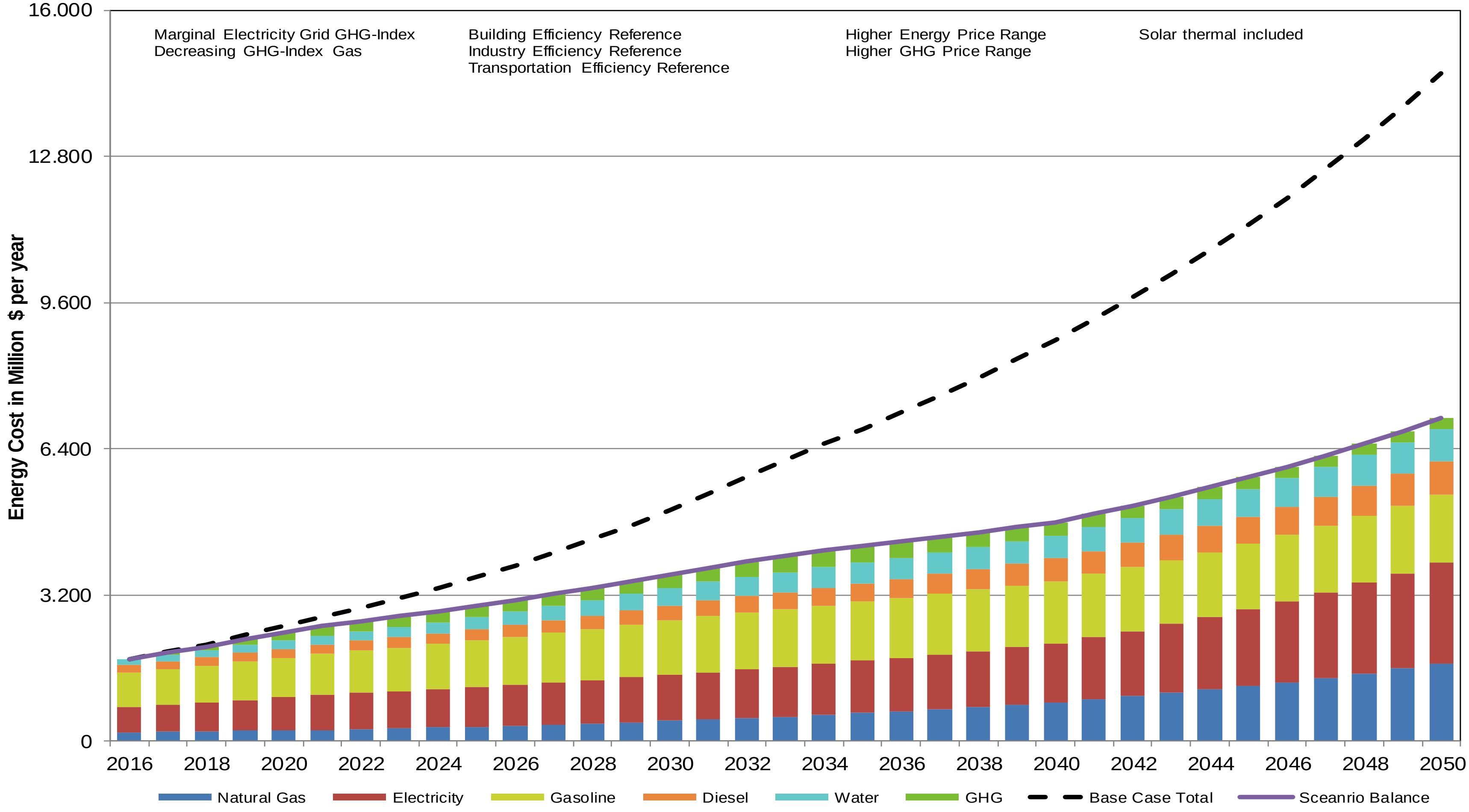

Figure 6: Projected reduction in energy costs ($) by fuel type from 2016 to 2050 for Scenario 3 using the reference implementation regimen and the higher energy price range.

Scenario 3 High Action Efficiency Case

Figures 7 to 12 provide the analytical outputs of the performance of Scenario 3 under a high action implementation regime.

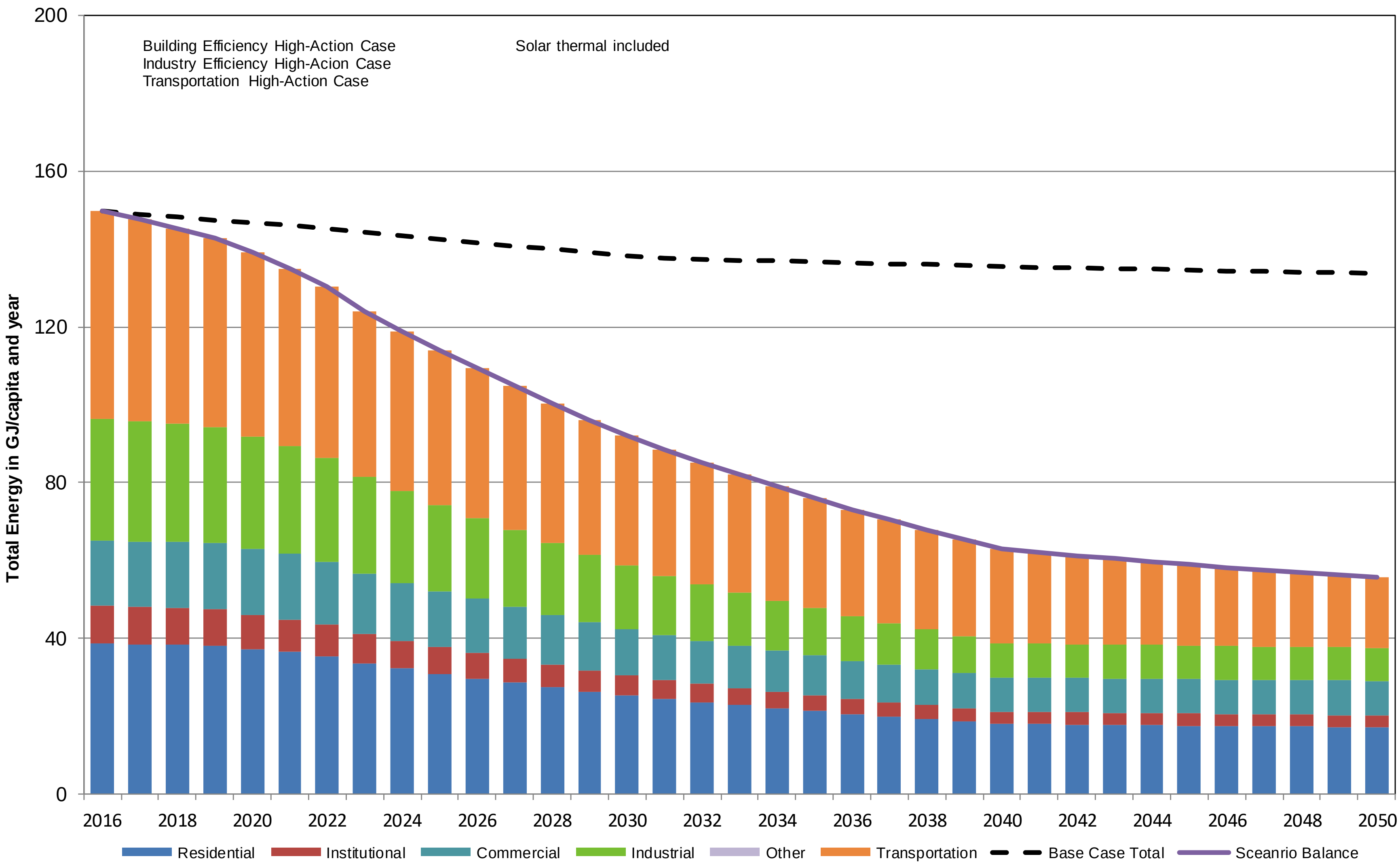

Figure 7: Projected reduction to source energy efficiency (GJ/capita) by sector from 2016 to 2050 for Scenario 3 using the high action implementation regimen.

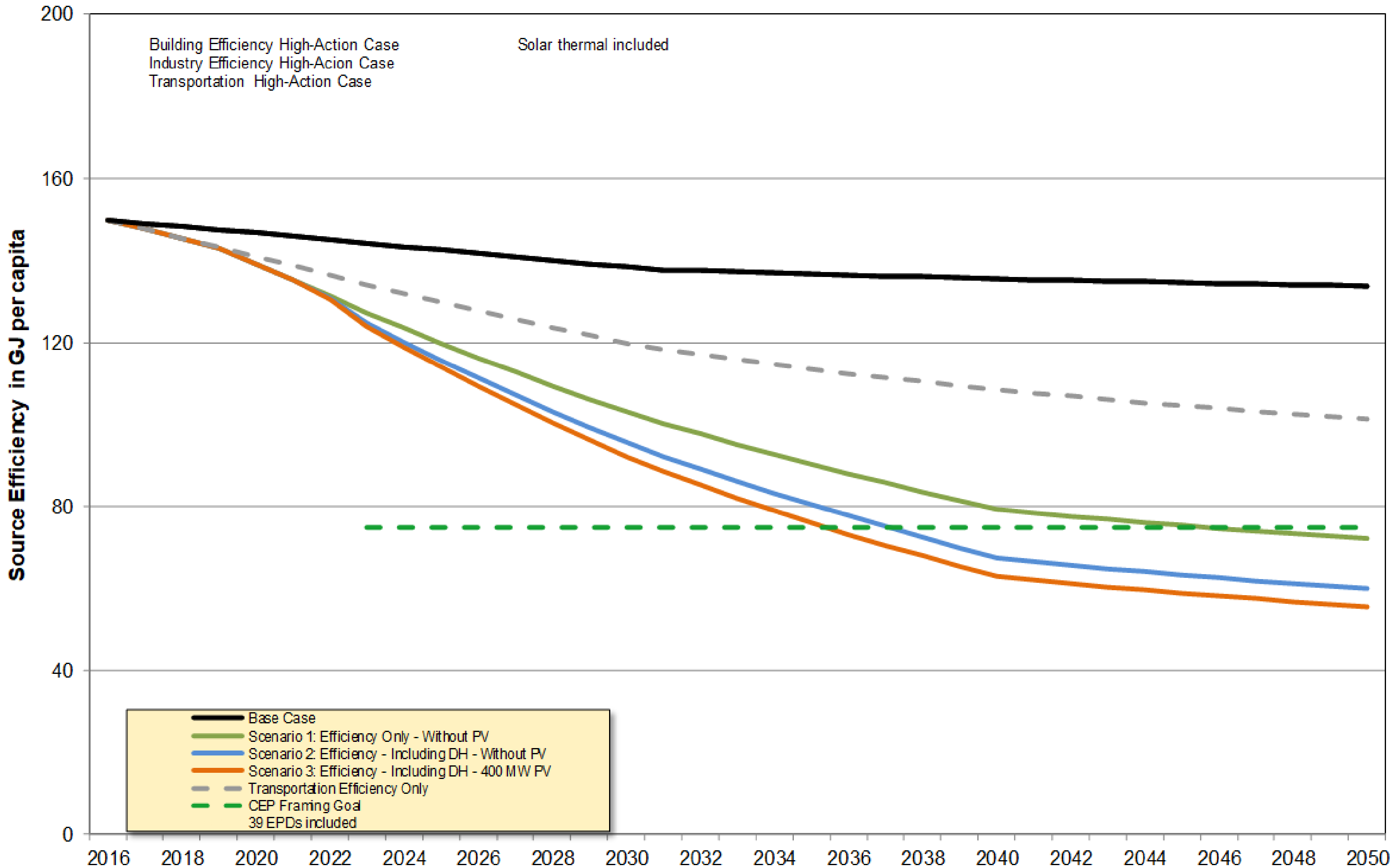

Figure 8: Projected reduction in source energy use (GJ/capita) by scenario from 2016 to 2050 using the high action implementation regimen.

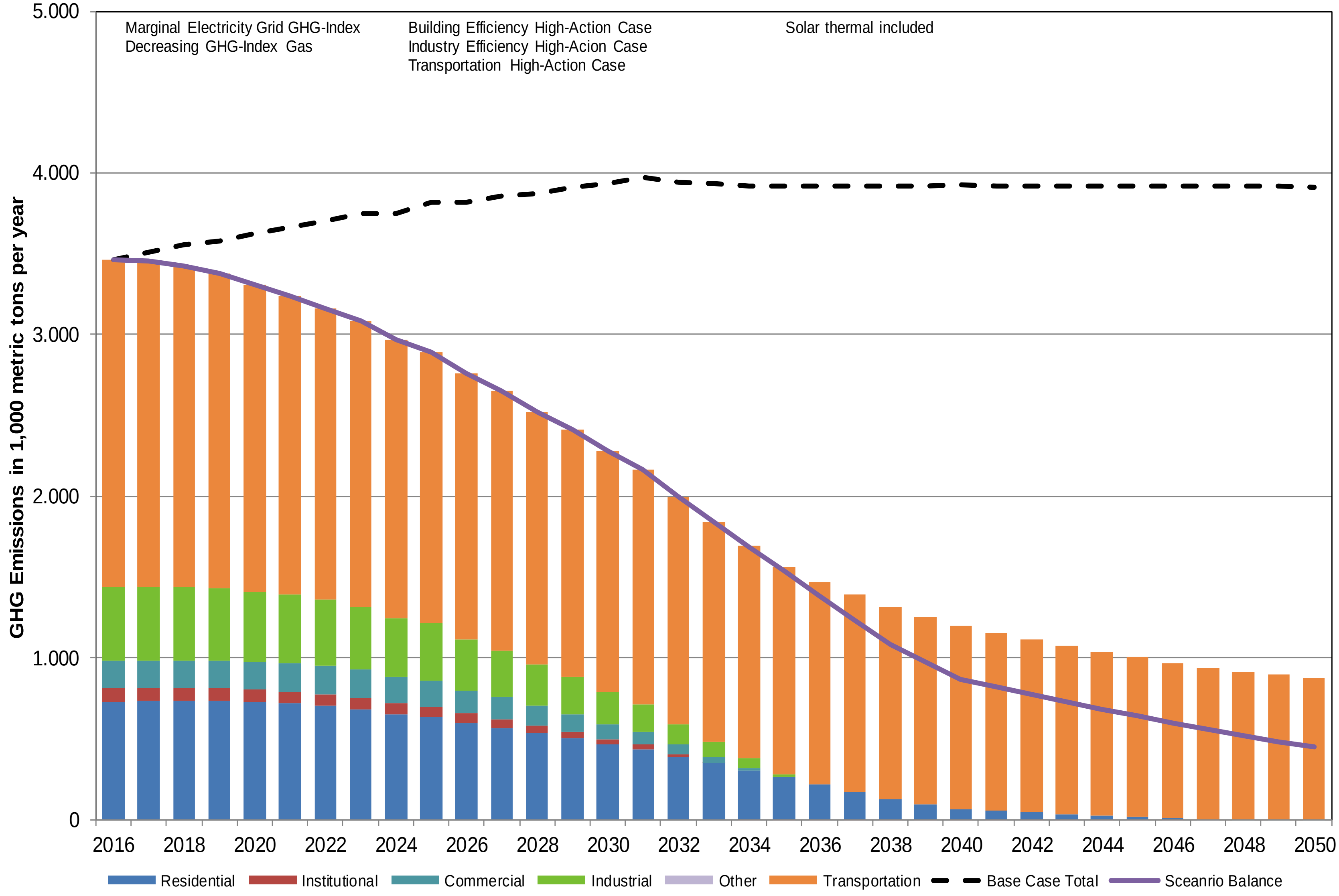

Figure 8: Projected reduction to greenhouse gas emissions (metric tons/year) by sector from 2016 to 2050 for Scenario 3 using the high action implementation regimen.

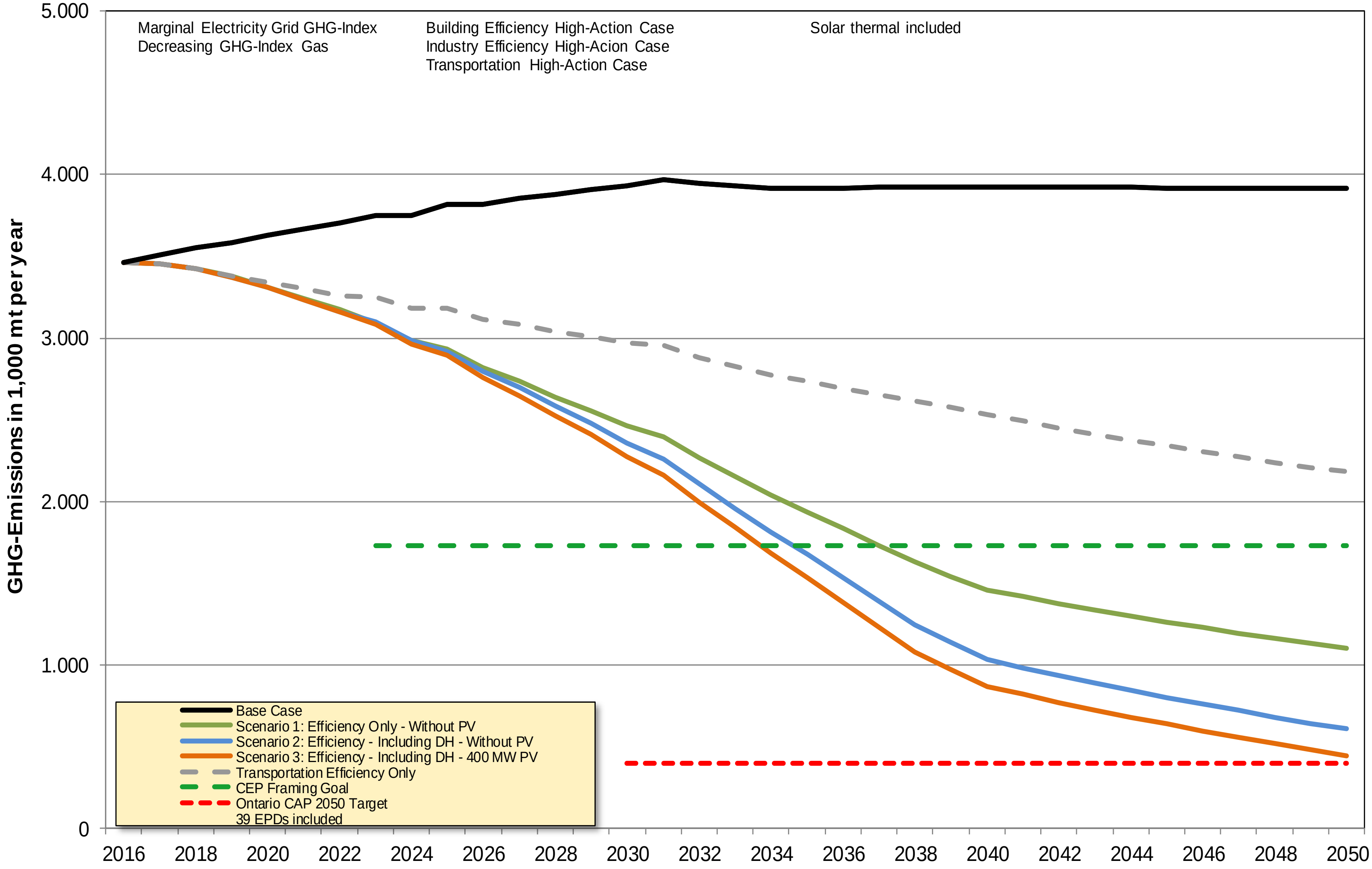

Figure 9: Projected reduction in greenhouse gas emissions (metric tons/year) by scenario from 2016 to 2050 using the high action implementation regimen.

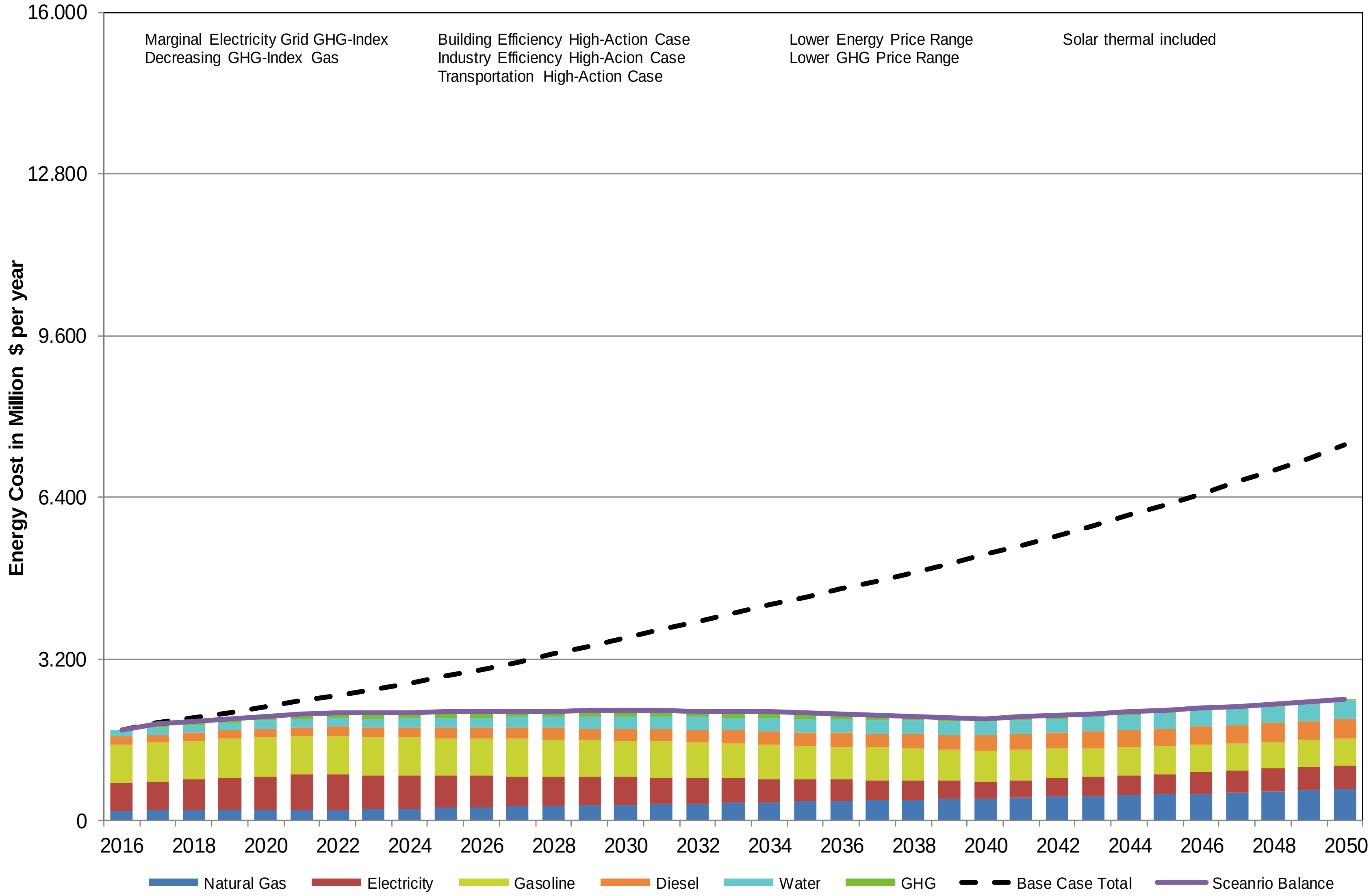

Figure 10: Reduction in energy costs ($) by fuel type (including carbon) from 2016 to 2050 under the high action implementation regime and low energy price range. Estimated cumulative savings of $74 billion.

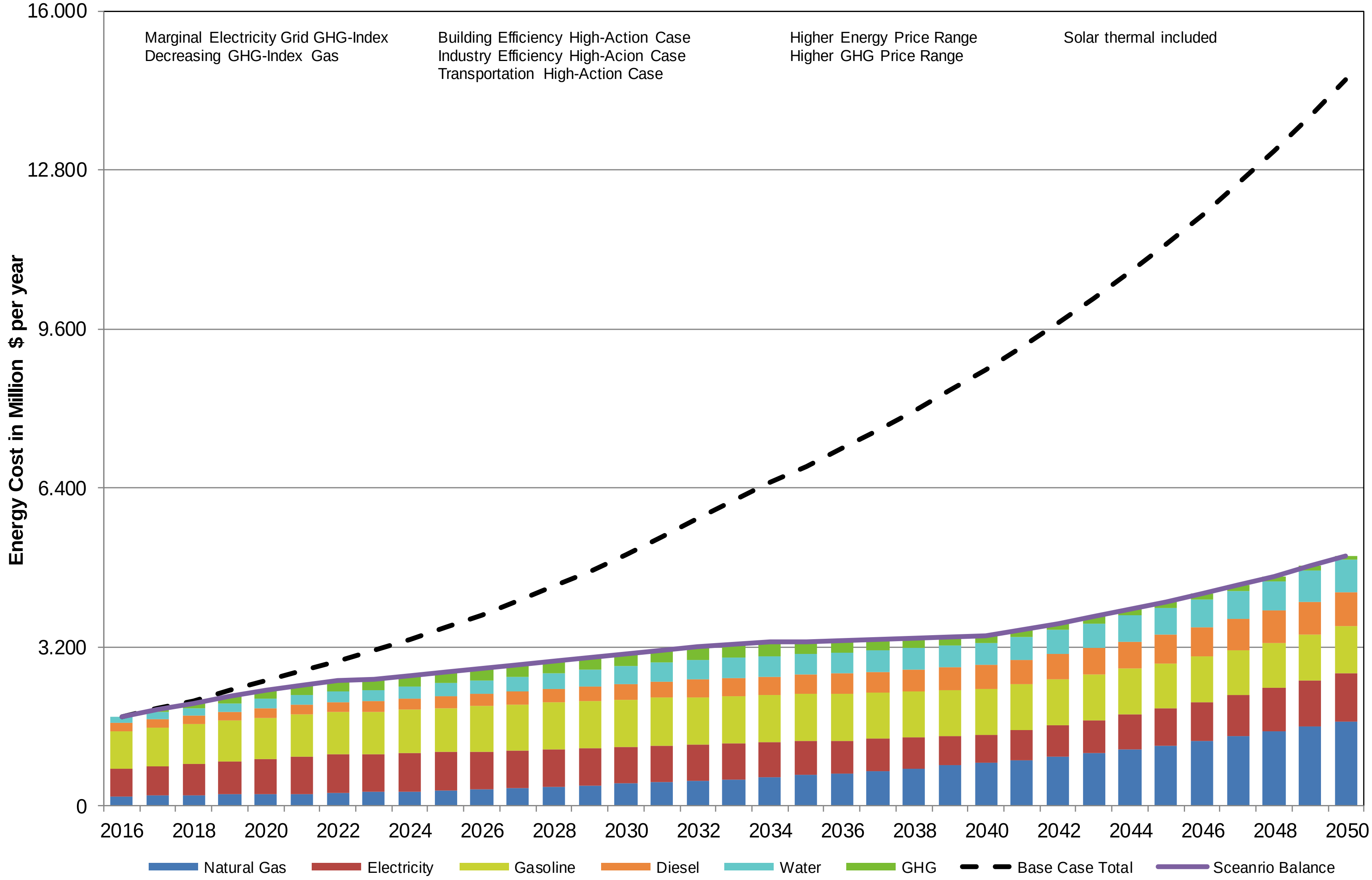

Figure 11: Reduction in energy costs ($) by fuel type (including carbon) from 2016 to 2050 under the high action implementation regime and high energy price range. Estimated cumulative savings of $123 billion.

Appendix 6 – Brampton Sankey Diagrams

This appendix summarizes the Brampton Sankey diagrams produced by the PWT.

Contents

1. What are Sankey diagrams?

Sankey diagrams have been named after Irish Captain Matthew Henry Phineas Riall Sankey. He developed the diagram in 1898 to illustrate the energy efficiency of a steam engine. Sankey diagrams continue to be used today to show the energy flow through a system and to identify opportunities to improve efficiency.

2. Why is the Sankey diagram important?

Community energy and emission reduction plans should consider all local energy flows from source to end-use to identify opportunities to increase efficiency from supply through distribution to end use.

A Sankey diagram illustrates the opportunity for efficiency at end-use (refer to green flows on the right of each of the following diagrams) as well as opportunities to improve system efficiency[1] (refer to light grey and dark grey flows on the right of each the following diagrams). Energy use, emissions and cost flow from the left to right through the system. Figure 1 describes how to read a Sankey diagram.

3. Brampton Sankey diagrams

Sankey diagrams were developed to show the energy use (Figures 2a, 2b, 2c), emissions (Figures 3a, 3b, 3c) and cost (Figures 4a, 4b, 4c) flows for the Brampton 2016 baseline (Figures

[1] Conversion losses occur when energy is transformed from one form to another (e.g., fossil fuel is converted to electricity). Additional system losses occur when energy is moved from one place to another (e.g., the transmission of electricity from point of generation to homes and businesses), or from one system to another.

2a, 3a, 4c) and in 2050 under two scenarios: Base Case (Figures 2b, 3b, and 4b) and CEERP Efficiency Case (Figures 2c, 3c and 4c).

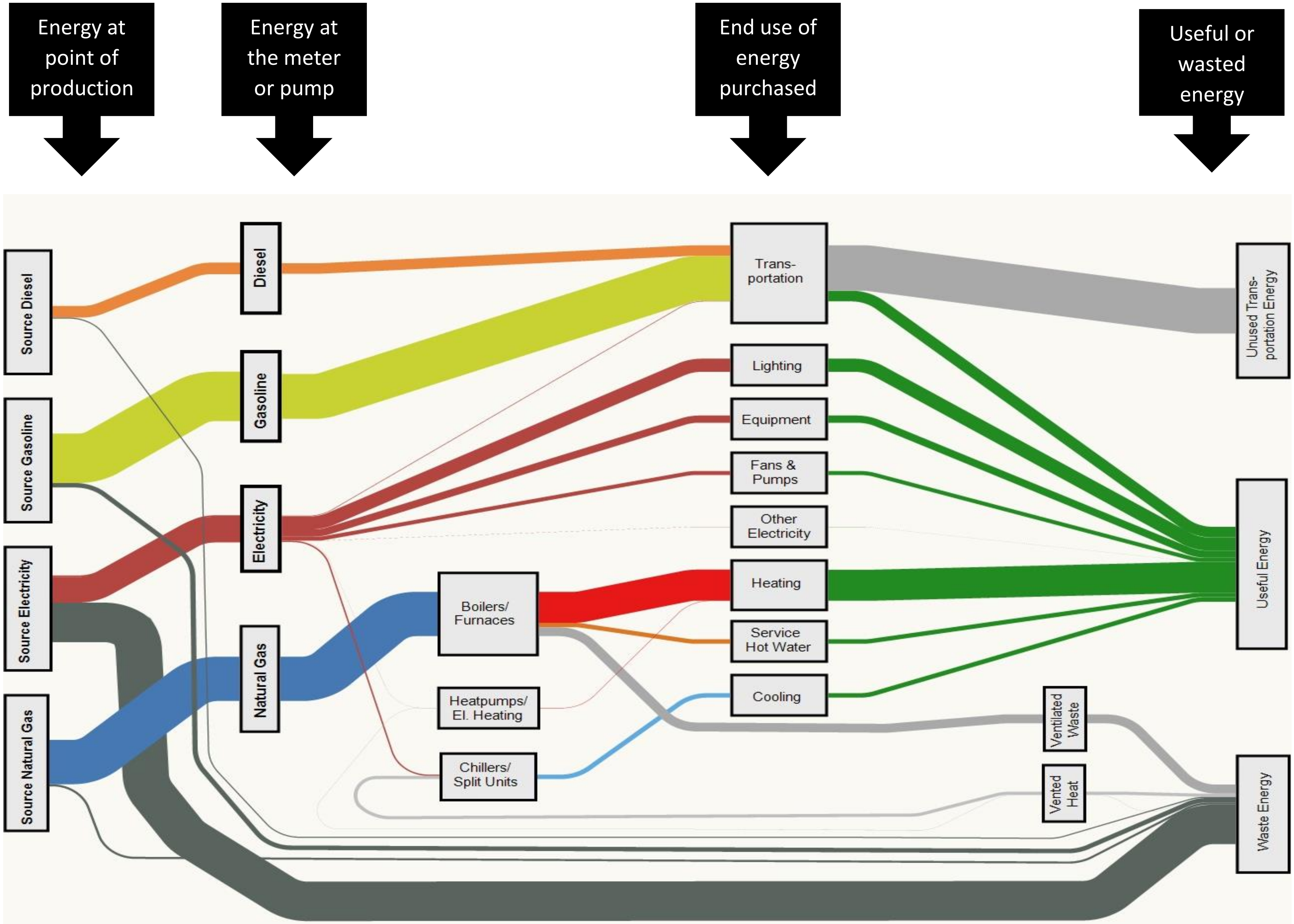

Figure 4: How to read the Sankey diagram.

3.1 Energy use

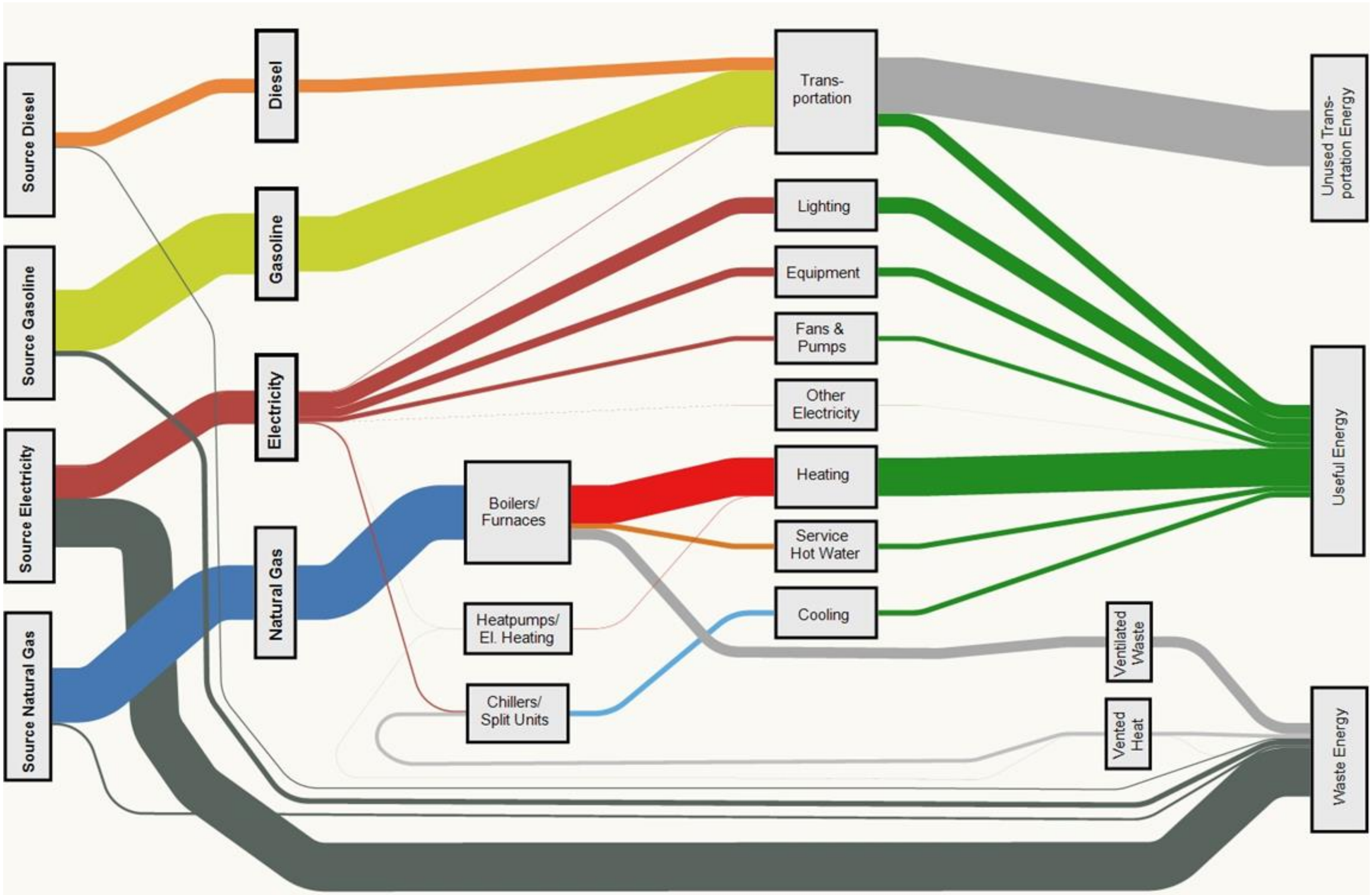

Figure 2a: Brampton Sankey diagram for 2016 baseline energy use.

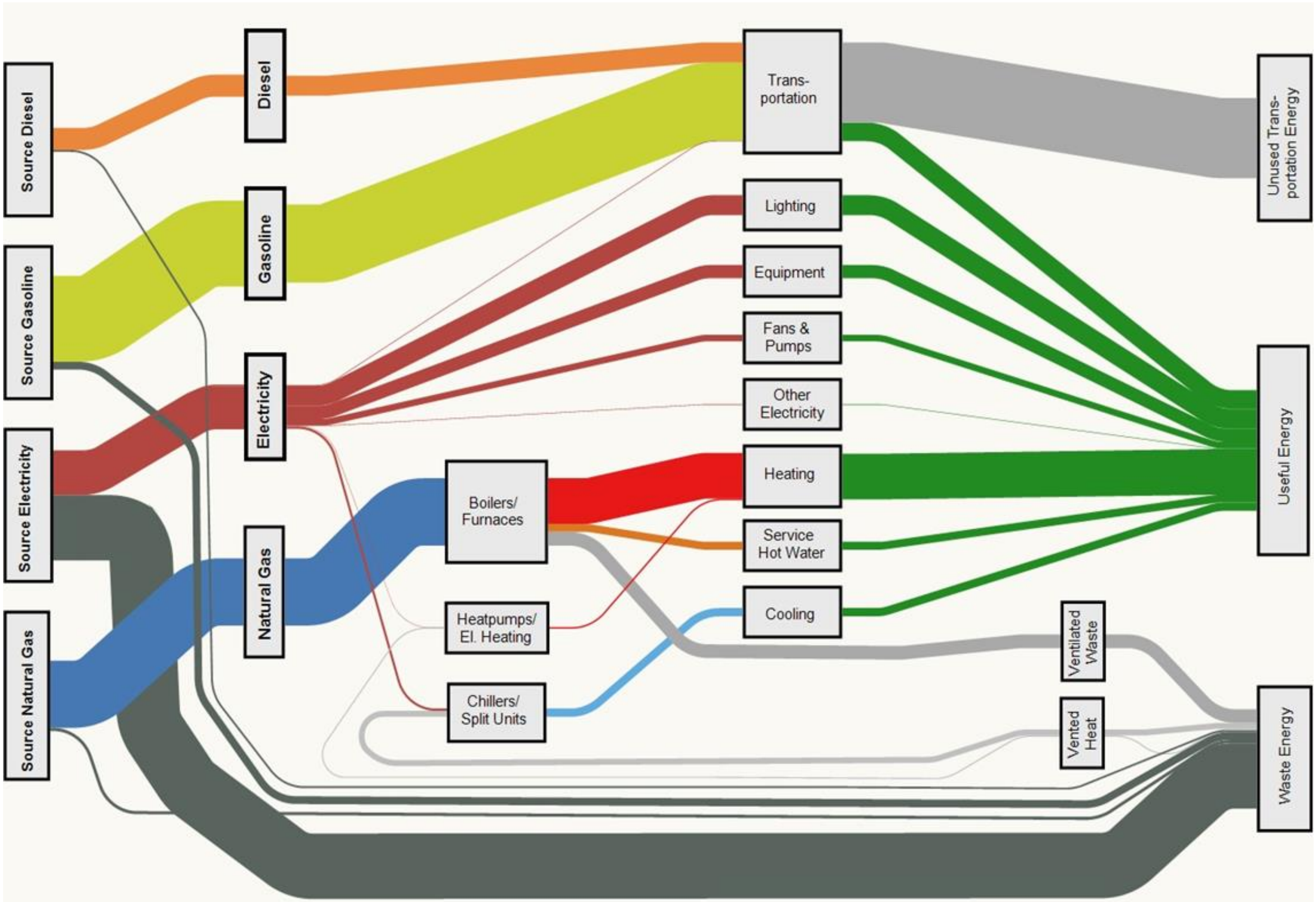

Figure 2b: Brampton Sankey diagram for 2050 Base Case energy use.

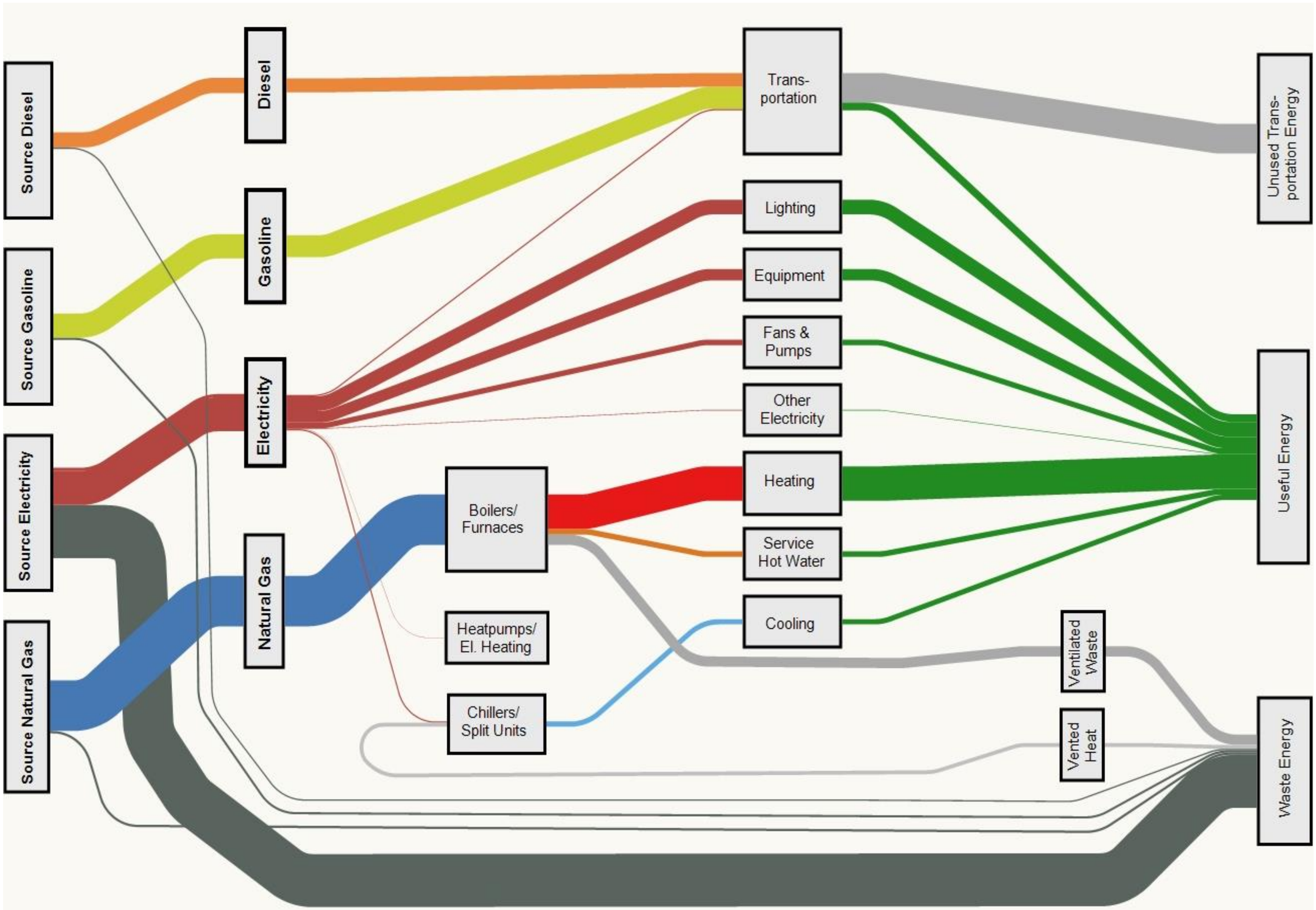

Figure 2c: Brampton Sankey diagram for 2050 CEERP Efficiency Case energy use.

3.2 Emissions

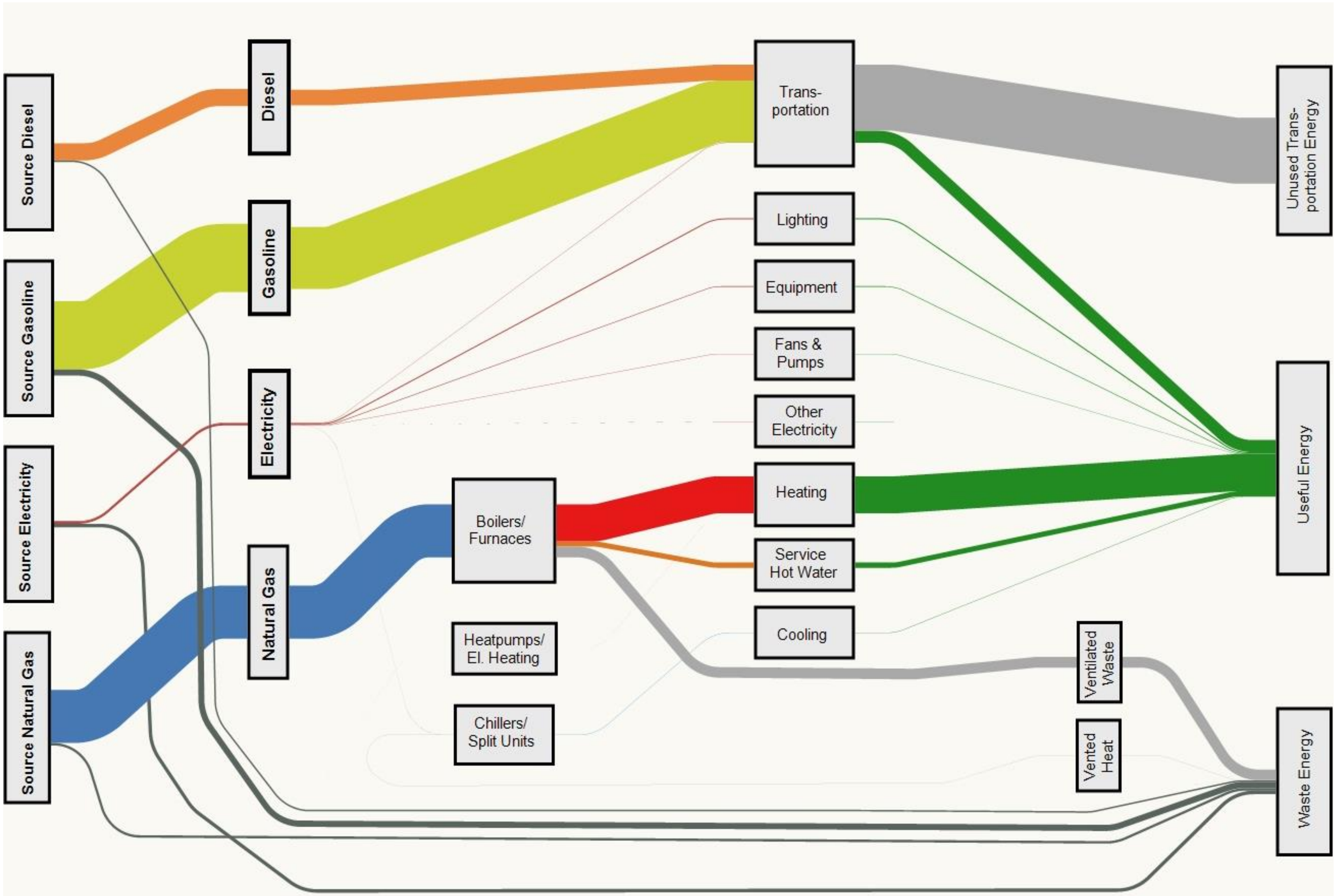

Figure 3a: Brampton Sankey diagram for 2016 baseline emissions.

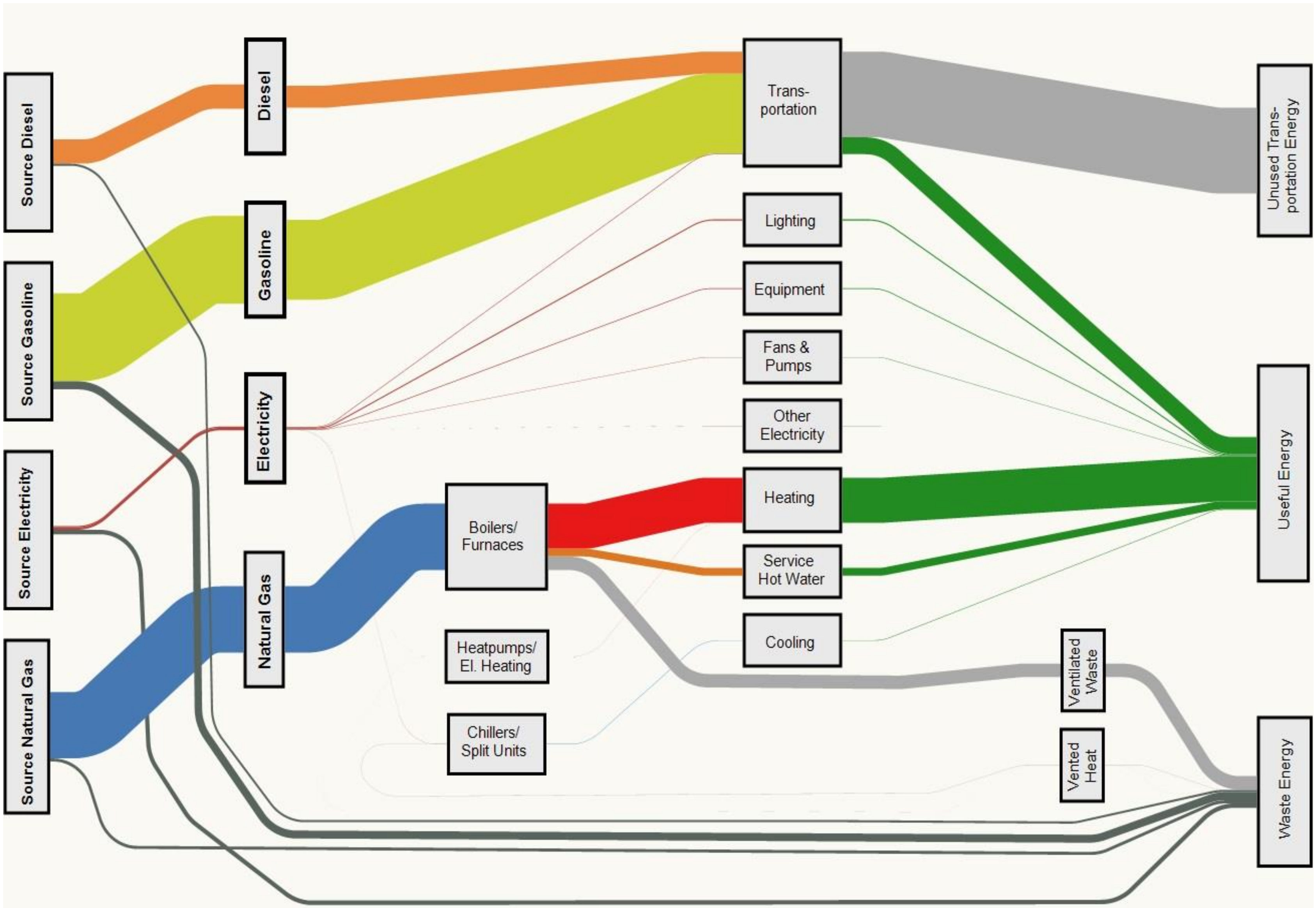

Figure 3b: Brampton Sankey diagram for 2050 Base Case greenhouse gas emissions.

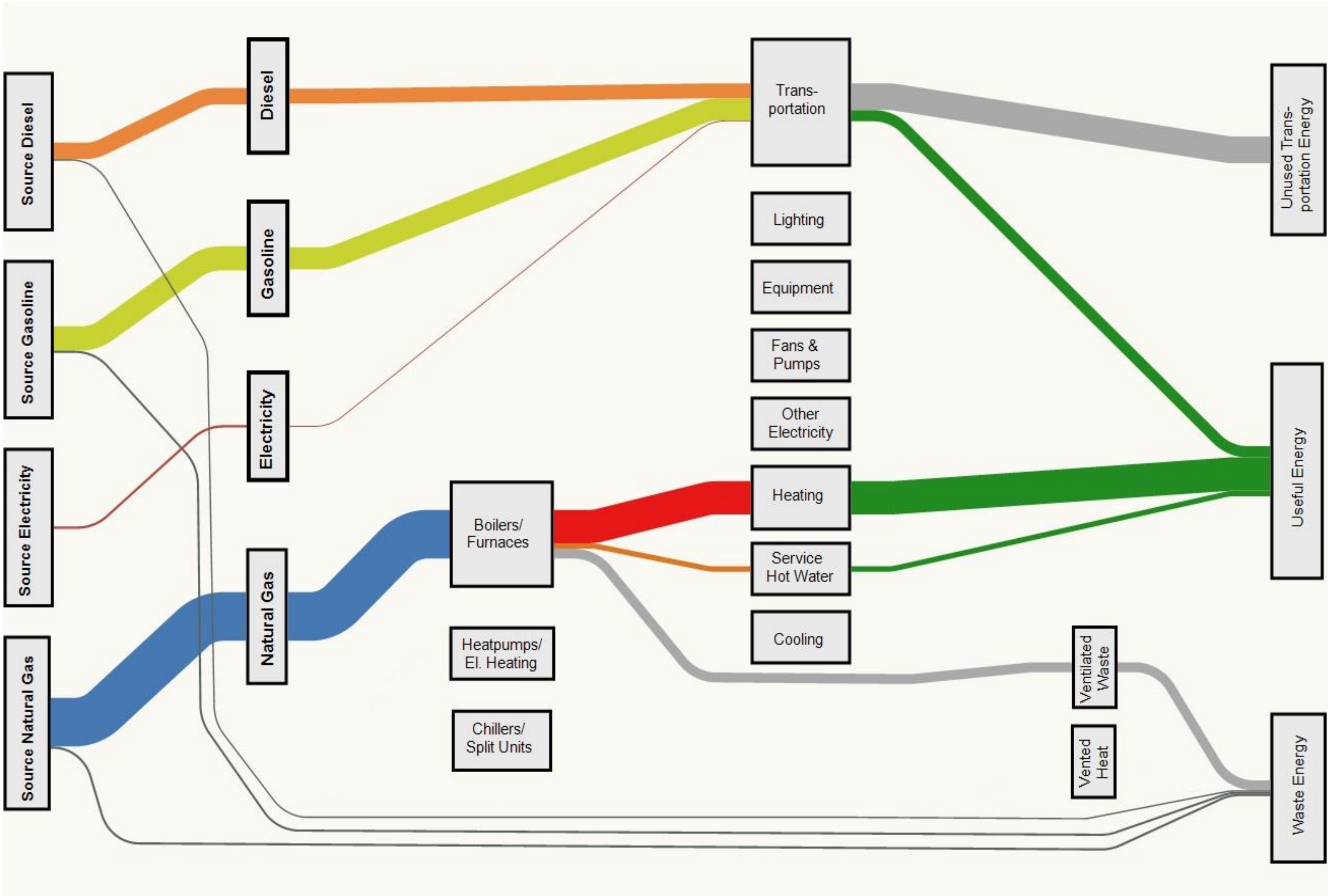

Figure 3c: Brampton Sankey diagram for 2050 CEP Efficiency Case for greenhouse gas emissions.

3.3 Energy Costs

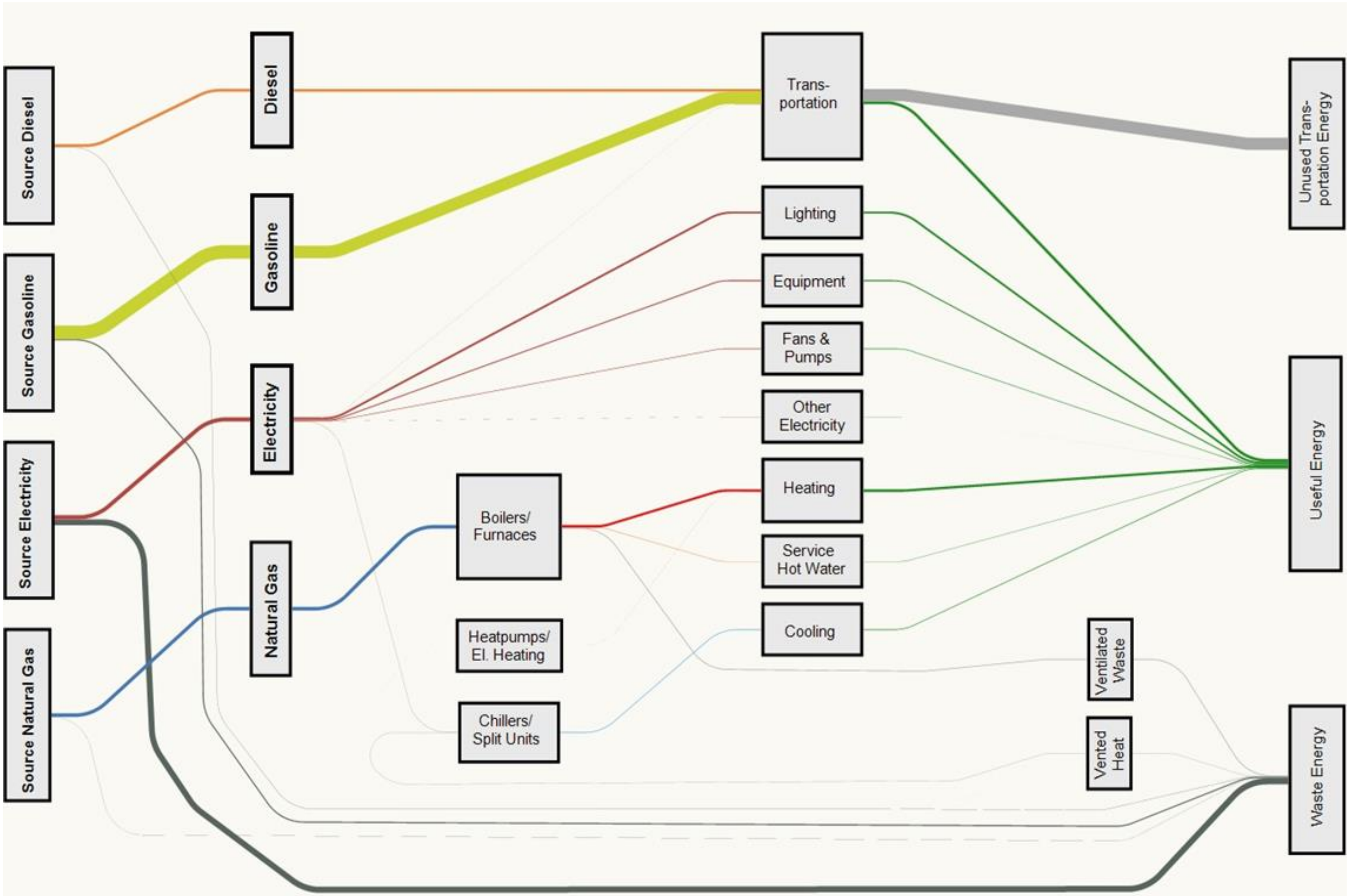

Figure 4a: Brampton Sankey diagram for 2016 baseline for energy cost.

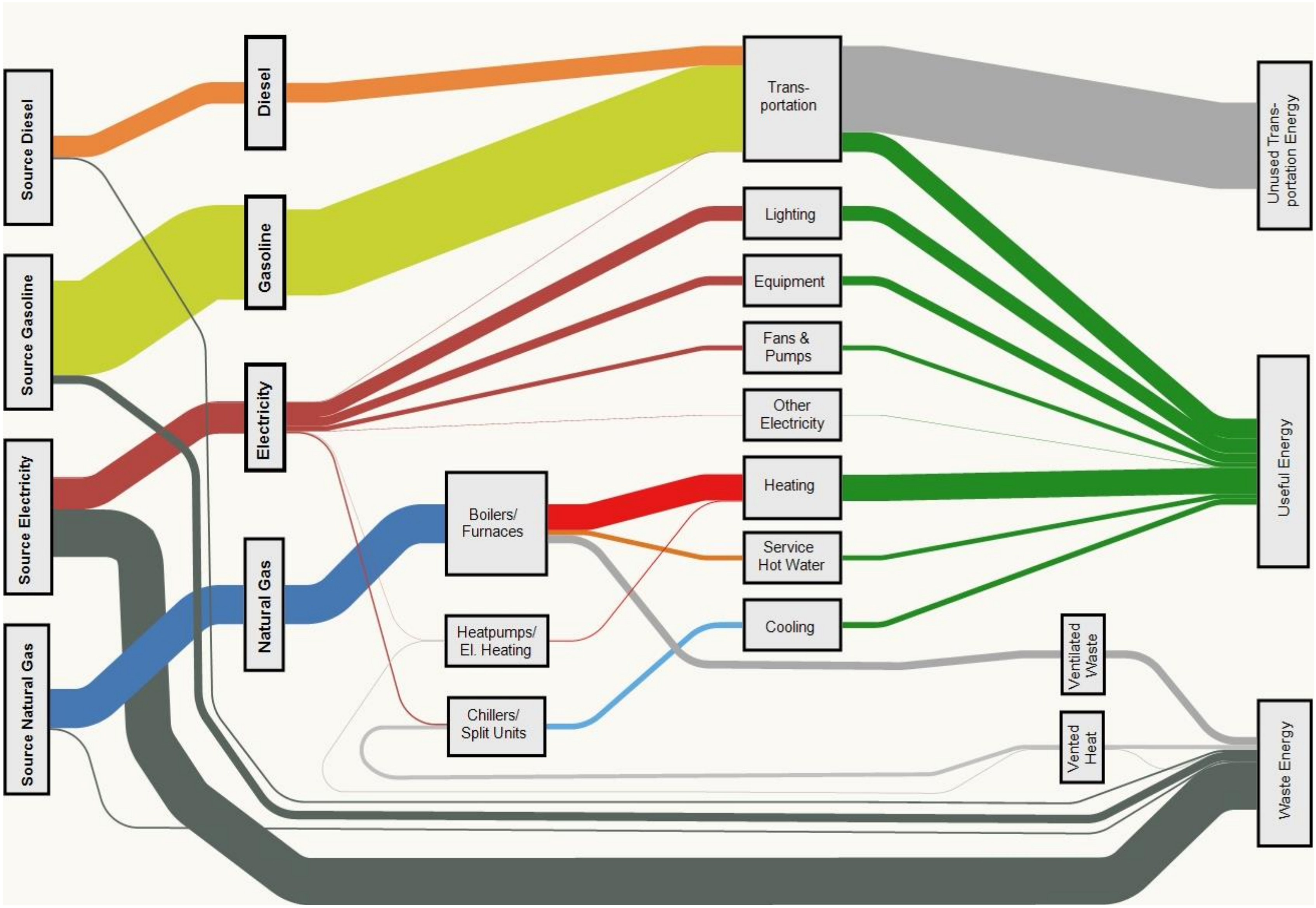

Figure 4b: Brampton Sankey diagram for 2050 Base Case energy costs.

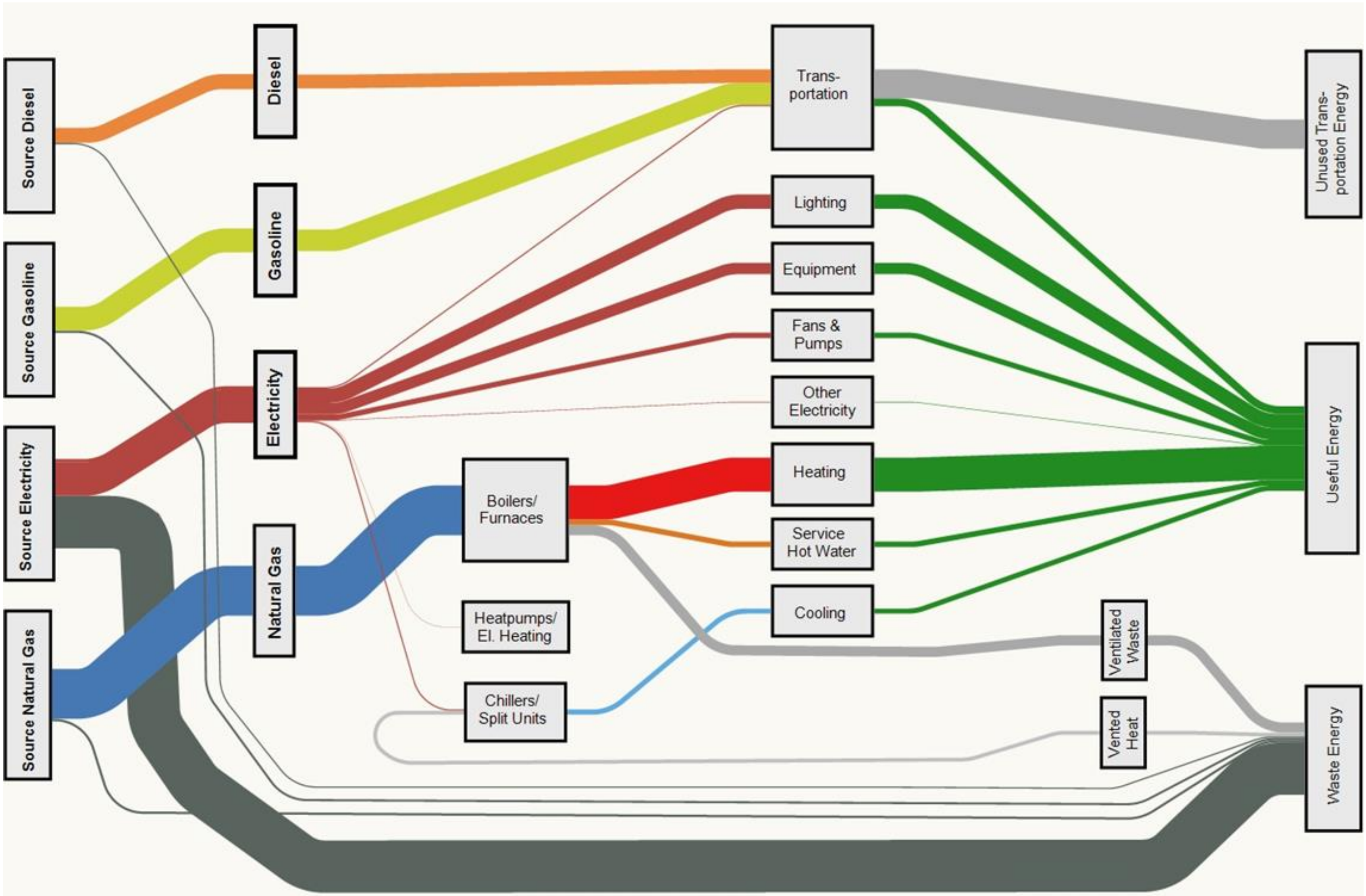

Figure 4c: Brampton Sankey diagram for 2050 CEERP Efficiency Case for energy costs.